CURRICULUM

POST GRADUATE & RESEARCH PROGRAMMES M.Tech., M.Tech.(Research), M.Sc., M.C.A., M.B.A., Ph.D.

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA SURATHKAL
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2020

MOTTO

* Work is Worship

VISION

* To Facilitate Transformation of Students into- Good Human Beings, Responsible Citizens and Competent Professionals, focusing on Assimilation, Generation and Dissemination of Knowledge.

MISSION

* Impart Quality Education to Meet the Needs of Profession and Society and Achieve Excellence in Teaching-Learning and Research.

* Attract and Develop Talented and Committed Human Resource and Provide an Environment Conducive to Innovation, Creativity, Team-spirit and Entrepreneurial Leadership

* Facilitate Effective Interactions Among Faculty and Students and Foster Networking with Alumni, Industries, Institutions and Other Stake-holders.

* Practise and Promote High Standards of Professional Ethics, Transparency and Accountability.

CURRICULUM 2019

POST GRADUATE & RESEARCH PROGRAMMES

M.Tech., M.Tech. (Research), M.Sc., M.C.A., M.B.A., Ph.D.

SECTIONS

REGULATIONS (General)

Common to all Degree Programmes

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL
Post Srinivasnagar, Mangalore - 575025, India. 2020

CONTENTS

REGULATIONS (General)
Common to all Degree Programmes

{also refer: REGULATIONS specific to the Degree Programmes}

G1. INTRODUCTION:

G1.0 The General Regulations that are common to all Degree Programmes of NITK Surathkal, are presented here. Specific aspects of the Regulations pertaining to a particular Degree Programme are given separately along with the corresponding Curriculum.

G1.1 The provisions contained in this set of Regulations govern the policies and procedures, on the admission of students, imparting instructions of courses, conducting of the examinations and evaluation and certification of students' performance leading to the said Degree Programme(s).

G1.2 This set of Regulations, on approval by the Senate, may supersede all the corresponding earlier sets of Regulations of the Institute, along with all the amendments thereto, and shall be binding on all students undergoing the said Degree Programme(s).

G1.3 This set of Regulations may evolve and get revised/refined or updated or amended or modified or changed through appropriate approvals from the Senate, from time to time, and shall be binding on all parties concerned, including the Students, Faculty, Staff, Departments, Institute Authorities.

G1.4 In order to *guarantee fairness and justice* to all the parties concerned, in view of the periodic evolutionary refinements, any specific issues or matters of concern shall be addressed separately, by the *appropriate authorities*, as and when found necessary.

G1.5 The effect of year -to-year (periodic) refinements in the Academic Regulations & Curriculum, on the students *admitted in earlier years*, shall be dealt with appropriately and carefully, so as to ensure that *those* students are not subjected to any unfair situation whatsoever, although they are required to conform to these revised set of Regulations & Curriculum, without any undue favour or considerations.

G1.6 The Senate may consider any issues or matters of concern relating to any or all the Academic Activities of the Institute, for appropriate action, irrespective of whether a reference is made (or the nature and extent of any reference if so present) here in this set of Regulations or otherwise.

G1.7 Whenever outside Experts need to be co-opted and/or invited for any of the Academic Committee Meetings, prior approval from the Chairman of the Senate/BOS shall be obtained, justifying the need, based on the agenda items of such Academic Committee Meetings. The outside experts shall be entitled for TA/DA/etc as per the prevailing Institute Rules.

G1.8 All disputes arising from this set of Regulations must be addressed to the Senate. The decision of the Senate is final and binding on all parties concerned. Further, any legal disputes arising from this set of Regulations shall be limited to the legal jurisdiction determined by the location of the Institute and not that of any other parties.

G2. DEFINITIONS: Unless the context otherwise requires –

- "**Institute"/"NITK"/"NITKS**" means, National Institute of Technology Karnataka, Surathkal.
- "**BOG**" means, the Board of Governors (BOG) of the Institute.
- "**MHRD**" means, the Ministry of Human Resources Development, GOI.
- "**JEE**" means, Joint Entrance Examination.
- "**GATE**" means, Graduate Aptitude Test in Engineering.
- "**Senate**" means, the Faculty Senate of the Institute.
- "**Director**" means, the Director of the Institute.
- "**BOS**" means, the Board of Studies of the Institute.
- "**Dean (A)**" means, the Dean (Academic).
- "**Dean (FW)**" means, the Dean (Faculty Welfare)
- "**Dean (P&D)**" means, the Dean (Planning and Development)
- "**Dean (R&C)"** means, the Dean (Research & Consultancy)
- "**Dean (SW)"** means, Dean (Students Welfare).
- "**Dean (AA&IR)"** means, Dean (Alumni Affairs & Institutional Relations).
- "**NITKS Hostels**" means, NITK-Surathkal Hostels.
- "**HOD**" means, the Head of the Department.
- "**Programme Co-ordinator**" means, a faculty in charge of an academic programme, particularly in case of PG and/or Research degree programmes.
- "**Parent Department" or "*D*egree *A*warding *D*epartment**" means, the department that offers the degree programme that a student undergoes, or the department to which the Research-Guide/Programme-Coordinator belongs.
- "**DAC**" or "PAC" means, the Departmental/Programme Academic Committee.
- "**DUGC**" means, the Departmental Under Graduate Committee.
- "**DPGC**" means, the Departmental Post Graduate Committee.
- "**PWEC**" means, the Project Work Evaluation Committee.
- "**DRPC**" means, Doctoral Research Programme Committee.
- "**RPAC**" means, Research Progress Assessment Committee.
- "**MTAC**" means Master's Thesis Assessment Committee.
- **"DTAC**" means, Doctoral Thesis Assessment Committee.
- "**DAAB**" means, the Departmental Academic Appeals Board.
- "**Faculty Advisor**" means the Faculty Advisor or the Panel of Faculty Advisors, in a Parent Department, for a group(admission-batch) of students.
- "**Course**" means, a specific *subject* usually identified by its *course-number* and *course-title*, with a specified *syllabus*/course-description, a set of *references*, taught by some *teacher*(*s*)/course-instructor(s) to a specific *class* (group of students) during a specific *academic-session*/semester.
- "**Course Instructor**" means, the teacher or the Course Instructor of a Course.
- "**Class/Course Committee**" means, the Class/Course Committee of a class/course.
- "**Project Guide**" means, the faculty who guides the Major Project of the student.
- "**Research Guide**" means, the faculty who guides the Research student/scholar, including the Additional Guide.
- "**He**" includes both genders he and she;
  similarly "his" and/or "him" includes "her" as well, in all the cases.
- "**Regulations**" means, this set of Academic Regulations.
- "**Curriculum**" includes the set of Academic Regulations, Course-Structure and Course-Contents.
- "**MOU**" means, Memorandum Of Understanding.

G3. ACADEMIC CALENDAR:

G3.1 The normal duration of the course leading to B.Tech degree will be *EIGHT* semesters.
G3.2 The normal duration of the course leading to M.Tech. degree will be *FOUR* semesters.
G3.3 The normal duration of the course leading to M.C.A. degree will be *SIX* semesters.
G3.4 The normal duration of the course leading to M.B.A. degree will be *FOUR* semesters.
G3.5 The normal duration of the course leading to M.Sc. degree will be *FOUR* semesters.
G3.6 Each academic year shall be divided into 2 semesters, each of *20 weeks* duration, including evaluation and grade finalization, etc. The Academic Session in each semester shall provide for at least *70 Teaching Days*, with at least 40 hours of teaching contact periods in a five-days session per week. The semester that is typically from Mid July to November is called the *ODD SEMESTER*, and the one that is from January to Mid-May is called the *EVEN SEMESTER*. Academic Session may be scheduled for the *Summer Session/Semester* as well.

G3.7 The schedule of academic activities for a Semester, including the dates of registration, mid-semester examination, end-semester examination, inter-semester vacation, etc. shall be referred to as the Academic Calendar of the Semester, which shall be prepared by the Dean (Academic), approved by the Senate, and announced at least TWO weeks before the Closing Date of the previous Semester.

G3.8 The Academic Calendar must be strictly adhered to, and all other activities including co-curricular and/or extra -curricular activities must be scheduled so as not to interfere with the Curricular Activities as stipulated in the Academic Calendar.

G3.9 Under any circumstances when any of the Teaching Days gets declared as a Holiday or otherwise when the classes get suspended, irrespective of whatsoever be the reasons, appropriate makeup for such loss shall be made by having the class/lab/teaching sessions conducted on a suitable Saturday by following the particular Class Time Table of that Teaching Day which was so lost.

G4. REGISTRATION:

G4.1 Every Student after consulting his Faculty-Advisor/Research-Guide is required to register for the approved courses with the DUGC/DPGC/DRPC of Parent Department at the commencement of each semester on the days fixed for such registration and notified in the academic calendar.

G4.2 Lower and Upper Limits for Course Credits Registered in a Semester, by a Full-Time Student of a Degree Programme:
A full time student of a particular degree programme shall register for the appropriate number of course credits in each semester/session that is within the minimum and maximum limits specific to that degree programme as stipulated in the specific Regulations pertaining to that degree programme.

G4.3 Mandatory Pre-Registration for higher semesters:
In order to facilitate proper planning of the academic activities of a semester, it is essential for the students to declare their intent to register for an elective course well in advance, before the actual start of the academic session, through the process of Pre-Registration, which is mandatory for all students of second or higher semesters.

G4.4 All students (other than the freshly admitted students) intending to register for the next higher semester are required to have completed the Mandatory Pre-Registration of elective courses, at least TWO weeks before the Last Day of Classes in the current semester. To facilitate this Pre-registration all teaching departments shall announce the list of courses to be offered for the next higher semester, at least FOUR weeks before the Last Day of Classes in the current semester.

G4.5 Ph.D. students can register for any of PG/Ph.D.courses and the corresponding rules of evaluation will apply. Under Graduate students may be permitted to register for a few selected Post Graduate courses, in exceptionally rare circumstances, only if the DUGC/DPGC is convinced of the level of the academic achievement and the potential in a student.

G4.6 ***Course Pre-Requisites:***

In order for a student to register for some courses, it may be required either to have exposure in, or to have completed satisfactorily, or to have prior *earned credits* in, some specified courses. In such instances, the DUGC/DPGC/DRPC shall specify clearly, any such course pre-requisites, as part of the curriculum.

G4.7 Students who do not register on the day announced for the purpose may be permitted *LATE REGISTRATION* up to the notified day in academic calendar on payment of late fee.

G4.8 *REGISTRATION IN ABSENTIA* will be allowed only in exceptional cases with the approval of the Dean (A) after the recommendation of DUGC/DPGC/DRPC through the authorized representatives of the student.

G4.9 A student will be permitted to register in the next semester only if he fulfills the following conditions:

(a) satisfied all the Academic Requirements to continue with the programme of Studies without termination (refer Clause No: G10);
(b) cleared all Institute, Hostel and Library dues and fines (if any) of the previous semesters;
(c) paid all required advance payments of the Institute and hostel for the current semester;
(d) not been debarred from registering on any specific ground by the Institute.

G4.10 Medium of Instruction/Evaluation/etc. shall all be: English.

G5. EVALUATION SYSTEM:

G5.1 *Course Credit Assignment:*

Every Course comprises of specific Lecture-Tutorial-Practical (L-T-P) Schedule. The Course Credits are fixed based on the following norms:

Lectures/ Tutorials:	One hour per week is assigned one Credit.
Practicals :	(i) a 3-hour session per week is assigned two Credits; OR (ii) a 2-hour session per week is assigned one Credit.

For example, a theory course with a L-T-P schedule of 3-1-0 will be assigned 4 credits; a laboratory practical course with a L-T-P schedule of 0-0-3 will be assigned 2 credits.

G5.2 The Academic Performance Evaluation of a Student shall be according to a *Letter Grading System*, based on the Class *Performance Distribution*, and *not* based upon any fixed apriori mappings or any absolute scale conversions from the Raw-Scores Scale (e.g. percentage-marks) to the Grade-Points Scale. The entire evaluation system (including these *Regulations) comprising of the Policies*, *Procedures*, *Mechanisms*, *Guidelines*, etc., have-been/shall-be designed, developed, evolved, implemented and adhered to, in order to meet the most fundamental/basic *quality* characteristics of being: fair/justifiable, objective/unbiased, reliable/precise, robust/resilient, while also being flexible/responsive and transparent/verifiable. It is equally essential to maintain appropriate level of confidentiality in terms of certain specific details, in order to achieve the above *quality* characteristics.

G5.3 The double-*letter grade* (AA, AB, BB, BC, CC, CD, DD, FF) indicates the level of academic achievement, assessed on a decimal (0-10) scale.

G5.4 ***Letter-Grades and Grade-Points:***

LETTER-GRADE	GRADE-POINTS	REMARKS
AA	10	
AB	9	
BB	8	
BC	7	
CC	6	
CD	5	
DD	4	
FF	0	Fail due to poor performance
FA	0	Fail due to attendance shortage
I	-	Incomplete
U	-	Audited
W	-	Withdrawal
S	-	Satisfactory
N	-	Unsatisfactory

G5.5 The *double-letter grade* awarded to a student in a course other than a 0-0-P (Practical) course, for which he has registered shall be based on his performance in quizzes, tutorials, assignments etc., as applicable, in addition to one mid-semester examination and one end-semester examination. The distribution of weightage among these components may be as follows:

End-Semester Examination	: 40 to 50% (3 - 4 hours duration)
Mid-Semester Examination	: 20 to 25% (1 – 1½ hours duration)
Quizzes, Tutorials, Assignments, etc.	: 25 to 40%
(*continuous evaluation*)	(to make up for 100%)

Any variation, other than the above distribution, requires the approval of the pertinent DUGC/DPGC/DRPC.

G5.6 For any Undergraduate/ Postgraduate course offered to more than one section/ Department a common question paper, scheme of evaluation and grading has to be followed for both mid semester and end semester examinations. The respective DUGC/DPGC may decide about the weightage to be given to each individual component, viz tutorials, assignments, mid semester and end semester examination etc.

G5.7 The *double-letter grade* awarded to a student in a 0 -0-P (Practical) course, is based on an appropriate continuous evaluation scheme that the course instructor shall evolve, with the approval of the pertinent DUGC/DPGC/ DRPC.

G5.8 The Course Instructor shall communicate clearly to the students, by announcements in the class, and/or by displaying prominently in the departments notice boards /website, and also report in writing to the DUGC/DPGC/DRPC the course plan and the details of the *Evaluation Scheme*, including the distribution of the weightage for each of the components, as well as the requirements for receiving a ‘U’ grade for auditing the course; within the first week of the semester in which the course is offered; so that there would be no ambiguities in this regard at the end of the semester while finalizing the grades.

G5.9 For courses offered exclusively for the Ph.D. programme, the method of evaluation will be decided by pertinent DRPC. It may be similar to PG course evaluations, or it may be based on combinations of (a) Report submitted by the student (under the guidance of the Instructor for that course), (b) an open seminar, (c) viva-voce examination. An appropriate letter grade shall be awarded after the completion of the evaluation.

G5.10 *Earned Credits*

This refers to the credits assigned to the course in which a student has obtained either 'S' grade, or any one of the *double-letter grades* 'AA', 'AB', 'BB', 'BC', 'CC', 'CD', 'DD' (but not 'FF' and 'FA').

G5.11 *Cutoff Marks for 'AA' & 'FF' and the Scale-Differential:*

The *minimum cutoff* marks for 'AA' grade as well as the *maximum cutoff* marks for 'FF' grade will be decided by the Course Instructor based on the specific relevant details of the Class Performance Distribution (using appropriate class performance statistics parameters, like the Class-Mean, Class-Standard-Deviation, etc). However as a general guideline approved by the senate the minimum cutoff marks for 'AA' and 'DD' grade have been fixed as 70% and 20% respectively. Faculty members who intend to give a 'AA' grade to those students getting marks less than 70% and 'DD' grade for those students who get marks less than 20% are required to give justification for the same to the DUGC/ DPGC /DRPC of their respective department.

The *Scale-Differential* is defined as the difference between the minimum cutoff marks for the 'AA' grade and the maximum cutoff marks for the 'FF' grade (normally expressed as a multiple of the class-standard-deviation parameter).

An appropriate value for the Scale-Differential shall be decided by the Course Instructor after having studied the specific relevant details of the Class Performance Distribution.

The *minimum/maximum cutoff* marks for the intermediate grades are determined by appropriate *partitioning/clustering method* based on the specific relevant details of the Class Performance Distribution.

G5.12 *Description of Grades:*

AA Grade:

An 'AA' grade stands for outstanding achievement, relative to the class, and the Course Instructor is supposed to take *utmost care* in awarding of this highest double-letter grade.

DD Grade:

The 'DD' grade stands for marginal performance and is the minimum passing double-letter grade.

FF and FA Grades:

The 'FF' grade denotes very poor performance, i.e. *failure* in a course due to poor performance and FA grade denotes poor attendance i.e. failure in a course due to attendance shortage (i.e. < 75%) and the Course Instructor is supposed to take *utmost care* while awarding these lowest double-letter grades. The students who have been awarded 'FF' grade in a course in any semester may be allowed to appear for a make-up end-semester examination. The make- up end- semester examination will be conducted possibly along with that arranged for those students who were awarded the 'I' grade, within the period announced in the academic calendar. If after considering make-up end-semester examination a student passes, then a minimum passing grade of 'DD' only be awarded, and if a student fails then a 'FF ' grade will be awarded. Only regular registrants of a given course during a given academic semester who have obtained FF grade in the course will be permitted to appear for the makeup examination. Students who continue to have FF grade after the makeup examination are required to re- register for the course whenever it is offered subsequently. All the 'FF' (other than the courses for which 'DD' grade is obtained by the student in the make-up end-semester examinations conducted prior to the starting of next semester) and 'FA' grades secured in any course stay permanently on the grade card.

A student who obtains 'FA' grade in any course has to necessarily re-register for the course in the subsequent semesters/sessions whenever the course is offered until a passing grade is obtained. However, for an elective course in which 'FA' or 'FF' grade has been obtained, the student may either repeat the same course or register for any other elective course.

Only first year and final year courses may be offered during the summer session.

I Grade:

An ‘I’ grade denotes incomplete performance in any course due to absence at the end semester examination (see also Clause No: G8.3) . When the ‘I’ grade is converted to a regular double-letter grade, a penalty of ONE Grade-Point is imposed, by awarding the double-letter grade that is immediately below the one that the student would have otherwise received.

U Grade:

This grade is awarded in a course that the student opts to register for audit. It is not mandatory for the student to go through the entire regular process of evaluation in an audit course. However, the student has to go through some process of minimal level of evaluation and also the minimum attendance requirement, as stipulated by the Course Instructor and approved by the corresponding DUGC/DPGC/DRPC, for getting the “U” grade awarded in a course, failing which that course will not be listed in the Grade Card.

W Grade:

A ‘W’ grade is awarded when the student withdraws from the course. Withdrawal from a course is permitted only under extremely exceptional circumstances (like medical emergencies, family tragedies and/or other unavoidable contingencies) and has to be recommended by the DUGC/DPGC/DRPC and approved by the Dean (Academic). However, no withdrawal is permitted after the finalization of the grades in the semester. Also, the ‘W’ grade once recorded remains permanently in the Grade Card.

S and N grades:

These grades are awarded for the Mandatory Learning Courses. The ‘S’ grade denotes satisfactory performance and completion of a course. The ‘N’ grade is awarded for non-completion of course requirements and the student will have to register for the course until he obtains the ‘S’ grade. The ‘N’ grade secured in a course stays permanently on the Grade Card.

G5.13 *Evaluation of Performance:*

The overall performance of a student will be indicated by two indices: SGPA which is the Semester Grade Point Average and CGPA which is the Cumulative Grade Point Average.

SGPA for a semester is computed as follows:

$$\text{SGPA} = \frac{[\sum \text{(Course credits) x (Grade Point)}]\ \text{for all courses with double-letter grades, including ‘FF’ and ‘FA’ (in that semester).}}{[\sum \text{(Course credits)}]\ \text{for all courses with double-letter grades, including ‘FF’ and ‘FA’ (in that semester).}}$$

CGPA is computed as follows:

$$\text{CGPA} = \frac{[\sum \text{(Course credits) x (Grade Point)}]\ \text{for all courses with double-letter grades, including all ‘FF’ and ‘FA’ grades.}}{[\sum \text{(Course credits)*}]\ \text{for all courses with double-letter grades, including all ‘FF’ and ‘FA’ grades.}}$$

* Whenever a student reappears for a course in which he / she has been awarded ‘FF’ or ‘FA’ grade, the CGPA computations will not once again include the course credits for the failed courses in the denominator.

* There is no equivalence between the CGPA scale and percentage. However, CGPA ≥ 6.5 can be considered as equivalent to first class and $5.5 \leq \text{CGPA} < 6.5$ can be considered as

equivalent to second class. Notionally, CGPA may be multiplied by a factor of 10 to obtain the numerical percentage.

G5.14 *Report of Marks, Grades and Class Performance Statistics:*

(a) The final grades shall be displayed for at least *ONE* working-day, during which period a student can approach the concerned course instructor(s) for any clarification. The process of evaluation shall be transparent and the students shall be made aware of all the factors included in the evaluation. In case of any correction, the course instructor shall have to incorporate the same before finalization of the grades.

(b) The course instructors shall submit the Report of Marks & Grades for each of the students in his course, along with the Summary Report of Marks & Grades containing the Class Performance Statistics, in the prescribed format, to the Chairman, DUGC/DPGC/DRPC by the stipulated date, for possible moderation (if and only when found necessary) and approval.

(c) The DUGC/DPGC/DRPC shall submit the final approved Report of Marks & Grades along with Summary Report of Marks & Grades containing the class performance statistics, in the prescribed format, to the office of the Dean (Academic) within the stipulated date.

(d) The Student Progress Report shall contain the Letter-Grade for each course; along with the SGPA, and the CGPA.

G5.15 *Appeal for review of Grades:*

(a) The entire process of evaluation shall be made transparent, and the course instructor shall explain to a student why he gets whatever grade he is awarded, if and when required. A mechanism for review of grades is incorporated in the evaluation system. However, before appealing for such review, a student shall first approach the concerned Course Instructor and then the concerned DUGC/DPGC/DRPC, with the request to do the needful; and only in situations where satisfactory remedial measures have not been taken, the student may then appeal to the Departmental Academic Appeals Board (DAAB).

(b) In case of any such grievances about the grades, the student may appeal for review of grades to the Departmental Academic Appeals Board (DAAB) before the date specified in Academic Calendar.

(c) The fee for such an appeal will be decided by the Senate from time to time. If the appeal is upheld by DAAB, then the fee amount will be refunded to the student.

G6. ADD / DROP / cU -options:

G6.1 *ADD-option:*
A student has the option to ADD courses for registration till the date specified for late registration in the Academic Calendar.

G6.2 *DROP-option:*

On recommendation of the Teaching Department as well as the Parent Department, a student has the option to DROP courses from registration *until 2 weeks after the commencement of the classes in the semester*, as indicated in the Academic Calendar.

G6.3 *cU-option:*

A student can register for auditing a course, or a course can even be converted from Credit to Audit or from Audit to Credit, with the consent of the Faculty Advisor and Course Instructor *until 2 weeks after the commencement of the classes in the semester as indicated in the Academic Calendar.* However, CORE Courses shall not be made available for audit.

G7. ATTENDANCE REQUIREMENTS:

7.1 All students must attend every lecture, tutorial and practical classes.

7.2 To account for approved leave of absence (eg. representing the Institute in sports, games or athletics; placement activities; NCC/NSS activities; etc.) and/or any other such contingencies like medical emergencies, etc., the attendance requirement shall be a *minimum of 75%* of the classes actually conducted. A maximum of seven days attendance in a semester may be granted to those students who have been absent for participating in curricular and extracurricular activities after due approval from the Institute.

7.3 A student with less than 75% attendance in a course during a semester, in lectures, tutorials and practicals taken together as applicable, will not be permitted to appear in the End Semester Examinations of the course in which the shortfall exists, irrespective of his academic performance, and irrespective of nature of his absence . He shall be awarded ‘FA’ grade in that course .

7.4 The course instructor handling a course must finalise the attendance 3 calendar days before the last day of classes in the current semester and communicate clearly to the students by displaying prominently in the department and also in report writing to the head of the department concerned.

7.5 The attendance records are to be maintained by the course instructor and he shall show it to the student, if and when required.

G8. ABSENCE DURING THE SEMESTER:

G8.1 *Leave of Absence:*

(a) If the period of leave is more than two days and less than two weeks, prior application for leave shall have to be submitted to the HOD concerned, with the recommendation of the Faculty-Advisor/Research-Guide stating fully the reasons for the leave requested, along with supporting documents.

(b) If the period of leave is two weeks or more, prior application for leave shall have to be made to the Dean (Academic) with the recommendations of the Faculty-Advisor/ Research Guide, HOD concerned stating fully the reasons for the leave requested, along with supporting documents. The Dean (Academic) may, on receipt of such application, grant leave or also decide whether the student be asked to withdraw from the course for that particular semester because of long absence.

(c) It will be the responsibility of the student to intimate the Course Instructors, and also the Dean (Students Welfare) as well as the Chief Warden of the hostel, regarding his absence before availing leave.

G8.2 *Absence during Mid-Semester Examination:*

A student who has been absent from a Mid Semester Examination due to illness and other contingencies may give a request for make-up examination within two weeks after the Mid Semester Examination to the HOD with necessary supporting documents and certifications from authorized personnel. The HOD may consider such requests depending on the merits of the case, and after consultation with the course instructor, may permit the make-up Mid Semester Examination for the concerned student.

G8.3 *Absence during End-Semester Examination:*

In case of absence for an End Semester Examination, on medical grounds or other special circumstances, the student can apply for ‘I’ grade in that course with necessary supporting documents and certifications by authorized personnel to the HOD. The HOD may consider the request, depending on the merit of the case, and after consultation with the Course Instructor, permit the make-up End Semester Examination for the concerned student (possibly arranged along with those students who were awarded the ‘FF’ grade). The student may subsequently complete all course requirements within the period announced in Academic Calendar (which may possibly be extended till first week of next semester under special circumstances) and 'I' grade will then be converted to an appropriate Double-letter grade, as per Clause No: G5.12 (Description of Grades: "I" Grade, above). All the particulars of such a decision with date of finalizing the grade shall becommunicated to Dean (Academic). If such an application for the 'I' grade is not made by the student then a double-letter grade will be awarded based on his in-semester performance.

G9. TRANSFER OF CREDITS

The courses credited elsewhere, in Indian or foreign University/Institutions/ Colleges by students during their study period at NITK may count towards the credit requirements for the award of degree. The credits transferred will reduce the number of courses to be registered by the student at NITK. The guidelines for such transfer of credits are as follows:

a) B.Tech students with consistent academic performance and CGPA $\geq$7.5 can credit courses approved by the concerned DUGC of the program, in other Institutions during 3rd and 4th year and during summer breaks.
b) PG students with consistent academic performance and CGPA $\geq$7.5 can credit courses, approved by the concerned DPGC of the program in other Institutions during the summer vacation /project work.
c) Credits transferred will not be used for SGPA/CGPA computations. However, credits transferred will be considered for overall credits requirements of the programme.
d) Students can earn external credits only from IISC/IITs/NITs/IIMs and other Indian or foreign Universities/Institutes /Colleges with which NITK has an MOU (and that MOU must have a specific clause for provision of credit transfer by students)
e) Credits transfer can be considered only for the course at same level i.e UG, PG etc.
f) A student must provide all details (original or attested authentic copies) such as course contents, number of contact hours, course instructor /project guide and evaluation system for the course for which he is requesting a credits transfer. He shall also provide the approval or acceptance letter from the other side. These details will be evaluated by the concerned departmental academic bodies (DUGC or DPGC) before giving approval. These academic bodies will then decide the number of equivalent credits the student will get for such course(s) in NITK. The complete details will then be forwarded to Dean (A) for approval.
g) The maximum number of credits that can be transferred by a student shall be limited to 20.
h) In case of major project for PG student, the External Guide will evaluate for only 50% credits (which will account for credits transfer) and the internal PWEC will evaluate for the remaining 50% credits.
i) A students has to get minimum passing grades/ marks for such courses for which the credits transfer are to be made.
j) Credits transfers availed by a student shall be properly recorded on academic record(s)of the student.

G10. WITHDRAWAL FROM THE PROGRAMME:

G10. 1 *Temporary Withdrawal:*

(a) A student who has been admitted to a degree programme of the Institute may be permitted to withdraw temporarily, for a period of one semester or more, on the grounds of prolonged illness or grave calamity in the family, etc., provided:

(i) He applies to the Institute stating fully the reasons for withdrawal together with supporting documents and endorsement from his parent/guardian;

(ii) The Institute is satisfied that, without counting the period of withdrawal, the student is likely to complete his requirements of the degree within the time specified (refer: "Degree Requirements") ;
(iii) There are no outstanding dues with the Departments / Institute / Hostels / Library / etc.;
(i) Scholarship holders are bound by the appropriate Rules applicable to them.
(ii) The decision of the Director of the Institute regarding withdrawal of a student is final and binding.

(b) Normally, a student will be permitted only one such temporary withdrawal during his tenure as a student and this withdrawal will not be counted for computing the duration of study.

G10.2 *Permanent Withdrawal:*

Any student who withdraws admission before the closing date of admission for the Academic Session is eligible for the refund of the all the fees and deposits, after a deduction of a processing fee.

Once the admission for the year is closed, the following conditions govern withdrawal of admissions:

(a) A student who wants to leave the Institute for good, will be permitted to do so (and take Transfer Certificate from the Institute, if needed), only after clearing all the dues, if any. Also, all the fees and charges already paid will not be refunded on any account.

(b) Those Students who have received any scholarship, stipend or other forms of assistance from the Institute shall repay all such amounts in addition to those mentioned in Clause No: G10.2
(a) above.

(c) The decision of the Director of the Institute regarding all aspects of withdrawal of a student shall be final and binding.

G11. CONDUCT AND DISCIPLINE:

G11.1 Students shall conduct themselves within and outside the premises of the Institute in a manner befitting the students of an Institution of National Importance.

G11.2 As per the order of Honorable Supreme Court of India, ragging in any form is considered as a criminal offence and is banned. Any form of ragging will be severely dealt with.

G11.3 The following acts of omission and/or commission shall constitute gross violation of the code of conduct and are liable to invoke disciplinary measures:

(a) Ragging.
(b) Lack of courtesy and decorum; indecent behavior anywhere within or outside the campus.
(c) Willful damage or stealthy removal of any property/belongings of the Institute/Hostel or of fellow students/citizens.
(d) Possession, consumption or distribution of alcoholic drinks or any kind of narcotics or hallucinogenic drugs.
(e) Mutilation or unauthorized possession of library books.
(f) Noisy and unseemly behavior, disturbing studies of fellow students.
(g) Hacking in computer systems (such as entering into other person's area without prior permission, manipulation and /or damage of computer hardware and software or any other cyber crime etc.)
(h) Plagiarism of any nature.
(i) Any other act of gross indiscipline as decided by the Senate from time to time.

Commensurate with the gravity of offense, the punishment may be: reprimand, fine, expulsion from the hostel, debarring from an examination, disallowing the use of certain facilities of the Institute, rustication for a specified period or even outright expulsion from the Institute, or even handing over the case to appropriate law enforcement authorities or the judiciary, as required by the circumstances.

G11.4 For an offence committed in (i) a hostel (ii) a department or in a class room and (iii) elsewhere, the Chief Warden, the Head of the Department and the Dean (Students Welfare), respectively, shall have the authority to reprimand or impose fine.

G11.5 Cases of adoption of unfair means and/or any malpractice in an examination shall be reported to the Dean (Academic) for taking appropriate action.

G11.6 All cases of serious offence, possibly requiring punishment other than reprimand, shall be reported to the Director.

G11.7 The Institute Level Standing Disciplinary Action Committee constituted by the Director, shall be the authority to investigate the details of the offence, and recommend disciplinary action based on the nature and extent of the offence committed.

G12. RESIDENCE:

G12.1 Institute is wholly residential and all full-time students shall be required to reside in the hostels.

G12.2 Under special circumstances, the Dean (Students Welfare) may permit a student to reside with his parent/guardian in the Institute campus or within a reasonable distance from the Institute.

G12.3 Students shall be required to abide by the Rules and Regulations of the NITKS Hostels as established by the Board of NITKS Hostels Management.

G13. GRADUATION REQUIREMENTS AND CONVOCATION:

G13.1 A student shall be declared to be eligible for the award of the degree if he has:

(a) Fulfilled Degree Requirements
(b) No dues to the Institute, Departments, Hostels, Library, CCC, and any other centers
(c) No disciplinary action pending against him.

G13.2 The award of the degree must be recommended by the concerned Departmental/Programme Academic Committee (DUGC/DPGC/DRPC) to the Senate, for approval and for further recommendation to the BOG.

G13.3 *Convocation:*

Degrees will be awarded in person for the students who have graduated during the preceding academic year. Degrees will be awarded in absentia to such students who are unable to attend the Convocation. Students are required to apply for the Convocation along with the prescribed fee, after having satisfactorily completed all the degree requirements (refer "Degree Requirements") within the specified date in order to arrange for the award of the degree during convocation.

G14. COMMITTEES / FUNCTIONARIES:

The following committees shall be constituted common for the various degree programmes:

G14.1 *Departmental Academic Appeals Board (DAAB):*

Constitution:

(a)	HOD of the teaching/parent Dept	…	Chairman
(b)	Three faculty members (1P + 1Asso.P + 1Asst.P)	…	Members
(c)	One Professor from outside the Department nominated by Dean (Academic)	…	Member
(d)	Faculty Advisor(s) of the Class from where the Appeal originates	…	Member(s)

Note:

- There shall be one DAAB for every department.
- The Chairman may co-opt and/or invite more members.
- Depending on the prevailing circumstances, a Senior Professor of the Department, nominated by the Dean (Academic), shall act as Chairman instead of Head of the Department.
- If the concerned instructor is a member of DAAB then he shall keep himself out of the Board during deliberations.

Functions (Highlights):

i. To receive grievance/ complaints in writing from the students regarding anomaly in award of grades due to bias, victimization, erratic evaluation, etc. and redress the complaints.

ii. To interact with the concerned course instructor and the student separately before taking the decision.

iii. The decision of the DAAB will be based on simple majority.

iv. The recommendations of the DAAB shall be communicated to the Dean (Academic) for further appropriate action as required.

G14.2 *Class/Course Committee:*

Every Class (group of students registered for a course) of the Degree Programme shall have a Class/Course Committee, consisting of Faculty and Students.

Constitution:

(a) One Faculty of the Parent/Teaching Department, not associated with the class; nominated by the HOD.	…	Chairman
(b) Faculty Advisor(s) for the Class	…	Member-Secretary
(c) Course Instructor(s)	…	Member(s)
(d) *FOUR* to SIX students from the Class/Course to be chosen by the students amongst themselves	…	Members

Functions (Highlights):

i. The basic responsibilities of the Class/Course Committees are to review periodically the progress of the classes, to discuss problems concerning curriculum and syllabi and the conduct of the classes.

ii. Each class/course committee will communicate its recommendations to the HOD/DUGC/DPGC/DRPC of the Parent/Teaching Department.

iii. There shall be minimum one class committee meeting at the middle of every semester as indicated in the academic calendar. However additional class committee meetings may be convened as decided by DUGC/DPGC/Course Instructor.

iv. During beginning of the semester, the Course Instructors shall present the method of evaluation and distribution of weightages for the various components.

v. The minutes of each class/course committee meeting shall be recorded in a separate minutes register maintained in the Parent/Teaching Department.

vi. Any appropriate responsibility or function assigned by the DUGC/DPGC or the Chairman of the DUGC/DPGC.

G14. 3 *Faculty Advisor(s):*

The Faculty Advisor(s) will be appointed by the HOD of the parent department, who will be assigned a specific group (admission-batch) of students of the concerned parent department, and will be valid throughout their duration of study.

Functions (Highlights):

i. To help the students in planning their courses and related activities during their study period.

ii. To monitor, guide, advise and counsel the students on *all* academic matters.

iii. To coordinate the activities regarding mandatory learning courses.

G14. 4 *Course Instructor:*

Functions (Highlights):

i. He shall follow all the Regulations related to teaching of a course and evaluation of students.

ii. He shall be responsible for all the records (i.e., course registration, answer books, attendance, etc.) of the students registered for the course.

iii. He shall conduct classes as prescribed in the Academic Calendar and as per the teaching assignment time table issued by the HOD.

iv. He will arrange to distribute a course plan and the evaluation plan together with the course objectives, background materials to all the students within the first week of each semester.

v. He will prepare an evaluation plan showing details of how the student's performance will be evaluated in the course.

vi. He will properly document the students' performance and announce to the students (including on the notice board) as stipulated in the Regulations.

vii. He will report to the HOD on a periodic (*monthly*) basis, the potential cases of very poor academic performance as well as those of low attendance that would possibly result in a 'FF' or 'FA' grade at the end of the semester.

G14. 5 *Departmental/Programme Academic Committee(s):*

Constitution:
The Departmental/ Programme Academic Committees are specific academic committees for each of the programmes/departments, like DUGC, DPGC, DRPC as given in the Regulations specific to such programmes/departments.

Functions (Highlights):

i. Specific functions as given in the Regulations specific to the concerned academic programme.
ii. Recommend to the BOS/Senate, appropriate measures to deal with the specific issues of concern, arising because of the effect of the year-to-year (periodic) refinements in the Academic Regulations & Curriculum, on the students *admitted in earlier years* (so as to ensure that *those* students are not subjected to any unfair situation whatsoever, although they are required to conform to these revised set of Regulations & Curriculum, without any undue favor or considerations) like the specific details of the credit requirements, etc., as and when such cases arise or need to be addressed, considering the nature and extent of the refinements, and implement the same with the appropriate approval of the BOS/Senate.

iii. Any appropriate responsibility or function assigned by the Senate or the Chairman of the Senate or the BOS or the Chairman of the BOS.

* * * * *

REGULATIONS

SPECIFIC TO

POST GRADUATE PROGRAMME

M.Tech. Degree

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL
Post : Srinivasnagar, Mangalore - 575025, India. - 2020

CONTENTS

REGULATIONS
specific to
M.Tech. Degree Programme

{also refer: REGULATIONS (General) – Common to all Degree Programmes}

1. DEGREE PROGRAMMES:

1.1 Post Graduate M.Tech. Degree Programmes are offered in the following disciplines by the respective programme hosting departments listed below:

(a) Department of Civil Engineering (CV)
- i. Structural Engineering
- ii. Geotechnical Engineering
- iii. Environmental Engineering
- iv. Transportation Engineering
- v. Construction Technology and Management

(b) Department of Water Resources and Ocean Engineering (WO)
- vi. Marine Structures
- vii. Water Resources Engineering and Management
- viii. Remote Sensing and GIS

(c) Department of Mining Engineering (MI)
- ix. Rock Excavation Technology & Management

(d) Department of Computer Science & Engineering (CS)
- x. Computer Science and Engineering
- xi. Computer Science and Engineering – Information Security

(e) Department of Electronics and Communication Engineering (EC)
- xii. VLSI Design
- xiii. Communication Engineering and Networks
- xiv. Signal Processing and Machine Learning

(f) Department of Electrical and Electronics Engineering (EE)
- xv. Power and Energy Systems

(g) Department of Information Technology (IT)
- xvi. Information Technology

(h) Department of Mechanical Engineering (ME)
- xvii. Thermal Engineering
- xviii. Manufacturing Engineering
- xix. Mechatronics Engineering
- xx. Mechanical Design

(i) Department of Chemical Engineering (CH)
- xxi. Chemical Engineering
- xxii. Environmental Science and Technology
- xxiii. Industrial Biotechnology

(j) Department of Metallurgical and Materials Engineering (MT)
- xxiv. Process Metallurgy
- xxv. Materials Engineering
- xxvi. Nanotechnology

(k) Department of Mathematical and Computational Sciences (MA)
- xxvi.i Computational and Data Science

1.2 The provisions of these Regulations shall be applicable to any new disciplines and/or that may be introduced from time to time and appended to the above list.

2. ADMISSION:

2.1 Student Status: There are three types of student status in the M.Tech. degree Programme:

(a) Full-time student on GATE-Scholarship
(b) Full-time sponsored student on QIP (AICTE)
(c) Full-time sponsored student from Industry or other Organizations including Educational Institutions

Note:

i. The full-time students are those who work on full-time basis at the Institute.

ii. *Duration:* For full-time students, the duration of study shall be a minimum of FOUR semesters and a maximum of FOUR years.

iii. A student of type (a) will receive GATE-Scholarship for the duration of four semesters, which is subjected to the GATE-Scholarship rules of MHRD.

iv. Student of the type (c) shall be sponsored and financed by the sponsoring organization. He should produce a sponsorship-cum-clearance certificate in the given format of the Institute. The candidate must have a minimum of 2 years of Full-time work experience in the sponsoring organization, after completing the qualifying degree.

v. No student can receive scholarship/assistantship from more than one source.

2.2 Admissions will be made in accordance with the instructions received from MHRD from time to time. Seats are reserved for candidates belonging to Other Backward Classes (OBC) Scheduled Caste and Scheduled Tribes, Persons with disability, children of defence personnel and other categories as per the guidelines issued by MHRD.

2.3 The minimum eligibility criteria for admission for the various M.Tech. Degree programmes shall be specified in the Institute Information Bulletin or the Prospectus. However, some general criteria are mentioned below.

2.4 The criteria for selection/admission for full-time students on GATE Scholarship will be based on GATE score. However the admission to other categories will be based on performance in qualifying exam, interview and other guidelines issued by the Senate from time to time. The prescribed qualifying examinations are given separately in the Prospectus or the Institute Information Brochure for each M.Tech. Programme.

2.5 Admission to a M.Tech. Programme shall be open to candidates who passed the prescribed qualifying examination, with a Cumulative Grade Point Average (CGPA) of at least 6.5 in the 0-10 scale grading system, OR not less than 60% marks in the aggregate (taking into account the marks scored in all the subjects of all the public/university examinations conducted during the entire prescribed period for the degree programme). However, this prescribed minimum shall be a CGPA of 6.0 OR 55% marks in the aggregate for SC/ST/PWD candidates.

2.6 A limited number of admissions is offered to Foreign Nationals and Indians Living Abroad in accordance with the rules applicable for such admission, issued from time to time, by MHRD.

2.7 If, at any time after admission, it is found that a candidate had not in fact fulfilled all the requirements stipulated in the offer of admission, in any form whatsoever, including possible misinformation etc., this matter shall be reported to the Senate, recommending revoking the admission of the candidate.

2.8 Candidates have to fulfil the medical standards required for admission as prescribed in the *Institute Information Brochure* or the *Prospectus*.

2.9 The Institute reserves the right to cancel the admission of any student and ask the student to discontinue the studies at any stage of his/her study period on the grounds of unsatisfactory academic performance or indiscipline or any misconduct.

2.10 The decision of the Senate regarding the admissions is final and binding.

2.11 Student Exchange Programmes and the Transfer of Credits in such cases shall be as per the corresponding MoU approved by Competent Authority.

2.12 Every Post Graduate student of the Institute shall be associated with *Parent Department*, offering the degree programme that the student undergoes, throughout his study period.

3. COURSE STRUCTURE;

3.1 The total course package for a M.Tech. Degree Programme will typically consist of the following components.

a) Programme Core Courses	PC	≥ 20 Credits
b) Elective Courses	Ele	≥ 09 Credits
c) Major Project	MP	= 8 - 12 Credits
d) Mandatory Learning Courses	MLC	= 04 Credits

3.2 The Department Post Graduate Committee (DPGC) will discuss and recommend the exact credits offered for the programme for the above components, the semester- wise distribution among them, as well as the syllabi of all postgraduate courses offered by the department from time to time before sending the same to the Board of Studies (BOS). The BOS will consider the proposals from the departments and make recommendations to the Senate for consideration and approval.

3.3 The Minimum Credit Requirement for the M.Tech. Degree is 50-55.

3.4 Major Project:

(a) The Major Project carries 8-12 credits and spreads over TWO semesters, normally during 3rd and 4th semesters (or as recommended by DPGC). The progress of the Project Work shall be monitored by the Project Guide.

(b) The method of evaluation, including intermediate assessment shall be evolved by the pertinent DPGC.

(c) The PWEC chairman (A faculty from the programme in the Department, nominated by the Chairman DPGC) should be identified in the third semester itself and the committee consisting of PWEC chairman and guide (s) shall evaluate the project in the Phase –I (third semester). Same chairman will continue for the phase –II of the project.

(d) The PWEC for the evaluation of the project in Phase II(end of fourth semester) shall consist of

i) PWEC Chairman

ii) Guide(s)

iii) External examiner (other than the External guide)/ Internal examiner (from NITK itself, but from outside the department). External examiner would be desirable

(e) BEFORE THE VIVA –VOCE EXAM: The student shall submit a copy of his/her thesis well in time (at least two weeks before the viva –voce exam) to all PWEC members and to chairman DPGC. The report of the Project Work to Chairman, DPGC, on or before the specified date. The Report shall be in the format prescribed by the Institute. For the effective assessment of the projects, all the M.Tech. projects theses of the department shall be assessed and approved by the concerned PWEC before the Viva –voce examination.

(f) DURING THE VIVA VOCE EXAMINATION: Appropriate weightage shall also be decided by DPGC for oral presentation (preparation of slides) and for questions and answers.

(g) The date for submission of the thesis would be announced by the Dean (A) and will be announced in the academic calendar. However, the Dean (A) may permit the students to submit the thesis one week prior to the date announced on a case to case basis.

(h) The final evaluation is done by a Project Work Evaluation Committee (PWEC) constituted by the pertinent DPGC. There shall be an open seminar followed by a viva-voce examination as part of the final evaluation. After the final evaluation, appropriate double-letter grade is awarded, which will be considered for SGPA and CGPA calculations.

(i) Extension of time beyond the announced last date for submission of the Project Report may be granted by the Dean (A) on recommendation from the Chairman, DPGC.

(j) If in the opinion of the PWEC, the Project Report is acceptable with minor modifications for the passing grade ‘DD’, the PWEC shall value and instruct the candidate suitably to incorporate the necessary modifications and to resubmit it to the Chairman, PWEC. After such resubmission, the Chairman, PWEC will certify that the necessary modifications have been incorporated.

(k) The title of the Project Report shall be indicated in the Grade Card.

3.5 *Mandatory Learning Courses:*

These are courses that must be completed by the student at appropriate time as suggested by the Faculty Adviser or the DPGC. The ‘S’ grade is awarded for satisfactory completion of the course and ‘ N’ grade is awarded for non- completion of the course. In case ‘N’ grade is awarded the student has to re-register for the same course wherein he has no alternative options. However, he can opt for other courses if he has been provided with multiple options. The ‘S’ and ‘N’ grades do not carry grade-points and hence not included in the SGPA, CGPA computations.

Courses that come under this category are the following:

(a) Practical Training / Minor Project:

This course is a 2-credit course. A full-time student will complete the Practical Training or the Minor Project at appropriate time stipulated by DPGC and register for it in the following Semester. The duration and the details, including the assessment scheme, shall be decided by the faculty advisor, with approval from DPGC.

(b) Seminar:

This course is a 2-credit course to be completed at appropriate time stipulated by DPGC. The student will make presentations on topics of academic interest.

4. DEGREE REQUIREMENTS:

4.1 The degree requirements of a student for the M.Tech. Degree programme are as follows:

(a) Institute Requirements:

(i) Minimum Earned Credit Requirement for Degree is 50-55.
(ii) Securing overall CGPA of at least 5.50.
(iii) Satisfactory completion of all Mandatory Learning Courses.

(b) Programme Requirements:
Minimum Earned Credit Requirements on all Core Courses, Elective Courses and Major Project as specified by the DPGC and conforming to Clause No: 3 (Course Structure) above.

(c) The Maximum duration for a student for complying to the degree requirement from the date of registration for his first semester, is FOUR years.

5. TERMINATION FROM THE PROGRAMME:

A student shall be required to leave the Institute without the award of the Degree, under the following circumstances:

(a) If a student fails to earn the minimum credit specified below:

Check Point	Credit Threshold
End of FIRST year	20

Note: The period of temporary withdrawal is not to be counted for the above Credit Threshold.

(b) If a student is absent for more than 6(Six) weeks in a semester without sanctioned leave.

(c) If overall CGPA of at least 5.50 is not secured.
{*in such cases the student is given the option of getting the P.G. Diploma instead of the M.Tech. Degree*}.

(d) Based on disciplinary action suggested by the Senate, on the recommendation of the appropriate committee.

NOTE: Under any circumstances of termination, the conditions specified in Permanent Withdrawal (refer: Clause No: G10.2) shall also apply.

6. COMMITTEES / FUNCTIONARIES:

The following committees shall be constituted for the Post Graduate Degree programme:

6.1 Board of Studies (BOS-PG):

Constitution:

(a)	Dean (A)	…	*Chairman*
(b)	Dean (FW)	…	Member
(c)	Dean (P&D)	…	Member
(d)	Dean (R&C)	…	Member
(e)	Dean (SW)	…	Member
(f)	Dean (AA&IR)	…	Member
(g)	Chairman of each DPGC/ his nominee	…	Member
(h)	BOG members representing the faculty	…	Members
(i)	Assistant Registrar (Academic)	…	*Convenor*
(j)	Dy. Registrar (Academic)	…	*Secretary*
(k)	TWO External Experts	…	Members

Note:

- There shall be one BOS-PG for the entire Institute.
- The Chairman may co-opt and/or invite more members including outside experts.
- The quorum of each meeting will be *NINE*.

Functions (Highlights):

i. To consider the recommendations of the DPGC on matters relating to postgraduate programme and to make suitable recommendations to the Senate.

ii. To approve curriculum framed/revised by DPGC for the postgraduate courses of study.

iii. To ensure that all norms and Regulations pertaining to postgraduate programme are strictly followed.

iv. To make periodic review of these Regulations pertaining to postgraduate programme and to recommend to the Senate any modifications thereof.

v. To review the academic performances and make suitable recommendations to the Senate regarding declaration of results, award of degrees etc.

vi. To recommend to the Senate, the award of stipends, scholarships, medals & prizes etc.

vii. To draw up general time table for the postgraduate course and finalise the PG academic calendar to be put up to the Senate for approval.

viii. To review the cases of malpractice in examinations and to recommend to the Director the punishment in such cases.

ix. To constitute a sub-committee for monitoring the implementation of the academic curriculum provided by the BOS and to provide guidance in curriculum assessment, evaluation process.

x. To conduct at least one meeting each semester and send the Resolutions to the Chairman of the Senate, and also to maintain a record of the same in the office of the Dean(A).

xi. Any appropriate responsibility or function assigned by the Senate or the Chairman of the Senate.

6.2 Departmental Post Graduate Committee (DPGC):

Constitution:

(a)	H.O.D. / Programme Co-ordinator	…	Chairman
(b)	Two Professors (by rotation for one year)	…	Members
(c)	Two Associate Professors (by rotation for one year)	…	Members
(d)	Two Assistant Professors (by rotation for one year)	…	Members

Note:

- There shall be one DPGC for every department that is involved in the teaching for any of the PG degree programmes.
- The Secretary (DPGC) shall be nominated by the Chairman on rotation basis for a period of one year.
- The Chairman may co-opt and/or invite more members including at most three outside experts.
- The quorum for each meeting shall be *FIVE*.

Functions (Highlights):

i. To monitor the conduct of all postgraduate courses of the department.

ii. To ensure academic standard and excellence of the courses offered by the department.

ii. To oversee the evaluation of the students in a class, for each of the courses.

iv. To evolve the methods of evaluation of major project including intermediate assessment

v. To develop the curriculum for postgraduate courses offered by the department, and recommend the same to the BOS.

vi. Moderation (only if and when found necessary) in consultation with the Course Instructor, and approval of the finalized grades, before submission of the same to the Academic Section of Dean (A).

vii. To consolidate the registration of the student and communicate to Course Instructors, and also to the Academic Section of the Dean (A).

viii. To conduct performance appraisal of Course Instructors.

ix To provide feedback of the performance appraisal to the Course Instructor and concerned authorities.

x. To consider any matter related to the postgraduate programme of the department.

xi. In cases where a course is taught by more than one faculty member, or by different faculty members for different sections of students, DPGC shall co-ordinate (only in case of need) among all such faculty members regarding the teaching and evaluation of such courses.

xii. To conduct at least two meetings each semester and send the Resolutions of the meeting to the Academic Section of the Dean (A), and also to maintain a record of the same in the department.

xiii. Any appropriate responsibility or function assigned by the Senate or the Chairman of the Senate or the BOS or the Chairman of the BOS.

6.3 Project Work Evaluation Committee (PWEC)

Constitution:

(a)	Chairman of DPGC or his nominee	…	Chairman
(b)	Project Guide(s)	…	Member(s)
(c)	One referee from outside the Department, selected by the DPGC	…	Member

Note:

- There shall be one PWEC for each PG project work.
- One external guide/referee, if any, invited as a member of PWEC, is entitled for TA/DA as per the Institute Rules.

Functions (Highlights):

i. To evaluate the PG project work and to award an appropriate letter grade. The chairman of PWEC shall submit the report, signed by all the members of the PWEC, to DPGC. The DPGC Chairman shall forward this report to the Academic Section of the Dean (A) without moderation.

6.4 Project Guide:

Functions (Highlights):

i. He will help the student under him in selecting the Project topic.

ii. He shall monitor the progress of the student working under him.

iii. He shall report to the DPGC the performance of the student from time to time.

iv. He will coordinate with the HOD/DPGC to arrange for facilities to carry out the project work.

7.0 Conversion from M.Tech to (M.Tech.-Ph.D.) Dual degree Programme:M.Tech. students who have secured more than 8.5 CGPA after the completion of first year can opt to convert to Ph. D.They should have joined the M.Tech programme with a valid GATE score.Procedure laid out for Ph.D admissions will be applicable for conversion from M.Tech. to Ph.D.The students who convert from M.Tech. to Ph. D. will be awarded M.Tech. degree on submission of Ph.D. synopsis.Course work of the Ph.D. programme can be waived in this case.However, these students have to complete the Research methodology course.In case of termination of student from a Ph.D. programme .he/she will be evalusted for the work done till then,to award the M.Tech. degree.

REGULATIONS

SPECIFIC TO

POST GRADUATE PROGRAMME

M.Tech. (Research) Degree

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL
Post: Srinivasnagar, Mangalore - 575025, India. - 2020

CONTENTS

REGULATIONS
specific to
M.Tech. (Research) Degree Programme

{also refer: REGULATIONS(General) – Common to all Degree Programmes}
{also refer: REGULATIONS(MTech) – Specific to M.Tech. Degree Programmes}

1. DEGREE PROGRAMMES:

1.1 Post Graduate M.Tech .(Research) Degree Programmes may be offered in the disciplines where a regular M.Tech. Degree Programme is already being offered or proposed to offer.

1.2 The provisions of these Regulations shall be applicable to any new disciplines and/or that may be introduced from time to time and appended to the above list.

2. ADMISSION:

2.1 Student Status: There are three types of student status in the M.Tech.(Research) degree Programme:

(a) Full-time student on GATE scholarship
(b) Full-time student - sponsored from Industry or other Organizations including Educational Institutions.
(c) External Registrants sponsored from industry or other organization including Educational Institutions

Note:

i. The full-time students work at the Institute on full-time basis. The external registrants register at the Institute but work outside the Institute.

ii. *Duration:* For full-time students, the duration of study shall be a minimum of FOUR semesters and a maximum of FOUR years. For External Registrants, the duration will be a minimum of FIVE semesters and a maximum of FIVE years.

iii. Student of the type (a) will receive GATE scholarship for the duration of four semesters, which is subjected to GATE scholarship rules of MHRD.

iv. Student of the type (b &c) shall be sponsored and financed by the sponsoring organization. He should produce a sponsorship-cum-clearance certificate in the given format of the Institute. The candidate must have minimum of 2 years of full-time work experience in the sponsoring organization, after completing the qualifying examination.

v. No student can receive scholarship/assistantship from more than one source.

2.2 Admissions will be made in accordance with the instructions received from MHRD from time to time. Seats are reserved for candidates belonging to Other Backward Classes, Scheduled Caste and Scheduled Tribes, Physically challenged candidates, children of defence personnel and other categories as per the guidelines issued by MHRD.

2.3 The minimum eligibility criteria for admission for the various M.Tech. (Research) Degree programmes shall be specified in the Institute Information Bulletin or the Prospectus. However, some general criteria are mentioned below.

2.4 The criteria for selection/admission will be based on performance in qualifying exam, interview and other guidelines issued by the Senate from time to time. The prescribed qualifying examinations for each M.Tech. (Research) Programme is given separately in the *Prospectus* or the *Institute Information Brochure*.

2.5 Admission to a M.Tech. (Research) Programme shall be open to candidates who passed the prescribed qualifying examination with a Cumulative Grade Point Average (CGPA) of at least 6.5 in the 0-10 scale grading system, OR not less than 60% marks in the aggregate (taking into account the marks scored in all the subjects of all the public/university examinations conducted during the entire prescribed period for the degree programme). However, this prescribed minimum shall be a CGPA of 6.0 OR 55% marks in the aggregate for SC/ST/PWD candidates.

2.6 A limited number of admissions is offered to Foreign Nationals and Indians Living Abroad in accordance with the rules applicable for such admission, issued from time to time, by MHRD.

2.7 If, at any time after admission, it is found that a candidate had not in fact fulfilled all the requirements stipulated in the offer of admission, in any form whatsoever, including possible misinformation etc., the Dean (A) shall report the matter to the Senate, recommending revoking the admission of the candidate.

2.8 Candidates have to fulfil the medical standards required for admission as prescribed in the *Institute Information Brochure* or the *Prospectus*.

2.9 The Institute reserves the right to cancel the admissions of any student and ask him to discontinue his studies at any stage of his study period on the grounds of unsatisfactory academic performance or indiscipline or any misconduct.

2.10 The decision of the Senate regarding the admissions is final and binding.

2.11 Student Exchange Programmes and the Transfer of Credits in such cases shall be as per the corresponding MoU approved by Competent Authority.

2.12 Every Post Graduate student of the Institute shall be associated with *Parent Department*, offering the degree programme that the student undergoes, throughout his study period.

3. PROGRAMME STRUCTURE:

3.1 The M.Tech.(Research) Degree Programme will typically consist of the following components.

a) Course Work≥ 12 Credits (Courses carrying S/N grades shall not be counted)
b) MLC Course, SM 900, Research Methodology
c) Research Thesis

3.2 The courses must be selected from the list of courses from the respective M.Tech discipline and must be completed *within the first THREE semesters* in case of Full- Time students, and *within the first SIX semesters* in case of External Registrants securing a CGPA of at least 5.50.

3.3 In case of external registrants, residential requirement may be waived. They are expected to complete their course work by opting for (pre-approved by DPGC) certified courses. For these courses, evaluation has to be done by departmental faculty and appropriate grade awarded. However the duration and number of visits to the institute after the course completion shall be decided by the research guide.

3.4 Students are required to undergo registration at the commencement of each semester on the days fixed for such registration and notified in the academic calendar.

4. RESEARCH GUIDE:

4.1 In each Department, applicants for M.Tech.(Research) programmes, will be given, at the time of selection, the details of research areas proposed by various faculty members, so that they will have an opportunity to discuss those areas with the respective faculty members and thereafter, indicate their choice in order of preference. The applicants shall then be interviewed by a committee constituted by the DPGC.

4.2 A permanent faculty of the Institute possessing a Ph.D. Degree shall be recognized as the Research Guide.

4.3 One Research Guide, selected among the faculty of the Department in which he has registered, shall be allotted to each Research student by the HoD on the recommendations of DPGC at the time of admission, and the same shall be intimated to the Dean (A).

4.4 Depending on the research requirements, an additional faculty member of the institute may be included as an Additional Guide. However, the main Research Guide shall be from within the parent department. The inclusion of additional guide is allowed till the submission of the research proposal.

4.5 External Registrants may have an additional Research Guide from the organization from which he is sponsored . The bio-data of intending Additional Guides from outside the Institute shall be scrutinized and recommended by the DPGC and approved by Dean (Academic).

4.6 Change of Research Guide(s) under exceptional circumstances shall be permitted on recommendation of the DPGC after obtaining the consent of (i) the Student (ii) the present Research Guide(s) and (iii) the proposed Research Guide(s).

5. EVALUATION SYSTEM:

5.1 Course Work Evaluation

The Course Work Evaluation shall be similar to that of other courses, and the details are given in the corresponding section in the Regulations (General) Common to all Degree Programmes (refer: Section G5).

5.2 Research Proposal Submission and Assessment

Every M.Tech. (Research) student is required to submit (within the first one year of joining the programme, his research proposal in the prescribed format, containing problem identification, state of the art technology, plan of research work etc. The RPAC shall assess the proposal through an open seminar and communicate the recommendation for approval or otherwise along with detailed comments to the Dean (A) through DPGC.

5.3 Research Progress Assessment

5.3.1 After approval of Research Work Proposal, half yearly assessments are made, through open seminars, to ensure satisfactory progress. The Research Scholar shall submit, through his Guide(s), a progress report of his research to the concerned RPAC twice a year. The RPAC will communicate to the DPGC about the periodic progress with detailedcomments. The DPGC shall forward the same to Dean (A).

5.3.2 The continuance of registration of all M.Tech.(Research) Students is subject to satisfactory progress made by them.

5.4 Pre-Synopsis Seminar and Synopsis Submission

5.4.1 Prior to the submission of the Synopsis of the Reseach Work, a comprehensive internal assessment of the research work should be made by RPAC by a Pre- Synopsis Seminar. The candidate can submit the Synopsis only if RPAC is satisfied about the quality of the work for submission as a M.Tech.(Research) Thesis.

5.4.2 Details of the Pre-Synopsis Seminar shall be notified well in advance, so as to enable interested staff members and students to attend the same.

5.4.3 The Chairman of the DPGC shall forward the RPAC's assessment report on the Pre-Synopsis Seminar to the Dean (A).

5.4.4 ONE printed copy and ONE soft copy of the Synopsis shall be submitted to the Dean (A), through Chairman of the DPGC, in the prescribed format consisting of a maximum of 15 pages including bibliography of research work.

5.5 Thesis Submission and Assessment

5.5.1 Prior to submission of thesis the scholar should a have at least one paper published preferably in refereed journal or in refereed conference proceedings.

5.5.2 THREE printed copies and one softcopy, in the prescribed format of the Thesis shall be submitted to the Dean (A), through Chairman of the DPGC, within THREE months from the date of submission of the Synopsis.

5.5.3 Along with the Thesis, the Research Scholar shall submit the requisite forms containing the authorization from the Research Guide(s) for submission of the Thesis and a certificate from Accounts Section that there are no dues against the Scholar.

5.5.4 The Thesis submitted by the student will be evaluated by MTAC constituted by Dean (A) by selecting two referees (one internal and one external) from the Panel submitted by DPGC.

5.5.5 If one of the examiners rejects the thesis, the thesis as it is has to be to be referred to a third referee selected from the Panel of referees.

5.5.6 If the thesis is rejected by two referees then it may be resubmitted after revision, incorporating the required modifications and / or alterations and / or additions etc in the light of referees' comments. Such re submission must be made not earlier than one month and not later than six months from the date of such intimation to the student by the Dean(A).The thesis so resubmitted may be examined either by the same referees or by new referees.

5.5.7 Rejection of the thesis so resubmitted will disqualify the candidate from further consideration for the award of M.Tech (Research) degree.

5.5.8 The copies of the referees' reports when received shall be confidentially made available to the Research Guide (s) through Chairman, DPGC. The Research guide (s) shall send comments on these reports through DPGC for consideration by the Dean (A)

5.5.9 On the basis of the referees' report and the Research Guide (s) comments thereon, the Dean(A) will decide whether the Thesis be accepted for the viva –voce examination, or be rejected or referred again to a new referee.

5.5.10 The student, whose thesis has been recommended for the award of M.Tech (Research) degree, shall be required to defend his thesis at an viva-voce examination conducted by MTAC,. After satisfactory defense of the thesis, the MTAC will recommend the approval of the thesis to the Dean (A) through DPGC for further action towards the award of M.Tech (Research) degree.

5.5.11 The MTAC shall submit its report in the prescribed form to Dean (A) within ONE month after completion of viva-voce exam.

5.5.12 After satisfactory completion of the viva-voce examination, the M.Tech. (Research) degree may be conferred on the student, after approval by the Senate.

5.5.13 After successful completion of the viva -voce examination, the candidate shall submit Dean(A) ONE copy of his approved Thesis duly bound along with a soft-copy in the prescribed format.

6. DEGREE REQUIREMENTS:

The degree requirements of a student for the M.Tech.(Research) Degree programme are as follows:

(a) *Institute Requirements:*

(i) Completion of Course Work of at least 12 Credits, and MLC course HU800, *within the first THREE semesters* in case of Full-Time students, and *within the first SIX semesters* in case of Internal/External Registrants.

(ii) Securing a CGPA of at least 5.50 in the Course Work.

(iii) Satisfactory defense of the M.Tech.(Research) Thesis.

(b) The Maximum duration for a student for complying to the degree requirement from the date of registration for his first semester is FOUR years for Full-time students and FIVE years for all other categories of students.

7. TERMINATION FROM THE PROGRAMME:

A student shall be required to leave the M.Tech. (Research) Degree Programme under the following circumstances:

(a) If the course work is not completed within the first THREE semesters in the case of full-time students, and within the first SIX semesters in case of internal/external registrants
(b) If a CGPA of at least 5.50 is not secured in the course work.
(c) If a student fails to submit satisfactory Research Proposal within one year of joining the program
(d) If the M.Tech.(Research) Thesis has not been accepted after *TWO submissions*.
(e) Based on disciplinary action on the recommendation of the appropriate committee.
(f) If a student is absent for more than 6 weeks in a semester without sanctioned leave

NOTE: Under any circumstances of termination, the conditions specified in Permanent Withdrawal (refer: Clause No: G10.2) shall also apply.

8. COMMITTEES / FUNCTIONARIES:

The following committees shall be constituted for the Post Graduate Degree programme:

8.1 Board of Studies (BOS-PG):
(Same as the BOS-PG mentioned in the M.Tech. Regulations)

8.2 Departmental Post Graduate Committee (DPGC):
(Same as the DPGC mentioned in the M.Tech. Regulations)

8.3 Research Progress Assessment Committee (RPAC):

Constitution:

(a) Guide	….	Chairman
(b) Co-Guide (if any)	….	Member
(c) At least One Faculty from the parent department of the M.Tech(R) scholar from the recommended panel, selected by Dean (A)	….	Member
(d) At least One Faculty from outside the parent department of the guide(s) from recommended panel, selected by Dean (A) `	….	Member

Note:
- There shall be one RPAC for each M.Tech. (Research) Student
- The RPAC shall be constituted by the Dean (A) when the student submits the Research Proposal for assessment.

Functions (Highlights)

(i) To assess and approve the Research Proposal and Synopsis.
(ii) To communicate the half yearly assessment reports about the progress of the research work to DPGC.
(iii) To assess the Pre-Synopsis Seminar and communicate the results to the Dean (A) through the DPGC.

8.4 Master’s Thesis Assessment Committee (MTAC):

Constitution:

(a)	Chairman DPGC or a Professor nominated by the Dean (A) on recommendation of DPGC	…	Chairman
(b)	Guide(s)	…	Member(s)
(c)	Two Referees	…	Members
(d)	At least one faculty from the parent department of the M.Tech.(Research) scholar from the recommended panel, selected by Dean (A)	….	Member
(e)	RPAC members	…	Invited Members

Note:
- There shall be one MTAC for each M.Tech. (Research) Student.

- The MTAC shall be constituted by the Dean (A) when the M.Tech. (Research) Student submits the M.Tech. Research Thesis for assessment.
- The TWO referees shall be selected by the Dean (A), from a panel of SIX referees (THREE from within the Institute and THREE from outside the Institute). These TWO Referees will be requested for an assessment of the M.Tech. Research Thesis, and one of these referees will be invited for the final *Thesis Defense and Viva-Voce Examination*.

Functions (Highlights):

(i) The TWO Referees will evaluate the M.Tech.(Research) Thesis and send the report to DPGC.

(ii) MTAC will evaluate the research work and the M.Tech.(Research) Thesis, based on the defense of the Thesis through an open seminar and viva-voce examination and send the report to Dean (A), through chairman, DPGC.

8.5 Research Guide:

Functions (Highlights):

i. He will guide the student to select a topic for research.

ii. He will suggest the courses for course work.

iii. He will monitor the progress of the student.

iv. He will suggest a Panel of Referees to the DPGC for constituting RPAC and MTAC.

v. He will approve and forward all the applications of the student.

vi. He will provide or arrange for facilities to carry out research work.

vii. In the event of leaving the Institute or away from the institute for a considerable period, he has to arrange for a Change of Research Guide as per Clause No: 4.6 above.

* * * * *

REGULATIONS

SPECIFIC TO

POST GRADUATE PROGRAMME

M.Sc. Degree

IN

CHEMISTRY / PHYSICS

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL
Post : Srinivasnagar, Mangalore - 575025, India. - 2020

CONTENTS

REGULATIONS
specific to
M.Sc. Degree Programme
in
Chemistry / Physics

{also refer: REGULATIONS (General) – Common to all Degree Programmes}

1. DEGREE PROGRAMMES:

1.1 Post Graduate M.Sc. Degree Programmes are offered in the following disciplines by the respective programme hosting departments listed below:

i.	Chemistry	(CY)
ii.	Physics	(PH)

1.2 The provisions of these Regulations shall be applicable to any new disciplines and/or that may be introduced from time to time and appended to the above list.

2. ADMISSION:

2.1 Student Status: There is only one type of student status in M.Sc. degree programme, namely, full time.

2.2 Duration: The duration of study shall be a minimum of FOUR semesters and a maximum of FOUR years.

2.3 Admissions shall be made in compliance to the general guidelines received from MHRD from time to time. Seats are reserved for candidates belonging to Other Backward Classes, Scheduled Caste and Scheduled Tribes, Physically challenged candidates, children of defence personnel and other categories as per the guidelines issued by MHRD.

2.4 Admission to M.Sc. Programme in Chemistry / Physics shall be open to candidates who have passed a Bachelor's degree in Chemistry /Physics with 60% (or cumulative Grade Point Average (CGPA) of at least 6.0 in the 0-10 scale grading system) of the aggregate in all the years of course of study in respective subjects and with 55% (Cumulative Grade Point Average (CGPA) of at least 5.5 in the 0-10 scale grading system) in respect of SC , ST and PWD candidates.

2.5 A limited number of admissions is offered to Foreign Nationals and Indians living abroad in accordance with the rules applicable for such admission, issued from time to time, by MHRD.

2.6 If, at any time after admission, it is found that a candidate had not in fact fulfilled all the requirements stipulated in the offer of admission, in any form whatsoever, including possible misinformation etc., this matter shall be reported to the Senate, recommending revoking the admission of the candidate.

2.8 Candidates have to fulfil the medical standards required for admission as prescribed in the Institute Information Brochure or the Prospectus.

2.9 The Institute reserves the right to cancel the admissions of any student and ask him to discontinue his studies at any stage of his study period on the grounds of unsatisfactory academic performance or indiscipline or any misconduct.

2.10 The decision of the Senate regarding the admissions is final and binding.

2.11 Student Exchange Programmes and the Transfer of Credits in such cases shall be as per the corresponding MOU approved by Competent Authority.

2.12 Every Post Graduate student of the Institute shall be associated with *Parent Department*, offering the degree programme that the student undergoes, throughout his study period.

3. COURSE STRUCTURE:

3.1 The total course credit requirement for the award of M. Sc. Degree will typically consist of the following components.

a) Core Courses	$\geq$ 40 Credits
b) Elective Courses	$\geq$ 12 Credits
c) Mandatory Learning Courses (Seminar)	$\geq$ 03 Credits
d) M.Sc. Project	08 Credits

3.2 The Department Post Graduate Committee (DPGC) will discuss and recommend the exact credits offered for the programme for the above components, the semester-wise distribution among them, as well as the syllabi of all postgraduate courses offered by the department from time to time before sending the same to the Board of Studies (BOS). The BOS will consider the proposals from the departments and make recommendations to the senate for consideration and approval.

3.3 The Minimum Credit Requirement for the M.Sc. Degree is 80

3.4 *Mandatory Learning Courses:*

These are courses that must be completed by the student at appropriate time as suggested by the Faculty Adviser or the DPGC. The 'S' grade is awarded for satisfactory completion of the course and ' N' grade is awarded for non-completion of the course. In case 'N' grade is awarded the student has to re-register for the same course wherein he has no alternative options. However, he can opt for other courses if he has been provided with multiple options. The 'S' and 'N' grades do not carry grade-points and hence not included in the SGPA, CGPA computations.

The Course that comes under this category is the following:

Seminar:
Each Seminar course is a 1- credit course. A student is required to register for three such Seminar Courses during his period of study for the M.Sc. Degree Programme, suitably arranged by the DPGC. The student is required to make presentations on topics of academic interest.

3.5 M.Sc. Project

(a) The M.Sc project will be undertaken during 4^{th} semester. The progress of the Project work shall be monitored by the Project Guide.
(b) The method of evaluation, including intermediate assessment shall be evolved by the pertinent DPGC.
(c) A candidate shall submit 5 copies of the Report of the project work to Chairman, DPGC, on or before the specified date. The report shall be in the format prescribed by the Institute.
(d) The date of submission of report shall be announced by the DPGC after getting the approval by Dean(A)

(e) The final evaluation is done by a Project work Evaluation Committee (PWEC) constituted by the pertinent DPGC. There shall be an open seminar followed by a viva-voce examination as part of the final evaluation. After the final evaluation, appropriate double letter grade is awarded, which will be considered for SGPA and CGPA calculations.
(f) Extension of time beyond the date for submission of the Project Report may be granted by the Dean (A) on recommendation from the Chairman, DPGC.
(g) If in the opinion of the PWEC, the Project Report is acceptable with minor modifications for the passing grade DD, the PWEC shall value and instruct the candidate suitably to incorporate the necessary modifications and to resubmit it to the Chairman, PWEC. After such resubmission, the Chairman, PWEC will certify that the necessary modifications have been incorporated.
(h) The title of the Project Report shall be indicated in the Grade Card.

4. DEGREE REQUIREMENTS:

4.1 The degree requirements of a student for the M.Sc. Degree programme are as follows:

(a) Institute Requirements:
(i) Minimum Earned Credit Requirement for Degree 80.
(ii) Securing overall CGPA of at least 5.50.
(iii) Satisfactory completion of all Mandatory Learning Courses.

(b) Programme Requirements:
Minimum Earned Credit Requirements on all Core Courses, Elective Courses and Project as specified by the DPGC and conforming to Clause No: 3 (Course Structure)

(c) The Maximum duration for a student for complying to the degree requirement from the date of registration for his first semester, is FOUR years.

5. TERMINATION FROM THE PROGRAMME:

A student shall be required to leave the Institute without the award of the Degree, under the following circumstances:

(a) If a student fails to earn the minimum credit specified below:

Check Point	Credit Threshold
End of FIRST year	20
End of SECOND year	40

Note: The period of temporary withdrawal is not to be counted for the above Credit Threshold.
(b) If a student is absent for more than 6 (Six) weeks in a semester without sanctioned leave.
(c) If overall CGPA of at least 5.50 is not secured.
(d) Based on disciplinary action suggested by the Senate, on the recommendation of the appropriate committee.

NOTE: Under any circumstances of termination, the conditions specified in Permanent Withdrawal (refer: Clause No: G10.2) shall also apply.

6. COMMITTEES / FUNCTIONARIES:

6.1 Board of Studies (BOS –PG)

(Same as the BOS-PG mentioned in M.Tech Regulations)

6.2 Departmental Post Graduate Committee (DPGC):

(Same as DPGC mentioned in M.Tech Regulations)

6.3 Project Work Evaluation Committee (PWEC)

Constitution:

(a)	Chairman of DPGC or his nominee	…	Chairman
(b)	Project Guide(s)	…	Member(s)
(c)	One referee from outside the Department, selected by the DPGC	…	Member

Note:

- There shall be one PWEC for each PG project work.
- One external guide/referee, if any, invited as a member of PWEC, is entitled for TA/DA as per the Institute Rules.

Functions (Highlights):

To evaluate the PG project work and to award an appropriate letter grade. The chairman of PWEC shall submit the report, signed by all the members of the PWEC, to DPGC. The DPGC Chairman shall forward this report to the Academic Section of the Dean (A) without moderation.

6.4 Project Guide:

Functions (Highlights):

i. He will help the student under him in selecting the Project topic.
ii. He shall monitor the progress of the student working under him.
iii. He shall report to the DPGC the performance of the student from time to time.
iv. He will coordinate with the HOD/DPGC to arrange for facilities to carry out the project work.

7.0. Conversion from M.Sc. to Dual degree (M.Sc.+Ph.D.) Programme: M.Sc. students who have secured more than 8.5 CGPA after the completion of first year can opt to convert to Ph.D.They should have obtained a valid NET/GATE score before the start of second year. Procedure laid out for Ph.D. admissions will be applicable for conversion from M.Sc to Ph.D.The students who convert from M.Sc to Ph.D. will be awarded M.Sc. degree on submission of Ph.D. synopsis.Course work of the Ph.D. programme can be waived in this case.However, these students have to complete the Research methodology course in addition to the second year courses of the M.Sc. programme. In case of termination of student from a Ph.D. programme,.he/she will be evalusted for the work done till then,to award the M.Sc. degree.

REGULATIONS

SPECIFIC TO

POST GRADUATE PROGRAMME

Master of Computer Applications (M.C.A.) Degree

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL
Post : Srinivasnagar, Mangalore - 575025, India. - 2020

CONTENTS

REGULATIONS
specific to
M.C.A. Degree Programme

{also refer: REGULATIONS (General) – Common to all Degree Programmes}

1. ADMISSION

1.1 Student Status — There is only one type of student status in the MCA degree Programme, namely, full-time.

1.2 Duration — The duration of study shall be a minimum of SIX semesters and a maximum of SIX years.

1.3 Admissions will be made in accordance with the instructions received from MHRD from time to time. Seats are reserved for candidates belonging to Other Backward Classes Scheduled Caste and Scheduled Tribes, Physically challenged candidates, children of defence personnel and other categories as per the guidelines issued by MHRD.

1.4 The admissions will be on the basis of the performance in the prescribed Entrance Examination, and performance in the qualifying examination and interview. The prescribed qualifying examinations are given separately in the Institute prospectus for M.C.A. Programme.

1.5 Admission to M.C.A. Programme shall be open to candidates who have -

(a) passed the prescribed qualifying examination with a Cumulative Grade Point Average (CGPA) of at least 6.5 in the 0-10 scale grading system, OR not less than 60% marks in the aggregate (taking into account the marks scored in all the subjects of all the public/university examinations conducted during the entire prescribed period for the degree programme). However, this prescribed minimum shall be CGPA of 6.0 OR 55% marks in the aggregate for SC/ST candidates.

(b) a valid score in NITMCA Common Entrance Test (NIMCET)

1.6 A limited number of admissions is offered to Foreign Nationals and Indians Living Abroad in accordance with the rules applicable for such admission, issued from time to time, by MHRD.

1.7 If, at any time after admission, it is found that a candidate had not in fact fulfilled all the requirements stipulated in the offer of admission, in any form whatsoever, including possible misinformation etc., this matter shall be reported to the Senate, recommending revoking the admission of the candidate.

1.8 Candidates have to fulfil the medical standards required for admission as prescribed in the *Information Brochure* or the *Prospectus*.

1.9 The Institute reserves the right to cancel the admissions of any student and ask him to discontinue his studies at any stage of his career on the grounds of unsatisfactory academic performance or indiscipline or any misconduct.

1.10 The decision of the Senate regarding the admissions is final and binding.

1.11 Student Exchange Programmes and the Transfer of Credits in such cases shall be as per the corresponding MOU approved by Competent Authority.

2. COURSE STRUCTURE:

2.1 The total course package for a M.C.A. Programme will typically consist of the following components.

(a)	Programme Core Courses	Pc	$\geq$	60 Credits
(b)	Elective Courses	Ele	$\geq$	24 Credits
(c)	Major Project	MP	=	10 Credits
(d)	Mandatory Learning Courses	MLC	=	04 Credits

2.2 The Department Post Graduate Committee (DPGC) will discuss and recommend the exact credits offered for the programme for the above components, the semester- wise distribution among them, as well as the syllabi of all postgraduate courses offered by the department from time to time before sending the same to the Board of Studies (BOS). The BOS will consider the proposals from the departments and make recommendations to the senate for consideration and approval.

2.3 The Minimum Credit Requirement for the M.C.A Degree is 102.

2.4 *Major Project:*

(a) The Major Project carries 10 credits and spreads over ONE semester, during 6th semester (or as recommended by DPGC). The progress of the Project Work shall be monitored by the Project Guide. No candidate will be permitted to submit the project report before the last day of the classes in the project work semester as per the Academic Calendar.
(b) The method of evaluation, including intermediate assessment shall be evolved by the pertinent DPGC.
(c) A candidate shall submit 5 copies of the Project Work to Chairman, DPGC, on or before the specified date. The dissertation shall be in the format prescribed by the Institute.
(d) The date for the submission of Report shall be announced by the DPGC after getting the approval of the Dean (A).
(e) The final evaluation is done by a Project Work Evaluation Committee (PWEC) constituted by the pertinent DPGC. There shall be an open seminar followed by a viva-voce examination as part of the final evaluation. After the final evaluation, appropriate double-letter grade is awarded, which will be considered for SGPA and CGPA calculations.
(f) Extension of time beyond the announced last date for submission of the Project Report may be granted by the Dean (A) on recommendation from the Chairman, DPGC.
(g) If in the opinion of the PWEC, the Project Report is acceptable with minor modifications for the passing grade ‘DD’, the PWEC shall value and instruct the candidate suitably to incorporate the necessary modifications and to resubmit it to the Chairman, PWEC. After such resubmission, the Chairman, PWEC will certify that the necessary modifications have been incorporated.
(h) The title of the Project Report shall be indicated in the Student Grade Card.

2.5 *Mandatory Learning Courses:*

These are courses that must be completed by the student at appropriate time as suggested by the Faculty Adviser or the DPGC. The ‘S’ grade is awarded for satisfactory completion of the course and ‘ N’ grade is awarded for non- completion of the course. In case ‘N’ grade is awarded the student has to re-register for the same course wherein he has no alternative options. However, he can opt for other courses if he has been provided with multiple options. The ‘S’ and ‘N’ grades do not carry grade points and hence not included in the SGPA, CGPA computations.

Course that comes under this category is the following:

Seminar:

This course is a 4-credit course to be completed at appropriate time stipulated by DPGC. The student will make presentations on topics of academic interest.

3. DEGREE REQUIREMENTS:

3.1 The degree requirements of a student for the M.C.A. programme are as follows:

(a) *Institute Requirements:*

(i) Minimum Earned Credit Requirement for Degree is 102.
(ii) Securing overall CGPA of at least 5.50.
(iii) Satisfactory completion of all Mandatory Learning Courses.

(b) *Programme Requirements:*
Minimum Earned Credit Requirements on all Core Courses, Elective Courses and Major Project as specified by the DPGC and conforming to Clause No: 2(Course Structure).

(c) The Maximum duration for a student for complying to the Degree Requirement from the date of registration for his first semester, is SIX years.

4. TERMINATION FROM THE PROGRAMME:

A student shall be required to leave the Institute without the award of the Degree, under the following circumstances:

(a) If a student fails to earn the minimum credit specified below:

Check Point	Credit Threshold
End of FIRST year	20
End of SECOND year	40
End of THIRD year	60

Note: The period of temporary withdrawal is not to be counted for the above Credit Threshold.

(b) If a student is absent for more than 6 (Six) weeks in a semester without sanctioned leave.
(c) If overall CGPA of at least 5.50 is not secured.
(d) Based on disciplinary action suggested by the Senate, on the recommendation of the appropriate committee.

NOTE: Under any circumstances of termination, the conditions specified in Permanent Withdrawal (refer: Clause No: G10.2) shall also apply.

5. COMMITTEES / FUNCTIONARIES:

The following committees shall be constituted for the Post Graduate Degree programme:

5.1 Board of Studies (BOS-PG):

(Same as BOS-PG Mentioned in M.Tech regulations)

5.2 Departmental Post Graduate Committee (DPGC):

(Same as DPGC mentioned in M.Tech regulations)

5.3 Project Work Evaluation Committee (PWEC)

Constitution:

(a) Chairman of DPGC or his nominee (b)	…	Chairman
Project Guide(s)	…	Member(s)
(c) One referee from outside the Department, selected by the DPGC	…	Member

Note:

- There shall be one PWEC for each MCA project work.
- One external guide/referee, if any, invited as a member of PWEC, is entitled for TA/DA as per the Institute Rules.

Functions (Highlights):

i. To evaluate the MCA project work and to award an appropriate letter grade. The chairman of PWEC shall submit the report, signed by all the members of the PWEC, to DPGC. The DPGC Chairman shall forward this report to the Academic Section of the Dean (A) without moderation.

5.4 Project Guide:

Functions (Highlights):

i. He will help the student under him in selecting the Project topic.

ii. He shall monitor the progress of the student working under him.

iii. He shall report to the DPGC the performance of the student from time to time.

iv. He will coordinate with the HOD/DPGC to arrange for facilities to carry out the project work.

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REGULATIONS

SPECIFIC TO

POST GRADUATE PROGRAMME

M.B.A. DEGREE

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL
Post : Srinivasnagar, Mangalore - 575025, India. - 2020

CONTENTS

REGULATIONS
specific to
M.B.A. Degree Programme

{also refer: REGULATIONS (General) – Common to all Degree Programmes}

1. ADMISSION

1.1 Student Status — There is only one type of student status in the MBA degree Programme, namely, full-time.

1.2 Duration — The duration of study shall be a minimum of FOUR semesters and a maximum of FOUR years.

1.3 Admissions will be made in accordance with the instructions received from MHRD from time to time. Seats are reserved for candidates belonging to Other Backward Classes Scheduled Castes and Scheduled Tribes, Physically challenged candidates, children of defence personnel and other categories as per the guidelines issued by MHRD.

1.4 The admissions will be on the basis of CAT/MAT/GATE score and performance in the qualifying examination and interview. The prescribed qualifying examinations are given separately in the Institute prospectus for M.B.A. Programme.

1.5 Bachelor's Degree in any discipline from a Recognized University with not less than 50% marks (or Cumulative Grade Point Average (CGPA) of at least 5.5 in the 0-10 scale grading system) in the aggregate taking into account the marks scored in all subjects of all the University examination conducted during the entire prescribed period of the degree programme. However, this prescribed minimum marks shall be 45% (CGPA of at least 5.0 in the 0-10 scale grading system) in the case of SC/ST.

1.6 A limited number of admissions is offered to Foreign Nationals and Indians Living Abroad in accordance with the rules applicable for such admission, issued from time to time, by MHRD.

1.7 If, at any time after admission, it is found that a candidate had not in fact fulfilled all the requirements stipulated in the offer of admission, in any form whatsoever, including possible misinformation etc., this matter shall be reported to the Senate, recommending revoking the admission of the candidate.

1.8 Candidates have to fulfil the medical standards required for admission as prescribed in the Information Brochure or the Prospectus.

1.9 The Institute reserves the right to cancel the admissions of any student and ask him to discontinue his studies at any stage of his career on the grounds of unsatisfactory academic performance or indiscipline or any misconduct.

1.10 The decision of the Senate regarding the admissions is final and binding.

1.11 Student Exchange Programmes and the Transfer of Credits in such cases shall be as per the corresponding MoU approved by Competent Authority.

2. COURSE STRUCTURE:

2.1 The total course package for a M.B.A. Programme will typically consist of the following components.

(a)	Foundation Courses	$\geq$ 20 Credits
(b)	Program Core(PC)	$\geq$ 25 Credits
(c)	Advanced Courses	$\geq$ 20 Credits
(d)	Elective Courses(Ele)	= 03 Credits
(e)	MLC	= 03 Credits
(e)	Major Project	= 08 Credits

2.2 The Department Post Graduate Committee (DPGC) will discuss and recommend the exact credits offered for the programme for the above components, the semester- wise distribution among them, as well as the syllabi of all postgraduate courses offered by the department from time to time before sending the same to the Board of Studies (BOS). The BOS will consider the proposals from the departments and make recommendations to the senate for consideration and approval.

2.3 The Minimum Credit Requirement for the M.B.A Degree is 90.

2.4 Summer Internship Project:

The Summer Internship Project of 8 weeks minimum duration shall be completed during vacation after second semester and carries 8 credits. The progress of the Summer Internship Project Work shall be monitored by the Project Guide.

(a) The Method of evaluation of the project work shall be evolved by the DPGC.
(b) A candidate shall submit 3 copies of the Summer Internship Project Work to Chairman, DPGC, on or before the specified date. The dissertation shall be in the format prescribed by the Institute.
(c) The final evaluation is done at the end of third semester by a Project Work Evaluation Committee (PWEC) constituted by the DPGC. There shall be an open seminar followed by a viva-voce examination as part of the final evaluation. After the final evaluation, appropriate double-letter grade is awarded, which will not however be considered for SGPA and CGPA calculations.
(d) If in the opinion of the PWEC, the Project Report is acceptable with minor modifications for the passing grade 'DD', the PWEC shall value and instruct the candidate suitable to incorporate the necessary modifications and to resubmit it to the Chairman, PWEC.
(e) The title of the Summer Internship Project Report shall be indicated in the Student Progress Report

2.5 Term Paper

The Term paper shall be undertaken by each student during the fourth semester and carries 3 credits. Each student will be attached to a faculty who would guide the student to take up a topic for self –study on any emerging area of interest related to the program.

(a) The method of evaluation shall be evolved by the DPGC.
(b) There shall be an open seminar followed by a viva -voce examination conducted by the concerned Faculty in-charge of the term paper for each student, as part of the final evaluation.
(c) After the final evaluation, appropriate double –letter grade is awarded, which will not however be considered for SGPA and CGPA calculations.

3. DEGREE REQUIREMENTS:

3.1 The degree requirements of a student for the M.B.A. programme are as follows:

(a) *Institute Requirements:*
(i) Minimum Earned Credit Requirement for Degree is 90.
(ii) Securing a CGPA of at least 5.50 in the Course Work.

(b) *Programme Requirements:*
Minimum Earned Credit Requirements on all Foundation Courses, Functional Courses, Elective Courses, Term Paper, MLC and Summer Internship Project as specified by the DPGC and conforming to Clause No: 2 (Course Structure).

(c) The Maximum duration for a student for complying to the Degree Requirement from the date of registration for his first semester, is FOUR years.

4. TERMINATION FROM THE PROGRAMME:

A student shall be required to leave the Institute without the award of the Degree, under the following circumstances:

(a) If a student fails to earn the minimum credit specified below:

Check Point	Credit Threshold
End of FIRSTyear	25
End of SECOND year	50

Note: The period of temporary withdrawal is not to be counted for the above Credit Threshold.

(b) If a student is absent for more than 6 (Six) weeks in a semester without sanctioned leave.

(c) Based on disciplinary action suggested by the Senate, on the recommendation of the appropriate committee.

(d) Fails to get the minimum cutoff CGPA of at least 5.50 in the Course Work

NOTE: Under any circumstances of termination, the conditions specified in Permanent Withdrawal (refer: Clause No: G10.2) shall also apply.

5. COMMITTEES / FUNCTIONARIES:

The following committees shall be constituted for the Post Graduate Degree programme:

5.1 Board of Studies (BOS-PG):
(Same as BOS-PG mentioned in M.Tech regulations)

5.2 Departmental Post Graduate Committee (DPGC):
(Same as DPGC mentioned in M.Tech regulations)

5.3 Project Work Evaluation Committee (PWEC)

Constitution:

(a) Chairman of DPGC or his nominee … Chairman
(b) Project Guide(s) … Member(s)
(c) One referee from outside the Department,

selected by the DPGC … Member

Note:

- There shall be one PWEC for each MBA project work.
- One external guide/referee, if any, invited as a member of PWEC, is entitled for TA/DA as per the Institute Rules.

Functions (Highlights):

i. To evaluate the MBA project work and to award an appropriate letter grade. The chairman of PWEC shall submit the report, signed by all the members of the PWEC, to DPGC. The DPGC Chairman shall forward this report to the Academic Section of the Dean (A) without moderation.

5.4 Project Guide:

Functions (Highlights):

i. He will help the student under him in selecting the Project topic.

ii. He shall monitor the progress of the student working under him.

iii. He shall report to the DPGC the performance of the student from time to time.

iv. He will coordinate with the HOD/DPGC to arrange for facilities to carry out the project work.

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REGULATIONS

SPECIFIC TO

DOCTORAL RESEARCH PROGRAMME

Ph.D. Degree

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL
Post : Srinivasnagar, Mangalore - 575025, India.
2020

CONTENTS

REGULATIONS
specific to
Ph.D. Degree Programme

{also refer: REGULATIONS (General) – Common to all Degree Programmes}

1. DEGREE PROGRAMMES:

1.1 Doctoral (Ph.D.) Degree Programmes are offered in the various departments/disciplines/ programmes as listed below:

a) Department of Civil Engineering
b) Department of Water Resources and Ocean Engineering
c) Department of Mechanical Engineering
d) Department of Electrical and Electronics Engineering
e) Department of Electronics and Communication Engineering
f) Department of Computer Engineering
g) Department of Chemical Engineering
h) Department of Metallurgical & Materials Engineering
i) Department of Mining Engineering
j) Department of Information Technology
k) Department of Mathematical & Computational Sciences
l) Department of Physics
m) Department of Chemistry
n) School of Management

1.2 The provisions contained in these Regulations shall be applicable to any new Doctoral Research Programmes, either by any of the departments, or even possibly as inter (multi)disciplinary programmes, that may be introduced from time to time.

2. ADMISSION:

2.1 Student Status: There are four types of student status in the Ph.D Degree Programme:

a) Full-time student on Institute Scholarship
(b) Full-time sponsored student on QIP (AICTE)
(c) Full-time/External Registrant - sponsored student from Industry or other Organizations including Educational Institutions
(d) Internal Registrant - sponsored Institute or Project staff of NITK

Note:

i. The full-time candidates are the registrants who work on full-time basis at the Institute. The external registrants are the candidates who register at the Institute but do research outside the Institute. The internal registrants are the Institute faculty/staff who work on part-time basis at the Institute.

ii. *Duration:* The duration of study shall be a minimum of TWO years and a maximum of SEVEN years for all categories of research scholars. Any student who concurrently registers for any postgraduate/research degree at another organization shall be automatically de-registered at the Institute. Also, a student, who has completed four years shall apply for extension of registration, in the prescribed format, every year till the submission of his thesis.

iii. A student of type (a) will receive Institute scholarship for a maximum duration of FIVE years of the Ph.D. programme, subjected to scholarship rules of the Institute.

iv. Student of the type (c) shall be sponsored and financed by the sponsoring organization. He should produce a sponsorship-cum-clearance certificate in the given format of the Institute.

v. An internal student of type (d) shall produce a sponsorship-cum-clearance certificate from the Director, NITK. They may be converted to Full-time research scholars after the completion of the project with the recommendation from the respective DRPC.

vi. The status of research scholar should be maintained the same throughout the program. However, change of status from full-time to internal registration may be considered based on the recommendations of DRPC on a case to case basis. In general, the conversion from internal/external registration to full time will not be permitted.

vii. No student can receive scholarship/ fellowship from more than one source.

2.2 Admission to a Ph.D. Programme shall be open to candidates who passed the prescribed qualifying degree examination in relevant field with a Cumulative Grade Point Average (CGPA) of at least 6.0 in the 0-10 scale grading system, or not less than 60% marks in the aggregate (taking into account the marks scored in all the subjects of all the public/ university examinations conducted during the entire prescribed period for the degree programme). However, this prescribed minimum shall be a CGPA of 5.5 or 55% marks in the aggregate for SC/ST/PWD candidates.

2.3 Students of type (a) must have passed GATE/ UGC-CSIR exam/ DAE- JEST to be admitted to Ph.D. Programme.

2.4 A limited number of admissions is offered to Foreign Nationals and Indians Living Abroad in accordance with the rules applicable for such admission issued from time to time by MHRD.

2.5 If, at any time after admission, it is found that a candidate had not in fact fulfilled all the requirements stipulated in the offer of admission, in any form whatsoever, including possible misinformation etc., this matter shall be reported to the Senate, recommending revoking the admission of the candidate.

2.6 Candidates have to fulfill the medical standards required for admission as prescribed in the information bulletin.

2.7 The Institute reserves the right to cancel the admissions of any student and ask him to discontinue his studies at any stage of his career on the grounds of unsatisfactory academic performance or indiscipline or any misconduct.

2.8 The decision of the Senate regarding the admissions is final and binding.

2.9 Every Ph.D. student/scholar of the Institute shall be associated with *Parent Department*, offering the degree programme that the student undergoes (or the department that his Research Guide belongs to), throughout his study period.

3. PROGRAMME STRUCTURE:

3.1 The Ph.D. Degree Programme Structure consists of the following stages:
(i) Ph.D. Course Work and Evaluation;
(ii) MLC: SM900 Research methodology
(iii) Comprehensive Examination
(iii) Research Proposal Submission and Assessment;
(iv) Research Progress Assessment;
(v) Pre-Synopsis Seminar and Synopsis Submission;
(vi) Ph.D. Thesis Submission and Assessment.

3.2 The Minimum Course Credit Requirement is 12.
(courses carrying ‘S’/’N’ grades shall not be counted).

Out of 12 credits required, only one self study course (900 level) with a maximum of 4 credits is permitted with the recommendation by the DRPC of the respective departments and approved by Dean (A).

3.3 The Course work must be completed within the first year of joining the program with a minimum CGPA of 6.0

3.4 In the case of Full time/External registrant sponsored student from the industry or other organizations, the minimum of one semester residential requirement may be waived by DRPC, on case to case basis. These students may be allowed to do pre-approved certified MOOCs and also a self-study course, towards 12 credits. Examination will be conducted for such certified courses to award grades, by the department. They also need to do a certified Research methodology course.

3.5 Every research scholar is required to undergo registration at the commencement of each semester on the days fixed for such registration and notified in the academic calendar.

4. RESEARCH GUIDE:

4.1 In each Department, applicants will be given at the time of selection the details of research areas proposed by various faculty members for Ph.D. programmes so that they will have an opportunity to discuss those areas with the respective faculty members and thereafter, indicate their choice in order of preference. The applicants shall then be interviewed by a committee constituted by the DRPC.

4.2 The faculty of the Institute who are appointed on permanent basis may be approved as Research Guide if they have Ph.D. degree or as and when they acquire Ph.D. A formal request in this regard may be made in the specified format for the approval of Dean (A) and the matter may be placed as reporting item in the BOS.

4.3 One Research Guide, selected among the faculty of the Department in which he has registered, shall be allotted to each Research scholar by the HOD of the parent department on the recommendations of DRPC at the time of admission. If the faculty is reaching superannuation and has less than 3 years of service in the Institute, an additional Research Guide from the parent department should also be assigned.

4.4 Depending on the research requirements, an additional faculty member or possibly an expert from outside the Department / Institute may be considered as a second Guide (additional-Guide). However, the *main* Research Guide shall be from within the *parent department*. In the case of external person applying for inclusion as an additional Research Guide for a specific research scholar, the application shall be scrutinized and approved by the BOS in order for a person to be recognized as an additional Research Guide. The list of approved guides will be reported to Senate.

4.5 The inclusion of additional guide is allowed till the submission of the research proposal seminar.

4.6 In case the Research guide is going to be away from the Institute for a period of more than one year then an additional guide from the Parent Department need to be identified and approved prior to leaving.

4.7 Change of Research Guide(s) under exceptional circumstances shall be permitted on recommendation of the DRPC after obtaining the consent of (i) the Research Scholar (ii) the present Guide(s) and (iii) the proposed Guide(s).

4.8 At any given time the number of Research Students/Scholars registered with a Research Guide shall not exceed FIVE(Excluding the number of students registered with the Guide in the case of funded projects). In this regard, being a co-guide for two Full-Time Research Scholars or being the sole Research Guide for two External/Internal Registrants (Research Scholars), is equivalent to being the sole Research Guide for one Research Scholar.

5. EVALUATION SYSTEM:

5.1 Ph.D. Course Work Evaluation

The Ph.D. course work evaluation shall be similar to that of other courses, and the details are given in the corresponding section in the Regulations (General) Common to all Post Graduate Degree Programmes (refer: Section G5).

5.2 Comprehensive Exam

Comprehensive exam will be conducted once in a semester and a student registered for Ph.D should qualify in this exam within one and half years from the date of registration. A student is deemed to have qualified in this exam if he/she obtains 60% marks in the exam and satisfactorily completes the oral exam. If a student performs non-satisfactorily in the oral exam, he/she needs to retake only the oral exam. A maximum of two attempts to qualify in the comprehensive exam will be given. If a student does not qualify in the comprehensive exam even after two attempts, his/her registration will be terminated. The question paper for comprehensive exam would be set by the respective DRPC.

5.3 Research Proposal Submission and Assessment

Every Ph.D. student is required to submit his research proposal in the prescribed format, within 24 months after joining the program. Extension by 6 months will be given to those students who do not qualify in the comprehensive exam in the first attempt. In case a research proposal is not submitted with in two and half years the registration will be terminated.

5.4 Research Progress Assessment

5.4.1 After the approval of Research Proposal, yearly assessments are made, through open seminars, to ensure satisfactory progress. The Research Scholar shall submit, through his Guide(s), a progress report of his research to the concerned RPAC every year. The progress seminars are to be presented within the first one month of every academic year as applicable to the scholar. Beyond four years the scholars are required to give half yearly progress seminars, (within the first month of every semester). In case of possible delay, prior permission should be obtained from Dean(A) at least 15 days before the due date. The RPAC will communicate to the DRPC a detailed report about the progress The DRPC will forward the RPAC Report to the Deputy Registrar (Academic) for filing in the appropriate records. Only those cases which require further action may be brought to the attention of the Dean (A) and/or the Director. If the research scholars fail to fulfill the above requirements, the registration is liable to be terminated.

5.4.2 (a) The continuance of registration of all research scholars is subject to satisfactory progress made by them. The progress seminars are to presented as per 5.3.1

(b) Ph.D registration is valid up to four years from the date of joining. Beyond four years, candidates should seek extension of registration by applying in the specific format within the stipulated date. Extension will be granted on yearly basis. The registration is liable to be terminated if the research scholars fail to obtain extension of registration

(c) For granting extension the following conditions must be fulfilled:

(i) For extension beyond 4 years – satisfactory progress (through a seminar) during the previous period and two conference papers.

(ii) For extension beyond 5 years –two half yearly progress seminars along with one journals publication and /or conference paper in the fifth year.

(iii) For extension beyond 6 years –two half yearly progress seminars along with one journals publication and /or conference paper in the sixth year.

5.4.3 Prior to Pre-synopsis seminar, the scholar is required to give at least TWO satisfactory Research Progress Assessment Seminars on the topic of his research, and have at least TWO papers published or accepted for publications in refereed Journals. (Scopus/SCI/ESCI/SSCI /AHCI).

5.5 Pre-Synopsis Seminar and Synopsis Submission

5.5.1 Prior to the submission of the Synopsis of the Thesis, a comprehensive internal assessment of the research work should be made by RPAC by a Pre-Synopsis Seminar. The candidate can submit the Synopsis only if RPAC is satisfied about the quality of the work for submission as a Ph.D. Thesis.

5.5.2 Details of the Pre-Synopsis Seminar shall be notified well in advance, so as to enable interested staff members and students to attend the same.

5.5.3 The Chairman of the DRPC shall forward the RPAC's assessment report on the Pre-Synopsis Seminar to the Director.

5.5.4 ONE printed copy and ONE soft copy (PDF format) of the synopsis shall be submitted to the Dean(A) through Chairman of the DRPC, in the prescribed format consisting of maximum of 15 pages including bibliography of research work, with the following certificates

(a) Certificate from the Chairman, DRPC that the Pre-Synopsis Seminar has been completed satisfactorily.

(b) Declaration from the Research Scholar in a prescribed proforma, stating:

i. Bonafide nature of the work;
ii. that the thesis does not contain any work which has been previously submitted for the award of any degree, and
iii. the extent of collaboration, if any.

(c) Details of the courses studied (for all categories of research scholars)

5.5.5 (a) Institute Scholars may be permitted to submit the thesis from outside only after submission of synopsis on recommendation of DRPC and approval by the Dean(A)

(b) QIP Scholars may be permitted to leave the Institute after 3 years and to submit the synopsis and thesis from outside, on recommendation of RPAC, DRPC and approval by Dean (A)

5.6 Ph.D. Thesis Submission and Assessment

5.6.1 .Prior to the thesis submission, the scholar should have Two papers published or accepted for publication in refereed journals (Scopus/SCI/ESCI/SSCI/AHCI)

5.6.2 THREE printed copies (soft-bound) and ONE soft copy (PDF format) of the thesis shall be submitted to the Dean(A), through Chairman of the DRPC, in the prescribed format, not later than three months from the date of submission of the Synopsis

(i) if the thesis is submitted after 3 months of submission of Synopsis, approval of the Chairman Senate is necessary for submission up to 6 months. However, a prescribed fine is to be paid by the scholar.

(ii) If the thesis is not submitted within six months after submitting the synopsis, the registration is liable be terminated.

5.6.3 Along with the Thesis, the Research Scholar shall submit the requisite forms containing the authorization from the Research Guide(s) for submission of the Thesis and a certificate from Accounts Section that there are no dues against the Scholar and the details on research publications.

5.6.4 The Ph.D. Thesis submitted by the scholar will be evaluated by DTAC constituted by Director by selecting two external referees (one will be invited for defense also) from the Panel submitted by DRPC.

5.6.5 The referees shall independently report to the Dean (A), preferably within six weeks from the date of their receipt of the Thesis. The referees will be requested to indicate their decision in a specific evaluation format supplied by the Institute and that their reports should include -

i. a critical survey and evaluation of the quality and quantity of the work as embodied in the thesis.

ii. questions, if any, to be asked or points to be clarified at the viva-voce examination, and

iii. a definite recommendation as to whether the Thesis is acceptable for the award of the degree of 'Doctor of Philosophy'.

5.6.6 If a referee in his report is not in a position to make a definite recommendation for the award of the degree, he should be requested to assist in deciding whether the candidate is required to make:

i. Substantial revisions involving rewriting of one or more chapters without, however, doing any further Research work.

ii. completely rewrite the thesis if the thesis, though not acceptable, in the present form, reveals sufficient quality and quantity of work to warrant the candidate being given an opportunity for further Research work and/ or reinterpretation of results.

5.6.7 The copies of the referees' reports when received shall be confidentially made available to the Research Guide(s) through Chairman, DRPC. The Research Guide(s) shall send comments on these reports through DRPC for consideration by the Dean (A).

5.6.8 On the basis of the referees' reports and the Research Guide(s)' comments thereon, the Dean (A) will decide whether the Thesis be accepted for the viva-voce examination, or be referred again to a new referee.

5.6.9 A thesis may be considered acceptable for holding the viva-voce examination if both the referees give positive recommendations. If one of them accepts and the other rejects; the Thesis as it is, shall be referred to a third referee chosen from the Panel of Referees by the Director.

5.6.10 Whenever a Thesis is referred to a third referee, the comments of the Research Guide point by point for the queries by the first two referees should also be reported to the Dean (A) along with the comments for the queries by the third referee.

5.6.11 If the referees recommend acceptance of the thesis subject to minor modifications only, the thesis can be resubmitted after incorporating the modifications in the light of the referees' comments, within a period of six months. The Thesis so resubmitted be preferably examined by the same referees. However ,a prescribed fine is to be paid by the scholar if the thesis is resubmitted after 6 months but within one year. If the thesis is not resubmitted within one year the registration is liable to be terminated.

5.6.12 A Thesis rejected by two referees may be re- submitted after revision, incorporating the required modifications and/or alterations and/or additions etc., in the light of the referees' comments. Such resubmission shall be made not earlier than three months and not later than one year from the date of such intimation to the Research Scholar by the Dean (A). The Thesis so resubmitted may be examined either by the same referees or by new referees.

5.6.13 Rejection of the thesis so resubmitted will disqualify the candidate from further consideration for the award of the Ph.D. degree, in the topic of research chosen by him.

5.6.14 A candidate, whose thesis has been recommended for the award of the Ph.D. degree, shall be required to defend his Thesis at an open viva-voce examination conducted by the DTAC. After satisfactory defense of the work, the DTAC will recommend the approval of thesis to the Director through DRPC for further action towards the award of the Ph.D. degree.

5.5.15 The DTAC shall submit its report in the prescribed form to the Director within ONE month after the completion of viva-voce exam. It is the responsibility of the Research Guide to see that all the necessary corrections are incorporated in the final version of the thesis before sending the DTAC report to the Director.

5.5.16 After satisfactory completion of the viva-voce examination, the degree may be conferred after approval by the Senate.

5.5.17 If a Thesis has been accepted but the candidate fails at the viva-voce examination, he may be permitted by the Director to re-appear for viva-voce examination again at a later date. The Recommendations of the DTAC conducting the viva-voce examination shall be considered by DRPC in taking a decision in this respect.

5.5.18 After successful completion of the viva- voce examination, the candidate shall submit to the DRPC the prescribed number of copies (one hard copy and a CD) of his approved Thesis (incorporating all the necessary corrections) in the prescribed format.

5.5.19 The abstracts of evaluation reports of Ph.D. theses will be placed before the Senate as reporting item. The full original reports of all examiners will be placed before the Senate only in those cases of rejection by one of the examiners.

6. SCHOLARSHIP AND PAYMENT OF FEES:

6.1 The Institute Research Scholars will be paid scholarship at a rate in accordance with the directives from the appropriate authorities.

6.2 In case of institute scholarship holders, the continuance of scholarship beyond two years will be subject to satisfactory progress made by them as assessed by the pertinent RPAC and approved by DRPC

6.3 The Ph.D. Research Scholars receiving scholarship or any other type of financial aid shall abide by the Scholarship Rules and/or other applicable Rules.

6.4 The Research Scholars need to pay the Institute fees till the submission of the Thesis.

7. DEGREE REQUIREMENTS:

The degree requirements of a scholar for the Ph.D Degree Programme are as follows:

7.1 *Institute Requirements:*

(i) Minimum Earned Credit in the Ph.D. Course Work of 12, with a minimum CGPA of 6.0, completed within the first TWO years (refer: Programme Structure, Clause No: 3.2 & 3.3 above).

(ii) Institute Residential Requirement (refer: Programme Structure, Clause No: 3.4 above).

(iii) Satisfactory completion of all the SIX stages of the Programme (refer: Programme Structure, Clause No: 3.1 above).

(iv) Satisfactory Defense of Thesis.

7.2 The Maximum duration for a student for complying to the degree requirement is SEVEN years from date of registration for his first semester for the Research Scholars of all categories.

8. TERMINATION FROM THE PROGRAMME:

A student shall be required to leave the Doctoral degree programme under following circumstances:

a) If the student is absent for more than SIX (6) weeks in a semester without sanctioned leave
b) If a student fails to qualify in the comprehensive exam in two attempts or within one and a half years from joining the programme.
c) Student fails to submit satisfactory Research Proposal within two and a half years of joining the programme.
d) Student fails to give the research progress seminars within the stipulated time
e) Student fails to register for each academic semester within the date specified
f) The Research scholar fails to obtain extension of registration
g) If the thesis is not submitted within six months after submitting the synopsis
h) If the Thesis is asked for re-submission and not submitted within one year after asking for resubmission
i) If the Ph.D Thesis has not been accepted after TWO submissions
j) At the end of seven years of registration.
k) Based on Disciplinary action, on recommendation by the appropriate committee.

NOTE: Under any circumstances of termination, the conditions specified in Permanent Withdrawal (refer: Clause No: G10.2) shall also apply.

9. COMMITTEES / FUNCTIONARIES:

The following committees shall be constituted for the Doctoral Research Degree programme:

9.1 Board of Studies (BOS-Research):

Constitution:

(a)	Dean (A)	…	*Chairman*
(b)	Dean (FW)	…	Member
(c)	Dean (P&D)	…	Member

(d)	Dean (R&C)	…	Member
(e)	Dean (SW)	…	Member
(f)	Dean(AA&IR)	…	Member
(g)	H.O.D of each department/his nominee	…	Member
(h)	BOG members representing the faculty	…	Member
(i)	Asst.. Registrar (Academic)	…	*Convenor*
(j)	Dy. Registrar (Academic)	…	*Secretary*
(k)	TWO External Experts	…	Members

Note:

- There shall be one BOS - Research for the entire Institute.
- The Chairman may co-opt and/or invite more members including outside experts.
- The quorum of each meeting will be *NINE.*

Functions (Highlights):

i. To frame and revise curricula for the courses of study.

ii. To consider the recommendations of the DRPC on matters relating to Ph.D. programme and to make suitable recommendations to the Senate.

iii. To ensure that all norms and Regulations pertaining to Ph.D. Programme are strictly followed.

iv. To make periodic review of ordinances, Regulations and instructions pertaining to Ph.D. Programme and to recommend to the Senate any modification thereof.

v. To scrutinize the Bio-data of the intending Research Guides and to recommend issue of registration letters to the competent persons.

vi. To recommend to the Senate, the award of stipends, scholarships, medals and prizes etc.

vii. To draw up general time table for the Ph.D. programme and finalise the Academic Calendar to be put up to the Senate for approval.

viii. To consider the cases of malpractice in examinations and to recommend to the Director the punishment for such cases.

ix. To conduct at least one meeting each semester and send the Resolutions to the Chairman of the Senate, and also to maintain a record of the same in the office of Dean (A).

x. Any appropriate responsibility or function assigned by the Senate or the Chairman of the Senate.

9.2 Doctoral Research Programme Committee (DRPC):

Constitution:

(a)	H.O.D. / Programme Co-ordinator or a Professor nominated by the Director	…	Chairman
(b)	All approved Ph.D. Guides associated with the Research Programme	…	Members

Note:

- There shall be one DRPC for every department that is involved in the Ph.D. degree programme, or for every inter (multi) disciplinary doctoral research programme.
- The Secretary (DRPC) shall be nominated by the Chairman on rotation basis for a period of one year.
- The Chairman may co-opt/invite more members including a maximum of three outside experts.
- The quorum for each meeting shall be THREE.

Functions (Highlights):

i. To monitor the conduct of all courses of the department for the Ph.D. programme.

ii. To ensure academic standard and excellence of the courses offered by the department.

iii. To obtain the evaluation of each student in a course separately for Course Instructor's assessment, mid-semester tests and end-semester tests.

iv. To consolidate the grades of the students registered for various courses offered by the Department and submitted by the different Course instructors. The CGPA for each scholar should be computed up to the end of Ph.D. Course Work and sent to the Academic Section of the Dean (A).

v. To take appropriate actions based on communication of RPAC and DTAC.

vi. To recommend the Panel of Members, as proposed by the Guide, for the formation of RPAC (three within Department, three outside the Department) to the Dean (A) for approval.

vii. To recommend the Panel of Referees in consultation with the Guide for formation of DTAC (TEN Referees) to the Director for approval, immediately after the acceptance of the RPAC's report on the Pre-Synopsis Seminar and along with the submission of the Synopsis to the Director.

viii. To consider any matter related to the Research programme of the department.

ix. To conduct at least two meetings each semester and send the proceedings of the meeting to Dean(A).

x. To maintain a separate register to record the minutes of all the meetings.

9.3 Research Progress Assessment Committee (RPAC):

Constitution:

(a)	Guide	….	Chairman
(b)	Additional -Guide (if any)	….	Member
(c)	At least One Faculty from the parent department of Ph.D. Scholar ,selected by Dean (A), from the recommended panel.	….	Member
(d)	At least One Faculty from outside the parent department of the, Guides selected by Dean (A), from the recommended panel.	….	Member

Note:

- There shall be one RPAC for each Ph.D. scholar.
- The RPAC shall be constituted by the Dean (A) based on the recommendation of DRPC.
- Under special circumstances, members from outside the Institute may be co-opted with the prior approval of Dean (A).

Functions (Highlights)

(i) To assess and approve the Research Proposal and Synopsis.

(ii) To communicate the yearly assessment reports about the progress of the research work to DRPC.

(iii) To assess the Pre-Synopsis Seminar and communicate the results to the Director through the DRPC.

9.4 Doctoral Thesis Assessment Committee (DTAC):

Constitution:

(a)	Chairman DRPC or a Professor nominated by the Director on recommendation of DRPC	…	Chairman
(b)	Guide(s)	…	Member(s)
(c)	At least One Faculty from within the parent department of Ph.D. scholar, selected by Dean (A)from the recommended panel.	…	Member
(d)	At least One Faculty from outside the parent department of the guides(s), selected by Dean(A) from the recommended panel	…	Member
(e)	One External Referee	…	Member
(f)	RPAC Members	…	Invited Members

Note:

- There shall be one DTAC for each Ph.D. scholar.
- The DTAC shall be constituted by the Director when the scholar submits the Ph.D. Thesis for assessment.
- The two external referees shall be selected by the Director, from a panel of TEN referees from the Institutions of India or abroad. These TWO External Referees will be requested for an assessment of the Ph.D. Thesis, and one of these Referees will be invited for the final *Thesis Defense and Viva-Voce Examination*.

Functions (Highlights):

(i) The two external referees will evaluate the Doctoral Thesis and send the report to Director.

(ii) DTAC will evaluate the research work and the Doctoral Thesis, based on the defense of the Thesis through an open seminar and viva-voce examination and send the report to Director through DRPC

9.5 Research Guide:

Functions (Highlights):

i. He will guide the student to select a topic for research.

ii. He will suggest the courses for doctoral course work.

iii. He will monitor the progress of the student / scholar.

iv. He will suggest a Panel of Referees to the DRPC for RPAC and DTAC.

v. He will approve and forward all the applications of the student/scholar.

vi. He will provide or arrange for facilities to carry out research.

vii. In the event of leaving the Institute or away from the institute for a considerable period, he has to arrange for a Change of Research Guide as per Clause No: 4.5 above.

* * * * *

FORMS & FORMATS

Post Graduate and Research Programmes

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL
Post : Srinivasnagar, Mangalore - 575025, India. - 2018

CONTENTS

COURSE REGISTRATION FORM
(Instructor Copy)

Course Code: Course Title: L.T.P: Credits:

Course Instructor(s): Teaching Dept.:

Sl. No.	Register No.	Name of the student	Semester	Branch	Signature	D/U/cU/W
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

D: Drop U: Audit cU: Credit-Audit Conversion W: Withdrawal

Note: The last column to be filled only if a student opts to drop / audit / credit-Audit conversion or withdrawal of the course.

Name & Signature of Course Instructor(s) date

N am e & Signature of HOD with with date & Dept. seal

COURSE REGISTRATION FORM (FACULTY ADVISOR COPY)

Name of Faculty Advisor: Dept. Semester:

Sl. No.	Register No.	Name of the student	Course Number and Credits (Ex: CV372(3))										Signature
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
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16													
17													
18													
19													
20													
21													
22													
23													
24													
25													

A: ADD D: DROP* U: Audit* cU: Credit-Audit Conversion* W: Withdrawal*

* Use separate card/s to enter D-U-cU-W options

Name & Signature of Faculty Advisor
Date:

Name & Signature of HOD
with Dept. Seal

COURSE REGISTRATION FORM
(Student Copy)

Reg. No.: Dept.: Semester & Programme:

Name of the student: Fee Receipt No:

Sl. No.	Course No.	Course Title	Credits	Course Instructor's Name	Signature of Instructor
1					
2					
3					
4					
5					
6					
7					
8					

Signature of Student Signature of Faculty Advisor Signature of HOD

Date: with seal

D / U / cU / W – Options

Sl. No.	Course No.	Course Title	Credits	D/U/cU/W	Signature of Faculty Adviser	Signature of Instructor
1						
2						
3						
4						
5						
6						
7						
8						

D: Drop U: Audit cU: Credit-Audit Conversion W: Withdrawal

Signature of Student Signature of Faculty Advisor Signature of HOD with seal

It is mandatory for a student to preserve this card as a proof of his / her registration till the end of the programme.

* To be signed by the student as soon as he/she completes the registration of all the courses and by the faculty advisor, the HOD after the last day of late registration announced in the academic calendar.

* To be signed by the student, faculty advisor and the HOD at the end of each semester after verifying the options exercised by the student and to be returned to the student at the end of the semester.

Faculty Advisor has to ensure that the entries in the Faculty Advisor Copy, Course Instructor Copy, and Student Copy are matching.

STUDENT'S LEAVE APPLICATION

Name of the Student :

Reg. No./Admission-No./Roll-No.:

Programme / Branch / Semester / Class :

Period of Absence : From: To:

: Number-of-days of Leave =

Reason for Leave-of-Absence :

Supporting Documents Attached :

Signature of Student :

Number of days of Leave : already-availed | being-applied-now | still-available(un-availed)

: | |

: | |

Forwarded by Faculty Advisor :

Remarks by Chairman (DUGC/DPGC/DRPC) :

Recommendation : Approval / No-approval

Signature of the Recommending Authority :
with Date :

Decision : Approved / No-approved

Signature of the Approving Authority :
with Date :

NOTE:

(i) *Chairman DPGC/DRPC can approve the leave up to 14 days.*

(ii) *If the leave is for more than 14 days, the leave application shall be forwarded to Dean (Academic) for approval.*

Course Evaluation Form for Lecture Courses

PURPOSE: The objective of this feedback is to collect information for assessing and improving the course and the instructor's teaching effectiveness

Course Code: Course Title:

Type of Course: Core / Elective Class Size:

Academic Year: Semester & Programme:

Department: Instructor's Name:

(Mark ' √ ' in the appropriate box)

RATINGS

5 - Strongly agree 4 - Agree 3 - Neither agree nor disagree 2 - Disagree 1- Strongly disagree

	COURSE	5	4	3	2	1
1	The course plan provided sufficient information on the objectives and contents					
2	The distribution of marks (for tests, assignments, tutorials and exams) was clearly stated in the course plan					
3	I found the course materials (class notes, handouts, prescribed text books) useful					
4	The assignments, tutorials, quizzes etc. helped me to understand the course					
5	The tests and examinations covered to a large extent what was taught in the class					
6	I was satisfied with the course coverage					
7	The evaluation was fair and transparent					
8	The course helped me to acquire knowledge and skills					
9	This course motivated me to learn more					
10	Overall, the course was satisfactory					
	INSTRUCTOR					
1	The instructor was generally well prepared for the classes					
2	The instructor presented the contents effectively					
3	The instructor generated interest in the subject					
4	The instructor delivered the lectures at an appropriate pace					
5	The instructor made use of appropriate teaching aids and methods					
6	The instructor encouraged students participation and interaction in the class					
7	The instructor provided timely and effective feedback regarding the assignments/tests/exams					
8	The instructor was available outside class hours for consultation					
9	The instructor was regular to the class					
10	Overall, the instructor was effective in his/her role as a teacher					

SUGGESTIONS / COMMENTS: Please turn over

Note: This course feedback form to be collected by any faculty member other than the course instructor and to be handed over to the concerned course instructor.
Please write below your suggestions/comments if any to improve the teaching-learning process:

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Course Evaluation Form for Practical Courses

PURPOSE: The objective of this feedback is to collect information for assessing and improving the course and the instructor's teaching effectiveness

Course Code: Course Title:

Type of Course: Core / Elective Class Size:

Academic Year: Semester & Programme:

Department: Instructor's Name:

(Mark ' √ ' in the appropriate box)

RATINGS

5 - Strongly agree 4 - Agree 3 - Neither agree nor disagree 2 - Disagree 1- Strongly disagree

LAB/PRACTICAL SESSIONS		5	4	3	2	1
1	The practical sessions/Experiments provided me an opportunity to understand the subject					
2	Handouts/laboratory manuals were available in advance					
3	Clear instructions to carry out the practical/Experiments were given in advance					
4	I was thoroughly prepared for all the practical/lab sessions					
5	The assistance given during the practical sessions was useful					
6	I was regular in submitting all my lab/practical reports					
7	The instructor's feedback on my report was prompt					
8	The instructor's feedback on my report was useful					
9	The evaluation was fair and transparent					
10	Overall, the lab/practical course was satisfactory					

SUGGESTIONS / COMMENTS: Please write below your suggestions/comments if any to improve the conduct of this lab/practical course

Note: This course feedback form to be collected by any faculty member other than the course instructor and to be handed over to the concerned course instructor.

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

SUMMARY REPORT OF MARKS and GRADES

Semester/Session & Year :

Course Number : Course Title : (L-T-P) Credits:

Name of the Instructor: Department:

CLASS PERFORMANCE DISTRIBUTION STATISTICS

Class – Size (No. of students) =
Class – Max. Mark (Xmax) =
Class - Min. Marks (Xmin) =
Class – Mean Marks (μ) =
Standard – Deviation (σ) =

A detailed Histogram of the Raw-Scores data is attached.

Grades	Cutoff Marks %		Number of Students
AA	=>		
AB	=>		
BB	=>		
BC	=>		
CC	=>		
CD	=>		
DD	=>		
FF	<=		
FA	Attendance less than 75%		

===

Course-Instructor(s) Name & Signature with Date

Secretary-DPGC/DRPC Name & Signature with Date

Chairman-DPGC/DRPC Signature with Date & Dept-Seal

REPORT of MARKS and GRADES

Semester/Session & Year :

Course Number : Course Title : (L-T-P) Credits :

Course Category : BSc / Esc / HSc / Pc / Ele / MP / MLC / ?

Name of the Instructor : Department :

SL.No.	Reg. No.	Name	%Marks	Letter-Grade
1.				
2.				
3				
4.				
5.				
6.				
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30.				

BSc: Basic Science Core; ESc: Engineering Science Core; HSc: Humanities & Social Sciences Core;
Pc: Programme Core; Ele: Elective; MP: Major Project; MLC: Mandatory Learning Course

Course-Instructor(s) Name & Signature with Date	Secretary-DPGC/DRPC Name & Signature with Date	Chairman-DPGC/DRPC Signature with Date & Dept-Seal

Permission to Carry out the M.Tech Project work outside the Institution

1	Name and Reg. No. of the student	
2	Department and Discipline	
3	Place where the work is planned to be carried out (attach copy of the offer letter)	
4	Duration (attach copy of the offer letter)	From (dd/mm/yyyy) To(dd/mm/yyyy)
5	Title of the project work(attach copy of the offer letter)	
6	Name and designation of the Guide from outside Institute	
7	Name and designation of the Guide from NITK	
8	Whether any financial assistance is received from the outside organization ? If yes, specify the nature and amount	

Signature of the student with date

Signature of the Internal Guide with date

Signature of Chairman DPGC with date

Permitted with GATE scholarship / Permitted without GATE scholarship / Not Permitted

Note: A monthly attendance report of the student should be obtained duly signed by the External Guide with the seal and to be submitted to the Academic Office along with the signatures of the Internal Guide and HoD.

Dean (Academic)

Panel Submission Form for constitution of PWEC

[DPGC → Dean (A)]

Department :

Programme : *MTech / MCA. / MSc / MBA*

Specialisation:

Sl. No.	Name and Reg. No. of the student	PWEC Chairperson	PWEC Members
1.			(a) Guide: (b)
2.			(a) Guide: (b)
3.			(a) Guide: (b)
4.			(a) Guide: (b)
5.			(a) Guide: (b)

(Please note that the Chairperson of PWEC shall be different from the Project Guide)

Secretary-DPGC

Name & Signature, with Date

Chairman-DPGC

Name & Signature, Date & Seal

[*Approval*]

Dean (Academic)

Request for Extension of Last Date for Submission of P.G. Project-Report / Thesis

[Student→ Guide → DPGC Chairperson → Dean (A)]

Part I [To be filled-in by the Student]

Name: Registration No. :

Date of Joining:

Department & Programme:

Name of Guide:

The last date currently specified:

Reasons for requesting the extension of time for submitting the project report/thesis:

Expected date of submission:

Declaration: I agree to pay the applicable fees for late submission as per the Institute Rules (semester fees as applicable to the degree programme).

Signature of the Student, with Date:

Part II [To be filled-in by the Guide]

Comments by the Guide:

Name: Signature: Date:

Part III [To be filled-in by the DPGC Chairperson]

Recommended / not-Recommended for extension of date for Report/Thesis submission.

Chairperson-DPGC

(Name & Signature, Date & Seal)

Part IV [To be filled-in by the Dean (A)]

Extension is (1) not granted (reason:)

(2) granted and the extended last date for submission of the project-report/thesis by the above student is ________________

Dean (Academic)

Note: After getting the permission from the Dean, the student shall pay the applicable fees, if any, to the cash section and submit this form to the Examination Section along with the fee receipt.

If the student has already completed the maximum duration for complying the degree requirement from the date of registration of first semester, as per the Regulations, no more extensions shall be permitted.

D E C L A R A T I O N

by the P.G. (M.Tech / M.Tech(Research)/ MCA / MSc / MBA) Student

I hereby *declare* that the Report of the P.G. Project Work entitled

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

which is being submitted to the National Institute of Technology Karnataka Surathkal, in partial fulfilment of the requirements for the award of the Degree of Master of …………………………………………… …

……………………………………………………………………………………………

in the department of ………………………………………………………………… , is a *bonafide report of the work carried out by me*. The material contained in this Report has not been submitted to any University or Institution for the award of any degree.

…………………………………………………………………………

(Registration Number, Name & Signature of the Student)

Department of …………………………………………………

Place: NITK, SURATHKAL

Date:

Declaration to be signed by the student and incorporated as part of the P.G. Project Work Report

C E R T I F I C A T E

This is to *certify* that the P.G. Project Work Report entitled …………

………………………………………………………………………………………………

………………………………………………………………………………………………

submitted by ……………………………………………………………………………… ,

(Register Number: …………………………) as the record of the work carried out by him/her, is *accepted as the P.G. Project Work Report submission* in partial fulfilment of the requirements for the award of degree of Master of……………………………………………………………………………………

………………………………………………………………………………………………

in the Department of……………………………………………………………………

External Guide (if any)
(Name and Signature
with Date and Seal)

Internal Guide
(Name and Signature
with Date and Seal)

Chairman - DPGC
(Signature with Date and Seal)

PWEC Report on P.G. Project Work Evaluation

[PWEC → DPGC → Dean (A)]

Part I [To be filled-in by the PWEC]

Name of the student : Registration No.:

Programme : *M.Tech. / M.C.A. / M.Sc / M.B.A*

Specialization :

Name of Project Guide(s) :

Title of Major Project :

Date of open seminar & viva-voce examination:

Decision of PWEC : (1) Project Report is acceptable and the letter grade is ______
(2) Project Report has to be resubmitted.
(3) Project Report is not acceptable and the letter grade is "FF". (*If the Report is not acceptable or if resubmission is required, specific reasons must be furnished by the PWEC, separately*)

Names & Signatures of PWEC chairperson & all the Members:

Name	Signature
1.	
2.	
3.	

Date:

Part II [To be filled-in by the DPGC]

The Project Work Evaluation Report by the PWEC is being forwarded to the Exam. Section.

Secretary-DPGC	Chairman-DPGC
(Name & Signature, with Date)	(Name & Signature, Date & Seal)

Note: The completed form (along with the photo copy of the cover page of the Project Report, where the Title and the name of the student are printed) has to be submitted, *in a sealed envelope*, to the Office of the Dean (A).

M.Tech.(Research) - RPAC Panel Submission Form

[Guide → RPAC → DPGC → . . . → Dean-A]

[*To be filled-in by the MTech.(Research) Scholar*]

Name of the Scholar: Registration No. :

Department: Date of joining:

Name of Research Guide(s):

Research Area:

Signature of the Scholar, with Date:

[*Panel Proposed by the Research Guide*]

Panel for RPAC from the parent Department of the MTech (Research) Scholar

(1)

(2)

(3)

Panel for RPAC from outside the parent Department of the guide(s)

(1)

(2)

(3)

Note: Guide(s) have obtained the consent of the faculty before forwarding their names for RPAC panel.

Signature(s) of Research Guide(s)

[*Forwarding by the DPGC*]

The RPAC panel is being forwarded to lDean(A)

Secretary-DPGC Date Chairman-DPGC

[*Verification of Records*]

The Records were verified and found to be in order.

Supdt. (Academic Section) Asst. Registrar (Academic)

[*Approval*]

Dean (Academic)

MTech (Research) Research Proposal Submission Form

[MTech.(Research) Scholar → Guide → RPAC → DPGC → . . . → Dean-A]

[*To be filled-in by the MTech(Research) Scholar*]

Name of the Scholar: Registration No. :

Department: Date of joining:

Name of Research Guide(s):

Title of Research Proposal:

Signature of the Scholar, with Date:

[*Recommendation by the RPAC*]

Date of receiving the Research Proposal:

Date of Open Seminar: Date of RPAC meeting:

Decision of RPAC: *The research proposal is acceptable / not-acceptable*

(if not acceptable, specific reasons must be furnished separately)

Names & Signatures of RPAC members:

(1)

(2)

(3)

[*Forwarding by the DPGC*]

The research proposal, along with the RPAC recommendations, is being forwarded to the Dean(A).

Secretary-DPGC Date Chairman-DPGC

[*Verification of Records*]

The Records were verified and found to be in order.

Supdt. (Academic Section) Asst. Registrar (Academic)

[*Approval*]

Research Proposal is approved / not-approved.

Dean (Academic)

Note: (1) The details of research proposal such as literature survey, problem identification, state of the art technology, detailed plan of research work etc. must be attached as an annexure in a bound form.

(2) The detailed observations of RPAC is to be attached.

M.Tech.(Research) Research Progress Assessment Report

[MTech(Research) Scholar → Guide → RPAC → DPGC → . . . → Dean-A]

[*To be filled-in by the MTech(Research) Scholar*]

Name of the Scholar: Registration No. :

Department: Date of Joining:

Name of Research Guide(s):

Title of Research Report:

Signature of the Scholar, with Date:

[*Recommendation by RPAC*]

Date of receiving the Research Report:

Date of Open Seminar: Date of RPAC meeting:

Decision of RPAC: *The research progress is satisfactory / not-satisfactory*

(if not satisfactory, specific reasons must be furnished separately)

Names & Signatures of RPAC members:

(1)

(2)

(3)

[*Forwarding by the DPGC*]

The research progress assessment report is being forwarded to the Dean(A).

Secretary-DPGC Date Chairman-DPGC

[*Verification of Records*]

The Records were verified and found to be in order.

Supdt. (Academic Section) Asst. Registrar (Academic)

[*Approval*]

Dean (Academic)

Note: 1.Progress report to be attached

(2) The detailed observations of RPAC, if any, may be attached.

(3) Research Progress Assessment shall be conducted on a half-yearly basis for research scholars beyond four years.

M.Tech (Research) Synopsis Submission Form

[MTech(Research) Scholar → Guide → RPAC → DPGC → . . . → Dean(A)]

[*To be filled-in by the MTech (Research) Scholar*]

Name of the Scholar: Registration No. :

Department: Date of joining:

Name of research Guide(s):

Title of MTech(Research) Synopsis:

Signature of the Scholar, with date:

[*Recommendation by RPAC*]

Total course credits earned (must be at least 12): CGPA (must be at least 5.50):
(above requirements are applicable for students under credit system)

Date of Pre-Synopsis Seminar: Date of RPAC meeting:

Decision of RPAC: *The research progress is acceptable / not-acceptable for submission of Synopsis of MTech(Research) Thesis.*
(for non-acceptance, specific reasons must be enclosed)

Names & Signatures of RPAC members:
(1)

(2)

(3)

[*Forwarding by DPGC]*

The MTech(Research) Synopsis, along with the RPAC recommendations, is being forwarded to the Dean(A).

Secretary-DPGC Date Chairman-DPGC

[*Verification of Records*]

The Records were verified and found to be in order.

Supdt. (Academic Section) Asst. Registrar (Academic)

[*Approval*]

The MTech(Research) Synopsis has been received and is accepted / not-accepted for evaluation.

Dean (Academic)

Note: The following documents must be enclosed:

1. ONE printed copy and ONE soft copy of the Synopsis.
2. Details of the courses studied(copy of grade card to be enclosed)
3. Certificate regarding residential requirement.
4. The detailed observations of RPAC on Presynopsis seminar, to be attached.
5. List of papers presented/published/accepted for publication or presentation, in the prescribed format, and reprints of those papers.

M.Tech.(Research)Course Details and Residential Requirement

[MTech(Research) Scholar → Guide → RPAC → DPGC → . . . → Dean(A)]

[*To be filled-in by the MTech(Research) Scholar*]

Name of the Scholar: Registration No. :

Department: Date of Joining:

Name of Research Guide(s):

Title of Research Report:

Signature of the Scholar, with Date:

1. Courses studied

Sl. No.	Semester, year	Course code	Course Title	Grade

2. Residential period
From:To:

Guide(s)

[*Forwarding by the DPGC*]

Secretary-DPGC Date Chairman-DPGC

[*Verification of Records*]

The Records were verified and found to be in order.

Supdt. (Academic Section) Asst. Registrar (Academic)

[*Approval*]

Dean (Academic)

C O N F I D E N T I A L

M.Tech. (Research) – MTAC Panel Submission Form

INTERNAL/EXTERNAL REFEREES

[Guide → DPGC → . . . (in sealed cover) . . .→ Dean(A)]

Name of the Scholar: Registration No. :

Department: Date of joining:

Name of Research Guide(s):

Title of the Thesis:

Panel of External Referees : Name, Address and Contact Details (1)

(2)

(3)

Panel of Internal Referees: Name, Address and contact Details 1)

2)

3)

Signature(s) of Research Guide(s) with Date

Secretary-DPGC Date Chairman-DPGC

MTech. (Research) Thesis Submission Form

[MTech(Research) Scholar → Guide → DPGC → . . . → Dean(A)]

[*To be filled-in by the MTech(Research) Scholar*]

Name of the Scholar: Registration No. :

Department: Date of joining:

Date of Synopsis submission:

Name of Research Guide(s):

Title of MTech(Research) Thesis:

Signature of the Scholar, with Date:

[*Recommendation by Research Guide*]

I/We authorize the above scholar to submit the MTech(Research) Thesis.

Name(s) of Guide(s)	Signature	Date

[*Forwarding by DPGC*]

The MTech(Research) Thesis is being forwarded to the Dean(A).

Secretary-DPGC Date Chairman-DPGC

[*Verification of Records*]

The Records were verified and found to be in order.

Supdt. (Academic Section) Asst. Registrar (Academic)

[*Approval*]

The MTech(Research) Thesis has been received and accepted / not-accepted for evaluation.

Dean(Academic)

Note: The following documents must be enclosed:

1. Three printed copies and one soft-copy (CD) of the thesis
2. No Dues Certificate
3. Plagiarism Report
4. List of papers presented/published/accepted for publication or presentation, in the prescribed format, and reprints of those papers.

CONFIDENTIAL

MTech. (Research) - MTAC Panel Submission Form (Internal)

(To be submitted after receipt of referees reports)

[Guide → DPGC → (In a sealed cover). . . → Dean-A]

Name of the Scholar: Registration No. :

Department: Date of joining:

Name of Research Guide(s):

Title of the Thesis :

Panel of Internal Referees (within the Department):

Panel from the parent Department of the MTech (Research) Scholar

(1)

(2)

(3)

Note: Guide(s) have obtained the consent of the faculty before forwarding their names for MTAC panel.

Signature(s) of Research Guide(s)

[*Forwarding by the DPGC*]

Secretary-DPGC Date Chairman-DPGC

[Approval]

Dean (Academic)

Report of MTAC on M.Tech.(Research) Thesis Defense / Viva-Voce Exam

[M.Tech (Research) student → Guide → MTAC → DPGC . . . (in sealed cover) . . . → Dean (A)]

[*To be filled-in by the M.Tech.(Research) Scholar*]

Name of the Scholar: Registration No.

Department: Date of Joining:

Name of Research Guide(s):

Title of Research Thesis:

Signature of the Scholar, with Date:

[*Recommendation by MTAC*]

Date of Thesis Defense/Viva-Voce Exam:
Date of MTAC meeting:
Decision of MTAC: *The Research Thesis is satisfactory / not-satisfactory*
(if not satisfactory, specific reasons must be furnished separately)
Names & Signatures of MTAC members:

(1)

(2)

(3)

(4)

(5)

(6)

(Forwarding by DPGC)
MTAC report is being forwarded to Dean (A)

Secretary-DPGC Date Chairman-DPGC

[*Approval*]

Dean(Academic)

Note: The detailed observations of MTAC is to be attached

Request for extension of MTech (Research) Registration

[MTech(Research) Scholar → Guide → DPGC → . . .→ Dean(A)]

[*To be filled-in by the MTech(Research) Scholar*]

Name of the Scholar: Registration No. :

Department: Date of Joining:

Name of Research Guide(s):

Currently specified last date:

Reasons for requesting the extension of Registration:

Declaration: *I agree to pay the applicable fees as per the Institute Rules - (semester fees as applicable).*

Signature of the Scholar, with Date:

[*Comments by the Research Guide, who is the Chairperson of RPAC*]

Comments:

Name(s) and Signature(s) with Date

[*Recommendation by the DPGC*

Recommended / not-Recommended for extension of registration.

Secretary-DPGC Date Chairman-DPGC

[*Verification of Records*]

The Records were verified and found to be in order.

Supdt. (Academic Section) Asst. Registrar (Academic)

[*Approval*]

Extension is (1) *not granted* (reason:)
(2) *granted and the extended last date is* ________________

Dean (Academic)

Note: (1) At a stretch, extension of six months (i.e., one semester) may be approved for MTech(R)
(2) The scholar has to pay the applicable semester fees to the cash section after the extension is approved.
(3) If the scholar has already completed the maximum duration for complying the degree requirement from the date of registration of first semester, as per the Regulations, no more extensions shall be permitted.

Request for Recognition as Research Guide for Ph.D. Program

[Proposed Research guide (internal/external) with Ph.D. → DRPC → Dean-A]

[*To be filled-in by the proposed Research Guide*]

Name :   Designation :

Department: Date of joining:

Name of University from where Ph.D. is obtained:

Month & Year of obtaining Ph.D.

Title of Doctoral Thesis:

Signature with Date:

[*Recommendation by the DRPC*]

Date of DRPC meeting:
In the case of external research guide, the name & Reg. No. of the student for whom the research guide is proposed :

Decision of DRPC: *The request for recognition as research guide is acceptable / not-acceptable (if not acceptable, specific reasons must be furnished separately)*

Names & Signatures of DRPC members:

(1)   (2)

(3)   (4)

(5)   (6)

[*Forwarding by the DRPC*]

The request for recognition as research guide, along with the DRPC recommendations, is being forwarded to the Dean (A).

Secretary-DRPC   Date   Chairman-DRPC

[*Verification of Records*]

The Records were verified and found to be in order.

Supdt. (Academic Section)   Asst. Registrar (Academic)

[*Approval*]

The request for recognition as Research Guide is approved / not-approved.

Dean (Academic)

Note: A brief bio-data with the copy of doctoral certificate is to be attached.

Ph.D - RPAC Panel Submission Form

[Guide → RPAC → DRPC → . . . → Dean-A]

[*To be filled-in by the Ph.D. Scholar*]

Name of the Scholar: Registration No. :

Department: Date of joining:

Name of Research Guide(s):

Research Area:

Signature of the Scholar, with Date:

[*Panel Proposed by the Research Guide*]

Panel for RPAC from the parent Department of the Ph.D. Scholar

(1)

(2)

(3)

Panel for RPAC from outside the parent Department of the guide(s)

(1)

(2)

(3)

Note: Guide(s) have obtained the consent of the faculty before forwarding their names for RPAC panel.

Signature(s) of Research Guide(s)

[*Forwarding by the DRPC*]

The RPAC Panel is being forwarded to Dean(A)

Secretary-DRPC Date Chairman-DRPC

[*Verification of Records*]

The Records were verified and found to be in order.

Supdt. (Academic Section) Asst. Registrar (Academic)

[*Approval*]

Dean (Academic)

Ph.D Proposal Submission Form

[Ph.D. → Guide → RPAC → DRPC → . . . → Dean-A]

[*To be filled-in by the Ph.D. Scholar*]

Name of the Scholar: Registration No. :

Department: Date of joining:

Name of Research Guide(s):

Title of Research Proposal:

Signature of the Scholar, with Date:

[*Recommendation by the RPAC*]

Date of receiving the Research Proposal:

Date of Open Seminar: Date of RPAC meeting:

Decision of RPAC: *The research proposal is acceptable / not-acceptable*

(if not acceptable, specific reasons must be furnished separately)

Names & Signatures of RPAC members:

(1)

(2)

(3)

[*Forwarding by the DRPC*]

The research proposal, along with the RPAC recommendations, is being forwarded to the Dean(A).The Ph.D. scholar has successfully completed the comprehensive examination held in the month of ------------ in the year-----------------.

Secretary-DRPC Date Chairman-DRPC

[*Verification of Records*]

The Records were verified and found to be in order.

Supdt. (Academic Section) Asst. Registrar (Academic)

[*Approval*]

Research Proposal is approved / not-approved.

Dean (Academic)

Note: (1) The research proposal report containing all the details such as literature survey, problem identification, state of the art technology, detailed plan of research work etc. must be attached as an annexure in a bound form.

(2) The detailed observations of RPAC is to be attached.

(3) Comprehensive Exam Result sheet must be attached for those schoalrs who have joined, in the academic year 2018-19 or later.

Ph.D Research Progress Assessment Report

[Ph.D. → Guide → RPAC → DRPC → . . . → Dean-A]

[*To be filled-in by the Ph.D. Scholar*]

Name of the Scholar: Registration No. :

Department: Date of Joining:

Name of Research Guide(s):

Title of Research Report:

Signature of the Scholar, with Date:

[*Recommendation by RPAC*]

Date of receiving the Research Report:

Date of Open Seminar: Date of RPAC meeting:

Decision of RPAC: *The research progress is satisfactory / not-satisfactory*

(if not satisfactory, specific reasons must be furnished separately)

Names & Signatures of RPAC members:

(1)

(2)

(3)

[*Forwarding by the DRPC*]

The research progress assessment report is being forwarded to the Dean(A).

Secretary-DRPC Date Chairman-DRPC

[*Verification of Records*]

The Records were verified and found to be in order.

Supdt. (Academic Section) Asst. Registrar (Academic)

[*Approval*]

Dean (Academic)

Note : 1) Progress Reports to be attached

(2) The detailed observations of RPAC, to be attached.

(3) Research Progress Assessment shall be conducted on a half-yearly basis for research scholars beyond four years.

Ph.D. Synopsis Submission Form

[Ph.D. Scholar → Guide → RPAC → DRPC → . . . → Dean(A)]

[To be filled-in by the Ph.D. Scholar]

Name of the Scholar: Registration No. :

Department: Date of joining:

Name of research Guide(s):

Title of Ph.D. Synopsis:

Signature of the Scholar, with date:

[*Recommendation by RPAC*]

Total course credits earned (must be at least 12): CGPA*:
(*CGPA must be atleast 6.0 for those who have been admitted in 2018-19 or later; atleast 5.5 for those admitted earlier)

Date of Pre-Synopsis Seminar: Date of RPAC meeting:
Decision of RPAC: *The Pre-synopsis Seminar has been completed satisfactorily and research work is acceptable / not-acceptable for submission of Synopsis of Ph.D. Thesis.*
(for non-acceptance, specific reasons must be enclosed)
Names & Signatures of RPAC members:
(1)

(2)

(3)

[*Forwarding by DRPC*]

The Ph.D. Synopsis, along with the RPAC recommendations, is being forwarded to the Director.

Secretary-DRPC Date Chairman-DRPC

[*Verification of Records*]

The Records were verified and found to be in order.

Supdt. (Academic Section) Asst. Registrar (Academic)

[*Approval*]

The Ph.D. Synopsis has been received and is accepted / not-accepted for evaluation.

Dean (Academic)

Note: The following documents must be enclosed:

1. ONE printed copy and ONE soft copy of the Synopsis.
2. The detailed observations of RPAC on Presynopsis seminar , to be attached
3. Declaration by the Research Scholar [refer : Regulations–PG&R(Ph.D.), Section5.4.4(b)]
4. List of papers presented/published/accepted for publication or presentation, in the prescribed format, and reprints of those papers.
5. Details of the courses studied (enclose copy of grade card)
6. Certificate regarding residential requirement.

Ph.D. Course Details and Residential Requirement

[Ph.D. Scholar → Guide → RPAC → DRPC → . . . → Dean(A)]

[*To be filled-in by the Ph.D. Scholar*]

Name of the Scholar: Registration No. :

Department: Date of Joining:

Name of Research Guide(s):

Title of Research Report:

Signature of the Scholar, with Date:

1. Courses studied

Sl. No.	Semester, year	Course code	Course Title	Grade

2. Residential period
From:To:

Guide(s)

[*Forwarding by the DRPC*]

Secretary-DRPC Date Chairman-DRPC

[*Verification of Records*]

The Records were verified and found to be in order.

Supdt. (Academic Section) Asst. Registrar (Academic)

[*Approval*]

Dean (Academic)

List of Publications based on Ph.D./M Tech(Research)Work

[to be filled-in by the Research Scholar and to be enclosed with *Synopsis/Thesis* submission Form]

Sl. No.	Title of the paper	Authors (in the same order as in the paper. Underline the Research Scholar's name)	Name of the Journal/ Conference/ Symposium, Vol., No., Pages	Month & Year of Publication	Category *
1					
2					
3					
4					

* Category: 1 : Journal paper, full paper reviewed 2 : Journal paper, Abstract reviewed
3 : Conference/Symposium paper, full paper reviewed
4 : Conference/Symposium paper, abstract reviewed
5 : others (including papers in Workshops, NITK Research Bulletins, Short notes etc.)
(If the paper has been accepted for publication but yet to be published, the supporting documents must be attached.)

Research Scholar | Research Guide

Name & Signature, with Date | Name & Signature, with Date

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

C O N F I D E N T I A L

Ph.D. - DTAC Panel Submission Form (External)

(To be submitted along with synopsis)

EXTERNAL REFEREES [Guide → DRPC → . . (in sealed cover) . . → Director]

Name of the Scholar:	Registration No. :
Department:	Date of joining: Name of
Research Guide(s):	
Title of the Ph.D. Thesis:	

Panel of External Referees : Name, Designation, Research area, Address and Contact Details
1
2
3
4
5
6
7
8
9
10

Signature(s) of Research Guide(s) with Date

Secretary-DRPC	Date	Chairman-DRPC

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Ph.D. Thesis Submission Form

[Ph.D. Scholar → Guide → DRPC → . . . → Dean (A)]

[*To be filled-in by the Ph.D .Scholar*]

Name of the Scholar: Registration No. :

Department: Date of joining:

Date of Synopsis submission:

Name of Research Guide(s):

Title of Ph.D. Thesis:

Signature of the Scholar, with Date:

[*Recommendation by Research Guide*]

I/We authorize the above scholar to submit the Ph.D. Thesis.

Name(s) of Guide(s)	Signature	Date

[*Forwarding by DRPC*]

The Ph.D. Thesis is being forwarded to Dean(A).

Secretary-DRPC Date Chairman-DRPC

[*Verification of Records*]

The Records were verified and found to be in order.

Supdt. (Academic Section) Asst. Registrar (Academic)

[*Approval*]

The Ph.D. Thesis has been received and accepted / not-accepted for evaluation.

Dean (Academic)

Note: The following documents must be enclosed:

1. Three printed copies and one soft-copy (CD) of the thesis
2. No Dues Certificate
3 Details on the Research Publications in the prescribed format with Reprints/Acceptance letter from the Journal editor

CONFIDENTIAL

Ph.D - DTAC Panel Submission Form (Internal)

(To be submitted after receipt of referees reports)

[Guide → DRPC → (In a sealed cover). . . → Dean-A]

Name of the Scholar: Registration No. :

Department: Date of joining:

Name of Research Guide(s):

Title of the Thesis :

Panel of Internal Referees (within and outside the Department):

Panel from the parent Department of the Ph.D. Scholar

(1)

(2)

(3)

Panel from outside the parent Department of the guide(s)

(1)

(2)

(3)

Note: Guide(s) have obtained the consent of the faculty before forwarding their names for DTAC panel.

Signature(s) of Research Guide(s)

[*Forwarding by the DRPC*]

Secretary-DRPC Date Chairman-DRPC

[Approval]

Dean (Academic)

Report of DTAC on Ph.D. Research Thesis Defense / Viva-Voce Exam

[Ph.D. Scholar → Guide → DTAC → . . . (in sealed cover) . . . → Director]

[*To be filled-in by the Ph.D. Scholar*]

Name of the Scholar: Registration No. :

Department: Date of Joining:

Name of Research Guide(s):

Title of Research Thesis:

Signature of the Scholar, with Date:

[*Recommendation by DTAC*]

Date of Thesis Defense/Viva-Voce Exam:

Date of DTAC meeting:

Decision of DTAC: *The Research Thesis is satisfactory / not-satisfactory*

(if not satisfactory, specific reasons must be furnished separately)

Names & Signatures of DTAC members:

(1)

(2)

(3)

(4)

(5)

(6)

[*Forwarding by the DRPC*]

DTAC report is being forwarded to the Director

Secretary-DRPC Date Chairman-DRPC

[*Approval*]

Director

Note: A brief, one page report with recommendation by the DTAC is to be attached with this form.

Request for extension of Ph.D. Registration

[Ph.D. Scholar → Guide → DRPC → . . . → Dean(A)]

[*To be filled-in by the Ph.D.]*]

Name of the Scholar: Registration No. :

Department: Date of Joining:

Name of Research Guide(s):

Currently specified last date:

Reasons for requesting the extension of Registration:

Declaration: *I agree to pay the applicable fees as per the Institute Rules - (semester fees as applicable).*

Signature of the Scholar, with Date:

[*Comments by the Research Guide, who is the Chairperson of RPAC*]

Comments:

Name(s) and Signature(s) with Date

[*Recommendation by the DRPC*]

Recommended / not-Recommended for extension of registration.

Secretary-DRPC Date Chairman-DRPC

[*Verification of Records*]

The Records were verified and found to be in order.

Supdt. (Academic Section) Asst. Registrar (Academic)

[*Approval*]

Extension is (1) *not granted* (reason:)

(2) *granted and the extended last date is* ______________________

Dean (Academic)

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Request for permission to leave the Institute & Submit the thesis from outside

[Ph.D. Scholar → Guide → DRPC → . . . → Dean(A)]

[*To be filled-in by the Ph.D. Scholar*]

Name of the Scholar: Registration No. :

Department: Date of Joining:

Name of Research Guide(s):

Date of submission of Synopsis:

Reasons for requesting the permission to leave the institute and submit the thesis from outside:

Declaration: *I agree to submit the thesis within the THREE months from the date of submission of Synopsis.*

[*Comments by the Research Guide, who is the Chairperson of RPAC*]

Comments:

Name(s) and Signature(s) with Date

[*Recommendation by the DRPC*]

Recommended / not-Recommended

(If not recommended, the reasons must be specified below)

Secretary-DRPC Date Chairman-DRPC

[*Verification of Records*]

The Records were verified and found to be in order.

Supdt. (Academic Section) Asst. Registrar (Academic)

[*Approval*]

Permission is (1) *not granted (reason:*)

(2) *granted to leave the Institute and submit the thesis from outside, within the stipulated period of THREE months from the date of synopsis submission.*

Dean (Academic)

Request for permission to leave the Institute after M.Tech./Ph.D. Viva-voce(For QIP)

[M.Tech / Ph.D. Scholar → Guide → /DPGC/DRPC → . . . → Dean(A)]

[*To be filled-in by the Ph.D. Scholar*]

Name of the Scholar: Registration No. :

Department: Date of Joining:

Name of Research Guide(s):

Title of M.Tech/Ph.D. Thesis :

Declaration: *I have cleared all the Institute/Hostel dues pending against me.*

Signature of the Scholar, with Date:

[*Recommendation by the Research Guide*]

Date of M.Tech./Ph.D. viva-voce : Date of Relief sought:

Name(s) and Signature(s) with Date

[*Recommendation by the DRPC*]

Recommended / not-Recommended.
(If not recommended, the reasons must be specified below)

Secretary-DRPC Date Chairman-DRPC/DPGC

[*Verification of Records*]

The Records were verified and no dues are pending against the candidate.

Supdt. (Academic Section) Asst. Registrar (Academic)

[*Approval*]

Permission is (1) *not granted (reason:*
(2) *granted to leave the Institute from the above specified date*

Dean (Academic)

Note : Copy of 'No Dues' certificate to be enclosed

Request for Change of Research Guide or *Inclusion* of Additional-Guide

(*Strike out whichever is not applicable*)

[Ph.D. Scholar → Guide(s) → RPAC → DRPC → . . . → Dean (A)]

[*To be filled-in by the Ph.D. Scholar*]

Name of the Scholar: Registration No. :

Department: Date of joining:

Research Area:

Name of present Research Guide:

Name of present Additional-Guide (if any):

Reasons for requesting change of Research Guide *OR* inclusion of Additional-Guide:
(to be stated clearly by the present Guide and/or additional-Guide if any)

Signature(s) of Research Guide(s) and Additional-Guide (if any)

	Name	Signature	Date
Ph.D. Scholar :			
Present Research Guide :			
Present Additional-Guide :			
Proposed Research Guide :			
Proposed Additional-Guide :			

[*Forwarding by the DRPC*]

Secretary-DRPC Date Chairman-DRPC

[*Verification of Records*]

The Records were verified and found to be in order.

Supdt. (Academic Section) Asst. Registrar (Academic)

[*Approval*]

Dean (Academic)

D E C L A R A T I O N

by the Ph.D. Research Scholar

I hereby *declare* that the Research Thesis/Synopsis entitled

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………… … ……

which is being submitted to the National Institute of Technology Karnataka, Surathkal in partial fulfilment of the requirements for the award of the Degree of Doctor of Philosophy in

………………………………………………………………… … … … … … … …

…………………………………………………………………… … …………………

is a *bonafide report of the research work carried out by me*. The material contained in this Research Thesis/Synopsis has not been submitted to any University or Institution for the award of any degree.

…………………………………………………………………………………
(Register Number, Name & Signature of the Research Scholar)

Department of ……………………………………………………

Place: NITK-Surathkal
Date:

Note: Declaration to be signed by the Scholar and incorporated as part of the Ph.D. Research Thesis /Synopsis

CERTIFICATE

This is to *certify* that the Research Thesis/Synopsis entitled ....

....

....

....

....

submitted by ....,

(Register Number: ....) as the record of the research work carried out by him/her, is *accepted as the Research Thesis/Synopsis submission* in partial fulfilment of the requirements for the award of degree of Doctor of Philosophy.

Research Guide(s)
(Name and
Signature with Date
and Seal)

Chairman - DRPC
(Signature with Date and Seal)

NO DUES CERTIFICATE
[for Ph.D./MTech (Research) Scholars]

Part I [To be filled-in by the Scholar]

Name of the Scholar: Registration No. :

Department: Date of joining:

Name of research Guide(s):

Declaration

I hereby declare that in the event of any money being found due from me at a later date, I shall refund the same to the Institution without any loss of time.

Signature of the Scholar, with date:

Part II

Certified that no amount is due from the scholar :

(1) Department of ______________________ Head of the Department (Signature with date and seal)

(2) Library Librarian (Signature with date and seal)

(3) Hostel Hostel Superintendent (Signature with date and seal)

(4) Central Computer Centre Systems Manager (Signature with date and seal)

(5) Games & Sports Physical Director (Signature with date and seal)

NO DUES CERTIFICATE
[for Ph.D./ MTech (Research) Scholars]

(6) Students' Aid Fund	Section Superintendent (Signature with date and seal)
(7) Dispensary/Health Centre	R M O (Signature with date and seal)
(8) Cash Section	Cashier (Signature with date and seal)
(9) Accounts – I	Section Superintendent (Signature with date and seal)
(10) Academic Section	Section Superintendent (Signature with date and seal)

Based on certifications as above, it is hereby certified that no amount is due from the research scholar.

Asst. Registrar (Academic)
(Signature with date and seal)

NO DUES CERIFICATE

[for Internal registrants- PG/Ph.D. Scholars who are regular employees of NITK]

Part I (To be filled-in by the Scholar)

Name of the Scholar: Registration No. :

Department: Date of Joining:

Name of Research Guide(s):

Declaration

I hereby declare that in the event of any money being found due from me at a later date, I shall refund the same to the Institution without any loss of time.

Signature of the Scholar, with date:

Part II

Certified that no amount is due from the scholar.

Superintendent (Accounts I)
(Signature with date and seal)

Part III

Certified that no amount is due from the scholar.

Superintendent (Academic Section)
(Signature with date and seal)

Part IV

Based on certifications from the Accounts Section & Exam Section,
it is hereby certified that no amount is due from the scholar.

Asst. Registrar (Academic)
(Signature with date and seal)

Note: The Superintendents of the Accounts Section and Examination Section shall certify only after confirming that no amount is due from the scholar and that he/she has paid all the fees such as tuition fees and all other applicable fees and charges of the PG/Ph.D. programme.

M.Tech. / M.Tech.(Research) / M.Sc. / MCA / MBA THESIS FORMAT

1.PRESENTATION

1.1 Precision and Consistency: Every effort must be made to avoid unwarranted repetitions, padding with irrelevant material. Further, the thesis must be self consistent in the use of symbols, abbreviations, spellings and punctuation. Once chosen, the same must be used throughout. Also, the pattern of presentation must be uniform in every detail right through the thesis. Above all, previous work must be clearly demarcated from that of the candidate. It is recommended that the thesis must be as brief and precise to the point.

1.2 Chapters: The basic material of the thesis shall be presented in the form of chapters, each carrying an appropriate and specific title which must convey the scope of its content. A separate chapter on Review of Literature is not mandatory. The chapters will be serially numbered using Arabic numerals.

1.3 Introduction: The first chapter shall be titled as Introduction which will (a) introduce the research problem presenting the current state of relevant knowledge (b) define the scope and objectives of the investigation and (c) describe the contents of the thesis preferably chapter-wise.

1.4 Last Chapter : It is strongly recommended, but not made obligatory that the last chapter of the thesis, or each part be devoted to conclusions and to highlight the specific contributions made along with the scope for further research. The summary of the work may also be combined with the conclusions.

1.5 Appendixes : It is important that the presentation must ensure utmost continuity in the theoretical discussions, in the description of experimental results and in their interpretations. Hence, lengthy derivations and voluminous tables, charts and figures which are likely to disturb the smooth flow for the reader must be presented in the appendixes.

1.6 Bio – Data: Contact address, qualification and list of publications

2. SEQUENCE

2.1 Title Sheet : The title sheet shall be the first page and it shall conform to the specimen.

2.2 Declaration: The declaration by the student as per specified format.

2.3 Certificate : The certification by the guide and the chairman, DPGC as per specified format.

2.4 Acknowledgement : The acknowledgement by the candidate for successfully carrying out the project work.

2.5 Abstract : It is the condensed version of the thesis, useful for documentation purpose. It should contain aim of the work, methods used, important results obtained and major conclusions. The write up should be self contained and list of references need not be there. The abstract should occupy maximum one page in A-4 size, typed in one-and-half space. The bottom line should contain key words which could be used for documentation.

2.6 Contents : The content shall follow the abstract and indicate the page numbers of the chapters, sections, sub-sections, appendixes and references. The numbers and titles of all the items must be clearly entered with the page numbers against them. It is not necessary to give separate lists of figures, tables etc.

2.7 Nomenclature : Nomenclature will follow the contents. Its purpose will be to define all the symbols, abbreviations, Greek or Latin letters, superscripts etc.

2.8 The Chapters : The chapter 1- Introduction shall follow the previous item. Chapter 2 and the subsequent chapters will follow in the usual sequence.

2.9 References : References shall follow the last chapter or the appendixes, if there are any. Research papers, reviews, treaties, web sources and books shall be listed therein in the alphabetical order. The text citation appears where the material to be cited is presented. They will be placed within the brackets appropriately in the text citing the author name and the year without a comma in between. Use the first author's name followed by "et al." in citations for publications with three or more authors. When the researcher is part of the sentence, only the year need to be put inside the brackets. A quick guide to common types of referenced material is as follows:

Journal References

Include year, volume, issue and page numbers

Stahl, D.C., Wolfe, R.W. and Begel, M. (2004). "Improved analysis of timber rivet connections." *J.Struct. Eng*., 130(8), 1272-1279.

Books

Include author, book title, publisher, the publisher's location and chapter title and inclusive of page numbers (if applicable)

Zadeh, L.A.(1981). " Possibility theory and soft data analysis." *Mathematical frontiers of the social and policy sciences*, L. Cobb and R.M. Tharall, eds., Westview, Boulder, Colo., 69-129. Cotton, F.A. (2003). *Chemical applications of group theory*, McMilan, London.

Conference Proceedings and Symposiums

Include the sponsor of the conference or publisher of the proceedings and the location-city and state or city and country.

Garrett, D.L. (2003). " Coupled analysis of floating production systems." *Proc., Int. Symp. on Deep Mooring Systems*, ASCE, Reston, Va., 152-167.

Reports

Same as for books, as above. For reports authored by institutions: spell out institution acronym on first use and follow with acronym in parentheses, if applicable. If subsequent references were also authored by that same institution, use only the acronym. For reports authored persons, include the full institution name and its location.

Web Pages

Include author, copyright date, title of "page", web address and date on which the material was downloaded.

Burkha, L.P. (1993). " A hypertext history of multi-user dimensions." *MUD history*, http://www.ccs.neu.edu (Dec. 5, 1994).

CD-ROM

Include authors, copyright date, titles, medium and producer/publisher and its location

Liggett, J.A. and Caughey, D.A. (1998). " Fluid statics." *Fluid mechanics* (CD-ROM), ASCE Press, Reston, Va.

Theses and Dissertations

Include authors, copyright date, title and the name and location of the institution where the research was conducted. Note that some institutions use specific terminology; for example, " doctoral dissertation" rather than "Ph.D. thesis".

Sotiropulos, S.N. (1991). " Statis response of bridge superstructures made of fibre reinforced plastic. " MTech thesis, West Virginia Univ., Morgantown, W. Va.

Unpublished Material

Unpublished material is not included in the references but may be cited in the text as follows: (John Smith, personal communication, May 16, 1983; J. Smith, unpublished internal report, February 2003).

3. TECHNICAL

3.1 Paper : The thesis (original + copies) should preferably printed on A4 size bond sheet on both sides of paper (back to back)

3.2 Typing : The typing shall be in standard letter size i.e. font size 12 of Times New Roman, with spacing of 1.5. The chapter number and title shall be three spaces between them. The number and title of a section in block capitals will be placed on the left. The number and title of a sub-section will not be in capital and placed on the left.

3.3 Margins : Each typed sheet will bear the margin shown here. For odd numbered pages Left 1.5", top 1.5", right 1" and bottom 1" and for Even numbered pages Left 1.0", top 1.5", right 1.5 and bottom 1.0

3.4 Binding : While submitting, the thesis will be bound through soft binding with blue cover and black font. After the defence and approval of the thesis, one hard copy and CD are to be submitted to the Institute which will go to the library. The front cover should be as per specimen A. The front cover will carry the title of the thesis in 22 font size gold letters properly centered at the top. In the middle, the full name of the candidate shall be typed in 16 font size gold letters. At the bottom, the name of the department, the Institute name, month and the year of submission, all in capitals and in separate lines and in 16 font gold letters.

3.5 Numbering System : The chapters will be designated by Arabic numerals, chapter 1, chapter 2 … etc. The sections of a chapter will be numbered using decimal type notations, e.g., 3.2 refers to the second section of chapter 3. Similarly, the sub-sections will be numbered using two digits after the decimal. Alternatively, the same may be numbered as 3.2.4. Decimal type notations will be used for numbering the figures/photos, charts, tables and drawings in a chapter. Equations may also preferably be numbered in decimal type notation within the brackets. Figure 3.2 refers to the second figure in chapter 3. Similarly, Table 4.2, chart 3.3 etc. Appendixes will be numbered with capital Roman numerals, e.g. Appendix I, Appendix II …..etc.

The pages carrying the Title sheet, Declaration, Certificate and Acknowledgements will not be numbered. One set of small Roman numerals (i, ii, iii…) will be used for numbering the pages of contents and nomenclature. These will be typed at the bottom centre of the page.

The pages of the chapters, the appendixes and the references will be designated by one set of Arabic numerals (1,2,3…etc). These will be typed on the bottom centre of the page. Pages carrying figures, charts, table etc. will carry appropriate page numbers. The page number of the first page of contents, the first page of each chapter including the conclusions need not be typed as is often the practice.

Specimen A : Title Sheet

T I T L E

(In capital letters)

Thesis

Submitted in partial fulfilment of the requirements for the degree of

MASTER OF TECHNOLOGY in

SPECIALIZATION

by

N A M E

(Registration No.)

Emblem (1.5” x 1.5”)

DEPARTMENT

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA

SURATHKAL, MANGALORE -575025

Month, Year

Ph.D. THESIS FORMAT

1.PRESENTATION

The doctoral thesis will naturally conform to the general practice adopted in the literature of the area in which the investigation is carried out. Each discipline has associated with it a mode of presentation of theoretical discussions, of experimental results and their interpretations. However, it is necessary to evolve a set of guidelines and rules common to all theses submitted to it.

1.1 Precision and Consistency: Every effort must be made to avoid unwarranted repetitions, padding with irrelevant material. Further, the thesis must be self consistent in the use of symbols, abbreviations, spellings and punctuation. Once chosen, the same must be used throughout. Also, the pattern of presentation must be uniform in every detail right through the thesis. Above all, previous work must be clearly demarcated from that of the candidate. It is recommended that the thesis must be as brief as possible and should be precise. 1.2 Chapters: The basic material of the thesis shall be presented in the form of chapters, each carrying an appropriate and specific title which must convey the scope of its content. A separate chapter on Review of Literature is not mandatory. The chapters will be serially numbered using Arabic numerals.

1.3 Parts: If the work comprises two or more mutually independent investigations, the thesis may be divided into two or more parts, each with an appropriate title. However, the numbering of chapters will be continuous right through, e.g. Part one may comprise Chapters 2-5, Part two chapters 6-9.

1.4 Introduction: The first chapter shall be titled as Introduction. If there are two or more parts, the Introduction shall be common to all of them and it will (a) introduce the research problem presenting the current state of relevant knowledge (b) define the scope and objectives of the investigation and (c) describe the contents of the thesis preferably chapter-wise.

1.5 Last Chapter : It is strongly recommended, but not made obligatory that the last chapter of the thesis, or each part be devoted to conclusions and to highlight the specific contributions made along with the scope for further research. The summary of the work may also be combined with the conclusions. The summary is the concise statement in which the candidate will define the problem, indicate the work carried out underlining the important conclusions reached. The summary is expected to provide sufficient information about the work contained in the thesis. It could be chapter-wise also and should be a maximum of six pages in one and a half space.

1.6 Appendixes : It is important that the presentation must ensure utmost continuity in the theoretical discussions, in the description of experimental results and in their interpretations. Hence, lengthy derivations and voluminous tables, charts and figures which are likely to disturb the smooth flow for the reader are to be presented in the appendixes.

1.7 Brief bio-data containing contact address, qualification and list of publications

2. SEQUENCE

2.1 Title Sheet : The title sheet shall be the first page and it shall conform to the specimen A.

2.2 Declaration: The declaration by the student as per specified format.

2.3 Certificate : The certification by the guide and the chairman, DRPC as per specified format.

2.4 Acknowledgement : The acknowledgement by the candidate for successfully carrying out the research work.

2.5 Abstract : It is the condensed version of the thesis, useful for documentation purpose. It should contain aim of the work, methods used, important results obtained and major conclusions. The write up should be self contain and list of references need not be there. The abstract should occupy maximum one page in A-4 size, typed in one-and-half space. The bottom line should contain key words which could be used for documentation.

2.6 Contents : The content shall follow the abstract and indicate the page numbers of the chapters, sections, sub-sections, appendixes and references. The numbers and titles of all the items must be clearly entered with the page numbers against them.

2.7 List of Figures, Charts, Tables : It is not necessary to give separate lists of these items.
However, if the author considers it necessary to do so, he may place these immediately after the contents.

2.8 Nomenclature : Nomenclature will follow the contents. Its purpose will be to define all the symbols, abbreviations, Greek or Latin letters, superscripts etc.

2.9 The Chapters : The chapter 1- Introduction shall follow the previous item. Chapter 2 and the subsequent chapters will follow in the usual sequence. The un-numbered title page of a part will be placed before the first chapter of that part as in specimen B.

2.10 References : References shall follow the last chapter or the appendixes, if there are any. Research papers, reviews, treaties, web sources and books shall be listed therein in the alphabetical order. The text citation appears where the material to be cited is presented. They will be placed within the brackets appropriately in the text citing the author name and the year without a comma in between. Use the first author's name followed by "et al." in citations for publications with three or more authors. When the researcher is part of the sentence, only the year need to be put inside the brackets. A quick guide to common types of referenced material is as follows:

Journal References

Include year, volume, issue and page numbers

Stahl, D.C., Wolfe, R.W. and Begel, M. (2004). „Improved analysis of timber rivet connections." *J.Struct. Eng.*, 130(8), 1272-1279.

Books

Include author, book title, publisher, the publisher's location and chapter title and inclusive of page numbers (if applicable)

Zadeh, L.A.(1981). " Possibility theory and soft data analysis." *Mathematical frontiers of the social and policy sciences*, L. Cobb and R.M. Tharall, eds., Westview, Boulder, Colo., 69-129. Cotton, F.A. (2003). *Chemical applications of group theory*, McMilan, London.

Conference Proceedings and Symposiums

Include the sponsor of the conference or publisher of the proceedings and the location-city and state or city and country.

Garrett, D.L. (2003). " Coupled analysis of floating production systems." *Proc., Int. Symp. on DeepMooring Systems*, ASCE, Reston, Va., 152-167.

Reports

Same as for books, as above. For reports authored by institutions: spell out institution acronym on first use and follow with acronym in parentheses, if applicable. If subsequent references were also authored by that same institution, use only the acronym. For reports authored persons, include the full institution name and its location.

Web Pages

Include author, copyright date, title of "page", web address and date on which the material was downloaded.

Burkha, L.P. (1993). " A hypertext history of multi-user dimensions." *MUD history*, http://www.ccs.neu.edu (Dec. 5, 1994).

CD-ROM

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The following must be printed in 16 font size gold letters one the spine of the thesis: Ph.D., full name of the candidate and the year.

3.5 Numbering System : Parts of a thesis will be designated by alphabetical numbers, e.g., Part one, Part two .. etc. The chapters will be designated by Arabic numerals, chapter 1, chapter 2 … etc. The sections of a chapter will be numbered using decimal type notations, e.g., 3.2 refers to the second section of chapter 3. Similarly, the sub-sections will be numbered using two digits after the decimal. Alternatively, the same may be numbered as 3.2.4. Decimal type notations will be used for numbering the figures/photos, charts, tables and drawings in a chapter. Equations may also preferably be numbered in decimal type notation within the brackets. Figure 3.2 refers to the second figure in chapter 3. Similarly, Table 4.2, chart 3.3 etc. Appendixes will be numbered with capital Roman numerals, e.g. Appendix I, Appendix II …..etc.

The pages carrying the Title sheet, approval sheet, acknowledgements and titles pages of parts will not be numbered. One set of small Roman numerals (i, ii, iii…) will be used for numbering the pages of contents, lists of figures, charts and tables and nomenclature. These will be typed at the bottom centre of the page.

The pages of the chapters, the appendixes and the references will be designated by one set of Arabic numerals (1,2,3…etc). These will be typed on the bottom centre of the page. Pages carrying figures, charts, table etc. will carry appropriate page numbers. The page number of the first page of contents, the first page of each chapter including the conclusions need not be typed as is often the practice.

– Specimen A : Title Sheet

T I T L E

(In capital letters)

Thesis

Submitted in partial fulfilment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

by

N A M E

Emblem (1.5" x 1.5")

DEPARTMENT

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA,

SURATHKAL, MANGALORE -575025

Month, Year

SPECIMEN B :

Note : This sheet is not designated by a page number

PART ONE

T I T L E

(In capital letters)

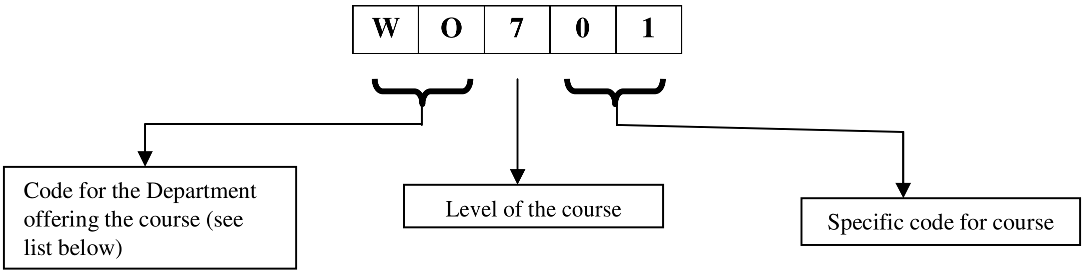
COURSE STRUCTURE – PG & R

Post Graduate & Research Programmes

Department	Programmes offered
Water Resources and Ocean Engineering (WO)	• M.Tech. & MTech (R) • Ph.D.
Civil Engineering (CV)	• M.Tech. & M.Tech (R) • Ph.D.
Mining Engineering (MN)	• M.Tech.(R) • Ph.D.
Computer Science and Engineering (CS)	• M.Tech. & MTech (R) • Ph.D.
Electronics & Communication Engineering (EC)	• M.Tech. & MTech (R) • Ph.D.
Electrical & Electronics Engineering (EE)	• M.Tech. & MTech (R) • Ph.D.
Information Technology (IT)	• Ph.D.
Chemical Engineering (CH)	• M.Tech. & MTech (R) • Ph.D.
Mechanical Engineering (ME)	• M.Tech & MTech (R). • Ph.D.
Metallurgical & Materials Engineering (MT)	• M.Tech. & MTech (R) • Ph.D.
Chemistry (CY)	• M.Sc. (Chemistry) • Ph.D.
Physics (PH)	• M.Sc. • Ph.D.
Mathematical & Computational Sciences (MA)	• M.Tech. & MTech (R) • M.C.A. • Ph.D.
School of Management (SM)	• M.B.A. • Ph.D.

Course Numbering Scheme

Course Numbers are denoted by character strings



Typically, courses whose three numerals are between 600 and 899 are taken by postgraduate and research students. Courses with numbers 900-999 are taken exclusively by Ph.D. students.

List of Codes for Departments

Department Code		Programme Offered
WO	Water Resources and Ocean Engineering	M Tech and MTech (R) in Water Resources Engineering and Management; Marine Structures; RS&GIS and PhD
CV	Civil Engineering	M.Tech and M.Tech(R) in Structural Engineering; Geotechnical Engineering; Environmental Engineering; Transportation Engineering; Construction Technology and Management and Ph.D
MI	Mining Engineering	M.Tech(R) in Rock Excavation Technology & Management and PhD.
CS	Computer Science and Engineering	M.Tech and M.Tech(R) in Computer Science & Engg.; Computer Science & Engg.-Information Security and PhD
EC	Electronics & Communication Engg	M.Tech and M.Tech(R) in Communications Engg. And Networks ; Signal Processing and Machine Learning ; VLSI Design and PhD.
EE	Electrical & Electronics Engg	M.Tech and M.Tech(R) in Power & Energy Systems and PhD
IT	Information Technology	M.Tech and M.Tech(R) in Information Technology and PhD
CH	Chemical Engineering	M.Tech and M.Tech(R) in Chemical Engg. ; Environmental Science and Technology; Industrial Biotechnology and PhD
ME	Mechanical Engineering	M.Tech and M.Tech(R) in Manufacturing Engg.; Thermal Engg.; Mechatronics Engg.; Mechanical Design and PhD
MI	Metallurgical & Materials Engg	M.Tech and M.Tech(R) in Materials Engg.;Process Metallurgy; Nanotechnology and PhD
CY	Chemistry	MSc Chemistry and PhD
MA	Mathematical & Computational Sciences	M Tech , M Tech(R) in Computational and Data Science; MCA and PhD
PH	Physics	MSc Physics and PhD
SM	School of Management	MBA and PhD

Contact Hours and Credits

Every Course comprises of specific Lecture-Tutorial-Practical (L-T-P) Schedule. The Course Credits are fixed based on the following norms:

Lectures/Tutorials - One hour per week is assigned one credit.
Practicals - 3-hour session per week is assigned 2 credits OR 2-hour session per week is assigned 1 credit.
For example, a theory course with a L-T-P schedule of 3-1-0 will be assigned 4 credits; a laboratory practical course with a L-T-P schedule of 0-0-3 will be assigned 2 credits.
In this booklet, the number of credits and contact hours per week are given after the course number and title.
Example: WO701 Wave Hydraulics (3-0-0) 3
It is 3 credit course consisting of 3 hour Lectures, 0 hour Tutorial and 0 hour Practical per week.

M.Tech. in Water Resources Engineering and Management

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	WO761	WO765	WO786/ WO787	WO789
2	WO762	WO766	WO788	
3	WO763	WO767		
4	WO764	WO768		
5	Elective 1	WO785		
6	Elective 2	Elective 3		
7	----	Elective 4		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	24
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	52

Programme Core (Pc)

WO761	Statistical Methods for Civil Engineering Applications	(3-0-0) 3
WO762	Surface Water Hydrology	(3-0-0) 3
WO763	Systems Approach in Water Resources Engineering	(3-1-0) 4
WO764	Groundwater Engineering	(3-0-0) 3
WO765	Hydrology & Hydraulics Lab	(0-0-3) 2
WO766	Design of Hydraulic Systems	(3-0-0) 3
WO767	Infrastructural Project Management	(3-0-0) 3
WO768	Sustainable Water Management	(3-0-0) 3

Elective (Ele.) Courses

WO861	Optimization Techniques & Engineering Applications	(3-0-0) 3
WO862	Irrigation Technology & Water Management	(3-0-0) 3
WO863	Computational Methods in Subsurface Flow	(3-0-0) 3
WO864	Integrated River Basin Development	(3-0-0) 3
WO865	River Engineering	(3-0-0) 3
WO866	Geo-informatics Applications in Water Resources Engineering	(3-0-0) 3
WO867	Water Quality Modelling and Management	(3-0-0) 3
WO868	Soft Computing techniques and Applications	(3-0-0) 3
WO869	Stochastic Hydrology	(3-0-0) 3
WO870	Integrated Watershed Management	(3-0-0) 3
WO889	Selected Topics in Water Resources Engineering & Management	(3-0-0) 3

Mandatory Learning Courses (MLC)

WO785	Seminar	2
WO786/ WO787	Practical Training/Minor Project (to be completed during vacation between 2nd & 3rd sem)	2

Major Project (MP)

WO788	Major Project *(3rd sem.)*	5
WO789	Major Project *(4th sem.)*	7

M.Tech. in Marine Structures

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	WO701	WO706	WO726/ WO727	WO729
2	WO702	WO707	WO728	
3	WO703	WO708		
4	WO704	WO709		
5	WO705	WO725		
6	Elective 1	Elective 3		
7	Elective 2	Elective 4		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	24
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	52

Programme Core (Pc)

WO701	Wave Hydrodynamics	(3-0-0) 3
WO702	Coastal and Ocean Engineering	(3-0-0) 3
WO703	Marine Geotechnical Engineering	(3-0-0) 3
WO704	Marine Structures & Instrumentation Lab.	(0-0-3) 2
WO705	Wave Mechanics & Marine Geotechnical Lab	(0-0-3) 2
WO706	Port Engineering	(3-0-0) 3
WO707	Analysis and Design of Marine Structures	(3-0-0) 3
WO708	Offshore Engineering	(3-0-0) 3
WO709	Computational Hydrodynamics Lab	(0-0-3) 2

Elective (Ele.) Courses

WO801	Coastal Erosion and its Mitigation	(3-0-0) 3
WO802	Geo-informatics Applications in Coastal Engineering	(3-0-0) 3
WO803	Numerical Methods for Civil Engineering Applications	(3-0-0) 3
WO804	Foundation of Marine Structures	(3-0-0) 3
WO805	Sedimentation and Dredging	(3-0-0) 3
WO806	Integrated Coastal Zone Management	(3-0-0) 3
WO807	Marine Project Management	(3-0-0) 3
WO808	Coastal Disaster Management and Mitigation	(3-0-0) 3
WO809	Reliability Analysis of Marine Structures	(3-0-0) 3
WO810	Applied Elasticity	(3-0-0) 3
WO811	Numerical Modelling of Coastal Processes	(3-0-0) 3
WO812	Finite Element Method and Applications	(3-0-0) 3
WO813	Approximate Methods in Structural Mechanics	(3-0-0) 3
WO814	Thin Walled Structures	(3-0-0) 3
WO815	Experimental Methods in Stress Analysis	(3-0-0) 3
WO816	Coastal Environmental Management	(3-0-0) 3
WO817	Nonlinear Problems in Ocean Engineering	(3-0-0) 3
WO818	Mechanics Of Floating Bodies	(3-0-0) 3
WO819	Hydroelasticity	(3-0-0) 3
WO820	Offshore Renewable Energy	(3-0-0) 3
WO821	Computational Marine Hydrodynamics	(3-0-0) 3
WO822	Foundation for Offshore Structures	(3-0-0) 3
WO823	Design of Offshore Structures	(3-0-0) 3
WO824	Structural Health Monitoring	(3-0-0) 3
WO825	Adavanced Technology Applications in monitoring of Marine Structures	(3-0-0) 3
WO829	Selected Topics in Marine Structures	(3-0-0) 3

Mandatory Learning Courses (MLC)

WO725 Seminar 2

WO726/727 Practical Training/Minor Project 2

(to be completed during vacation between 2nd & 3rd sem.)

Major Projects (MP)

WO728 Major Project (3rd sem.) 5

WO729 Major Project (4th sem.) 7

M.Tech. in Remote Sensing and GIS

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	WO761	WO734	WO756/ WO757	WO759
2	WO731	WO735	WO758	
3	WO732	MA709		
4	WO733	WO736		
5	Elective 1	WO737		
6	Elective 2	WO755		
7	----	Elective 3		
8	----	Elective 4		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	24
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	52

Programme Core (Pc)

WO761	Statistical Methods for Civil Engineering Applications	(3-0-0) 3
WO731	Principles of Remote Sensing	(3-0-0) 3
WO732	Geographic Information Systems	(3-0-0) 3
WO733	Remote Sensing and GIS Lab	(0-0-3) 2
WO734	Satellite Digital Image Analysis	(3-0-0) 3
WO735	Microwave Remote Sensing	(3-0-0) 3
WO736	Satellite Digital Image Analysis Lab	(0-0-3) 2
WO737	Design Project	(0-0-3) 2
MA709	Database Management	(3-0-0) 3

Elective (Ele.) Courses

WO831	Advanced tools for Image processing	(2-0-2) 3
WO832	Applications of RS &GIS in Agriculture & Soil Science	(3-0-0) 3
WO833	Applications of RS & GIS in Town & Country Planning	(3-0-0) 3
WO834	Applications of RS &GIS in Forestry, Ecology & Environment	(3-0-0) 3
WO835	Applications of Unmanned Aerial Vehicles in Engineering	(2-0-2) 3
WO836	Geo-informatics Applications in Water Resources Engineering	(3-0-0) 3
WO837	Hyperspectral remote sensing and Applications	(3-0-0) 3
WO838	Thermal Remote Sensing	(2-1-0) 3
WO868	Soft computing techniques and Applications	(3-0-0) 3
WO859	Selected Topics in RS & GIS	(3-0-0) 3

Mandatory Learning Courses (MLC)

WO755	Seminar	2
WO756/ WO757	Practical Training/Minor Project (to be completed during vacation between 2nd 3rd sem.)	2

Major Project (MP)

WO758	Major Project (3rd sem.)	5
WO759	Major Project (4th sem.)	7

M.Tech. in Environmental Engineering

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	CV761	CV765	CV776/ CV777	CV779
2	CV762	CV766	CV778	
3	CV763	CV767		
4	CV764	CV775		
5	MA704	Elective 2		
6	Elective 1	Elective 3		
7	----	Elective 4		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	27
Elective Courses (Ele.)	9
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	52

Programme Core Courses (Pc)

CV761	Environmental Quality & Monitoring	(3-1-0) 4
CV762	Physico-Chemical Processes for Water &Wastewater Treatment	(3-1-0) 4
CV763	Biological Process Design for Wastewater Treatment	(3-1-0) 4
CV764	Environmental Engineering Lab	(0-0-3) 2
CV765	Solid & Hazardous Waste Management	(3-0-0) 3
CV766	Unit Processes Lab & Field Studies	(0-0-6) 4
CV767	Environmental Impact Assessment	(3-0-0) 3
MA704	Numerical Analysis	(3-0-0) 3

Elective Courses (Ele)

CV861	Earth & Environment	(3-0-0) 3
CV862	Transport of Water & Wastewater	(3-0-0) 3
CV863	Air Quality Management	(3-0-0) 3
CV864	Models for Water & Air Quality	(3-0-0) 3
CV865	Environmental Systems Analysis	(3-0-0) 3
CV866	Management of Water, Waste & Sanitation Utilities	(3-0-0) 3
CV867	Membrane Processes for Water & Waste Treatment	(3-0-0) 3
CV868	Industrial Waste Treatment	(3-0-0) 3
CV869	Environmental Issues based on Case studies	(3-0-0) 3
CV870	Remote Sensing & GIS Applications	(3-0-0) 3
CV871	Ecotechnology	(3-0-0) 3
CV872	Environmental Biotechnology	(3-0-0) 3
CV873	Industrial Pollution Management	(3-0-0) 3
CV874	Environmental Microbiology	(3-0-0) 3
CV875	Environmental Management	(3-0-0) 3
CV876	Environmental Toxicology	(3-0-0) 3
CV877	Environmental Hydraulics	(3-0-0) 3
CV878	Modelling Waste Water Treatment Processes And Plants	(3-0-0) 3
CV828	Environmental Geotechnology	(3-0-0) 3
CV879	Selected Topics in Environmental Engg.	(3-0-0) 3
CV880	Environment and Climate Change	(3-0-0) 3

Mandatory Learning Courses (MLC)

CV775	Seminar	2
CV776/ CV777	Practical Training/Minor Project (to be completed during vacation between 2nd & 3rd sem.)	2

Major Project (MP)

CV778	Major Project (3rd Sem.)	4
CV779	Major Project (4th Sem.)	8

M.Tech. in Geotechnical Engineering

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	CV721	CV724	CV736/ CV737	CV739
2	CV722	CV725	CV738	
3	CV723	CV726		
4	MA704	CV727		
5	Elective 1	CV735		
6	Elective 2	Elective 3		
7	----	Elective 4		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	24
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	52

Programme Core Courses (Pc)

CV721	Basic Geomechanics	(3-1-0) 4
CV722	Shallow Foundations	(3-0-0) 3
CV723	Geotechnical Engineering Laboratory	(0-0-3) 2
CV724	Earth and Earth Retaining Structures	(3-0-0) 3
CV725	Pile Foundations	(3-1-0) 4
CV726	Ground Improvement Techniques	(3-0-0) 3
CV727	Computational Lab for Geotechnical Engineers	(0-0-3) 2
MA704	Numerical Analysis	(3-0-0) 3

Elective Courses (Ele)

CV821	Rock Mechanics	(3-0-0) 3
CV822	Soil Dynamics & Machine Foundations	(3-0-0) 3
CV823	Advanced Engineering Geology	(3-0-0) 3
CV824	FEM for Geotechnical Engineers	(3-0-0) 3
CV825	Earth & Rockfill Dams	(3-0-0) 3
CV826	Geotechnical Instrumentation	(3-0-0) 3
CV827	Soil Reinforcement & Geosynthetics	(3-0-0) 3
CV828	Environmental Geotechnology	(3-0-0) 3
CV802	Earthquake Engineering	(3-0-0) 3
CV741	Pavement Design	(3-0-0) 3
AM703	Marine Geotechnical Engineering	(3-0-0) 3
MI805	Tunnel Engineering	(3-0-0) 3
CV804	Soil-Structure Interaction	(3-0-0) 3
CV702	Finite Element Method	(3-0-0) 3
CV706	Advanced Design of Concrete Structures	(3-0-0) 3
CV807	Advanced Concrete Technology	(3-0-0) 3
CV786	Construction Methods & Equipment	(3-0-0) 3
CV829	Selected Topics in Geotechnical Engineering	(3-0-0) 3
CV830	Geo-Disaster Mitigation	(3-0-0) 3

Mandatory Learning Courses (MLC)

CV735	Seminar	2
CV736/ CV737	Practical Training/ Minor Project (to be completed during vacation between 2nd& 3rd sem.)	2

Major Project (MP)

CV738	Major Project (3rd Sem.)	4
CV739	Major Project (4th Sem.)	8

M.Tech. in Structural Engineering

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	CV701	CV706	CV716/ CV717	CV719
2	CV702	CV707	CV718	
3	CV703	CV708		
4	CV704	CV709		
5	CV705	CV715		
6	Elective 1	Elective 3		
7	Elective 2	Elective 4		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	25
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	53

Programme Core Courses (Pc)

CV701	Theory of Elasticity & Plasticity	(3-0-0) 3
CV702	Finite Element Method	(3-0-0) 3
CV703	Mathematical Methods in Structural Engg.	(3-0-0) 3
CV704	Structural Dynamics	(3-0-0) 3
CV705	Computer Lab	(0-0-3) 2
CV706	Advanced Design of Concrete Structures	(3-0-0) 3
CV707	Advanced Design of Steel Structures	(3-0-0) 3
CV708	Theory of Plates	(3-0-0) 3
CV709	Structures Lab	(0-0-3) 2

Elective Courses (Ele)

CV801	Stability of Structures	(3-0-0) 3
CV802	Earthquake Engineering	(3-0-0) 3
CV803	Structural Optimization	(3-0-0) 3
CV804	Soil-Structure Interaction	(3-0-0) 3
CV805	Structural Reliability	(3-0-0) 3
CV806	Offshore Structural Engineering	(3-0-0) 3
CV807	Advanced Concrete Technology	(3-0-0) 3
CV808	Wind Resistant Design of Structures	(3-0-0) 3
CV809	Mechanics of Composite Laminates	(3-0-0) 3
CV810	Advanced Bridge Engineering	(3-0-0) 3
CV811	Analysis & Design of Substructures	(3-0-0) 3
CV812	Computer Aided Design in Structural Engg.	(3-0-0) 3
CV813	Repair and Rehabilitation of Structures	(3-0-0) 3
CV814	Pre-engineered Structures	(3-0-0) 3
CV815	Fracture Mechanics of Concrete	(3-0-0) 3
CV816	Analysis and Design of Shells & Folded Plates	(3-0-0) 3
CV817	Aseismic Design of RC Buildings	(3-0-0) 3
CV818	Selected Topics in Structural Engineering	(3-0-0) 3

Mandatory Learning Courses (MLC)

CV715	Seminar	2
CV716/ CV717	Practical Training/ Minor Project (to be completed during vacation between 2nd & 3rd sem)	2

Major Project (MP)

CV718	Major Project (3rd sem.)	4
CV719	Major Project (4th sem.)	8

M.Tech. in Transportation Engineering

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	CV741	CV745	CV756/ CV757	CV759
2	CV742	CV746	CV758	
3	CV743	CV747		
4	CV744	CV755		
5	MA708	MA705		
6	Elective 1	Elective 3		
7	Elective 2	Elective 4		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	26
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	54

Programme Core Courses (Pc)

CV741	Pavement Design	(3-0-0) 3
CV742	Urban Transport Planning	(3-1-0) 4
CV743	Road Materials, Constn. Methods, and Quality Control	(3-0-0) 3
CV744	Road Materials Testing Laboratory	(0-0-3) 2
CV745	Traffic Flow Theory	(3-0-0) 3
CV746	Transportation Asset Management	(3-0-0) 3
CV747	Transportation Design Studio	(0-0-3) 2
MA705	Operations Research	(3-0-0) 3
MA708	Statistical Methods	(3-0-0) 3

Elective Courses (Ele)

CV841	Highway and Airport Geometric Design	(3-0-0) 3
CV842	Air Transport Planning and Design	(3-0-0) 3
CV843	Infrastructure Development: Policies, Planning, Engineering, and Appraisal	(3-0-0) 3
CV844	Railway Track Engineering	(3-0-0) 3
CV845	Rural Roads	(3-0-0) 3
CV846	Advanced Asphalt Technology	(3-0-0) 3
CV847	Concrete Microstructure, Properties, and Mechanics	(3-0-0) 3
CV848	Characterization and Modelling of Asphalt Mixtures	(3-0-0) 3
CV849	Traffic Simulation and Modelling	(3-0-0) 3
CV850	Mass Transport Systems	(3-0-0) 3
CV851	Soil Mechanics for Highway Engineers	(3-0-0) 3
CV852	Traffic Engineering and Management	(3-0-0) 3
CV721	Basic Geomechanics	(3-1-0) 4
CV724	Earth and Earth Retaining Structures	(3-0-0) 3
CV726	Ground Improvement Techniques	(3-0-0) 3
CV701	Theory of Elasticity and Plasticity	(3-0-0) 3
CV702	Finite Element Method	(3-0-0) 3
CV810	Advanced Bridge Engineering	(3-0-0) 3
CV767	Environmental Impact Assessment	(3-0-0) 3
CV853	Selected Topics in Transportation Engineering	(3-0-0) 3

Mandatory Learning Courses (MLC)

CV755	Seminar	2
CV756/ CV757	Practical Training/ Minor Project (to be completed during vacation between 2nd& 3rd sem)	2

Major Project (MP)

CV758	Major Project (3rd Sem.)	4
CV759	Major Project (4th Sem.)	8

M.Tech. in_Construction Technology and Management

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	CV781	CV786	CV796/ CV797	CV799
2	CV782	CV787	CV798	
3	CV783	CV788		
4	CV784	CV789		
5	CV785	CV795		
6	Elective 1	Elective 3		
7	Elective 2	Elective 4		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	24
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	52

Programme Core Courses (Pc)

CV781	Construction Planning & Control	(3-0-0) 3
CV782	Construction Economics & Accounting	(3-0-0) 3
CV783	Contracts &Specifications	(3-0-0) 3
CV784	Construction Materials Lab	(0-0-3) 2
CV785	Construction Personnel Management	(2-0-0) 2
CV786	Construction Methods & Equipment	(3-0-0) 3
CV787	Construction Quality & Safety Management	(3-0-0) 3
CV788	Organizational Behaviour	(3-0-0) 3
CV789	Construction Software Lab	(0-0-3) 2

Elective Courses (Ele)

CV881	Repair & Restoration of Structures	(3-0-0) 3
CV882	Operation Research & Decision Theory	(3-0-0) 3
CV883	Maintenance & Rehabilitation of Structures	(3-0-0) 3
CV884	Structural Systems & Design	(3-0-0) 3
CV885	Valuation techniques in Engineering	(3-0-0) 3
CV886	Contract Laws & Regulations	(3-0-0) 3
CV887	Quality Control & Assurance	(3-0-0) 3
CV888	Management Information Systems	(3-0-0) 3
CV889	Functional Efficiency of Buildings	(3-0-0) 3
CV890	Supervision of Field Operations	(3-0-0) 3
CV891	Computer Aided Design in Civil Engineering	(3-0-0) 3
CV892	Excavation Technology for Construction projects	(3-0-0) 3
CV893	Global Business Management	(3-0-0) 3
CV894	Sustainability in Built Environment	(3-0-0) 3
CV895	Modern Concrete Materials & Technology	(3-0-0) 3
CV762	Physico-Chemical Process for Water & Waste Water Treatment	(3-0-0) 3
CV765	Solid & Hazardous Waste Management	(3-0-0) 3
CV767	Environmental Impact Assessment	(3-0-0) 3
CV863	Air Quality Management	(3-0-0) 3
CV726	Ground Improvement Techniques	(3-0-0) 3
CV827	Soil Reinforcement & Geosynthetics	(3-0-0) 3
CV802	Earthquake Engineering	(3-0-0) 3
AM864	Integrated River Basin Development	(3-0-0) 3
AM706	Port Engineering	(3-0-0) 3
AM708	Offshore Engineering	(3-0-0) 3
AM805	Sedimentation and Dredging	(3-0-0) 3
AM807	Marine Projects Management	(3-0-0) 3
MI700	Rock Excavation Technology	(4-0-0) 4
MI805	Tunnelling Engineering	(3-0-0) 3
EE702	Power Systems Modeling and Analysis	(4-0-0) 4
EE750	Computer Control of Power Systems	(4-0-0) 4
EE853	Renewable Energy Systems	(3-0-0) 3
ME853	Design of Air-conditioning Systems	(3-0-0) 3
MT803	Non-destructive Testing	(3-0-0) 3
MT811	Advanced Welding Technology	(3-0-0) 3
CV896	Selected Topics in Construction Technology and Management	(3-0-0) 3

Apart from the above elective subjects, students may choose any of the 700/ 800 level courses as electives relevant to their degree with the consent of the faculty advisor, course instructor, and the DPGC.

Mandatory Learning Courses (MLC)

CV795	Seminar	2
CV796/ CV797	Practical Training/ Minor Project (to be completed during vacation between 2nd & 3rd sem.)	2

Major Project (MP)

CV798	Major Project (3rd Sem.)	4
CV799	Major Project (4th Sem.)	8

M.Tech in Rock Excavation Technology & Management

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	MA701	MI704	MI891/ MI897	MI799
2	MI700	MI705	MI898	
3	MI701	MI706		
4	MI702	MI890		
5	MI703	Elective 3		
6	Elective 1	Elective 4		
7	Elective 2			

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	24
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	52

Programme Core (Pc)

MA701	Applied Statistics & Numerical Analysis	(3-0-0) 3
MI700	Rock Excavation Technology	(4-0-0) 4
MI701	Geomechanics & Geotech Engg.	(3-0-0) 3
MI702	Geomechanics & Geotech Engg. Lab	(0-0-3) 2
MI703	Design of Rock Structures	(3-0-0) 3
MI704	Stress Analysis of Excavations	(3-0-0) 3
MI705	Project Management	(3-0-0) 3
MI706	Environmental Management in Rock Excavation Projects	(3-0-0) 3

Elective (Ele) Courses

MI800	Rock Slope Engineering	(3-0-0) 3
MI801	Rock Fragmentation Engineering	(3-0-0) 3
MI802	Rock Reinforcement Engineering	(3-0-0) 3
MI 803	Rock Mechanics Instrumentation	(3-0-0) 3
MI 804	Underground space Technology	(3-0-0) 3
MI805	Tunneling Engineering	(3-0-0) 3
MI806	Reliability Engineering	(3-0-0) 3
MI807	Safety Engineering	(3-0-0) 3
AM702	Introduction to Geo-informatics Systems	(3-0-0)3
CV800	Environmental Geo-technology	(3-0-0) 3

Mandatory Learning Courses (MLC)

MI890	Seminar	2
MI891/MI897	Practical Training/Minor Project (to be completed during vacation between 2nd & 3rd sem)	2

Major Project (MP)

MI898	Major Project (3rd sem.)	4
MI899	Major Project (4th sem.)	8

M.Tech in Computer Science & Engineering

Suggested Plan of Study:

Sl. No.	Semester I	Semester II	Semester III	Semester IV
1	CS700	CS750	CS753	CS755
2	CS701	CS751	CS754	
3	CS702	Elective II		
4	Elective I	Elective III		
5	MA714	CS752		
6	CS709			

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	23
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	51

Programme Core (Pc)

CS700	Algorithm and Complexity	(3-0-2) 4
CS701	High Performance Computing	(3-0-2) 4
CS702	Computing Lab	(0-0-3) 2
CS750	Distributed Data Management	(3-0-2) 4
CS751	Network Engineering	(3-0-2) 4
CS752	Mini Project	2
MA714	Mathematical Foundations of Computer Science	(3-0-0) 3

Elective Courses

(at least TWO electives must be chosen from CSE Electives)

CS710	Parallel and Distributed Databases	(3-1-0) 4
CS711	Network Management and Operations	(3-1-0) 4
CS712	Software Architecture	(3-1-0) 4
CS713	Software Testing Techniques	(3-1-0) 4
CS714	Distributed Operating Systems	(3-1-0) 4
CS715	Power Aware Computing	(3-1-0) 4
CS716	Topics in Image Processing	(3-1-0) 4
CS717	Topics in Speech Processing	(3-1-0) 4
CS718	Data Science	(3-1-0) 4
CS719	Mobile Computing Systems	(3-1-0) 4
CS720	Wireless Networks and Applications	(3-1-0) 4
CS721	Advanced Algorithms	(3-1-0) 4
CS722	Optimization Algorithms	(3-1-0) 4
CS723	Distributed Algorithms	(3-1-0) 4
CS724	Internet of Things and Applications	(3-1-0) 4
CS725	Network Optimization	(3-1-0) 4
CS726	Compiler Optimization	(3-1-0) 4
CS727	Service Oriented Computing	(3-1-0) 4
CS728	Virtualization and Cloud Computing	(3-1-0) 4
CS729	Social Media Mining	(3-1-0) 4
CS730	Big Data Analytics and Tools	(3-1-0) 4
CS731	Software Defined Networking	(3-1-0) 4
CS732	Topics in Information Centric Networking	(3-1-0) 4
CS733	Natural Language Processing	(3-1-0) 4
CS734	Parallel Programming Techniques	(3-1-0) 4
CS738	Topics in Computer Networks	(3-1-0) 4

Elective Courses[M.Tech (CSE, CSE-IS)]

CS735	Data Mining Techniques	(3-1-0) 4
CS736	Machine Learning and Applications	(3-1-0) 4
CS737	Deep Learning	(3-1-0) 4
CS813	Cyber law and Ethics	(3-1-0) 4
CS814	Principles of Information Security	(3-1-0) 4

Mandatory Learning Courses (MLC)

CS709	Seminar	2
CS753	Practical Training	2

Major Project (MP)

CS754	Major Project (3rdSem)	4
CS755	Major Project (4thSem)	8

M.Tech in Computer Science & Engineering-Information Security

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	CS700	CS850	CS853	CS855
2	CS800	CS851	CS854	
3	CS801	Elective II		
4	Elective I	Elective III		
5	MA714	CS852		
6	CS809			

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	23
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	51

Programme Core (PC)

CS700	Algorithms and Complexity	(3-0-2) 4
CS800	Number Theory & Cryptography	(3-0-2) 4
CS801	Computing Lab	(0-0-3) 2
CS850	Database Security	(3-0-2) 4
CS851	Network Security	(3-0-2) 4
CS852	Mini Project	2
MA714	Mathematical Foundations of Computer Science	(3-0-0) 3

Elective Courses

(at least TWO electives must be chosen from CSE Electives)

CS810	Security Architecture: Design & Analysis	(3-1-0) 4
CS811	Secure Coding	(3-1-0) 4
CS812	Formal Analysis and Verification	(3-1-0) 4
CS813	Cyber Laws and Ethics	(3-1-0) 4
CS814	Principles of Information Security	(3-1-0) 4
CS815	Web Application Security	(3-1-0) 4
CS816	Biometrics Security	(3-1-0) 4
CS817	Security Policies	(3-1-0) 4
CS818	Cyber Crime and Information Warfare	(3-1-0) 4
CS819	Malware Analysis	(3-1-0) 4
CS820	Digital Watermarking and Steganalysis	(3-1-0) 4
CS821	Game Theory & Its Applications	(3-1-0) 4
CS822	Cryptanalysis	(3-1-0) 4
CS823	Advanced Cryptography	(3-1-0) 4
CS824	Applied Cryptography	(3-1-0) 4
CS825	Advanced Topics in Security	(3-1-0) 4
CS826	Quantum Cryptography	(3-1-0) 4
CS827	Cloud Security	(3-1-0) 4
CS828	Wireless Network Security	(3-1-0) 4
CS829	IoT Security	(3-1-0) 4
CS830	SCADA Security	(3-1-0) 4
CS831	Cyber Forensics	(3-1-0) 4
CS832	Social Network Security	(3-1-0) 4
CS833	Information Security and Risk Management	(3-1-0) 4
CS834	Computer Security Audit and Assurance	(3-1-0) 4

Elective Courses[M.Tech (CSE, CSE-IS)]

CS724	Internet of Things and Applications	(3-1-0) 4
CS728	Virtualization and Cloud Computing	(3-1-0) 4
CS735	Data Mining Techniques	(3-1-0) 4
CS736	Machine Learning and Applications	(3-1-0) 4
CS737	Deep Learning	(3-1-0) 4

Mandatory Learning Courses (MLC)

CS809	Seminar	2
CS853	Practical Training	2

Major Project(MP)

CS854	Major Project(3rd Sem)	4
CS855	Major Project(4th Sem)	8

M. Tech. in VLSI Design

Suggested Plan of Study:

Sl. No.	Semester I	Semester II	Semester III	Semester IV
1	EC701	EC703	EC729	EC730
2	EC702	EC704		
3	EC791	EC792		
4	EC705	Elective 3		
5	Elective 1	EC727		
6	Elective 2	EC728		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	26
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	54

Program Core (Pc)

EC701	CMOS VLSI	(4-0- 0) 4
EC702	Analog Integrated Circuit Design	(4-0- 0) 4
EC703	VLSI Data Converters	(4-0-0) 4
EC704	VLSI Design Automation	(4-0-0) 4
EC705	IC Design Lab	(0-0-3) 2
EC791	Linear Algebra and Stochastic Processes	(4-0-0) 4
EC792	High Performance Computing Architectures	(4-0-0) 4

Electives (Ele)

(At least ONE must be chosen from this list)

EC801	Logic Synthesis Techniques	(4-0-0) 4
EC802	Low Power VLSI Design	(4-0-0) 4
EC803	Microelectronic Devices	(4-0-0) 4
EC804	Digital VLSI Testing & Testability	(4-0-0) 4
EC805	Embedded Systems	(2-0-3)4
EC806	Digital Design using FPGAs	(2-0-3)4
EC807	Active Filter Design	(4-0-0) 4
EC808	CMOS RF Integrated Circuits	(4-0-0) 4
EC809	Heterogeneous and Parallel Programming	(2-0-3)4
EC810	Selected Topics in VLSI Design	(4-0-0) 4
EC870	Architectures for Signal Processing and Machine Learning	(4-0-0) 4

Mandatory Learning Courses (MLC)

EC727	Seminar	2
EC728	Minor Project	2

Major Project (MP)

EC729	Major Project - I	4
EC730	Major Project - II	8

M. Tech. in Signal Processing and Machine Learning (SPML)

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	EC791	EC792	EC789	EC790
2	EC793	EC762		
3	EC761	EC763		
4	EC764	Elective 3		
5	Elective 1	EC787		
6	Elective 2	EC788		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	26
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	54

Program Core (PC)

EC791	Linear Algebra and Stochastic Processes	(4-0-0) 4
EC792	High Performance Computing Architectures	(4-0-0) 4
EC793	Signal Analysis and Processing	(4-0-0) 4
EC761	Information Processing and Compression	(4-0-0) 4
EC762	Pattern Recognition and Machine Learning	(4-0-0) 4
EC763	Optimization	(4-0-0) 4
EC764	Signal Processing Laboratory	(0-0-3) 2

Electives (EL)

(At least ONE elective must be chosen from this list)

EC861	Image Processing and Computer Vision	(4-0-0) 4
EC862	Time Series Analysis and Data Science	(4-0-0) 4
EC863	Statistical Signal Processing	(4-0-0) 4
EC864	Speech and Audio Processing	(4-0-0) 4
EC865	Multimedia Systems	(4-0-0) 4
EC866	Deep Learning and Applications	(3-0-2) 4
EC867	Fourier and Wavelet Analysis	(4-0-0) 4
EC868	Time Frequency Analysis	(4-0-0) 4
EC869	Medical Imaging and Biosignal Analysis	(4-0-0) 4
EC870	Architectures for Signal Processing and Machine Learning	(4-0-0) 4
EC871	Selected Topics in Signal Processing	(4-0-0) 4
EC872	Nonlinear Dynamics, Chaos and Fractals	(4-0-0) 4
EC873	Computational Imaging and Physics	(4-0-0) 4
EC874	Detection, Estimation and Statistical Learning Theory	(4-0-0) 4
EC875	Probabilistic Models in Machine Learning	(4-0-0) 4
EC876	System Identification and Control	(4-0-0) 4
EC877	Inverse Problems : Theory and Applications	(4-0-0) 4
EC734	Signal Detection and Estimation	(4-0-0) 4

Mandatory Learning Courses (MLC)

EC787	Seminar	2
EC788	Minor Project	2

Major Project (MP)

EC789	Major Project - I	4
EC790	Major Project - II	8

M. Tech. in Communication Engineering And Networks

Suggested Plan of Study:

Sl. No.	Semester I	Semester II	Semester III	Semester IV
1	EC731	EC733	EC759	EC760
2	EC732	EC734		
3	EC791	EC758		
4	EC793	EC736		
5	EC757	Elective 2		
6	Elective 1	Elective 3		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	26
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	54

Program Core (PC)

EC731	Wireless Communication & Networks	(4-0-0) 4
EC732	RF Circuit Design	(4-0-0) 4
EC733	Optical Networks and Switching	(4-0-0) 4
EC734	Signal Detection and Estimation	(4-0-0) 4
EC736	Communication & Networking Lab	(0-0-3) 2
EC791	Linear Algebra and Stochastic Processes	(4-0-0) 4
EC793	Signal Analysis and Processing	(4-0-0) 4

Electives(EL)

(At least ONE elective must be chosen from this list)

EC831	Spread Spectrum Communication Systems	(4-0-0) 4
EC832	MIMO Communication Systems	(4-0-0) 4
EC833	Internet of Things	(4-0-0) 4
EC834	Error Control Coding	(4-0-0) 4
EC835	Algorithms for Parameter and State Estimation	(4-0-0) 4
EC836	Radar Signal Processing	(4-0-0) 4
EC837	Advanced Radiating Systems	(4-0-0) 4
EC838	Multi Target Tracking and Multi-Sensor Information Fusion	(4-0-0) 4
EC839	Nano-Photonics	(4-0-0) 4
EC840	Millimetre Wave Communications	(4-0-0) 4
EC841	Cryptography	(4-0-0) 4
EC842	Information Theory	(4-0-0) 4
EC843	Broadband Communications	(4-0-0) 4
EC844	Electromagnetic Interference and Compatibility	(4-0-0) 4
EC845	Principles of Communication Systems Simulation	(4-0-0) 4
EC846	Computer Communication Networks	(4-0-0) 4
EC847	Selected Topics in Communication Engineering	(4-0-0) 4
EC848	Signal Processing Techniques for Software defined Radios	(4-0-0) 4
EC849	RF Transceiver Systems Design for Wireless Communication	(4-0-0) 4
EC850	Design and Integrated Circuits for Wireless Communication	(4-0-0) 4

Mandatory Learning Courses (MLC)

EC757	Seminar	2
EC758	Minor Project	2

Major Project(MP)

EC759	Major Project - I	4
EC760	Major Project - II	8

M. Tech. in Power and Energy Systems

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	EE700	EE750	EE891/ EE897	EE899
2	EE701	EE751	EE898	
3	EE702	Elective 3		
4	EE703	Elective 4		
5	Elective 1	Elective 5		
6	Elective 2	EE890		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	22
Elective Courses (Ele.)	14
Mandatory Learning Courses (MLC)	4
Major Project (MP)	6+6=12
Total	52

Programme Core (PC)

EE700	Computer-Aided Protection of Power Systems	(4-0-0) 4
EE701	Power Electronics: Modeling and Design	(4-0-0) 4
EE702	Power System Modeling and Analysis	(4-0-0) 4
EE703	Power System Modeling and Analysis Lab	(0-0-3) 2
EE750	Computer Control of Energy Systems	(4-0-0) 4
EE751	Control Systems	(4-0-0) 4

Elective (EL) Courses

EE800	Fuzzy-Neural Control	(4-0-0) 4
EE801	EMI Testing and Design for Compatibility	(4-0-0) 4
EE802	Energy Management	(3-0-0) 3
EE803	Microcontroller Based System Design	(3-0-0) 3
EE804	Electric Power Quality	(3-0-0) 3
EE805	Discrete Fourier Transforms and Digital Filter Design	(4-0-0) 4
EE806	Sensor Technology and Instrumentation Design	(3-0-0) 3
EE807	Optimization Techniques	(4-0-0) 4
EE808	Finite Element Methods and Applications	(3-0-0) 3
EE809	DC-AC System Interaction	(3-1-0) 4
EE810	Power System Transients and Overvoltages	(3-0-0) 3
EE811	Distribution System Automation	(3-0-0) 3
EE812	Energy Management Lab	(0-0-3) 2
EE813	Electric Power Quality Lab	(0-0-3) 2
EE814	Discrete Fourier Transforms and Digital Filter Design Lab	(0-0-3) 2
EE815	Power Electronics Design Lab	(0-0-3) 2
EE816	Distribution Automation Lab	(0-0-3) 2
EE817	Power System Operation under Deregulations	(4-0-0) 4
EE818	Advanced Semiconductor Devices	(3-0-0) 3
EE820	Analysis Of Faulted Power Systems	(4-0-0)4
EE850	FACTS and Custom Power Devices	(3-0-0) 3
EE851	High-Voltage Testing and Measurements	(3-0-0) 3
EE852	PV Power Systems	(3-0-0) 3
EE853	Renewable Energy Systems	(3-0-0) 3
EE854	Distributed Generation	(3-0-0) 3
EE855	Communication Networks for Power Systems	(3-0-0) 3
EE856	Application of Digital Signal Processing Techniques to Power Systems	(4-0-0) 4
EE857	Design of Embedded Controllers	(3-0-0) 3
EE858	Electric Drives	(3-0-0) 3
EE859	Computational Methods for Large Power Systems	(4-0-0) 4
EE860	Industrial Applications of HV and Fields	(3-0-0) 3
EE861	LabVIEW™ -based Data Acquisition and Instrumentation Lab	(0-0-3) 2
EE862	Computer Control of Energy Systems Lab	(0-0-3) 2
EE863	Power System Signal Processing Lab	(0-0-3) 2
EE864	Embedded Controllers Design Lab	(0-0-3) 2
EE865	High-Voltage Testing Lab	(0-0-3) 2
EE866	Gaseous Insulation & Gas Insulated Systems	(3-0-0) 3
EE867	Power System Simulation Laboratory	(0-0-3) 2
EE868	Switched Electric Networks - A Power Electronics Perspective	(4-0-0) 4
EE869	Tensors	(4-0-0) 4
EE870	Tensor Analysis of Networks	(4-0-0) 4
EE871	Machine Learning	(3-1-2) 5
EE872	Smart Grid Control and Operation	(4-0-0) 4
EE873	Soft-switching Power Converters	(3-0-0) 3
EE874	Soft-switching Power Converters Laboratory	(0-0-3) 2

Mandatory Learning Courses (MLC)

EE890	Seminar	2
EE891/ EE897	Practical Training/ Minor Project (to be completed during vacation between 2nd & 3rd sem.)	2

Major Project (MP)

EE898	Major Project (*3rd sem.*)	6
EE899	Major Project (*4th sem.*)	6

M.Tech in Information Technology

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	IT700	IT750	IT891/ IT897	IT899
2	IT701	IT751	IT898	
3	IT702	IT752		
4	Elective 1	Elective 3		
5	Elective 2	Elective 4		
6	----	IT890		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	24
Elective Courses (Ele.)	14
Mandatory Learning Courses (MLC)	4
Major Project (MP)	10
Total	52

Program Core (PC)

IT700	Advanced Algorithms	(3-0-2) 4
IT701	Advanced Database Systems	(3-0-2) 4
IT702	Deep Learning	(3-0-2) 4
IT750	Cyber Security	(3-0-2) 4
IT751	Distributed Computing Systems	(3-0-2) 4
IT752	Web and Social Computing	(3-0-2) 4

Elective Courses (EL)

IT800	Mobile Computing	(3-0-0) 3
IT801	Genetic Algorithms	(3-0-2) 4
IT802	Artificial Intelligence	(3-0-0) 3
IT803	Software Architecture	(3-0-0) 3
IT804	Artificial Neural Networks	(3-0-2) 4
IT805	Topics in Web Semantics	(3-0-2) 4
IT806	Perceptual Audio and Speech Processing	(3-0-0) 3
IT807	Enterprise Resource Planning and Systems	(3-0-0) 3
IT808	Cyber Law and Intellectual Property Issues	(3-0-0) 3
IT809	Data Mining	(3-0-0) 3
IT810	E-Commerce	(3-0-0) 3
IT811	Web Services	(3-0-0) 3
IT812	Virtual Reality	(3-0-0) 3
IT813	Computer Vision	(3-0-2) 4
IT814	Cloud Computing	(3-0-2) 4
IT815	System Integration	(3-0-0) 3
IT816	Mobile Adhoc Networks	(3-0-2) 4
IT817	Wireless Sensor Networks	(3-0-2) 4
IT818	Intelligent Information Systems	(3-0-0) 3
IT819	Blind Signal and Image Processing	(3-0-0) 3
IT820	Information Technology for Healthcare	(3-0-0) 3
IT821	Perceptual Image and Video Processing	(3-0-0) 3
IT822	Advanced Computer Networks	(3-0-2) 4
IT823	Topics in Natural Language Processing	(3-0-2) 4
IT824	Topics in Soft Computing	(3-0-2) 4
IT825	Designing Internet of Things	(3-0-2) 4
IT826	Cyber-Physical Systems	(3-0-0) 3
IT827	High Performance Computing	(3-0-2) 4
IT828	Modern Cryptography	(3-0-2) 4
IT829	Advanced Computer Architecture	(3-0-0) 3
IT830	Multimedia Information Retrieval	(3-0-2) 4
IT831	Game Theory	(3-0-0) 3
IT832	Blockchain Technologies and Appliations -Decentralization and Smart Contracts	(3-0-2) 4
IT833	Advanced Time Series Analysis	(3-0-2) 4
IT834	Performance Evaluation of Computer Systems and Software	(3-0-2) 4

Mandatory Learning Courses (MLC)

IT890	Professional Practice / Seminar	2
IT891 / IT897	Practical Training / Minor Project (To be completed during Vacation between 2nd & 3rd Sem.)	2

Major Project (MP)

IT898	Major Project-I	4
IT899	Major Project-II	6

M.Tech. in Chemical Engineering

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	CH701	CH705	CH822/ CH823	CH825
2	CH702	MA702	CH824	
3	CH706	CH707		
4	CH704	CH821		
5	Elective 1	Elective 3		
6	Elective 2	Elective 4		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	25
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	53

Programme Core (Pc)

CH701	Molecular and Turbulent Transport	(3-1-0) 4
CH702	Process system analysis and Control	(3-1-0) 4
MA702	Design& Analysis of Experiments	(3-0-0) 3
CH704	Instrumental Analysis Lab	(0-0-3) 2
CH705	Process Modelling and Simulation	(3-0-2) 4
CH706	Statistical and Irreversible Thermodynamics	(3-1-0) 4
CH707	Chemical Reactor Design	(3-1-0) 4

Elective Courses (Ele)

CH801	Chemical Process Optimization	(3-0-0) 3
CH802	Process Equipment Design	(3-1-0) 4
CH803	Biochemical Engineering and Bioreactor Design	(3-0-0) 3
CH804	Advanced Separation Processes	(3-0-0) 3
CH 805	Computational Methods in Chemical Engineering	(3-0-0) 3
CH806	Risk & Safety Management in Process Industries	(3-0-0) 3
CH807	Process Energy Integration	(3-0-0) 3
CH808	Cavitation and its Applications in Chemical Engineering	(2-1-0) 3
CH809	Multiphase Flow	(3-0-0) 3
CH810	Mathematical Methods in Chemical Engineering	(3-0-0) 3
CH811	Computational Fluid Dynamics (CFD)	(3-1-0) 4
CH812	Mechanical Design of Process Vessels	(3-0-0) 3
CH813	Integrated Process Design Flow Sheeting &Synthesis	(3-0-0) 3
CH814	Polymerisation Reaction Engineering	(3-0-0) 3
CH815	Molecular Simulations	(3-0-0) 3

Mandatory Learning Courses (MLC)

CH821	Seminar	2
CH822/ CH823	Practical Training/Minor Project	2

(to be completed during vacation between 2nd & 3rd Sem.)

Major Project (MP)

CH824	Major Project (3rd sem.)	4
CH825	Major Project (4rd sem.)	8

M.Tech. in Environmental Science and Technology

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	CH730	CH732	CH852/ CH853	CH855
2	CH731	CH734	CH854	
3	CH733	MA702		
4	CH735	CH736		
5	Elective 1	CH851		
6	Elective 2	Elective 3		
7	----	Elective 4		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	25
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	53

Programme Core (PC)

CH730	Industrial & Domestic Waste Water Treatment	(3-1-0) 4
CH731	Solid Waste Management	(3-1-0) 4
MA702	Design & Analysis of Experiments	(3-0-0) 3
CH732	Air Pollution Control & Design of Equipment	(3-1-0) 4
CH733	Environmental Impact Assessment & Management Plan	(3-0-0) 3
CH734	Mathematical Modeling of Environmental Systems	(3-1-0) 4
CH735	Environmental Quality Analysis Lab-I	(0-0-3) 2
CH736	Environmental Quality Analysis Lab-II	(0-0-2) 1

Elective Courses (Ele)

CH803	Biochemical Engineering and Bioreactor Design	(3-0-0) 3
CH804	Advanced Separation Processes	(3-0-0) 3
CH806	Risk &Safety Management in Process Industries	(3-0-0) 3
CH807	Process Energy Integration	(3-0-0) 3
CH808	Cavitation and Its Applications in Chemical Engineering	(2-1-0) 3
CH809	Multiphase Flow	(3-0-0) 3
CH811	Computational Fluid Dynamics (CFD)	(3-1-0) 4
CH831	Environmental Biotechnology	(3-0-0) 3
CH832	Industrial Pollution Prevention	(3-0-0) 3
CH833	Bioremediation Techniques	(3-0-0) 3
CH810	Mathematical Methods in Chemical Engineering	(3-0-0) 3
CH834	Sustainable Technologies	(3-0-0) 3
CH835	Economics for Pollution Control	(3-0-0) 3
CH836	Environmental Management System	(3-0-0) 3
CH837	Industrial Waste Management and Audit	(3-0-0) 3
CH838	Sustainable Technologies	(3-0-0) 3

Mandatory Learning Courses (MLC)

CH851	Seminar	2
CH852/CH853	Practical Training/Minor Project	2

Major Project (MP)

CH854	Major Project	4
CH855	Major Project	8

M.Tech. in Industrial Biotechnology

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	CH760	CH763	CH882/ CH883	CH885
2	CH761	CH764	CH884	
3	CH762	CH765		
4	CH881	MA702		
5	Elective 1	Elective 3		
6	Elective 2	Elective 4		

Program Core (PC):

CH760	Transport phenomena	(3-1-0) 4
CH761	Bioprocess engineering	(3-1-0) 4
CH762	Environmental biotechnology	(3-0-0) 3
MA702	Design and analysis of experiments	(3-0-0) 3
CH763	Downstream process technology	(3-1-0) 4
CH764	Bioreactor engineering	(3-1-0) 4
CH765	Bioprocess lab	(0-0-4) 2

Program electives (Ele):

CH861	Bioanalytical techniques	(3-0-0) 3
CH862	Genetic engineering	(3-0-0) 3
CH863	Industrial and environmental epidemiology	(3-0-0) 3
CH864	Enzyme technology	(3-0-0) 3
CH865	Quality control in Biopharmaceutical Industries	(3-0-0) 3
CH866	Biosensors	(3-0-0) 3
CH867	Bioremediation Techniques	(3-0-0) 3
CH868	Animal Cell Biosystems and Immunotechnology	(3-0-0) 3
CH869	Protein Engineering	(3-0-0) 3
CH870	Cell signalling & Systems Biology	(3-0-0) 3

Mandatory learning courses (MLC):

CH881	Seminar	2
CH882/CH883	Practical training/ Mini project	2

Major project (MP):

CH884	Major project(III semester)	4
CH885	Major project (IV semester)	8

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	24
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	52

M.Tech. in Thermal Engineering

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	ME730	ME734	ME893/ ME899	ME895
2	ME731	ME735	ME894	
3	ME732	ME736		
4	ME733	ME737		
5	Elective 1	ME892		
6	Elective 2/ *Elective (PSEG-II)	Elective 3		
7	----	Elective 4		
8	----	Elective 5/ *Elective (PSEG-II)		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	22
Elective Courses (Ele.)	15
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	53

*All PG students have to take FOUR electives from PSEG –I and ONE from PSEG –II as suggested in the Plan of Structures

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Programme Core (Pc)

ME730	Advanced Fluid Mechanics	(3-0-0) 3
ME731	Heat and Mass Transfer	(3-0-0) 3
ME732	Refrigeration Systems	(3-0-0) 3
ME733	Thermal Engineering Lab	(0-0-3) 2
ME734	Design of Renewable Energy Systems	(3-0-0) 3
ME735	Measurements in Thermal Systems	(3-0-0) 3
ME736	Combustion	(3-0-0) 3
ME737	Thermal Computational Lab	(0-0-3) 2

Program Specific Electives –Group I (PSEG-I)

ME845	Transport Phenomena in Porous Media	(3-0-0) 3
ME846	Industrial Pollution Control	(3-0-0) 3
ME847	Design and analysis of Solar Energy Systems	(3-0-0) 3
ME848	Nuclear Engineering	(3-0-0) 3
ME849	Turbomachinery	(3-0-0) 3
ME850	Multiphase Flows	(3-0-0) 3
ME851	Advanced Thermodynamics	(3-0-0) 3
ME852	Theory & Design of IC Engines	(3-0-0) 3
ME853	Design of Air Conditioning Systems	(3-0-0) 3
ME854	Cryogenic Technology	(3-0-0) 3
ME855	Gas Dynamics	(3-0-0) 3
ME856	Alternative fuels for IC Engines	(3-0-0) 3
ME857	Sustainable Energy Technologies	(3-0-0) 3
ME858	Wind Energy	(3-0-0) 3
ME859	Nanoscale Fluid Flow and Heat Transfer	(3-0-0) 3
ME860	Applied Computational Methods in Thermal Engineering	(3-0-0) 3

Program Specific Electives –Group II (PSEG-II)

ME861	Finite Element Method	(3-0-0) 3
ME862	Virtual Instrumentation	(2-0-2) 3
ME863	Design for Manufacturing	(3-0-0) 3
ME864	Computational Fluid Dynamics	(3-0-0) 3
ME865	Robotics: Mechanics and Control	(3-0-0) 3
ME866	Optimization Techniques	(3-0-0) 3
ME867	Product Design and Development	(3-0-0) 3
ME868	Design of Thermal equipment	(3-0-0) 3
ME869	Theory and Practice of sensors and actuators	(2-0-2) 3
ME870	Biomechanics and Materials	(3-0-0) 3
ME871	Mechanical Systems And Signal Processing	(3-0-0) 3
ME872	Machine Tool Design	(3-0-0) 3
MA702	Design and Analysis of Experiments	(3-0-0) 3

Mandatory Learning Courses (MLC)

ME892	Seminar	2
ME893/ ME899	Practical Training/Minor Project	2

(to be completed during vacation between 2nd & 3rd sem.)

Major Project (MP)

ME894	Major Project (3rd sem.)	4
ME895	Major Project (4th sem.)	8

M.Tech. in Manufacturing Engineering

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	ME700	ME704	ME881/ ME896	ME883
2	ME701	ME705	ME882	
3	ME702	ME706		
4	ME703	ME707		
5	Elective 1	ME880		
6	Elective 2/ *Elective (PSEG-II)	Elective 3		
7	----	Elective 4		
8	----	Elective 5/ *Elective (PSEG-II)		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	22
Elective Courses (Ele.)	15
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	53

*All PG students have to take FOUR electives from PSEG –I and ONE from PSEG –II as suggested in the Plan of Structures

Programme Core (Pc)

ME700	Machining Processes	(3-0-0) 3
ME701	Computer Integrated Manufacturing	(3-0-0) 3
ME702	Metal Forming Processes	(3-0-0) 3
ME703	Manufacturing Systems Lab-I	(0-0-2) 2
ME704	Metal Casting Processes	(3-0-0) 3
ME705	Micro Manufacturing	(3-0-0) 3
ME706	Additive Manufacturing	(3-0-0) 3
ME707	Manufacturing Systems Lab-II	(0-0-2) 2

Program Specific Electives –Group I (PSEG-I)

ME800	Metal Joining Processes	(3-0-0) 3
ME801	Surface Engineering	(3-0-0) 3
ME802	Composite Mechanics and Processing	(3-0-0) 3
ME803	Artificial Intelligence in Manufacturing	(3-0-0) 3
ME804	Modeling and Simulation of Manufacturing Processes	(3-0-0) 3
ME805	Lean Manufacturing	(3-0-0) 3
ME806	Precision Manufacturing	(3-0-0) 3
ME807	Fluid Power Automation	(3-0-0) 3
ME808	Laser Processing of Materials	(3-0-0) 3
ME809	Tool Engineering	(3-0-0) 3
ME810	Production Management	(3-0-0) 3
ME811	Destructive and Non-Destructive Evaluation	(3-0-0) 3
ME812	Near Net Shape Processes	(3-0-0) 3

Program Specific Electives –Group II (PSEG-II)

ME861	Finite Element Method	(3-0-0) 3
ME862	Virtual Instrumentation	(2-0-2) 3
ME863	Design for Manufacturing	(3-0-0) 3
ME864	Computational Fluid Dynamics	(3-0-0) 3
ME865	Robotics: Mechanics and Control	(3-0-0) 3
ME866	Optimization Techniques	(3-0-0) 3
ME867	Product Design and Development	(3-0-0) 3
ME868	Design of Thermal equipments	(3-0-0) 3
ME869	Theory and Practice of sensors and actuators	(2-0-2) 3
ME870	Biomechanics and Materials	(3-0-0) 3
ME871	Mechanical Systems and Signal Processing	(3-0-0) 3
ME872	Machine Tool Design	(3-0-0) 3
MA702	Design and Analysis of Experiments	(3-0-0) 3

Mandatory Learning Courses (MLC)

ME880	Seminar	2
ME881/ ME896	Practical Training/Minor Project	2

(to be completed during vacation between 2nd & 3rd sem.)

Major Project (MP)

ME882	Major Project (3rd sem.)	4
ME883	Major Project (4th sem.)	8

M.Tech. in Mechatronics Engineering

Suggested Plan of Study:

Sl. No.	Semester I	Semester II	Semester III	Semester IV
1	ME720	MA713	ME889/ ME898	ME891
2	ME721	ME724	ME890	
3	ME722	ME725		
4	ME723	ME726		
5	Elective 1	ME888		
6	Elective 2/ *Elective (PSEG-II)	Elective 3		
7	----	Elective 4		
8	----	Elective 5/ *Elective (PSEG-II)		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	23
Elective Courses (Ele.)	15
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	54

*All PG students have to take FOUR electives from PSEG –I and ONE from PSEG –II as suggested in the Plan of Structures

Programme Core (Pc)

MA713	Mathematical Methods for Engineers	(3-1-0) 4
ME720	Introduction to Mechanical Systems	(3-0-0) 3
ME721	Sensors and Signal Conditioning	(2-0-2) 3
ME722	Actuators and Control	(2-0-2) 3
ME723	ADE and Microcontroller Lab	(0-0-3) 2
ME724	Control Engineering	(3-0-0) 3
ME725	Micro-Electro-Mechanical Systems Design	(3-0-0) 3
ME726	FMS and Simulation Lab	(0-0-3) 2

Program Specific Electives –Group I (PSEG-I)

ME831	Smart Structures & Materials	(3-0-0) 3
ME832	Intelligent Systems	(3-0-0) 3
ME833	Nano Technology	(3-0-0) 3
ME834	Digital Systems Design	(3-0-0) 3
ME835	Modeling and Simulation of Mechatronics Systems	(2-0-2) 3
ME836	Electronic Measurement and Instrumentation	(3-0-0) 3
ME837	Embedded System Design	(3-0-0) 3
ME838	Modern Control Engineering	(3-0-0) 3
ME839	Smart Sensor and Actuator	(3-0-0) 3
ME840	Automation System and Internet of things	(3-0-0) 3
ME841	Automotive Electronics	(2-0-2) 3

Program Specific Electives –Group II (PSEG-II)

ME861	Finite Element Method	(3-0-0) 3
ME862	Virtual Instrumentation	(2-0-2) 3
ME863	Design for Manufacturing	(3-0-0) 3
ME864	Computational Fluid Dynamics	(3-0-0) 3
ME865	Robotics: Mechanics and Control	(3-0-0) 3
ME866	Optimization Techniques	(3-0-0) 3
ME867	Product Design and Development	(3-0-0) 3
ME868	Design of Thermal Systems	(3-0-0) 3
ME869	Theory and Practice of Sensors & Actuators	(2-0-2) 3
ME870	Biomechanics and Materials	(3-0-0) 3
ME871	Mechanical Systems And Signal Processing	(3-0-0) 3
ME872	Machine Tool Design	(3-0-0) 3
MA702	Design and Analysis of Experiments	(3-0-0) 3

Mandatory Learning Courses (MLC)

ME888	Seminar	2
ME889/ ME898	Practical Training/Minor Project	2

(to be completed during vacation between 2nd & 3rd sem.)

Major Project (MP)

ME890	Major Project (3rd sem.)	4
ME891	Major Project (4th sem.)	8

M.Tech. in Mechanical Design

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	ME 710	ME 714	ME885/ ME897	ME887
2	ME 711	ME 715	ME886	
3	ME 712	ME 716		
4	ME 713	ME 717		
5	Elective 1	ME884		
6	Elective 2/ *Elective (PSEG-II)	Elective 3		
7	----	Elective 4		
8	----	Elective 5/ *Elective (PSEG-II)		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	22
Elective Courses (Ele.)	15
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	53

*All PG students have to take FOUR electives from PSEG –I and ONE from PSEG –II as suggested in the Plan of Structures

Programme Core (Pc)

ME710	Mathematical Methods for Engineers	(3-0-0) 3
ME711	Applied Elasticity	(3-0-0) 3
ME712	Engineering Fracture Mechanics	(3-0-0) 3
ME713	Mechanical Systems Lab	(0-0-3) 2
ME714	Advanced Mechanism Design	(3-0-0) 3
ME715	Applications of FEM in Design	(3-0-0) 3
ME716	Theory of Vibration	(3-0-0) 3
ME717	Dynamics and Stress Analysis Lab	(0-0-3) 2

Program Specific Electives –Group I (PSEG-I)

ME816	Lubrication and Bearing Design	(3-0-0) 3
ME817	Experimental Stress Analysis	(3-0-0) 3
ME818	Advanced Materials for Design	(3-0-0) 3
ME819	Mechanics of Polymer Composites	(3-0-0) 3
ME820	Dynamic Analysis of Rotating Systems	(3-0-0) 3
ME821	Engineering Acoustics	(3-0-0) 3
ME822	Design of Plates and Shells	(3-0-0) 3
ME823	Design for Fatigue	(3-0-0) 3
ME824	Design of Aircraft Structures	(3-0-0) 3
ME825	Machine Diagnostics	(3-0-0) 3
ME826	Mechanics of Viscoelastic Materials	(3-0-0) 3

Program Specific Electives –Group II (PSEG-II)

ME861	Finite Element Method	(3-0-0) 3
ME862	Virtual Instrumentation	(2-0-2) 3
ME863	Design for Manufacturing	(3-0-0) 3
ME864	Computational Fluid Dynamics	(3-0-0) 3
ME865	Robotics: Mechanics and Control	(3-0-0) 3
ME866	Optimization Techniques	(3-0-0) 3
ME867	Product Design and Development	(3-0-0) 3
ME868	Design of Thermal equipment	(3-0-0) 3
ME869	Theory and Practice of sensors and actuators	(2-0-2) 3
ME870	Biomechanics and Materials	(3-0-0) 3
ME871	Mechanical Systems And Signal Processing	(3-0-0) 3
ME872	Machine Tool Design	(3-0-0) 3
MA702	Design and Analysis of Experiments	(3-0-0) 3

Mandatory Learning Courses (MLC)

ME884	Seminar	2
ME885/ ME897	Practical Training/Minor Project	2

(to be completed during vacation between 2nd & 3rd sem.)

Major Project (MP)

ME886	Major Project (3rd sem.)	4
ME887	Major Project (4th sem.)	8

M. Tech. in Materials Engineering

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	MT700	MT706	MT891/ MT897	MT899
2	MT701	MT890	MT898	
3	MT702	Elective 1		
4	MT703	Elective 2		
5	MT704	Elective 3		
6	MT705	Elective 4		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	24
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	52

Programme Core (Pc)

MT700	Foundations of Physical Metallurgy	(3-1-0) 4
MT701	Materials Characterization	(3-1-0) 4
MT702	Thermodynamics of Solids	(3-1-0) 4
MT703	Polymer Technology	(3-0-0) 3
MT704	Mechanical Behaviour & Design of Materials	(3-1-0) 4
MT705	Materials Laboratory	(0-0-3) 2
MT706	Ceramic Technology	(3-0-0) 3

Elective Courses (Ele)

MT800	Steels & Their Heat Treatment	(3-0-0) 3
MT801	Composite Materials	(3-0-0) 3
MT802	Electronic Properties of Materials	(3-0-0) 3
MT803	Non-destructive Testing	(3-0-0) 3
MT804	High Temperature Materials	(3-0-0) 3
MT805	Fracture Mechanics	(3-0-0) 3
MT806	Surface Engineering	(3-0-0) 3
MT807	Science and Technology of Nanomaterials	(3-0-0) 3
MT808	Non-Equilibrium Materials and Processing	(3-0-0) 3
MT809	Advanced Polymeric Materials and Technology	(3-0-0) 3
MT810	Science and Technology of Biomaterials	(3-0-0) 3
MT811	Advanced Welding Technology	(3-0-0) 3
MT812	Corrosion Engineering	(3-0-0) 3
MA702	Design & Analysis of Experiments	(3-0-0) 3

Mandatory Learning Courses (MLC)

MT890	Seminar	2
MT891/ MT897	Practical Training/Minor Project	2

(to be completed during vacation between 2nd & 3rd Sem.)

Major Project (MP)

MT898	Major Project (3rd Sem.)	4
MT899	Major Project (4th Sem.)	8

M. Tech. in Process Metallurgy

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	MT700	MT713	MT851/ MT852	MT859
2	MT701	MT850	MT858	
3	MT710	Elective 1		
4	MT711	Elective 2		
5	MT712	Elective 3		
6	MT705	Elective 4		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	26
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	54

Programme Core (Pc)

MT700	Foundations of Physical Metallurgy	(3-1-0) 4
MT701	Materials Characterisation	(3-1-0) 4
MT705	Materials Laboratory	(0-0-3) 2
MT710	Advances in Iron Making	(3-1-0) 4
MT711	Thermodynamics of Materials	(3-1-0) 4
MT712	Momentum &Thermal Transport Phenomena	(3-1-0) 4
MT713	Mass Transfer and Metallurgical Kinetics	(3-1-0) 4

Elective Courses (Ele)

MA702	Design & Analysis of Experiments	(3-0-0) 3
MT811	Advanced Welding Technology	(3-0-0) 3
MT812	Corrosion Engineering	(3-0-0) 3
MT813	Advances in Steel Making	(3-0-0) 3
MT814	Mechanical Processing of Steel	(3-0-0) 3
MT815	Solidification and Casting	(3-0-0) 3
MT816	Advanced non-ferrous Extractive Metallurgy	(3-0-0) 3
MT817	Advanced Mineral Processing	(3-0-0) 3

Mandatory Learning Courses (MLC)

MT850	Seminar	2
MT851/ MT852	Practical Training /Minor Project	2

(to be completed during vacation between 2nd & 3rd sem)

Major Project (MP)

MT858	Major Project (3rd sem)	4
MT859	Major Project (4th sem)	8

M. Tech. in Nanotechnology

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	MT700	MT723	MT871	MT879
2	MT701	MT870	MT878	
3	MT702	Elective 1		
4	MT721	Elective 2		
5	MT722	Elective 3		
6	MT705	Elective 4		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	28
Elective Courses (Ele.)	9
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	53

Programme Core (Pc)

MT700	Foundations of Physical Metallurgy	(3-1-0) 4
MT701	Materials Characterisation	(3-1-0) 4
MT702	Thermodynamics of Solids	(3-1-0) 4
MT705	Materials Laboratory	(0-0-3) 2
MT721	Introduction to Nanoscience & Nanotechnology	(3-1-0) 4
MT722	Quantum Theory of Nanoscale Materials	(3-1-0) 4
MT723	Synthesis Techniques for Nanomaterials	(3-1-0) 4
MT724	Nanomaterials Synthesis and Characterization V	(0-0-3) 2

Elective Courses (Ele)

MA702	Design & Analysis of Experiments	(3-0-0) 3
MT821	Nanophotonics	(3-0-0) 3
MT822	Nanoelectronics	(3-0-0) 3
MT823	Surface Phenomena	(3-0-0) 3
MT824	Carbon Nano Structures &Applications	(3-0-0) 3
MT825	Nano Biotechnology	(3-0-0) 3
MT826	Polymer Nanotechnology	(3-0-0) 3
MT827	Nano Composites	(3-0-0) 3
MT828	Chemistry of Nanomaterials	(3-0-0) 3
MT829	Advanced Characterization Techniques	(3-0-0) 3
MT830	Microstructure & Mechanical Properties of Nano-structures	(3- 0-0) 3
MT831	Nanomaterials for Energy Conversion	(3-0-0) 3
MT832	Integrated Microelectronic Devices	(3-0-0) 3
MT833	MEMS/NEMS Devices and Systems	(3-0-0) 3
MT834	Nanotribology	(3-0-0) 3
MT835	Computational Material Science	(3-0-0) 3

Mandatory Learning Courses (MLC)

MT870	Seminar	2
MT871	Minor Project	2

(to be completed During the vacation between 2nd & 3rd sem

Major Project (MP)

MT878	Major Project (3rd Sem.)	4
MT879	Major Project (4th Sem.)	8

M.Tech in Computational and Data Science

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	MA721	MA725	MA890	MA899
2	MA722	MA726	MA891	
3	MA723	Elective 2	MA898	
4	MA724	Elective 3		
5	Elective 1	Elective 4		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	23
Elective Courses (Ele.)	12
Mandatory Learning Courses (MLC)	4
Major Project (MP)	12
Total	51

Programme Core (Pc)

MA721	Introduction to Scalable Systems	(3-0-2) 4
MA722	Data Structures and Algorithms	(3-0-2) 4
MA723	Introduction to Data Science	(3-1-0) 4
MA724	Probability, Statistics and Stochastic Processes	(3-0-0) 3
MA725	Numerical Methods	(3-1-0) 4
MA726	Machine Learning	(3-0-2) 4

Elective (Ele) Courses:

MA841	Cloud Computing	(3-0-0) 3
MA842	Distributed Computing Systems	(3-0-0) 3
MA843	Advanced Database Systems	(3-0-0) 3
MA844	Advanced Data Science	(3-0-0) 3
MA845	Computational Linear Algebra	(3-0-0) 3
MA846	Image Processing	(3-0-0) 3
MA847	Soft Computing	(3-0-0) 3
MA848	Combinatorial Optimization	(3-0-0) 3
MA849	Number Theory and Cryptography	(3-0-0) 3
MA850	Mathematical Modeling	(3-0-0) 3
MA851	Numerical Solutions of Differential Equations	(3-0-0) 3
MA852	Optimization Techniques	(3-0-0) 3
MA853	Pattern Recognition	(3-0-0) 3
MA854	Statistical Techniques for Data Mining	(3-0-0) 3
MA855	Big Data Analytics	(3-0-0) 3
MA856	Computer Networks	(3-0-0) 3
MA857	Software Engineering	(3-0-0) 3
MA858	Algorithmic Combinatorics	(3-0-0) 3
MA859	Selected Topics in Graph Theory	(3-0-0) 3
MA860	Systems Modeling and Simulation	(3-0-0) 3
MA861	Selected Topics in Computer Algorithms	(3-0-0) 3
MA862	Mobile Computing	(3-0-0) 3
MA863	Computational Fluid Dynamics	(3-0-0) 3
MA864	Design and Analysis of Experiments	(3-0-0) 3
MA865	Reliability Theory and Applications	(3-0-0) 3
MA866	Computational Number Theory	(3-0-0) 3
MA867	Game Theory	(3-0-0) 3
MA868	Theory of Computation	(3-0-0) 3
MA869	Network Security	(3-0-0) 3

Mandatory Learning Courses (MLC)

MA890	Seminar	2
MA891	Practical Training/ Minor Project	2

Major Project (MP)

MA898	Major Project -Phase 1	4
MA899	Major Project -Phase 2	8

Master of Computer Applications (MCA)

Suggested Plan of Study:

Sl. No.	Semester					
	I	II	III	IV	V	VI
1	MA601	MA606	MA612	MA617	Elective 5	MA699
2	MA602	MA607	MA613	MA618	Elective 6	
3	MA603	MA608	MA614	SM612	Elective 7	
4	SM703	MA609	Elective 2	MA619	Elective 8	
5	MA604	MA610	MA615	Elective 3	MA622	
6	MA605	Elective 1	MA616	Elective 4		
7	----	MA611	MA691	MA620		
8	----	MA690	----	MA621		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	64
Elective Courses (Ele.)	24
Mandatory Learning Courses (MLC)	4
Major Project (MP)	10
Total	102

Programme Core (Pc)

MA601	Problem Solving and Programming	(3-0-0) 3
MA602	Discrete Mathematical Structures	(3-0-0) 3
MA603	Computer Organization Architecture	(3-0-0) 3
MA604	Programming Lab	(0-0-3) 2
MA605	Computer Architecture Lab	(0-0-3) 2
SM703	Accounting and Financial Management	(3-0-0) 3
MA606	Data Structures and Algorithms	(3-0-0) 3
MA607	Database Management Systems	(3-0-0) 3
MA608	Computational Mathematics	(3-0-0) 3
MA609	Object Oriented Programming	(3-0-0) 3
MA610	DSA Lab using OOP concept	(0-0-3) 2
MA611	Database Management Systems Lab	(0-0-3) 2
MA612	Operating Systems	(3-0-0) 3
MA613	Software Engineering	(3-0-0) 3
MA614	Introduction to Web Technology	(3-0-0) 3
MA615	Operating Systems Lab	(0-0-3) 2
MA616	Software Engineering Lab	(0-0-3) 2
MA617	Probability and Statistics	(3-0-0) 3
MA618	Computer Graphics	(3-0-0) 3
MA619	Computer Networks	(3-0-0) 3
MA620	Computer Graphics lab	(0-0-3) 2
MA621	Networking Lab	(0-0-3) 2
SM612	Managerial Economics	(3-0-0) 3
MA622	Computer Applications Lab	(0-0-6) 3

Elective (Ele) Courses

MA641	Computer Algorithms	(3-0-0) 3
MA642	Fuzzy System Models	(3-0-0) 3
MA643	Management Information Systems	(3-0-0) 3
MA644	Operations Research	(3-0-0) 3
MA645	Optimization Techniques & Statistical Methods	(3-0-0) 3
MA646	Artificial Intelligence	(3-0-0) 3
MA647	Cloud Computing	(3-0-0) 3
MA648	Big Data Analytics	(3-0-0) 3
MA649	Machine Learning	(3-0-0) 3
MA650	Computer Simulation & Modeling	(3-0-0) 3
MA651	Genetic Algorithms	(3-0-0) 3
MA652	Knowledge Management	(3-0-0) 3
MA653	Natural Language Processing	(3-0-0) 3
MA654	Network Optimization	(3-0-0) 3
MA655	Object Oriented Analysis & Design	(3-0-0) 3
MA656	Performance Modeling	(3-0-0) 3
MA657	Stochastic & Queuing Systems	(3-0-0) 3
MA658	Unix & Network Programming	(3-0-0) 3
MA659	Advanced Client Server Computing	(3-0-0) 3
MA660	Adv Database Management Systems	(3-0-0) 3
MA661	Advanced Operating Systems	(3-0-0) 3
MA662	Cryptography & Network Security	(3-0-0) 3
MA663	Data Mining & Warehousing	(3-0-0) 3
MA664	Digital Image Processing	(3-0-0) 3
MA665	Distributed Computing Systems	(3-0-0) 3
MA666	Information & Coding Theory	(3-0-0) 3
MA667	Parallel Processing	(3-0-0) 3
MA668	Pattern Recognition & Scene Analysis	(3-0-0) 3
MA669	Web Design	(3-0-0) 3
MA670	Compiler Design	(3-0-0) 3
MA671	Theory of Computation	(3-0-0) 3
MA672	Object oriented programming with java	(3-0-0) 3
MA673	Internet Technology and Applications	(3-0-0) 3
MA674	Artificial Neural Networks	(3-0-0) 3

Mandatory Learning Courses (MLC)

MA690	Seminar 1(MLC)	2
MA691	Seminar 2 (MLC)	2

Major Project (MP)

MA699	Major Project	10

M.Sc. Chemistry

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	CY701	CY751	CY801	Elective 3
2	CY702	CY752	CY802	Elective 4
3	CY703	CY753	CY803	Elective 5
4	CY704	CY754	CY804	CY 893
5	CY705	CY755	CY805	CY 898
6	CY706	CY756	CY806	
7	CY707	Elective 1	Elective 2	
8	----	CY891	CY892	

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	54
Elective Courses (Ele.)	15
Mandatory Learning Courses (MLC)	3
Major Project (MP)	8
Total	80

Program Core Course

CY701	Analytical Chemistry	(3-0-0) 3
CY702	Inorganic Chemistry I	(3-0-0) 3
CY703	Organic Chemistry I	(3-0-0) 3
CY704	Physical Chemistry I	(3-0-0) 3
CY705	Symmetry, Group Theory and Quantum Chemistry	(3-0-0) 3
CY706	Organic Chemistry Practicals I	(0-0-6) 3
CY707	Physical Chemistry Practicals I	(0-0-4) 2
CY751	Inorganic Chemistry II	(3-0-0) 3
CY752	Organic Chemistry II	(3-0-0) 3
CY753	Physical Chemistry II	(3-0-0) 3
CY754	Spectroscopy	(3-0-0) 3
CY755	Inorganic Chemistry Practicals I	(0-0-6) 3
CY756	Physical Chemistry Practicals II	(0-0-6) 3
CY801	Inorganic Chemistry III	(3-0-0) 3
CY802	Organic Chemistry III	(3-0-3) 3
CY803	Physical Chemistry III	(3-0-3) 3
CY804	Spectroscopy Applications in Chemistry	(3-0-0) 3
CY805	Inorganic Chemistry Practicals II	(0-0-4) 2
CY806	Organic Chemistry Practicals II	(0-0-4) 2

Elective (Ele) Courses

CY861	Advanced Instrumental Methods of Analysis	(3-0-0) 3
CY862	Advanced Organic Synthesis	(3-0-0) 3
CY863	Advanced Polymer Membrane Technology	(3-0-0) 3
CY864	Applied Organic Chemistry	(3-0-0) 3
CY865	Biochemistry	(3-0-0) 3
CY866	Bio-Inorganic Chemistry	(3-0-0) 3
CY867	Bio-Physical and Photo Chemistry	(3-0-0) 3
CY868	Chemical & Electrochemical Energy Systems	(3-0-0) 3
CY869	Chemistry of Macro Molecules	(3-0-0) 3
CY870	Chemistry of Nano-materials	(3-0-0) 3
CY871	Chemistry of Natural Products	(3-0-0) 3
CY872	Computational Chemistry	(3-0-0) 3
CY873	Corrosion Science	(3-0-0) 3
CY874	Environmental Chemistry	(3-0-0) 3
CY875	Green Chemistry	(3-0-0) 3
CY876	Medicinal Chemistry	(3-0-0) 3
CY877	Modern Methods and Reagents in Organic synthesis	(3-0-0) 3
CY878	Molecular Modeling & Drug Design	(3-0-0) 3
CY879	Novel Inorganic Compounds	(3-0-0) 3
CY880	Nuclear & Radiation Chemistry	(3-0-0) 3
CY881	Organic Electronics: Materials and Applications	(3-0-0) 3
CY882	Polymer Chemistry and Catalysis	(3-0-0) 3
CY883	Solid State Chemistry	(3-0-0) 3
CY884	Supra-molecular Chemistry and Crystal Engineering	(3-0-0) 3
CY885	Surface Chemistry and Catalysis	(3-0-0) 3
CY886	Synthetic Methods in Organic Chemistry	(3-0-0) 3

Major Project (MP)

CY898	Major Project	8

Mandatory Learning courses (MLC)

CY891	Seminar 1	1
CY892	Seminar 2	1
CY893	Seminar 3	1

M.Sc in Physics

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	PH701	PH751	PH801	PH851
2	PH702	PH752	PH802	PH852
3	PH703	PH753	Elective 1	PH853
4	PH704	PH754	Elective 2	Elective 3
5	PH705	PH755	PH803	PH899
6	PH891	PH756	PH898	
7	----	PH892		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	59
Elective Courses (Ele.)	9
Mandatory Learning Courses (MLC)	4
Major Project (MP)	8
Total	80

Program Core (Pc) Courses

PH701	Mathematical Methods – 1	(3-1-0) 4
PH702	Classical Mechanics	(3-1-0) 4
PH703	Quantum Mechanics – I	(3-1-0) 4
PH704	Electronics	(3-1-0) 4
PH705	Electronics Laboratory	(0-0-3) 2
PH751	Mathematical Methods – 2	(3-1-0) 4
PH752	Quantum Mechanics – 2	(3-1-0) 4
PH753	Statistical Mechanics	(3-1-0) 4
PH754	Electromagnetic Theory	(3-1-0) 4
PH755	Computational Physics	(2-1-0) 3
PH756	Physics Laboratory – I	(0-0-3) 2
PH801	Condensed Matter Physics – 1	(3-1-0) 4
PH802	Atomic & Molecular Spectroscopy	(3-1-0) 4
PH803	Physics Laboratory – II	(0-0-3) 2
PH851	Nuclear & Particle Physics	(3-0-0) 3
PH852	Relativistic Physics	(3-0-0) 3
PH853	Condensed Matter Physics – 2	(3-1-0) 4

Electives (Ele) Courses

PH860	Vacuum Technology & Thin Films	(3-0-0) 3
PH861	Magnetism & Superconductivity	(3-0-0) 3
PH862	Lasers & Fiber Optics	(3-0-0) 3
PH863	General Theory of Relativity	(3-0-0) 3
PH864	Phys. Of Low Dimensional Syst.	(3-0-0) 3
PH865	Nanomaterials	(3-0-0) 3
PH866	Charact. Technique of Materials	(3-0-0) 3
PH867	Nonlinear Dynamics & Chaos	(3-0-0) 3
PH868	Solid State Electronic Devices	(3-0-0) 3
PH869	Computational Materials Science	(3-0-0) 3
PH870	Quantum Computation	(3-0-0) 3
PH871	Classical Field Theory	(3-0-0) 3
PH872	Cosmology	(3-0-0) 3

Mandatory Learning Courses

PH891	Seminar – 1	2
PH892	Seminar – 2	2

Major Project (MP)

PH898	M.Sc Project - I (3rd Sem)	3
PH899	M.Sc Project – II (4th Sem)	5

Master of Business Administration [MBA]

Suggested Plan of Study:

Sl. No.	Semester I	II	III	IV
1	SM711	SM721	SM731	SM741
2	SM712	SM722	SM732	Elective 5
3	SM713	SM723	SM733	Elective 6
4	SM714	SM724	Elective 1	Elective 7
5	MA715	SM725	Elective 2	Elective 8
6	SM716	SM726	Elective 3	SM748
7	SM718	SM727	Elective 4	
8	SM719	SM729	SM738	
9	----	----	SM739	

Credit Requirements

Category	Minimum Credits to be Earned
Foundation Courses	>= 23
Functional Courses	>= 29
Elective Courses	>= 24
Mandatory Learning Courses (MLC)	3
Term Paper	3
Summer Internship Project	8
Total	90

Foundation Courses

SM711	Research Methodology	(3-0-0) 3
SM712	Organization Behavior	(3-0-0) 3
SM713	Financial Accounting	(3-0-0) 3
SM714	Managerial Economics	(3-0-0) 3
MA715	Statistics for Business Management	(3-0-0) 3
SM716	Corporate Communication	(3-0-0) 3
SM718	Spreadsheet Modeling for Business	(2-0-2) 2
SM741	Ethics and Sustainability	(3-0-0) 3

Functional Courses

SM721	Managerial Accounting	(3-0-0) 3
SM722	Marketing Management	(3-0-0) 3
SM723	Entrepreneurship	(3-0-0) 3
SM724	Operations Management	(3-0-0) 3
SM725	Financial Management	(3-0-0) 3
SM726	Human Resource Management	(3-0-0) 3
SM727	Business Analytics and Decision Making	(3-0-0) 3
SM731	Strategic Management	(3-0-0) 3
SM732	Corporate Information System	(3-0-0) 3
SM733	Legal Environment	(2-0-0) 2

Mandatory Learning Courses (MLC)

SM719	Seminar	1
SM729	Seminar	1
SM739	Seminar	1

Project

SM738	Summer Internship Project	8
SM748	Term Paper	(0-1-2) 3

Note: Students shall select total 3 electives for third and fourth semester from any one group of specialization out of the five groups : Human Resources; Marketing; Finance; Operations; Analytics. Remaining 5 electives shall be selected from any group other than the specialization subject to a maximum of 2 electives in any group of specialization

Elective Courses

Group 1 : Human Resource Management

SM811	Organization Development and Management of Change	(3-0-0)3
SM812	Industrial Relations	(3-0-0) 3
SM813	Compensation Management	(3-0-0) 3
SM814	Training & Development	(3-0-0) 3
SM815	Performance Management	(3-0-0) 3
SM816	Multicultural Workforce Management	(3-0-0) 3

Group 2 : Marketing

SM819	Marketing Metrics	(3-0-0) 3
SM820	Digital Marketing	(3-0-0) 3
SM821	Marketing Communication	(3-0-0) 3
SM822	Business-To-Business Marketing	(3-0-0) 3
SM823	Brand Management	(3-0-0) 3
SM824	Consumer Behaviour	(3-0-0) 3
SM825	Marketing Research	(3-0-0) 3
SM826	Retail Marketing	(3-0-0) 3
SM827	Rural Marketing	(3-0-0) 3
SM828	Sales and Distribution Management	(3-0-0) 3
SM829	Services Marketing	(3-0-0) 3
SM830	International Marketing	(3-0-0) 3

Group 3 : Finance

SM831	International Financial Management	(3-0-0) 3
SM832	Banking, Financial Services and Insurance	(3-0-0) 3
SM833	Financial Derivatives	(3-0-0) 3
SM834	Corporate Finance	(3-0-0) 3
SM835	Financial Risk Management	(3-0-0) 3
SM836	Security Analysis & Portfolio Management	(3-0-0) 3
SM837	Merger and Acquisitions	(3-0-0) 3

Group 4 : Operations

SM841	Service Operations	(3-0-0) 3
SM842	Operations Strategy	(3-0-0) 3
SM843	Project Management	(3-0-0) 3
SM844	Six Sigma	(3-0-0) 3
SM845	Materials Management	(3-0-0) 3
SM846	Supply Chain Management	(3-0-0) 3

Group 5 : Analytics

SM851	Customer Relationship Management	(3-0-0) 3
SM852	System Thinking and Strategic Modeling	(3-0-0) 3
SM853	Enterprise Resource Planning	(3-0-0) 3
SM854	Product Pricing	(3-0-0) 3
SM855	Forecasting Models	(3-0-0) 3
SM856	Introduction to Management Science and Big Data	(3-0-0) 3
SM857	HR Analytics	(3-0-0) 3
SM858	Marketing Analytics	(3-0-0) 3
SM859	Machine Learning for Business Management	(3-0-0) 3
SM860	Data Analytics: Business Decision Making	(3-0-0) 3

Group G : General Electives

SM861	Business Process Design and Reengineering	(3-0-0) 3
SM862	Contemporary Issues in Management	(3-0-0) 3
SM863	Economic Environment & Policy	(3-0-0) 3
SM864	International Business Management	(3-0-0) 3
SM865	Enterprise Risk Management (ERM)	(3-0-0) 3
SM867	Sustainable Management of Environmental Resources	(3-0-0) 3
SM868	Management Control System	(3-0-0) 3
SM870	Services Management	(3-0-0) 3

COURSE CONTENTS - PG&R

DEPARTMENT OF WATER RESOURCES & OCEAN ENGINEERING

WO701 Wave Hydrodynamics **(3-0-0) 3**

General meteorology, Dynamic coastal environment, wave generation theories, statistical and spectral analysis of waves, directional spectrum, wave forecasting and hindcasting, small and finite amplitude wave theories, tsunami waves, wave transformations.

Ippen A.T., Estuary and Coastline Wave Hydrodynamics, McGraw-Hill Book Company, 1966 Bendat and Piersol, Random Data Analysis and Measurement Techniques, 4th edition, Wiley, 2010

Dalrymple. D.N.. Water Wave Mechanics for Scientists and Engineers, 2nd Edition, World scientific publishing company, 1991

Kanphuis A., Introduction to coastal Engineering and Management, 2nd Edition, World scientific publishing company, 2010

WO702 Coastal and Ocean Engineering **(3-0-0) 3**

Properties of seawater, coastal resources and hazards, oceanographic instruments, types of ocean currents, tides and tide producing forces, oceanography of east and west coast of India, coastal processes, coastal features, sediment transport, coastal engineering problems, solutions, coastal zone management.

George L. Pickard and W.J.Emery- Descriptive physical Oceanography, 5th edition, Pergamon Press, 1990

Gross HG and E. Gross, Ocenography on view of Earth, Prentice Hall, New Jersey, USA, 1972.

Komar P.D., Beach processes and sedimentation, 2nd edition, Prentice Hall, 1998

Horikawa. K An .Introduction to coastal engineering,University of Tokyo Press, 1978

Pinet, PR, Invitation to oceanography, Jones and Bartlett Pub., Boston, USA, 2009

Richard Silvestor., Coastal Engineering, Vol.2, Elsevier Scientific Publishing Company, 1974

Robert L. Weigel., Oceanographical Engineering, Dover publications, 2013

WO703 Marine Geotechnical Engineering **(3-0-0) 3**

Subsurface and Sub-Marine Explorations for On-Shore and Offshore structures: General planning of soil investigation programme, Boring and sampling in marine deposits. Mineralogy, and Chemistry of Marine Sediments:Morphology and genesis of marine sediments. Origin of clay minerals and their identification by the use of DTA. Xray diffraction. and Electron microscope methods Engineering properties of Marine Sediments General failure theories - Lateral earth pressure - Rankine and Coulomb theories, Bearing capacity of deep and shallow foundations, Slope stability analysis.

Hsai Yang Fang, Foundation Engineering hand book, 2nd Edition, Springer science + Business Media, 2013

Tirant. P .L., Sea bed reconnaissance and offshore soil mechanics for installation of petroleum structures., Imprimerie Louis-jean, 1979

Ardus. D.A., Offshore Site Investigation, Vol.3, Society for Underwater Technology, 1985

WO704 Marine Structures and Instrumentation Lab **(0-0-3) 2**

Experiments on hydrodynamics and structural applications using transducers

WO705 Wave Mechanics and MarineGeotechnical Lab **(0-0-3) 2**

Experiments using wave flume and marine soils

WO706 Port Engineering **(3-0-0) 3**

Economic importance, waterway transport, port development, classification of ports, traffic and hinterland studies, site investigation, queuing theory and its application, preparation of master plan for ports. Design and planning of bulk, passenger, fishery, containers, dry and liquid bulk terminals, cargo handling facilities. Harbour tranquility, siltation in harbours. Fundamentals of dredging and dredging execution.

Ernst G. Frankel, Port Planning and Development, John Wiley & Sons, USA, 1987.

UNCTAD Manual, Port Development, A Hand Book for Planner in Developing Countries, United Nations Publications, 1985

Per Bruun, Port Engineering Vol. I & II, 3rd Edition, Gulf Pub .Co, 1981 Hans Agerchou et.al., Design of Marine Terminals, PIANC publications, 1983

WO707Analysis and Design of Marine Structures **(3-0-0) 3**

Introduction - Design principles - Functional design - safety factors, General code provisions, Breakwaters, factors

determining their selection. Rubble mound breakwaters - Design factors - Hydraulics of cover layer design. Design of structure cross section - stability of foundations. Vertical wall breakwaters - Types - Design factors .pile breakwaters, tandem breakwater and floating breakwaters and structures. Coastal protection measures against tsunami. Wharves, Piers, Bulkheads, Dolphins and Moorings - Types and factors controlling selection of type, Design considerations -Design of piled jetties and dolphins - mooring forces- Dock fenders. Dry docks, types of dock walls and floors – design factors.
US Army Corps of Engineers - Shore Protection Manual - 1984, C.E.M. - 2001
De F. Quinn - Design of Ports and Harbour Structures, 2nd Edotion, Mcgraw-Hill Inc, 1972 Per Bruun, Port Engineering Vol. I, II, &III, 3rd Edition, Gulf Pub .Co, 1981.
Pilarczyk and & Zeidler - Offshore Breakwaters and Shoreline Control, A.A.Balkema Publishers, 1996 John Herbich - Hand Book of Coastal & Ocean Engg. Vol. I, II, III.Gulf Pub. Co., 1990
Goda Y., Random Seas & Design of Marine Structures. 3rd Edition, World Scientific, 1985

WO708 Offshore Engineering (3-0-0) 3
The Ocean environment -Waves, Currents, Winds, Sea bed Geology, Earthquakes, Floating ice. Common Structural Systems - Jacket or Tension leg structures, Tower, Caissons, Concrete gravity platforms, Steel, Gravity platforms, FPSO spar platforms, Hybrids, Compliant structures, factors governing selection. Hydrodynamic loading of large offshore structures - Diffraction theory - Regions of validity - Application - Linear dynamic analysis. Foundations of offshore structures - Pile foundations, Prediction of axial pile capacity, Bearing capacity of footings, settlement of foundations. Offshore construction - Drilling techniques, logging methods, location of drill sites, Completion of walls, Marine survey, Welding, Checks on welding and codes, Corrosion and its prevention measures.
Dawson. T.H.- Offshore Structural Engineering, Prentice-Hall, 1983
Det Norske Veritas, Rules for the Design, Construction and Inspection of Fixed Offshore Structure, DNV, 1974.
American Petroleum Institute, Recommended practice for Planning, Designing, and Construction of Fixed Offshore Structures-1986
Sarpakaya & Issacson, Fluid loading on structures, Van Nostrand Reinhold Co., 1981.

WO709 Computational Hydrodynamics Lab (0-0-3) 2
Numerical simulation using open source software

WO801 Coastal Erosion and its Mitigation (3-0-0) 3
Origin of Coasts, Sediment Transport and Budgeting, Coastal Erosion and Mitigation: Global Scenario and Indian Perspective, Coastal Processes, Planning and Design of Coastal Protection Works, Soft and Hard Options, Innovative Technologies, Performance of Coastal Protection Works in India, Coastal Zone Regulation, Integrated Coastal Zone Management, Coastal Pollution and Environmental Impact Assessment.
Bruun, P., Port Engineering, Vol. I &II, Gulf Pub .Co, 1981.
Shore Protection Manual, U.S.Army Corps of Engineers, Coastal Engineering Research Center, U.S.Govt. Printing office,Washington D.C., Vol. 1 & 2. 1984.
Ippen A.T., Estuary and Coast line Hydrodynamics McGraw Hill, 1966.

WO802 Geo-informatics Applications in Coastal Engineering (3-0-0) 3
The electromagnetic spectrum and atmospheric considerations, Spectral Characteristics, Sensors and platforms, Data Products, Image Interpretation and Analysis. GIS and GPS, Applications: Shore line change, Erosion, accretion area identification, Port Planning, Ocean Temperature Mapping, Ship routing.
Mischael Hord, "Remote Sensing Methods and Applications", John Wiley & Sons, New York, 1986.
Lillesand, T.M., R.W. Kiefer, and J.W. Chipman. 2004. Remote Sensing and Image Interpretation. 5th Edition,John Wiley & Sons.
Sabins, F.J. Jr. Remote Sensing: Principles and Interpretation. Third Edition. W.H. Freeman and Company, New York. 1996.
John R Jensen, Remote Sensing of the Environment An Earth Resource Perspective 2nd Edition, Dorling Kindersley India Pvt Ltd
Srinivas M.G. (Edited by), Remote Sensing Applications, Narosa Publishing House, 2001.

WO803 Numerical Methods for Civil Engineering Applications (3-0-0) 3
Numerical Solution of Non-linear Equations: Method of Bisection; Regula Falsi method; Secant method; Newton-Raphson Method; Fixed Point of a Function; Generalised Newton Raphson Method. Approximation of Functions;

Numerical Differentiation: Richardson's Extrapolation Method; Approximation Formulas for Higher Order Derivatives. Numerical Integration: Newton-Cotes Rules; Compound Quadrature Rules; Gauss Legendre Rules; Approximate Evaluation of Double Integrals. Numerical Solution of Differential Equations: Euler's method; Modified Euler method; Runge-Kutta Methods; System of Linear Equations*:* Direct methods; Iterative methods. Application: Case studies

S.C. Chapra and R.P. Canale, 2013. Numerical Methods for Engineers, McGraw Hill.
R.L Burden and J.D. Faires, 2011. Numerical Analysis, Clengage Learning, USA.
K. Atkinson, AN 1989. Introduction to Numerical Analysis, John Wiley & Sons, USA.
M.K. Jain, S.R.K. Iyengar and R.K. Jain, 1985.Numerical methods for Scientific and Engineering Computation, Wiley Eastern.
C.G. Koutitas & P.D. Scarlatos,2016. Computational Modelling in Hydraulic and Coastal Engineering, CRC Press, Taylor & Francis Group.

WO804 Foundation of Marine Structures (3-0-0) 3

Soil structure interaction: Critical study of conventional methods of foundation design, Nature and complexities, advance techniques of analysis, relaxation and iteration for the evaluation of soil structure interaction for different types of structures under various types of loads and subsoil characteristics. Design of combined footing using soil structure interaction. Analysis and design of pile foundations, bored piles, technique of offshore piling for various types of structures, pile behaviour under cyclic lateral loads, development of p-y curves etc. Analysis and Design of Caissons & Well foundations.

Bowles J.E., Foundation analysis and design, 5th Edition, The McGraw-Hill Co., 1974.
Polous & Davis, Pile foundation, Rainbow-Bridge Book Co., 1980
Winter Korn and Fang, Foundation Engineering hand book, 2nd Edition, Van Nostrand Reinhold, 1990

WO805 Sedimentation and Dredging (3-0-0) 3

Introduction: Port structures, dredging overview, environmental aspects, Geotechnical Information: Classificationof soils and rocks, Geotechnical investigation for field test, Principle & methodology of dredging: Dredging process pretreatment, type of dredgers selection of dredgers, Dredging in Indian context, Drilling & Blasting environmental impact. Design of dredging works, Dredging for navigation improvement, fill material, channel design &maintenance. Performance of dredging plant: Description and method of operation, production cycle and ancillary equipment for some important types of dredging and estimating their output. Use and disposal of dredged material: Reclamation fill, beach nourishment, disposal at sea, onshore disposal. Dredging costs and prices: Mobilization anddemobilization, capital costs, running costs, building up a cost estimate.

Bray RN, Bates AD, Land J M - Dredging - A Hand book for Engineers - Published by Arnold London, 1997.
Solsbey, Dynamics of Marine Sciences.
Related studies in Journal of Indian Ports
Related studies in Dredging - Journals

WO806 Integrated Coastal Zone Management (3-0-0) 3

Estuaries - Classification, circulation pattern and sedimentation, determination of sediment yield from streams. Salt water intrusion. Marine environment pollution: Pollution of estuaries and seas and its implementations. Coastal erosion: Introduction, magnitude, consequences. Soft and hard options: various hard and soft options of coastal erosion mitigation. Innovative methods. Performance of hard and soft options. Environmental impact assessment of various mitigation measures, remedies. Coastal Zone Management: Principle, CRZ act, sustainable development, integrated CZM, issues, constraints. Implementation of ICZM: world scenario, Indian scenario - case studies. Riskanalysis of coastal structures, Socio economic analysis, tourism. Territorial water, EEZ and contiguous zone. Living and non-living resources. Application of RS and GIS in ICZM.

Fleming. C.A., Coastal Management, Putting policy into practice, Thomas Telford, London, 1996.
Mce Barett, Coastal Zone Planning and Management, Thomas Telford, London 1992.
Barret.M.G., Coastal Management, Thomas Telford , London 1989.

WO807 Marine Project Management (3-0-0) 3

Project-definition, characteristics, life cycle phases, types. PER, TEFR and DPR. Project Economic and profitability analyses. Project Organisation, Work breakdown structure, Contracts, Disputes, Arbitration. Planning tools – Bar charts, Network analysis - Pert & CPM. Resources allocation, materials management and inventory control, equipment management, Decision analysis, EIA of projects. Special Construction Methods, Maintenance of Marine

Structures, Corrosion and its prevention measures, Engineering & Economics.
Chaudhary. S., Project Management, Tata McGraw - Hill, 1988.
Roy. P. K., Total Project Management, Mcmillan India Limited, 1994.
Chandra. P., Projects:Planning, Analysis, Selection, Financing, Implementation, and Review, Tata McGraw - Hill, 2014

WO808 Coastal Disaster Management and Mitigation (3-0-0) 3
Types of Disasters, Earthquake, tsunami, flood, landslide, cyclones, forest fire, draught, coastal hazards, pollution, oils spill, erosion, Impact of Disasters, Forecasting, Role of Remote Sensing and Geographical Information System in Disaster Management, Vulnerability, Disaster Reduction Strategies and contingency planning, Multi Hazard Mapping, Financial Management, Losses from Global Disasters and Expenses in Reconstruction and Retrofitting of Structures, Role of NGOs, Government Bodies and Public, Social and Economic Development of Disaster Prone areas.
Proceedings of World Congress on Disaster Mitigation and Management, Inst. Engrs (India), New Delhi, 2004
Report on Disaster Management Planning, NMPT, 2001.
Related studies in Journal paper

WO809 Reliability analysis of Marine Structures (3-0-0) 3
Concepts of structural safety; Basic statistics and probability; Resistance parameters and distributions; Probabilistic analysis of loads, live load and wind load; Determination of reliability; Monte Carlo study of structural safety; Level 2 reliability methods including advanced level 2 method; Reliability analysis of components; Reliability based design, determination of partial safety factors, code calibration; Reliability of structural systems; Applications to steel and concrete structures; Offshore structures etc.
Palle Thoft Christensen and M.J. Baker, Structural Reliability Theory and its Application, Springer-Verlag,1982.
Melchers. R.E., Structural Reliability Analysis and Prediction, Ellis Horwood, Chisester, England, 1987.
Ang. A.H.S. and. Tang. W.H, Probability Concepts in Engineering Planning and Design, Vol. II, John Wiley, New York, 1984.
Palle Thoft Cristensen and Murotsu. Y., Applications of Structural Systems Reliability Theory, Springer-Verlag, Berlin, 1986.

WO810 Applied Elasticity (3–0–0) 3
Saint Venant’s principle - Principal Stresses, Stress Ellipsoid - Stress invariants. Airy’s stress function, Bi-harmonic equations, Polynomial solutions, Simple two-dimensional problems in Cartesian coordinates like bending of cantilever and simply supported beams. Equations of equilibrium, Strain - displacement relations, Stress – strain relations, Airy’s stress function, Axi – symmetric problems, Introduction to Dunder’s table, Curved beam analysis, Kirsch, Michell’s and Boussinesque problems – Rotating discs. Navier’s theory, St. Venant ’s theory, Prandtl’s theory on torsion, semiinverse method and applications to shafts of circular, elliptical, equilateral triangular and rectangular sections.
Timoshenko, S., and Goodier, T.N., Theory of Elasticity, McGraw – Hill Ltd., Tokyo, 1990. Bhaskar, K., and Varadan, T. K., Theory of Isotropic/Orthotropic Elasticity, CRC Press USA, 2009. Barber, J. R., Elasiticity, Kluwer Academic Publishers, 2004

WO811 Numerical Modelling of Coastal Processes (3-0-0) 3
Numerical Solution of Ordinary Differential Equations and Partial Differential Equations: Finite Difference Approach; Boundary Element Method. Sediment Transport Phenomenon: Physical Properties of Fluid and Sediments; Hydrodynamic Principle; Boundary Layer; Hydrodynamic Drag and Lift on Particle; Numerical Modelling of Sediment Transport; Long Wave Theory and Applications; Boussinesq Approximation; Mild-slope Approximation; Wavemaker Theory; Spectral and Statistical Analysis of Random Waves; Wave Forces on Offshore Structures; Modelling of Wave Energy Conversion Device; Computer Programming
C.G. Koutitas & P.D. Scarlatos, 2016. Computational Modelling in Hydraulic and Coastal Engineering, CRC Press, Taylor & Francis Group.
Horikawa K., 1978. Coastal Engineering: An Introduction to Ocean Engineering, University of Tokyo Press.
S. Dey, 2014. Fluvial Hydrodynamics: Hydrodynamic and Sediment Transport Phenomena, Springer-Verlag.
P.K. Banerjee, 1994. The Boundary Element Methods in Engineering, Mc-Graw Hill Book Company, London.
M.W. Dingemans, 1997. Water Wave Propagation over Uneven Bottom: Linear Wave Propagation, Part 1&II, World Scientific, Singapore.

WO812 Finite Element Method and Applications **(3-0-0) 3**
Direct approach. Basic structural elements. Plane elasticity problems. Galerkin weighted residual approach. Element properties. Linear and quadratic elements. Lagrange and Hermite shape functions. Isoparametric elements. Numerical integration using Newton-Cotes quadratures and Gauss-Legender quadratures. Finite element applications - case studies
Segerlind. L.T., Applied Finite Element Analysis, John-Wiley and Sons 1976
Reddy. J.N. An Introduction to the Finite Element Method, McGraw-Hill Book Company, 2006.

WO813 Approximate Methods in Structural Mechanics **(3–0–0) 3**
Introduction, Weighted residual methods: Least square method, collocation method, subdomain method, method of moments, basic Galerkin form and modified Galerkin form. Variational method: Elementary study on calculus of variation, Rayleigh Ritz method (strain energy method). Application to statically determinate and indeterminate structures, Free vibration and stability analysis. Improvement of solution accuracy. Application to statically determinate and indeterminate structures: Free vibration and stability analysis. Various matrix methods; Code generation for structural mechanics problems using approximate methods.
Reddy, J. N., An Introduction to the Finite Element Method, McGraw-Hill, 2004.
Asghar Bhatti, M., Fundamental Finite Element Analysis and Applications: with Mathematica and MATLAB Computations, John Wiley & Sons Inc, 2005.
Tauchert, T.R., Energy Principles in Structural Mechanics, McGraw Hill,International Student Edition, 1989.

WO814 Thin Walled Structures **(3–0–0) 3**
Bending of symmetric beams subject to skew loads - bending stresses in beams of unsymmetrical sections – generalized 'k' method, neutral axis method, principal axis method. Thin walled beams – concept of shear flow – the shear centre and its determination – shear flow distribution in symmetrical and unsymmetrical thin-walled sections – structural idealization – shear flow variation in idealized sections. Bredt - Batho theory – single-cell and multi-cell tubes subject to torsion – shear flow distribution in thin-walled single & multi-cell structures subject to combined bending torsion –with walls effective and ineffective in bending – shear centre of closed sections. Bending of thin plates – rectangular sheets under compression - local buckling stress of thin walled sections – crippling strength estimation – thin-walled column strength – load carrying capacity of sheet stiffener panels – effective width.
Megson T M G , 'Aircraft Structures for Engineering Students', Elsevier Ltd, 2007 Peery, D.J., and Azar, J.J.,' Aircraft Structures', 2nd edition, McGraw – Hill, N.Y., 1999 Howard D Curtis, 'Fundamentals of Aircraft Structural Analysis', WCB-McGraw Hill, 1997

WO815 Experimental Methods in Stress Analysis **(3–0–0) 3**
Principles of measurements, Accuracy, Sensitivity and range of measurements, Mechanical, Optical, Acoustical and Electrical extensometers and their uses, Advantages and disadvantages, Capacitance gauges, Laser displacement sensors. Principle of operation and requirements, Types and their uses, Materials for strain gauges, Calibration and temperature compensation, cross sensitivity, Wheatstone bridge and potentiometer circuits for static and dynamic strain measurements, strain indicators, Rosette analysis, stress gauges, load cells. Two dimensional photo elasticity, Photo elastic materials, Concept of light - photoelastic effects, stress optic law, Transmission and Reflection polariscopes, calibration of photoelastic materials, Interpretation of fringe pattern, Compensation and separation techniques, calibration of photoelastic materials, Introduction to three dimensional photo elasticity. Introduction to Moiré techniques, Brittle coating methods and Holography.
Dally, J.W., and Riley, W.F., Experimental Stress Analysis, McGraw Hill Inc., New York 1998.
Hetenyi, M., Hand book of Experimental Stress Analysis, John Wiley and Sons Inc., New York, 1972.
Ramesh, K., Digital Photoelasticity, Springer, New York, 2000.

WO816 Coastal Environmental Management **(3-0-0) 3**
Pollution of Ocean Environment –Discharges from ships and offshore platforms, Pollution of coastal waters – discharge from industries, revering discharge and dredging; Pollution of Port waters – ballast water, ships discharge, cargo discharge (oil and ore); Environmental problems due to maritime construction on near shore areas, dismantling of maritime structures and ships; Occupational health and hazards. IMO and regulatory mechanism to check pollution; Quality systems for environmental control; Environmental maneuvering, maritime laws. Coastal erosion and related issues. Mangroves and its management. Application of RS and GIS in managing coastal pollution.
North K., Environmental Management, Second Rvised Edition, International Labour Office, Geneva, 1997 Sapru R.K., Environmental Management in India, Ashish Publishers, New Delhi, 1987. Weber W. Jr., Environmental

Systems and Processes, Wiley Interscience, 2001.

WO817 Nonlinear Problems in Ocean Engineering (3-0-0) 3

Conservative and non-conservative systems, Quadratic and cubic nonlinearities, Nonlinear damping, Forced oscillations, Sub and Super harmonic responses, Parametrically excited systems, Chaotic motion, System identification. Nonlinear wave theories and wave loading, Nonlinear models of compliant platforms and soil-structure interaction, Risers and moorings, Nonlinear wave loading on large floating systems, Slow drift oscillation, Random response and statistical analysis.

Ali H. Nayfeh, and Dean T. Mook, Nonlinear Oscillations, John Wiley, 1995
Subrata K.Chakrabarti, Handbook of Offshore Engineering, Elsevier, 2005
Y.Goda, Random seas and design of marine structure, 3rd Edition, World Scientific, 2010

WO818 Mechanics of Floating Bodies (3-0-0) 3

Statics: Fluid pressure and centre of pressure – estimation of weight and centre of gravity – conditions of equilibrium –definition of meta-centre – hydrostatic particulars – stability at small angles of inclinations – problems of heel and trim-free surface effect – inclining experiment – stability at large angles. Dynamics: Equations of motion for SDOF systems, time and frequency domain solutions – oscillations of floating bodies, added mass and moment of inertia, and hydrodynamic damping – Exciting forces and moments due to waves – Strip theory for slender bodies – Introduction to random response theory – Random response of linear systems under wave loading, General motion analysis of floating bodies, time and frequency domain approaches.

C.B.Barrass and C.R.Derrett, Ship stability for Masters and Mates, Butterworth – Heinemann, 2012
Edward V. Lewis, Principles of Naval Architecture: Stability and Strength, Society of Naval Architects and Marine Engineers, 1989
Eric C.Tupper, Introduction to Naval Architecture,5th Edition, Butterworth – Heinemann,2013. Rameswar Bhattacharyya, Dynamics of Marine Vehicles, John Wiley, 1978

WO819 Hydroelasticity (3-0-0) 3

Introduction to Hydrodynamics and Structural mechanics; Unsteady hydro elasticity problems; Hull and its structural dynamic behaviour; Wave forces; Response of VLFS to waves; Statistical analysis of ship response - Flow-induced vibration; Transient loading seaquakes and Tsunamis; Analysis of floating structures on fluid base-stationary loads; Moving loads and critical speed. Fluid structure interaction-structures in steady flow and structures in waves; Structural damping; Numerical methods associated with hydro elasticity problems - mode matching method, conjugate gradient method, finite element and boundary element methods; Application of hydro elasticity - Sloshing in vertical caisson, hydro elasticity of multimodal structures, wave ice interaction and wave interaction with floating and submerged structures, high speed vessel, very large hinged vessels, array of elastically connected cylinders, risers and pipelines.

R.E.D.Bishop and W.G.Price, "Hydroelasticity of ships"; Cambridge University Press, 1979. S.K.Chakrabarti and C.A.Brebbia, "Fluid structure interaction", Southampton; Boston: WIT Press, 2001. S.K.Chakrabarti and C.A.Brebbia, "Fluid structure interaction and moving boundary problems IV", Southampton: WIT Press, 2007.
S.K. Chakrabarti, "Handbook of offshore engineering", Amsterdam; London: Elsevier, 2005.

WO820 Offshore Renewable Energy (3-0-0) 3

Wave Energy: Description of wave oscillation; Wave power and energy transport; Resonance absorption; Wave transport of energy and momentum; Description and operation of various wave energy converters for inshore and offshore application; Design of wave environment; Maximum power absorption from ocean waves, Hydrodynamic characteristics of wave energy converters, Response of floating structures; Time and frequency domain numerical methods. Wind Energy: Design of offshore wind turbines; Design of wind environment; Aerodynamic characteristics of wind turbines; Aerofoil theory; Boundary element method; Momentum method; Boundary element momentum method. Tidal Energy: Current stream devices; Barrage systems hydrodynamics characteristics of tidal devices; Wave and current effects. Energy storage: Transmission and distribution issues and solutions.

Joao Cruz, "*Ocean Wave Energy: Current Status and Future Perspectives", Springer Verlag, 2007.*
Johannes Falnes, "Ocean Waves and Oscillating Systems", Cambridge University Press, 2002.
John Twidell and Gaetano Gaudiosi, "Offshore Wind Power", Multi-Science Publishing Co-Ltd, UK, 2009.
Wei Tong, "Wind power generation and wind turbine design", WIT Press, 2010.
R.H. Charlier, *C.W.* Finkl., *"Ocean Energy: Tide and Tidal Power", Springer Verlag, 2009.*

WO821 Computational Marine Hydrodynamics (3-0-0) 3

Averaged Navier-Stokes Equations; Euler's Equation; Bernoulli Theorems for Inviscid Flow; Vorticity Dynamics and Kelvin's Circulation Theorem; Potential Flows; Green Functions, Green's Theorem and Boundary Integral Equations; Froude-Krylov Surge Force on a Ship; Numerical Methods for Scientific Computation; Finite Difference Method; Two Dimensional Panel Methods; Sea Spectra; Fourier Transforms; Computational FFT and IFFT of Real Numbers; Simulation of Random Waves; Potentials and Boundary Conditions; Simulations of Ship Motions in Random Seas.

Hans-Gerhard Ramming, Numerical Modelling of Marine Hydrodynamics: Applications to Dynamic Physical Processes, Elsevier, 2000.
O.M Faltinsen, Sea Loads on Ships and Offshore Structures, Cambridge University Press, 1990.
Whitham, G.B. Linear and Nonlinear Waves, John Wiley & Sons, 1974.
Kendall E. Atkinson, An Introduction to Numerical Analysis, *John Wiley & Sons*, 2008.

WO822 Foundation for Offshore Structures (3-0-0) 3

Basic soil properties, Pile foundation, lateral load on piles, p -y, t-z and q-z curves, pile group effect, scour around piles, Seabed subsidence and design of piles against seabed movement, negative skin friction, cyclic degradation, main pile to jacket connections, skirt pile to jacket connections, API RP 2A provisions. Pile installation: Minimum pile wall thickness, pile handling stresses, static and dynamic stresses, pile stick up, stresses during stick up, wave and current loads, hammer selection, pile driving stresses, wave equation analysis, pile driving fatigue, API RP 2A provisions. Pile Testing: Working load test, ultimate load test, pile monitoring during driving, pile integrity Testing, high strain dynamic testing, rebound method. Special foundations: Mud-mats: bearing capacity, sliding stability, overturning stability, short term and long Term settlements, factor of safety, bucket foundation, suction anchors, gravity foundation. Use of SACS software in the analysis and design.

Bowles, J.E.,2001. Foundation analysis and design, McGraw Hill.
Poulos, H.G and Davis, E.H., 1980. Pile Foundation Analysis and Design, John Wiley.
Winter Korn and Fang, 2001. Foundation Engineering hand book
Prakash S., 1981. Soil Dynamics, McGraw Hill.
API Recommended practice, 2000. 2A-WSD (RP 2A-WSD), API Recommended practice, 2000. 2A-WSD (RP 2A-LRFD)

WO823 Design of Offshore Structures (3-0-0) 3

Loads on Offshore Structures, Design Wave heights and Spectral Definition; Hydrodynamic Coefficients and Marine growth; Fatigue Load Definition and Joint Probability distribution; Seismic Loads. Concepts of Fixed Platform Jacket and Deck, In -service and Pre-service Loads and analysis. Steel Tubular Member Design: Principles of WSD and LRFD, Tubular Members, Slenderness effects; Column Buckling, Design for Hydrostatic pressure; Design for combined axial and bending stresses (API RP 2A guidelines). Tubular Joint Design for Static and Cyclic Loads, stress concentration factors; S-N curves and fatigue damage calculations. Jackup Rigs: Configuration and operation of jackups; Simplified analysis; Spudcan Penetration and extraction; Spudcan – pile interaction; Design of jackup legs; Design against Accidental Loads (Fire, Blast and Collision): Behaviour of steel at elevated temperature; Fire Rating for Hydrocarbon fire; Design of structures for high temperature; Blast Mitigation-Blast walls; Collision of Boats and energy.

Subrata K.Chakrabarti,2005. Handbook of Offshore Engineering, Elsevier.
Y.Goda, 2010. Random seas and design of marine structure, World Scientific.
Dawson, 1983. Offshore Structural Engineering, Prentice Hall.
A.S. Arya and J.L. Ajmani, 1996. Design of steel structures, Nem Chand Bros, Roorkee.
Johon E. Lothers 1999. Advanced Structural Design in Steel.
API Recommended practice, 2000. 2A-WSD (RP 2A-WSD)
API recommended practice, 2000. 2A-WSD (RP 2A-LRFD)

WO824 Structural Health Monitoring (3-0-0) 3

Introduction to SHM, Structural Health Monitoring versus Non Destructive Evaluation, A broad Overview of Smart Materials, Emerging SHM Technologies using Piezo Sensors, Magnetostrictive Sensors, Optical Fibres and other sensors. Vibration Control using SHM –Introduction to FE formulation, Constitutive Relationship, Element Stiffness Matrix for High Precision Finite Element. SHM using Electrical resistance, Low frequency electromagnetic techniques. Case studies on civil and marine structures applications.

Daniel Balageas, Claus-Peter Fritzen, Alfredo Güemes, Structural Health Monitoring, Wiley-ISTE, 2006.

Douglas E Adams, Health Monitoring of Structural Materials and Components-Methods with Applications, John Wiley and Sons, 2007.
J.P. Ou, H.Li and Z.D. Duan, Structural Health Monitoring and Intelligent Infrastructure, Vol-1, Taylor and Francis Group, London, U.K, 2006.
Victor Giurglutiu, Structural Health Monitoring with Wafer Active Sensors, Academic Press Inc, 2007.
Gandhi and Thompson, Smart Materials and Structures, First edition, Chapman & Hall, 1992
Fu Ko Chang , Structural Health Monitoring, Technomic Publishing co inc.,2000.

WO825 Advanced Technology applications in Monitoring of Marine Structures (2-0-2) 3
Remotely operated vehicles (ROV) systems – ROV operational techniques, data collection using echo sounding-single and multibeam techniques, hydroacoustics, underwater inspection & investigation and health inspection of submerged marine structures.
UAV technology application for 3D aerial coastal terrain mapping, coastal processes and monitoring the performance of marine structures.
Numerical modeling of deterioration and functionality assessment of marine structures using open source software, mesh generation, post-processing techniques.
Robert d Christ, Robert L. WernliSr (2013) , The ROV Manual: A User Guide for Remotely Operated Vehicles Hardcover – 2nd Edition
Paul Fahlstorm, Thomas Gleason (2012), Introduction to UAV systems, Wiley, 4th Edition
Valavanis, K. Vachtsevanos, George J. (2015) Handbook of Unmanned Aerial Vehicles, Springer International Publishing.
Anderson, John D., Jr Computational Fluid Dynamics: The Basics with Applications 1st ed., McGraw-Hill, New York, 2012.
Griebel M., Dornseifer T., Neunhoeffer T. (1998), Numerical simulation in Fluid Dynamics, a Practical Introduction, SIAM.
Ferziger J.H., Peric M. (2002), Computational Methods for Fluid Dynamics, Springer.
Osher S., Fedkiw R. (2002), Level Set Methods and Dynamic Implicit surfaces, Springer.
Shu C.W. (1999), High-Order ENO and Weno Schemes for Computational Science and Engineering Vol. 9, Springer.
Barrett R., Berry M., Chan T.F., Demmel J., Dongarra J., Eij

WO829 Selected Topics in Marine Structures (3-0-0) 3

WO761 Statistical Methods for Civil Engineering Applications (3-0-0) 3
Elements of Probability; Random Variables and Expectations: Random Variables and Distribution Functions; Jointly Distributed Random Variables; Mathematical Expectation; Covariance and Variance; Moment Generating Function. Special Discrete and Continuous Probability Distributions: Discrete Uniform Distribution; Binomial Distribution; Sampling theory and distribution; Test of Hypothesis. Correlation and Regression: Method of Least Square and Curve Fitting (linear and non-linear); Statistical Performance Measures; Reliability and Risk Analysis. Application and case studies
B.M. Ayyub and R.H. McCuen, Probability, Statistics and Reliability for Engineers, CRC Press, 1997.
G.G. Vining *and* S. Kowalski, Statistical Methods for Engineers, *Brooks/Cole, Clengage Learning, USA, 2010.*
M.S. Ross, Introduction to Probability and Statistics for Engineers and Scientists, Elesevier, 2009
R.V. Hogg, J.W. KcKean and A.T. Craig, Introduction to Mathematical Statistics, Pearson, 1995.

WO762 Surface Water Hydrology (3-0-0) 3
Overview; Review of water problems; Hydrological cycle and water balance; Catchment/watershed; Rainfall, interception, infiltration, soil moisture, evapotranspiration, runoff, groundwater (process description measurement spatio- temporal data analysis, estimation). Runoff – process, components, measurement, representation of data, estimation; Catchment modeling; Assessment & characterization of water availability at catchment scale; Unit Hydrograph – Derivation, Application; Flow routing; Flood estimation. *Chow et al, Applied Hydrology, International Edition, McGraw-Hill, 1988 Subramanya K, Engineering Hydrology, 3rd Edition, McGraw-Hill, 2008 Beven K J, Rainfall-Runoff Modelling – The Primer, John-Wiley, 2001*

WO763 System Approach in Water Resources Engg. (3-0-0) 3
Definition of a system, classification, steps in system design. Water resources systems, Concept of a system,

Classification, systems analysis techniques, Issues in system approach, Advantages and limitations, Objectives of Water Resources development, steps in system design. Linear Programming: Formulation, Graphical method, Simplex method, Primal-dual relationship, introduction to sensitivity analysis, Application of LP. Dynamic Programming (DP) and applications in Water Resources Engineering. Network models -Transportation models , WR System as a network flow problem, Non-linear programming, Unconstrained and constrained Optimization, Lagrange multipliers method and Kuhn - Tucker conditions. Multi-objective models, Plan formulation and selection techniques.
D.P.Loucks et al., Water Resources Systems Planning and Analysis Ravindran et al., Operations Research - Principles and Practice. S.S.Rao, Engineering Optimisation
F.S.Hiller and G.J.Liberman, Introduction to Operations Research.
Y.Y.Haimes,Hierarchial Analysis of Water Resources Systems

WO764 Groundwater Engineering (3-0-0)3
Occurrence of groundwater, types of aquifers, formulation of governing equation for groundwater movement, groundwater budget, mechanics of well flow-solutions to unsteady flow to fully and partially penetrating wells in confined/unconfined, non-leaky aquifers, well design criteria, parameter estimation; Finite difference/finite element modeling for groundwater flow, Pollutant transport in groundwater, Seawater intrusion in coastal aquifers; Artificial recharge, water-logging, Stream-aquifer interaction, Conjunctive use management of surface and groundwater.
Mc Whorter, D.B. and D.K. Sunada, 1977. Groundwater hydrology and hydraulics, Water Resource Pub., Fort Collins, USA.
Fetter, CW., 1990. Applied hydrogeology, CBS Publishers, New Delhi, 2nd Edition, 1990.
Todd, D.K. Groundwater hydrology, John Wiley.
Rushton, K.R. and Redshaw SC., 1976. Seepage and groundwater flow, Arnold, London.
Karanth, K.R. 1987. Groundwater assessment, development and management, Tata McGraw Hill, New Delhi.

WO765 Hydrology& Hydraulics Lab (0-0-3) 2
Experiments on flumes and field hydrology problems

WO766 Design of Hydraulic Systems (3-0-0) 3
Objectives of hydraulic structures in Water Resources Systems. Preliminary investigation and preparation of reports. Design of water storage structures: weirs, earthen dam, vented dam (Barrage). Design principles of urban drainage. Water Conveyance systems: Open Channel and pipe networks, Design of storm water drainage system.
Creager, Justin & Hinds, Engineering for Dams, Vols. I, II, III Varshney, Hydraulic & Irrigation Structures Mays, Handbook of Water *Resources*

WO767 Infrastructural Project Management (3-0-0) 3
Project - definitions, characteristics, life cycle phases, types. Pre-feasibility, Techno-economic feasibility &Detailed Project reports. Project economics, Project economic evaluation. Project Risk - measures, types. Risk analysis - sensitivity analysis, scenario analysis, Monte Carlo simulation, Decision trees. Decision making under risk and uncertainty. Project organization, Work Breakdown Structure. Contracts, Tendering, Disputes, Arbitration. Construction Planning & Management, Scheduling tools - Bar charts, CPM, PERT (brief description only). Resources allocation - smoothening & leveling. Materials management and inventory control, Equipment/machinery management and economic analysis.
S Chawdary, Project Management
P.K. Joy, Total Project Management
P Chandra, Projects Planning Analysis.

WO768 Sustainable Water Management (3-0-0) 3
Water resources management-purpose, water managers, sustainability, comprehensive framework for sustainable water management. Water and environmental law. Financial planning and management-economic analysis, benefit cost ratio, total economic value evaluation, water allocation. Reservoir operation- deterministic flow, reservoir sizing, sequent peak analysis, conjunctive use management- water budget, models, water harvesting. *Grigg, N.S., Water Resources Management, McGraw Hill, New York,*
1996. A. S. Goodman, Principle of Water resource Planning, Prentice Hall,1998.
Y. Heiman, Hierarchical analysis of water resources Systems, McGraw Hill, 2003.
Lorry W. Meyer, Water Resources Handbook, McGraw Hill,1993.

James, S. & Lee, W., Economics of Water Resources,1982.

WO861 Optimization Techniques and Engineering applications (3-0-0) 3
Unconstrained and constrained optimization, Lagrange multipliers and Kuhn – Tuckerconditions. Linear Programming (LP): Formulation of LP, Graphical solution, Simplex method, Finding a feasible basis Dual problem. Primal-dual relationship, Sensitivity analysis, Economic interpretation of Duality, Interpretation of the Simplex method. Dynamic Programming (DP): Stage coach problem to resource allocation, Distribution of efforts problems, Scheduling problem. Network analysis: Transportation problems, Assignment Problems.
Hiller. F.S .and Liberman. G.J., Introduction to Operations Research, Irwin/McGraw-Hill, 2000 Ravindran ,D.T.Philips and J.J.Solberg , Operations Research - Principles and Practice, Wiley, 1987. Hadly.G, Linear Programming. LP, Addison-Wesley *Pub. Co. 1962.*
Rao. S. S.,Engineering Optimisation, 3nd Edition, 1996 by John Wiley & Sons, Inc., Wiley Eastern Limited, Publishers, and New Age International Publishers, Ltd

WO862 Irrigation Technology & Water Management (3-0-0) 3
Basic soil physics- soil properties, soil water storage and movement in vadose zone. Climatic variables. Crop water requirements, irrigation water requirements. Irrigation scheduling. Types of irrigation schemes, methods of irrigation. Components of micro-irrigation methods (sprinkler, drip) - design features. Drainage system-components and design. Irrigation water quality, salt balance, soil salinity problems & remediation. Farm irrigation management schemes-conjunctive use, deficit irrigation. Socio-economic, institutional and environmental aspects of irrigation systems. Performance indicators- water production functions, economic productivity.
Larry James, Principles of farm irrigation system design
NH Rao, Irrigation scheduling with limited water supplies, CBIP Publ. 218
0Smedema & Reycroft, Land Drainage, Batsford Academic

WO863 Computational Methods in Subsurface Flow (3-0-0) 3
Partial differential equations in subsurface flow, initial and boundary value problems, solution methodology. Finite difference method -various schemes and their solution, simulation of single phase subsurface fluid flow. Finite element method - Galerkin method, element families, solution of steady and transient groundwater flow problems. Boundary element method - Basic concepts, application to one and two dimensional sub-surface flow problems. Method of characteristics and its applications, Analytical elements, infinite elements and applications. *P.S. Huyakern and G F Pinder, Computational methods in sub-surface flow, Academic Press, 1983*
J.Bear and A.Verruijit, Modelling groundwater flow and pollution, 1988

WO864 Integrated River Basin Development (3-0-0) 3
Necessary conditions for river basin development Heceristic approach, sequential approach, components of river basin development, conjunctive use of surface water and groundwater, planning design and development of regional groundwater system in a river basin. Inverse modeling in regional GW system. Role of industries, NGO and VO in river basin development, Socio-economic factors rehabitation, concept of sustainable development, some typical case studies.
T.M.Chaturvedi, Water Resource Systems
W.G.Yeh, Groundwater Management

WO865 River Engineering (3-0-0)3
Watershed erosion and yield modelling concepts. Hydraulics of loose boundary channels; Dispersion and diffusion in channels and fluid transport of contaminants. Aggradations and degradation problems; local scour and its protection measures; special alluvial problems. Design of stable channels. River engineering: channel morphology, methods of river training.
Mays L.W., Water resources engg,John Wiley,USA,2001.
Chow. V.T., Open channel hydraulics, McGraw Hill,1959.
Andre Rrobber. River processes: An introduction to alluvial dynamics, Arnold,London,1995.

WO866 Geo-informatics Applications in Water Resources Engineering (3-0-0) 3
The electromagnetic spectrum and atmospheric considerations, Spectral Characteristics, Sensors and platforms: Data Products, Image Interpretation and Analysis GIS and GPS, Applications: Land use/land cover, NDVI, Evaluation of
Sabins, F.J. Jr. Remote Sensing: Principles and Interpretation. Third Edition. W.H. Freeman and Company, New

York. 1996.
John R Jensen, Remote Sensing of the Environment An Earth Resource Perspective 2nd Edition, Dorling Kindersley India Pvt Ltd M.G. Srinivas(Edited by), Remote Sensing Applications, Narosa Publishing House, 2001.
Mischael Hord, "Remote Sensing Methods and Applications", John Wiley & Sons, New York, 1986.

WO867 Water Quality Modelling & Management (3-0-0) 3
Water quality description, various characteristics of water, water quality criteria and standards, elements of reaction kinetics, spatial and temporal aspects of contaminant transport, transport mechanisms - advection, diffusion, dispersion. Rivers and streams, convective diffusion equation and its applications. Estuaries, estuarine hydraulics, estuarine water quality models. Lakes and reservoirs, eutrophication. Contaminant transport in unsaturated flow, solute transport models for conservative species, solute transport in spatially variable soils. Contaminant transport in groundwater, advection, dispersion, one dimensional transport with linear adsorption, dual porosity models, numerical models, biodegradation reactions. Water quality management, socio-economic aspects of water quality management, management alternatives for water quality control, waste load allocation process, lake quality management, groundwater remediation.
Thomann,& Mueller, Principles of Surface Water Quality Modeling and Control
Chapra Surface Water-Quality Modeling
Schnoor, Environmental Modeling
Thomann,. Systems Analysis and Water Quality Management

WO868 Soft Computing techniques and Applications (3-0-0)3
Fuzzy logic- Classical sets and fuzzy sets, fuzzy sets operations, fuzzy relations, Membership functions, de-fuzzification, fuzzy rule based systems, Applications. Artificial neural network-Model of a neuron, learning rules, activation functions, single layer perceptron networks, multilayer feed forward networks, back-propagation algorithm, Hopfield networks, Applications. Genetic algorithm-Fitness function, genetic algorithm operators-reproduction, crossover, mutation, schemata and schema theorem, Applications.
Ross T.J., Fuzzy logic with engineering applications-McGraw Hill, *1995*
Haykin S., Neural networks-a comprehensive foundation -Prentice Hall,2nd edition, 1998.
Goldberg D., Genetic algorithms- Addison-Wesley, 1st edition,1989.

WO869 Stochastic Hydrology (3-0-0)3
Brief review of probability concepts, Random Variable–properties, one dimensional, higher dimensional Probability distributions, Joint distributions. Parameter estimation. Generation of hydrologic data and applications. Time series analysis – definitions, stationarity, autocorrelation, partial autocorrelation, spectral analysis. Purely random stochastic models, Markov process, Periodicity. ARMA models – Box Jenkins model, time series simulation and forecasting, applications.
Hann, C.T., "Statistical Methods in Hydrology", First East-West Press Edition, New Delhi, 1995
Jayarami Reddy, P., "Stochastic Hydrology", Laxmi Publications, New Delhi, 2016
Machiwal. D and Jha M.K., "Hydrologic Time Series Analysis", Capital Publishing Company, 2012

WO870 Integrated Watershed Management (3-0-0)3
Introduction and basic concepts of watersheds; Sustainable watershed approach & watershed management practices; Integrated watershed management- integrated approach, conjunctive use, rainwater harvesting; Watershed modelling-modelling approaches, system concept, hydrologic processes, rainfall, run- off, sub-surface flow; Socio-economic aspects, RS&GIS in watershed management; Water quality management – sources of pollution, water quality modelling, environmental guidelines; Flood and drought management; Principles of water conservation and recycling.
Murthy JVS 1998. Watershed management, New Age International, New Delhi.
V. Lazarova, and Akica Bahri 2004. Water re-use for irrigation. CRC Press, London. Black Peter E. 1991. Watershed hydrology, Prentice Hall, London.
CWC Report 2005. General guidelines for water audit and water conservation. Ministry of Water Resources, New Delhi

WO889 Selected Topics in Water Resources Engineering & Management (3-0-0) 3

WO731 Principles of Remote Sensing **(3-0-0) 3**
Introduction to remote sensing, laws of remote sensing, Electromagnetic radiation and its interaction with matter and atmosphere:Satellites/orbits, sensors – platforms – image resolutions, FCC, TCC, Visual interpretation keys, Atmospheric effects and corrections: DN to radiance conversion, BRDF; radiometric corrections, introduction to Multispectral, Thermal and Hyperspectral remote sensing, Image pre-processing methods: Data formats, image enhancement and its methods Classification-supervised classification methods, change detection, accuracy assessment.
References:
George Joseph, "Fundmentals of Remote Sensing", Universities press (India) Private Limited, Hyderabad, 2005.
Jenson, John R. Remote Sensing of the Environment: An Earth Resource Perspective. Person Prentice Hall, 2007.
Khorram*, S.,*van der Wiele*, C.F.,*Koch*, F.H.,*Nelson*, S.A.C.,*Potts*, M.D.,Principles of Applied Remote Sensing, Springer publication, 2015.*
Lillesand, Thomas & Kiefer, Remote Sensing and Image Interpretation, John Wiley & Sons Inc. New York, 2004

WO732 Geographic Information Systems **(3-0-0) 3**
Introduction, principle, definition, components of GIS, Application, coordinate systems, GIS data types, data input, geometric transformation, spatial data editing, attribute data input and management, data exploration, vector and raster data analysis, terrain mapping and analysis, watershed delineation, spatial interpolation, network application and GIS model, GPS - components, working principle, applications.
Burrough & McDonnell, Principles of Geographical Information Systems, 3rd Edition, Oxford University Press, 2015.
Chang, KT, Introduction to Geographic Information System, 8th Edition, McGraw Hill, 2016 Jan Van Sickle, GPS for land surveyors, Sleeping Bear Press, Michigan, 2001
Yang, Snyder & Tobler, Map projection Transformation principles and applications, CRC Press, 1999.

WO733 Remote Sensing and GIS Lab **(0-0-3) 2**
Study and use of Theodolite for plotting of ground objects, Study of the given stereo pairs of aerial, Visual Interpretation of given stereo pairs of aerial photographs, Use of stereoscope for the analysis of stereo pairs of aerial photographs, GPS surveys, thematic layer creation and analysis using GIS , use of radio meter and data analysis, data capture using UAV.
References: User Manual

WO734 Satellite Digital Image Analysis **(3-0-0) 3**
Introduction to digital image processing, pre-processing techniques-enhancement, geometric and radiometric corrections, Image transforms – Fourier transform, Multiband transformations- Principal component transform and dimensionality reduction, band arithmetic – ratios and differences, utility of indices, variants, Image fusion – fusion techniques, Pansharpening, advantages, PCA/HSI/Brovey transform methods, evaluation, Image classification-supervised and unsupervised image classification methods, accuracy assessment, classification based change detection, change matrix.
Gonzalez, R.C., and Woods, R.E., Digital Image Processing, 3rd Edition, Prentice-Hall, NJ, 2008.
Jensen, J.R., Introductory Digital Image Processing: A Remote Sensing Perspective, 4th Edition, Pearson, 2016
Lillesand, Thomas & Kiefer, Remote Sensing and Image Interpretation, John Wiley & Sons Inc., New York, 2004
Schowengerdt, R., Remote Sensing: Models and Methods for Image Processing, Academic Press, Elsevier, NY, 2007.

WO735 Microwave Remote Sensing **(3-0-0) 3**
Principles and physics of microwave remote sensing. Sensor technology, platforms and data portals. Principal processing techniques and applications of active and passive microwave remote sensing data. Hands- on exercises with special processing techniques to applications. Advanced processing techniques such as InSAR, differential InSAR and polarimetric InSAR
Floyd. M. Handerson and Anthony, J. Lewis "Principles and applications of Imaging RADAR", Manual of Remote sensing, Third edition, vol.2, ASPRS, Jhumurley and sons, Inc., 1998.
Iain H Woodhouse, "Introduction to microwave remote sensing", 2004, CRC Press; 1st edition, ISBN-13: 978-0415271233
Ian Faulconbridge, "Radar Fundamentals", Published by Argos Press, 2002.
Philippe Lacomme, Jean clande Marchais, Jean-Philippe Hardarge and Eric Normant, "Air and space borne radar systems - An introduction", Elsevier publications, 2001.

Ulaby, F.T., Moore,K.R. and Fung, "Microwave remote sensing" vol-1,vol-2 and vol- Addison - Wesley Publishing Company, London, 1986.

WO736 Satellite Digital Image Analysis Lab (0-0-3) 2
Satellite image pre-processing and analysis using open sources software: basic operations, satellite image reading and manipulations, Geo-referencing of remote sensing satellite images, image enhancement, image noise removal, Hyperspectral /microwave image pre-processing and analysis, image Classification using, Programming using open source software: Basic coding on images -read, write, opening, display, RGB<->BW<->Grey color, histogram, extraction of image statistics, etc., Enhancement of image, Multispectral image processing, Hyperspectral image read, opening, display, analysis, Change detection analysis.
Reference: Lab Manual

WO737 Design Project (0-0-3) 2
Students will be given a topic for Design Project at the end of first semester. Evaluation of the project will be carried out at the end of second semester. The objective of this project is to address some applied or theoretical concepts in RS & GIS and to prepare a scientific report

WO831 Advanced tools for image processing (2-0-2) 3
The basics / Overview of software features; programming, command prompt & expressions, variables, lists, vectors, matrices and operators,, basic plotting,; arrays; use of files; functions and data structures; programming; Programmer's Toolbox, Selection, Loops, Data Types, File Input/Output. Displaying Images, Geometric Operations, Neighborhood and Block Operations, Linear Filtering and Filter Design, Analysing and Enhancing Images, Binary Image Operations, Region-Based Processing, image noise, image statistics, image restoration, image fusion, image classification.
A basic guide on digital image processing/ analysis/ editing/ raster representation/ image enhancement and classification using ILWIS 3.3academic.
Digital Image Processing Laboratory Manual(V1.X), by Bhaskar Mondal, Dept. of Computer Science, NIT-Jamshedpur, 2014
Gonzalez and woods; Digital Image Processing with MatLab, TMH., Prentice hall, 2008
Verbyla,David.L : Satellite Remote Sensing of Natural Resources, Lewis Publishers (CRC Press), NY., 1995

WO832 Applications of RS & GIS in Agriculture & Soil Science (3-0-0) 3
Agricultural area mapping, Agricultural Planning, Suitability analysis of Agricultural land, Estimation & Forecasting of crop acreages and production, Identification of Optimal crop combination regions in different environments, Monitoring & Forecasting of crop health, Soil resources mapping, Soil classification on the basis of soil depth, color, texture, moisture content, chemical composition etc. through GIS.
Jenson, John R. Remote Sensing of the Environment: An Earth Resource Perspective. Person Prentice Hall, 2007.
Lillesand, T.M., R.W. Kiefer, and J.W. Chipman. Remote Sensing and Image Interpretation. 5th Edition. John Wiley & Sons. NY, 2004.
Mischael Hord, "Remote Sensing Methods and Applications", John Wiley & Sons, New York, 1986.
Sabins, F.J. Jr. Remote Sensing: Principles and Interpretation. Third Edition. W.H. Freeman and Company, New York. 1996.

WO833 Applications of RS & GIS in Town & Country Planning (3-0-0) 3
Land use/Land cover Analysis, Change detection in Land use/ Land cover, Site suitability analysis for residential, commercial, recreational, religious, medical, waste material disposal sites for Urban and Regional planning, Network Analysis for sewage, communicational, telecom, traffic flow in town and country planning, Parcel based studies for any ward of a town route networking, shopping complexes, parking space, sewage line, etc., Creation of databases of cities for municipal corporations, Urban population identification, control and management, Urban slums: Trend, pattern and management, Waste land mapping and management, Land evaluation analysis, Generation of city information system.
Jenson, John R. Remote Sensing of the Environment: An Earth Resource Perspective. Person Prentice Hall, 2007.
Lillesand, T.M., R.W. Kiefer, and J.W. Chipman. Remote Sensing and Image Interpretation. 5th Edition. John Wiley & Sons. NY., 2004.
Mischael Hord, "Remote Sensing Methods and Applications", John Wiley & Sons, New York, 1986.
Sabins, F.J. Jr. Remote Sensing: Principles and Interpretation. Third Edition. W.H. Freeman and Company, New

York. 1996.

WO834 Applications of RS & GIS in Forestry, Ecology & Environment (3-0-0) 3

Forest mapping & classification, Study of Bio-diversity in different Biomes, Forest Fire: Identification, Control, Estimation of losses and management, Environmental Planning & Management, Study of Ecological imbalances and controls, Monitoring and forecasting of vegetation Health, Deforestation and Land degradation: Identification, control & management.

Jenson, John R. Remote Sensing of the Environment: An Earth Resource Perspective. Person Prentice Hall, 2007.
Lillesand, T.M., R.W. Kiefer, and J.W. Chipman. 2004. Remote Sensing and Image Interpretation. 5th Edition. John Wiley & Sons.
Mischael Hord, "Remote Sensing Methods and Applications", John Wiley & Sons, New York, 1986.
Sabins, F.J. Jr. Remote Sensing: Principles and Interpretation. Third Edition. W.H. Freeman and Company, New York. 1996.

WO835 Applications of Unmanned Aerial Vehicles in Engineering (2-0-2) 3

Basics of Aerial Photogrammetry using unmanned Aerial Vehicles, Theory and Techniques of Orientation, Project Planning for Aerial Photogrammetry, georeferenced 2D maps and 3D models, 3D Point Cloud, Digital Surface & Terrain Model, Volume calculation, Contour line, 3D textured model and its applications in archelogy and mining, Thermography and multispectral imaging

F. Moffitt and E. Mikhail, Photogrammetry, 3rd edition, Harper & Row, Inc., 1980. Manual of Photogrammetry, 2010. 5th edition, American Society of Photogrammetry, 2010
P. Wolf and B. Dewitt., Elements of photogrammetry, 3rd edition, , by, McGraw-Hill Book Co., 2014.
Valavanis, K., Vachtsevanos, George J. (Eds.). Handbook of Unmanned Aerial Vehicles (Volume 1), 2010.

WO836 Geo-informatics Applications in Water Resources Engineering (3-0-0) 3

The electromagnetic spectrum and atmospheric considerations, Spectral Characteristics, Sensors and platforms: Data Products, Image Interpretation and Analysis GIS and GPS, Applications: Land use/land cover, NDVI, Evaluation of surface and ground water resources, Watershed Management, flood inundation modelling and mapping.

Jenson, John R. Remote Sensing of the Environment: An Earth Resource Perspective. Person Prentice Hall, 2007.
Lillesand, T.M., R.W. Kiefer, and J.W. Chipman. Remote Sensing and Image Interpretation. 5th Edition. John Wiley & Sons. NY, 2004.
M.G. Srinivas (Edited by), Remote Sensing Applications, Narosa Publishing House, 2001.
Sabins, F.J. Jr. Remote Sensing: Principles and Interpretation. Third Edition. W.H. Freeman and Company, New York. 1996.

WO837 Hyperspectral Remote sensing and application (3-0-0) 3

Introduction to Hyperspectral Remote Sensing, Hyperspectral Sensors and Data Collection, Hyperspectral Image Display and Basic Analysis (Virtual dimensionality –representation systems -hypercube –red edge –indices –Hughes phenomenon -multivariate analysis for data reduction -data calibration, normalization –spectral library), Pre-processing of Hyperspectral Data (–response functions –MNF transformation –Kalman filters-library matching, spectral angle mapper, BBMLC-spectral mixture analysis –endmember extraction –spectral unmixing-MIA analysis concepts -PCF, PCA, WPCA spectral transformation –band detection, reduction and selection principles -data compression), Reducing High Dimensionality of Hyperspectral Imagery and Endmember Selection, Thematic Information Extraction from Hyperspectral Imagery, Hyperspectral Image Classification, Hyperspectral Applications: Soil, Vegetation, Mineral & Rock, Urban Area and Water

Borengasser, M., W.S. Hungate, and R.Wadkins, Hyperspectral Remote Sensing: Principles and Applications . CRC Press , 2004.
Eismann, M.T., Hyperspectral Remote Sensing, ISBN: 9780819487872, 2012.
Jensen, J. R., 2016. Introductory Digital Image Processing(4thEdition), Prentice Hall, ISBN-13: 978-0134058160; ISBN-10: 013405816X
Thenkabail, P.S., J. G. Lyon, and A. Huete, .Hyperspectral Remote Sensing of Vegetation. CRC Press, ISBN: 9781439845370, 2011

WO838 Thermal Remote Sensing (2-1-0) 3

Principles of thermal remote sensing, history, characteristics of thermal infrared images and factors affecting thermal images, geometric and radiometric calibration in thermal images, interaction of thermal radiation with terrain elements, Retrieval of land emissivity and surface temperature, airborne and spaceborne thermal sensors, future development and perspectives, thermal remote sensing in land surface processes, time series corrections and analysis in thermal remote sensing. Hands on exercises to pre-process thermal images and to retrieve physical parameters.

Tang, Huajun., Li, Zhao-Liang., Quantitative Remote Sensing in Thermal Infrared-Theory and Applications, Springer-Verlag Berlin Heidelberg, 2013.
Claudia Kunzer., Stefan Dech., Thermal Infrared Remote Sensing- Sensors, Methods, Applications, Springer Netherlands, 2013.
Dale, A, Quattrochi., .Jeffrey, C, Luvall., Thermal Remote Sensing in Land SurfaceProcesses,CRC Press,2000.

WO859 Selected Topics in Remote Sensing and GIS (3-0-0) 3

DEPARTMENT OF CIVIL ENGINEERING

CV701Theory of Elasticity & Plasticity **(3-0-0) 3**

Elasticity : Definition and notation of components of stress and strain, Generalized Hooke's Law. Plane stress and plane strains. Airy's stress function. Differential equations of equilibrium, Solution of two-dimensional problems using polynomials. Solution in rectangular and polar co-ordinates. Torsion of Prismatic, Circular and Rectangular bars. Prandtl's membrane analogy.

Plasticity : Introduction to plasticity, Criterion of yielding, Bending of prismatic beams, residual stresses, Plastic torsion.

S.P. Timoshenko and N.Godier, Theory of Elasticity, McGraw Hill J. Chakrabarthy, Theory of Plasticity, McGraw Hill

Sadhu Singh, Theory of Plasticity, Khanna Publishers.

CV702 Finite Element Method **(3-0-0) 3**

Types of elements-Discretization of structures-Interpolation functions-Generalised and natural coordinates-Direct method of element formulation-Limitations-Variational method-Numerical integration-Timoshenko beam element-Plate bending elements-Mindlin element-Shell elements-Techniques for material and geometric non-linear problems.

C. S. Krishnamoorthy, Finite Element Analysis, Theory and Programming, Tata McGraw-Hill.

O. C. Zienkiewicz and R. L. Taylor, The Finite Element Method (vol. 1 and vol. 2), McGraw-Hill

Daryl L Logon , A First Course in Finite Element Method, Cengage Learning

CV703 Mathematical Methods in Structural Engineering **(3-0-0) 3**

Solution of algebraic transcendental and polynomial equations, Interpolation, Numerical differentiation, Numerical Integration, Integration over infinite intervals, Error analysis, Numerical solution of ordinary differential equations, Numerical solution of partial differential equations, Probability & statistics in structural engineering

Erwin Kreyszic, Advanced Engineering Mathamatics, John Wiley & Sons

M. K. Jain, S.R.K. Iyengar, and R.K.Jain, Numerical Methods for Scientific and Engineering Computation, New Age International

S. M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, Elsevier

CV704 Structural Dynamics **(3-0-0) 3**

Types of dynamic problems. D'Alembert's principle, Equations of motion, degrees of freedom. SDOF systems - free and forced vibrations, support motion, vibration isolation, transmissibility, Duhamel's integral and its numerical evaluation. MDOF systems - Free vibrations, natural modes, orthogonality conditions, shear frame, matrix iteration for eigenvalues and eigenvectors, forced vibrations, mode superposition method, damping in MDOF systems. Vibrations of beams with different end conditions.

Mario Paz, Structural Dynamics, CBS Publishers

Clough and Penzien, Dynamics of Structures, McGraw-Hill

CV705 Computer Lab **(0-0-3) 2**

Students should develop flow charts and programs for design and detailing of RC elements. Analysis of structures using available softwares.

CV706 Advanced Design of Concrete Structures **(3-0-0) 3**

Review of limit state design method. Design of floor systems, ribbed slabs, hollow cored slabs, grid floors, yield line analysis, strip method. Redistribution of moments, continuous beams and frames. Industrial buildings, purlins, crane gantry girders, precast roof systems, shell and folded plate elements, double pitched roof beams, trusses, columns, corbels, deep beams, R.C. walls. Storage structures, silos and bunkers. Raft and pile foundations. *Mark Fintel, Hand book of concrete engineering, ReinHold, New York*

N. Krishna Raju, Advanced reinforced concrete design, CBS Publishers

P. Purushothaman, Reinforced concrete structural elements Tata McGraw Hill P.C.Varghese, Advanced Design of RCC Structures, PHI Learning

CV707 Advanced Design of Steel Structures (3-0-0) 3

Review of Limit state method of design - Bolted and welded connections - Flexible, Semi-rigid and rigid connections.Design of tension members, compression members and beams. Beam Columns– Plate girders and Gantry Girders, Open web structures and castellated beams, Vierendeel girders,Design of light gauge cold formed steel sections.Design of steel and concrete composite beams, columns and floors.

J. E. Lothers, Advanced Structural Design in Steel, Prentice-Hall L. S. Beedle - Plastic Design of Steel Frames, John Wiley & Sons Handbook of Open-web Structures - CMERI - Durgapur

N. Subramanian - Design of Steel Structures, Oxford University Press, New Delhi

CV708 Theory of Plates (3-0-0) 3

Thin and thick plates-deflection of laterally loaded plates-Navier and Levy's method-Energy and finite difference methods-Plate subjected to in-plane and lateral loads-Circular plate with symmetrical loading- Introduction to buckling of plates. Vibrations of Plates.

S. P. Timoshenko and S. W. Krieger, Theory of Plates and Shells, McGraw-Hill

S. P. Timoshenko and J. M. Gere, Theory of Elastic Stability, McGraw-Hill

A.W.Leissa, Vibration of Plates, NASA Special Publication

CV709 Structures Lab (0-0-3) 2

Concrete Mix Design by different methods, Strain measurements using mechanical and electrical strain gauges. Study of Structural behaviour of beams and columns, Non-destructive testing of concrete.

CV721 Basic Geomechanics (3-1-0) 4

Concepts of failure and yield in soil, Failure theories, Effective stresses in soils, Microstructural considerations, Stress-path concepts and their applications. Shear Strength of soils and rocks, Mohr-Coulomb strength theory, Shear strength tests, Stress-deformation characteristics. Critical state concepts and their application, constitutive relationships. Deformation analysis, components of settlement, permissible settlements, consolidation settlements. Flow through soils. Introduction to Unsaturated Soil Mechanics.

Lambe, T.W. and Whitman, R.V. Soil Mechanics, Wiley Eastern.

CV722 Shallow Foundations (3-0-0) 3

Assessments of foundation loads, Choice of foundation types, Determination of bearing capacity by theoretical approaches, penetration tests and plate load tests, Proportioning of footings by conventional and uniform settlement methods, Structural design(limit state) of shallow foundations, Expansive soils- Problems and remedial measures. Footings on layered soils and sloping grounds.

Bowles, J.E., Foundation analysis and design, McGraw Hill. Swamisaran S., Design of substructures, Oxford and IBH publishers

Winterkorn and Fang, Foundation Engineering handbook, Von NostranReenhold Co.

CV723 Geotechnical Engineering Laboratory (0-0-3) 2

Identification of soils, Index properties, Hydraulic properties, Shear strength properties, Settlement characteristics, parametric studies. Rock testing, Demonstration of SPT and Pressuremeter.

Lambe, T.W., Soil testing, Wiley International. Relevant latest IS Codes.

Head, K.H., Manual of soil laboratory testing, Volumes 1-3.

CV724 Earth & Earth Retaining Structures (3-0-0)3

Introduction, Rankine and Coulomb theories, Graphical method, Passive earth pressure by curved rupture surface, Stability analysis of gravity type, Cantilever type, Counterfort type retaining walls, Design of Soil reinforced retaining walls. Braced excavations, Analysis and design of sheet piles, Stability of slopes, Finite and infinite slopes, Swedish circle method, Taylor's modified Swedish circle method, Taylor’s stability charts and Bishop's method of analysis.

Terzaghi K, and Peck, R.B., Soil Mechanics in engineering practice, McGraw Hill.

Bowles, J.E., Foundation analysis and design, McGraw Hill.

CV725 Pile Foundations (3-1-0) 4

Shallow vs. deep foundations, Classification of pile foundations, axial load carrying capacity of a single pile by different methods, negative skin friction, pile group efficiency, distribution of load to piles in groups, Design of piles

and pile cap; settlement analysis of single pile and pile groups; Laterally loaded piles, batter piles, under-reamed piles; Construction of pile foundation, pile driving equipments and Pile load tests; durability and protection of piles, economics of pile foundations.
Tomlinson, M.J., Pile Design and Construction Practice, E and FN Spon.
Poulos, H.G and Davis, E.H., Pile Foundation Analysis and Design, John Wiley IS 2911

CV726 Ground Improvement Techniques (3-0-0) 3
Introduction to engineering ground modification, need and objectives, Soil stabilization techniques; Mechanical modifications (shallow and deep compaction methods); Hydraulic modification, Dewatering systems, use of Geosynthetics and Prefabricated vertical drains, Preloading and Vertical drains; Chemical Modifications, Modification by admixtures, grouting, deep jet mixing methods, stabilization using industrial wastes; Modification by inclusion and Confinement.
Hausmann, M.R., Engineering Principles of Ground Modification, McGraw-Hill.
Purushotham Raj, Ground Improvement Techniques, Laxmi Publications, New Delhi.

CV727 Computational Lab for Geotechnical Engineers (0-0-3) 2
Slope stability analysis by different methods, Analysis and design of single pile and pile groups. Use of FEM software(Plaxis) to Geotechnical problems.
Bowles J.E, Foundation analysis and design, McGraw Hill. Iqbal H. Khan, A text book of Geotechnical Engineering, Prentice-Hall

CV741 Pavement Design (3-0-0) 3
Introduction to Pavement - types-factors affecting design and performance of pavements. Highway and Airport Pavements, Subgrade and climate, Stresses and deflections in Flexible Pavements, Flexible Pavement Design Methods for Highways and Airports, Stresses in Rigid Pavements, Rigid Pavement Design, Use of advanced computer software for the design of flexible and rigid pavements
Yoder, E.J., Principles of Pavement Design, John Wiley & Sons Yoder &Witczak, Principles of Pavement Design, John Wiley

CV742 Urban Transport Planning (3-1-0) 4
Transport Systems and Travel Demand: Overview of Major Transport Systems, Interactions with Industry, Transportation-System Components and Problems, Travel Demand, Demand Function, and forecasting. Transportation Planning Process: Trip Generation, Trip Distribution, Modal Split, and Trip Assignment. Land Use Transport Planning: Lowry Model, Garin-Lowry Model, Graph Theory, Entropy in Transportation, Commodity Flows, Urban goods movement.
Hutchinson, B.G., Principles of Urban Transport Systems Planning, McGraw Hill, London, 1974.
Bruton, Michael J., Introduction to Transport Planning, Hutchinson, London, 1970.
Wilson, A..G., Entropy in Urban and Regional Modeling, Pion Ltd., London, 1970**.**

CV743 Road Materials, Construction Methods, and Quality Control (3-0-0) 3
Introduction to road pavement types and component layers. Materials used, construction operations involved, and quality control aspects for the following types of roadworks: embankment and subgrade, ground improvement for weak embankment foundation, sub-bases, bases (non-bituminous) and shoulders; bases and surface courses (bituminous); and concrete pavements.
"Specifications for Road and Bridge Works", Fifth Revision, Ministry of Road Transport and Highways, Published by Indian Roads Congress, New Delhi, 2013.
Relevant Indian Standards, ASTM International Standards.

CV744 Road Materials Testing Laboratory (0-0-3) 2
Tests on subgrade soils, use of suitable techniques to improve the qualities of subgrade soils. Design of non-bituminous sub-base and bases course mixes, dense graded bituminous mixes, and pavement quality concrete mixes.
"Specifications for Road and Bridge Works", Fifth Revision, Ministry of Road Transport and Highways, Published by Indian Roads Congress, New Delhi, 2013.
"Asphalt Mix Design Methods", Seventh Edition, Asphalt Institute, Lexington, KY.
Relevant Indian Standards, ASTM International Standards.

CV745 Traffic Flow Theory **(3-0-0) 3**
Traffic Studies and Surveys (Traffic Speed, Delay, Volume, and O-D Studies and Surveys, Time Mean Speed, Space Mean Speed and Lane Occupancy), Statistical Distributions in Traffic Engineering, Traffic Steam Models (Speed-concentration relationships, Flow- concentration relationship, Lighthill and Witham's Theory), Car Following Theory and Models, Queuing Theory and Applications, Vehicle Arrivals, Headways, and Gaps, and Simulation of Traffic.
Whol, Martin Traffic Systems Analysis for Engineers and Planners, McGraw Hill, London.
Haight, Frank A. Mathematical Theories of Traffic Flow, Academic Press, London.
Kadiyali, L.R., Traffic Engineering and Transport Planning, Khanna Publishers, New Delhi.

CV746 Transportation Asset Management **(3-0-0) 3**
Transport Asset Management with four major themes: management, data and modeling, planning, and application. Management: Implementation of asset management, organisation, strategy, and performance management; Data and modelling: Inventory and condition, performance monitoring, risk, and lifecycle planning; Planning: Developing an asset management plan, financial plan, asset valuation, and programming; Application: Asset management tools, and communication.Pavement asset management as the major focus under each of these themes. “Road Asset Management Manual”, World Road Association (PIARC).
“Pavement Asset Management” by R. Haas, W. R. Hudson, and L. C. Falls. Scrivener Publishing LLC, 2015.

CV747 Transportation Design Studio **(0-0-3) 2**
Volume Studies, Speed and Headway Studies, Journey time and delay studies, Intersection delays, Parking Surveys, Driver characteristics, Interviews, Exercise on driver knowledge. Exposure to use of software such as TRANSYT (for signal design), and MAAP (for accident analysis)
G.J. Pingnataro, Principles of Traffic Engineering, Mc Graw-Hill.
Wohl and Martin, Traffic System Analysis for Engineering and Planners, Mc Graw Hill.

CV761 Environmental Quality & Monitoring **(3-1-0) 4**
Environmental Chemistry - Basic concepts from general chemistry, Acid -Base Equilibria, Solubility Equilibria, removal of heavy metals from complex water and wastewater systems, Oxidation-reduction Equlilibria, Water Stabilization, Water softening and neutralization. General principles of sample collection and data analysis.
Microbiology - The characterization, classification and identification of microorganisms, Pure cultures and cultural characteristics, Enzymes and their regulations, Microbial metabolism, Control of microorganisms. Microbiology of domestic water and wastewater, industrial microbiology. Epidemiology of infectious diseases, microbial agents of diseases.
Sawyer C.L, McCarthy, P.L and Parkin, G.F. Chemistry for Environmental Engineering. McGraw-Hill.
Pelczar M.J., Chan E.C.S. and Krieg, N.R. Microbiology. Tata McGraw-Hill.
Julia Levy, Campbell, J.J.R and Henry Blackburn, T., Introductory Microbiology, John Wiley and Sons.

CV762 Physico-Chemical Processes for Water & Wastewater Treatment **(3-1- 0)4**
Water Quality, Physical, chemical and biological parameters of water, Water Quality standards, Water quality indices. Water purification systems in natural systems, physical processes, chemical processes and biological processes. Primary, Secondary and tertiary treatment. Unit operations, unit processes. Aeration and gas transfer, Sedimentation, Filtration, Adsorption, Ion Exchange-processes, Membrane Processes, Reverse osmosis, Ultrafiltration, Electrodyalisis, Disinfection
Peavy, H.s, Rowe, D.R, Tchobanoglous, G. Environmental Engineering, Mc-Graw -Hill.
MetCalf and Eddy. Wastewater Engineering, Treatment, Disposal and Reuse, Third Edition, Tata McGraw-Hill.

CV763 Biological Processes Design for Wastewater Treatment **(3-1-0) 4**
Waste waters-Sources, nature and characteristics, Process Kinetics, Enzyme reactions
Reactor Analysis, Design of wastewater treatment systems, Activated Sludge and its process modifications, Biological Nitrification and denitrification, Aeration systems, Treatment Ponds and Lagoons, Attached Growth Biological Treatment Systems, Anaerobic processes, Sludge Disposal, Waste water reclamation and reuse, Effluent disposal, Stream Sanitation, Biotechnological tools like bioremediation, genetically modified organisms etc. for environmental management.
Benefield, L.D and Randall C.W. Biological Processes Design for Wastewaters, Prentice Hall.

Quasim, S.R. Wastewater Treatment Plants Planning, Design and Operation, CBS Publishing.
Van Haandel A.C & Lettinga G. Anaerobic Sewage Treatment, John Wiley and Sons Ltd. Chichester

CV764 Environmental Engineering Laboratory (0-0-3) 2
Laboratory Practices : Gravimetric methods for solids analysis in water and wastewater, analysis of common cations and anions in water/wastewater, determination of nitrogen, phosphorus and chemical oxygen demand (COD). Titrimetric methods; Electrochemical methods; Spectrophotometric methods; Nephelometric methods; Atomic Absorption spectroscopy; Biochemical oxygen demand (BOD), MPN test for microbial pollution, plate counts; confirmatory tests.
APHA, AWWA,WPEF Standard Methods for the testing of water and wastewater
Sawyer C.L, McCarthy, P.L and Parkin, G.F. Chemistry for Environmental Engineering. McGraw-Hill.
Pelczar M.J., Chan E.C.S. and Krieg, N.R. Microbiology. Tata McGraw-Hill.

CV765 Solid & Hazardous Waste Management (3-0-0) 3
Municipal Solid Waste : Generation, Rate Variation, characteristics; Management Options for Solid Waste, Transport of Municipal Solid Waste, Routing and Scheduling, Treatment, Transformations and Disposal Techniques. Norms, Rules and Regulations. Economics of the on-site v/s off site waste management options. Integrated waste management. Introduction to Hazardous wastes, Definition of Hazardous waste, Risk assessment, Transportation of hazardous waste, Current Management Practices: Environmental audit, Containment, remedial alternatives.
C.N. Haas and R.J. Vamos. Hazardous and Industrial Waste Treatment. Prentice Hall, Englewood Cliffs, New Jersey.
Freeman, H.W. Standard Handbook of Hazardous Waste Treatment and Disposal, McGraw Hill

CV766 Unit Processes Lab & Field Studies (0-0-6) 4
Examination of Microorganisms. Reactor design and operation - demonstration, session: laboratory biochemicalreactor, coagulation, chlorination of water, heavy metal removal, colour removal, Absorption studies using activated carbon. Estimation of suspended particulate matter and pollutants in air using high volume sampler.
American Public Health Association et al, Standard Methods for the Examinations of Water and Waste Water, APHA.
Aneja, K.R.,Experiments in Microbiology, Plant Pathology and Tissue Culture, Wishwa Prakashan, New Delhi.
Manual of methods of General Bacteriology, ASM Publication.

CV767 Environmental Impact Assessment (3-0-0) 3
Planning and Management of Environmental Impact Studies. Methodologies, Prediction and assessment of impacts, evaluation of alternatives. Case Studies. Sustainable development; Environmental policy.
Canter L.W., Environmental Impact Analysis, Mc. Graw Hill.
Srivastava A.K, Environmental Impact Analysis, APH Pub., New Delhi.

CV781 Construction Planning & Control (3-0-0)3
Principles of Project Management,Project Planning, Induction to Scheduling -work/ project break downstructures, Bar- Charts: principles of application of CPM and PERT; Precedence Method,; Updating; Time-cost tradeoffs, Resource Constrained Scheduling;Resource Levelling Project Control;PerformanceMeasurement,EarnedValue; Multiple Construction Projects;Other Net WorkTechniques;Project Management Software Packages
S. Chowdary,Project Management
P.K.Joy,TotalProjectManagement
P. Chandra,ProjectPlanningAnalysis
RoyPilcher,PrinciplesofConstructionManagementWalkerAntony,ProjectManagementin Construction

CV782 Construction Economics & Accounting (3-0-0)3
Economics-industrial development-Support matters of economy related to Engineering-Market Demandand Supply-Quality control-quality production-Audit-economic law of production.Construction economics-Development in housing,transport and other infrastructure-Environment, EcologyEconomics-LocalMaterials-Formand Functional Designs-Construction Workers-urban Problems-Poverty-Migration-unemployment-Pollution.Financing-Financial Management-Types of Finance-longTerm Borrowing-Leasing-EquityFinancing- Internal generation of Fund-External Commercial Borrowings-Govt.Budgeting Support-International Finance Corporations-Analysis of Financial Statements-Balance Sheet-Profit and Loss Account-cashflow-Fund Flow Analysis-Ratio Analysis-

Investment and Financing Decision-Financial Control-JobControl-Centralized Management. Accounting-Cash Basis-Accrual Basis-Percentage Completion Method-
Completed Contract Method-accounting for Tax Reporting & Financial reporting purposes. Lending to Contractors-Loans-interim Financing-Risk and Security.
KwakuA, Tenaand Jose MGuevera, FundamentalofConstructionManagementandOrganization
HalpinDW,Financial and Cost Concept for Construction Management
WarneerZHirsch,Urban Economics

CV783 Contracts & Specifications (3-0-0) 3
Construction Contracts-Elements of contracts-types of contracts-Design of contract documents–international contract document-Standard contract document.Tenders-Prequalification-bidding-accepting-evaluation of tender-potential contractual problems-World Bank procedures. Arbitration-Actions-laws-appointment of arbitrator-powers-rules of evidence. Legal requirements -Insurance-bonding-sale-purchase-land revenue codes-taxlaws-income tax-sales tax-customduties-influence on construction cost-legal requirement for planning-property law-agency law for approval-statutory regulations.
GajariaG.T.,LawsrelatingtobuildingsandEngineeringContractsinIndia
JosephT.Bockrath,ContractsandtheLegalEnvironmentforEngineersandArchitects

CV784 Construction Materials Lab (0-0-3) 2
Study of properties of building materials; study of testing methods and standard specifications for strength and other properties of building materials; concrete mix design and testing; non destructive testing methods; Studies on simple building system components.

CV785 Construction Personnel Management (2-0-0) 2
Sources of lost time,productivity assessment tools such as productivity measurement system, work sampling,foreman
Delay survey; productivity improvement tools such as crew balance charts, processdiagrams,Basic theories of motivation, leadership, communication and team behaviors adapted and applied to construction management; case studies. *Counter C.,Coutler J.J.,The Complete Standard Hand book of Construction Personnel Management, PrenticeHall, 1989 Loosemore M.,Dainty A.,Lingard,H.,Human Resource Management in Construction Projects:Strategic and operational approaches, Spon PressTaylor &Francis Group,UK,2003*

CV786 Construction Methods & Equipment (3-0-0) 3
Factors affecting selection of equipment and methods- Technical and economic; Construction Engineering fundamentals; Analysis of Production outputs andcosts;MethodsandequipmentforEarthmoving,Liftanderection, MaterialTransport,Piledriving,Dewatering;ConcreteConstruction-batching,mixing,transport,placement,finishing, formwork,scaffolding;SteelConstructions-fabrication anderection.

CV787 ConstructionQuality&SafetyManagement (3-0-0) 3
Quality control, Accepting sampling, Statistical Quality Control: Total Quality Management(TQM)- Quality Function Development; Benchmarking, critical factors of TQM in Projects. Concepts of reliability- Types of failures, Component and System Reliability-Use of Redundancy - Interaction between Reliability and Maintainability - Replacement and Maintenance Policies -Design of Reliability. Safety Systems and Organization-Safety Laws- Hazard Analysis and Cost effectiveness- Logical Analysis of safety Systems- Organization, equipment Reliability Consideration - Fault- tree Analysis _ Statistical and Safety Analysis- Safety Information Systems - Safety Budgeting
Jimmy W. Hinze, Construction Safety
Richard J Coble, Jimmy W. Hinze & Theo C Haupt, Construction Safety and Health Management. John L Ashford, The Management of Quality in Construction

CV788 Organizational Behaviour (3-0-0) 3
Approachesto Organizational Behaviour; Overview of the Field of Organization Development: Individuals in Organizations: Motivation and behaviour; Motivation at work; Designing motivating jobs; Creating and individual Decision making;Group Dynamics:Group behaviour,Inter-group relation and conflict;Communication;Leadership in Organizations.Characteristics of Organizations: Organization Structure and Design, Organizational change and Development; Organizational Culture and climate.Managing Innovation and Technology inchanging environments.

Case studies of OD intervention sin mega-construction projects. *GregeryMoorhead,RickyW.Griffin, OrganizationalBehaviour:Managing PeopleandOrganizations,3rd Edition, Houghton Miffin Company,2000 Stephen,PRobbins,Organizational Behaviour,9th edition, Pearson Education Asia,NewDelhi,2001 WendellLFrench,CecilH.Bell,Jr.,Organization Development:Behavioural Science Interventions for Organization Improvement, 6th edition,Pearson Education Asia,NewDelhi,2001.*
Jit.S..Chander,Organizational Behaviour,3rdedition,VikasPublishingHousePvt.Ltd.,,NewDelhi,2005.

CV789 Construction Software Laboratory (0-0-3) 2
Spread sheet applications, Database applications,Project management software,Simulation software, Optimization Software,Visualization software-Construction applications

CV801 Stability of Structures (3-0-0) 3
Concept of Stability, Bending of prismatic bars under simultaneous action of axial and lateral loads- Buckling of solid and open web columns, Critical loading on laced and battened columns, Lateral stability of beams-Analysis of beam columns-Instability of frames, Local buckling and post-buckling behaviour of plates and shells, Bifurcation buckling and limit-load analysis, Application of Energy methods, Numerical methods for solving elastic stability problems.
S. P. Timoshenko and J. M. Gere, Theory of Elastic Stability, McGraw-Hill
N.G.R.Iyengar, Structural Stability of Columns and Plates, East-west Press.

CV802 Earthquake Engineering (3-0-0) 3
Earthquakes Magnitude and intensity, earthquake waves, seismic zoning maps, seismic risk and hazard, ground response spectrum, site amplification, liquefaction, selection of design earthquakes, peak ground acceleration. Earthquake analysis of structures, idealization, equivalent force concepts, response spectrum analysis, concepts of earthquake resistant design: ductility, lateral stiffness, strong column-weak beam design. Seismic retrofitting and repair. Concepts of base isolation and structural response control. Introduction to IS codes -IS 1893, IS 4326, IS 13935, IS 13920.
N. M. Newmark and E. Rosenblueth, Fundamentals of Earthquake Engineering, Prentice-Hall D. J. Dowrick, Earthquake Resistant Design: A Manual for Engineers and Architects, Wiley

CV803 Structural Optimization (3-0-0) 3
Classical optimization techniques, Linear Programming - Simplex method, Nonlinear programming Unconstrained optimization techniques - Steepest descent method, DFP Method, Constrained techniques - SLP and SUMT, Introduction to GA. Applications to structural design problems, computer implementation.
S.S.*Rao, Optimization - Theory and Applications, Wiley Eastern Ltd. K. Deb, Optimization for Engineering Design, Prentice Hall of India.*

CV804 Soil-Structure Interaction (3-0-0) 3
Soil-Foundation Interaction. Soil response model, Elasto-plastic behaviour, Time dependent behaviour. Beams on Elastic Foundations, Analysis of beams of finite length. Plates on Elastic medium, Infinite plates, thin and thick plates. Elastic analysis of piles, Analysis of pile groups, Interaction analysis.
A.P.S. Selva durai, Elastic Analysis of Soil-Foundation Interaction.
H.G.Poulos and E.H. Davis, Pile-Foundation Analysis and Design, John Wiley & Sons R.F.Scott, Soil Mechanics and Engineering, McGraw Hill.

CV805 Structural Reliability (3-0-0) 3
Basic statistics and probability theory - Characteristics of random distributions, Levels of significance and confidence, Statistical distributions. Reliability theory, Structural reliability - level 1, 2 and 3. Characteristics of load and resistance - FOSM and AFOSM methods of assessment. Interpretation of safety. Determination of partial safety factors.
R. Ranganathan, Reliability Analysis and Design of Structures, GMH
R. E. Melchers and A.T. Beck, Structural Reliability Analysis and Prediction, Wiley

CV806 Offshore Structural Engineering (3-0-0) 3
Common offsh ore structures - jacket, gravity-type, hybrids, guyed towers, TLP, compliant structures. Environmental loadings - wind, waves, ice, buoyant, earthquakes, Diffraction theory and Morison equation approach

for wave force. Static analysis - steel structures, concrete platforms, design stress criteria, Examination for dynamic effects. Foundation analysis - piles, pile axial capacity, Bearing capacity of footings, Settlement of foundations. Dynamic analysis - governing equations for wave loadings, stress analysis, response to earthquake loadings.
Dawson, Offshore Structural Engineering, Prentice Hall

CV807 Advanced Concrete Technology (3-0-0) 3
Structure of Concrete - Concrete as a three-phase material - Strength Properties of Concrete - Compressive, tensile, shear, bi- and tri-axial stresses; Deformation Characteristics of Concrete - elastic deformations, shrinkage, creep and thermal properties; Durability of Concrete – Permeability- related problems, Alkali-aggregate reactions. Chemical and Mineral Admixtures, Concrete Mix Design Procedures, Testing and Quality Control of concrete - Conventional and non-destructive tests.
P. K. Mehta and P.J.M. Monteiro, Concrete: Microstructure, Properties and Materials, McGraw Hill A. M. Neville,, Properties of Concrete, Prentice Hall
S. Popovics, Concrete Materials: Properties, Specifications and Testing, Noyes

CV808 Wind Resistant Design of Structures (3-0-0) 3
Tall buildings - Structural concepts, wind effects, Lateral systems for steel buildings, concrete buildings and composite constructions - Shear walls and bracings; Gravity systems for steel buildings, concrete buildings and composite constructions. Analysis and design of Steel Transmission line towers, R.C. chimneys, R.C. cooling towers.
B. S. Taranath, Structural Analysis and Design of Tall Buildings, McGraw Hill.
G.M. Pinfold, Reinforced Concrete Chimneys and Towers, View point publisher.
S.S. Murthy and A.R. Santhakumar, Transmission line Structures.

CV809 Mechanics of Composite Laminates (3-0-0) 3
Types and Classification of composite materials. Composite Laminates, Lamina stress-strain relationship- Classification of laminates-Failure theories-Classical lamination theory-Stress strain variation in a laminate-Stress analysis-Intra and interlaminar stresses in laminates-First and higher order deformation theories-Bending, vibration and buckling analyses using the above theories-Equilibrium equations using PMPE-Boundary conditions-Solution methods.
R. M. Jones, Mechanics of Composite Materials, McGraw-Hill.
J. R. Vinson and R. L. Seierakowski, The Behaviour of Structures Composed of Composite Materials, Martinus Nijhoff Publ.

CV810 Advanced Bridge Engineering (3-0-0) 3
Review of IRC and IRS loadings. Effect of concentrated loads on deck slabs, load distribution methods for concrete bridges. Analysis and Design of superstructures -T beam and slab, bridge, Box girder bridge, Prestressed bridge, Balanced cantilever bridge, rigid frame, arch, bow, string girder. Steel plate girder and trussed bridges, Composite bridges, Cable-stayed bridges, Dynamics response of bridge decks.
D.J. Victor, Essentials of Bridge Engg., Oxford & IBH
N. Krishna Raju, Design of Bridges, Oxford & IBH
M.S. Troitsky, Cable Stayed Bridges, VNR.

CV811 Analysis & Design of Substructures (3-0-0) 3
Introduction, Bearing Capacity of shallow foundation, proportioning and designing of isolated footing, combined footing, strap footing and raft foundation. Pile foundations - Types of piles, Load carrying capacity of single pile and pile groups. Analysis design of pile group and pile cap. Analysis and design of various types of retaining walls.
S. Swamisaran., Design of Substructures, Oxford & IBH
J.E. Bowles, Foundation Analysis and Design, McGraw Hill
M. J. Tomlinson, Pile Design and Construction Practice, E & FN spon

CV812 Computer Aided Design in Structural Engineering (3-0-0) 3
Computer Aided Design Concepts. Program planning and sequencing, Stages in structural design. Computer graphics, Artificial intelligence, Knowledge-based expert Systems, Architecture and applications of KBES, Principles of Neural Net works. Flow- charts and programs for design and detailing of structural elements.
C.S.Krishnamoorthy and S.Rajeev, Computer Aided Design, NarosaPublishers. H.B.Harrison, Computer Methods

in Structural Analysis, Prentice Hall.
H.Adeli.. and K.V.Balasubramanyan, Expert systems for Structural Design, Prentice Hall.

CV813 Repair and Rehabilitation of Structures (3-0-0) 3
Introduction, Deterioration process, Planning, Investigation and diagnosis, Testing methods, Interpretation of results, Repair and renovation techniques.
R.T.L. Allen, and S. C. Edwards and D.N.Shah, The Repair of Concrete Structures, Slough Publications T. Key, Assessment and Renovation of Concrete Structures, Longman Scientific
P. H. Emmons and B. W. Emmons, Concrete Repair and Maintenance Illustrated, Means Co.

CV814 Pre-engineered Structures (3-0-0) 3
Necessity, Advantages, Types of prefab elements, Modular coordination, Classification, Production techniques, Precast and prestressing systems, Design and construction of pre-engineered buildins, Quality control aspects.
A. S. G. Bruggeling and G. F. Huyghe, Prefabrication With Concrete, Balkema
Laszlo Mokk, Prefabricated Concrete for Industrial and Public Structures, Akadémiai Kiadó

CV815 Fracture Mechanics of Concrete (3-0-0)3
Introduction, Principles of Linear Elastic Fracture Mechanics, Nonlinear Fracture Mechanics, Structure and Fracture Processes in Concrete, Test methods for the Determination of fracture Parameters, Brittleness & Size Effect of Concrete Structure, Tension softening of the Concrete, Application of Fracture Mechanics to Concrete Structures.
T. L. Anderson, Fracture Mechanics:Fundamental and Applications, CRC press David Broek, Elementary Engineering Fracture Mechanics, Noordhoff
S. P. Shah, S. E. Swartz, and C. Ouyang, Fracture Mechanics of Concrete, John Wiley & Sons
B. L. Karihaloo, Fracture Mechanics & Structural Concrete, Longman Scientific & Technical

CV816 Analysis and Design ofShells and Folded Plates (3-0-0) 3
Classification of shells, Membrane and bending theory of circular cylindrical shells, Beam method for Cylindrical shells. Membrane theory of doubly curved shells - Applications for spherical dome, Conical shell, Hyperboloid of revolution, Hyperbolic parabolids. Folded Plates.
G. S. Ramaswamy, Design and Construction of Shell Roofs, CBS Publishers
K. Chandrashekhara, Analysis of Thin Concrete Shells, Tata McGraw-Hill P.C.Varghese, Design of Shells ad Folded Plates, Prentice Hall of India

CV817 Aseismic Design of RC Buildings (3-0-0) 3
Planning for Aseismic buildings, Concepts of seismic design, An overview of seismic analysis procedures, Seismic Load combinations, Ductile Design provisions in IS 13920 :2016, General Specifications, Ductile detailing of beams, Ductile detailing of Columns subjected to bending and axial load, Ductile detailing of Reinforced concrete Shear walls, Design Examples of Beams, Columns, Beam-Column Joints, Shear-walls. Capacity Spectrum Procedure and Performance-based seismic design.
T Paulay, M J N Priestley, Seismic Design of Reinforced concrete and Masonry buildings, Wiley
B. S Taranath, Tall Buiding Design, CRC Press,
D. Dowrick, Earthquake Resistant Design and Risk Reduction, Wiley
S K Duggal, Earthquake Resistant Design of Structures, Oxford University press

CV821 Rock Mechanics (3-0-0) 3
Engineering classification of rocks, Engineering properties of intact rocks, Determination of insitu properties - shear strength, deformation, insitu stress, strength of jointed rocks, stability of rock slopes, Bearing Capacity determination, Ground improvement techniques in rock masses, Rock blasting.
Jaegar and Cook, Foundation of rock masses. Goodman, Introduction to rock mechanics, Wiley international

CV822 Soil Dynamics & Machine Foundations (3-0-0) 3
Dynamic loads, Types of machine foundations, Theory of free and forced vibrations, Dynamic soil properties, mass spring dash pot model, elastic half space model, damping in soils, Design of machine foundations, Foundations under reciprocating engines, Foundations for machines producing impact loads, Vibration Isolation.
Barkan, Dynamics of Bases and Foundations, McGraw Hill.
Richart R.E., Hall Ward Woods, Vibrations in soils and foundations, Prentice Hall.

Prakash S., Soil Dynamics, McGraw Hill

CV823 Advanced Engineering Geology (3-0-0) 3

Introduction, interior of the earth, weathering, Earthquakes, soils, mineralogy, petrology, study of igneous, sedimentary, metamorphic rocks, Engineering properties of rocks and their assessment, structural geology, geological structures, Dip and strike, folds, faults, joints, unconformities and their importance, clay mineralogy, stratigraphy, Hydrogeology, geophysical exploration, applied geology, geological investigations in dam projects, tunnel projects and in landslides, control measures.

Blyth, F.G.H & de Freitas, H.H., Engineering Geology,
ELBS Krynine& Judd, Principles of Engineering Geology and Geotechnics, McGraw Hill Robert F. Legget,
Geology and Engineering, McGraw Hill

CV824 FEM for Geotechnical Engineers (3-0-0) 3

Introduction; Single element - various shapes, displacement models, isoparametric elements, stresses and strains, stiffness matrices; The overall problem - an assemblage of elements; Techniques for nonlinear analysis; Application of FEM to soil and rock mechanics

Desai, C.S. & Abel, J.F., Introduction to Finite Element Method, CBS Publishers.
Gudehus, R.D., Finite Element in Geomechanics, John Wiley.

CV825 Earth & Rockfill Dams (3-0-0) 3

Introduction, site selection and exploration; Factors influencing design and design details; Treatment of rock foundations and abutments; Foundation treatment of Earth dams on pervious soils, controlling underseepage and relief wells; stability analysis; special design problems and details; measurements of porewater pressure and movements; Embankment construction procedures, equipments, quality control.

Sherard, J.C., Woodward, R.J., Gizienski, S.F. and Clevenger, W.A., Earth and Earth Rock Dams, John Wiley.
Sowers, G.P. and Sally, H.L., Earth and rockfill Dam Engineering, Asian Publ. House.

CV826 Geotechnical Instrumentation (3-0-0) 3

Requirements of a good instrumentation; Theory, Design, Methods of analysis of data; laboratory and field instrumentation; Planning an instrumentation program; transducers, hydrometers, strain measuring devices, load cells, LVDTs, pH meter etc., measuring rock and rock mass properties; settlement gauges, inclinometers, earth pressure cells, piezometers, instruments used in geophysical exploration methods, ground probing radar and instruments used in field tests such as SPT, SCPT, DCPT etc., nuclear moisture meter/densitometer, frequency analyzer, role of electronics in instrumentation; calibration, maintenance and installation of instruments, uncertainty analysis

Hanna, T.H., Field Instrumentation in Geotechnical Engineering, Trans-Tech Publ.
Bowles, J.E., Engineering Properties of Soils and their Measurements, McGraw Hill.

CV827 Soil Reinforcement & Geosynthetics (3-0-0) 3

Historical background, RCC, Vidalean concept of reinforced earth, Mechanisms, Types of reinforcements, Backfill soil properties, soil-reinforcement interaction studies, Internal and external stability criteria, Design principles of steep reinforced soil slopes, reinforced earth walls, MSE walls, reinforced soil footings, pavements, embankments on soft soils, geosynthetic clay liners, construction details; geosynthetic materials, functions, property characterization, testing methods for geosynthetics. Recent research & developments.

Koerner, R.M., Designing with geosynthetics, Prentice Hall Inc
Jones, C.J.F.P., Earth Reinforcement and Soil Structures, Butterworths, London.

CV828 Environmental Geotechnology (3-0-0) 3

Perspectives of Environmental Geotechnology, Soil - Environment water Interaction, Mass transport, Energy Gradient & Conductivity, Sources of water, Contamination - underground, ground water, Flow conditions, Contaminate migration, Disposal and Containment of Solid water, Remediation.

Donald P. Coduto, Geotechnical Engineering Principles and Practices, Prentice-Hall
Daniel, D. E. Geotechnical Practice for Waste Disposal, Chapman and Hall, London. Reddi, L. N., and Inyang, H. F.,Geoenvironmental Engineering- Principles and Applications, Marcel Dekker, Inc.

CV841 Highway & Airport Geometric Design **(3-0-0) 3**
Design Controls and Criteria: Factors Influencing Functional Design of Highways, Design Controls and Criteria, Topography and Physical Features, Traffic, Impact of Vehicular Characteristics on Road Geometrics, Speed, and Safety. Cross-sectional Elements and Highway Geometrics: Cross-sectional Elements, Sight Distance, Horizontal Alignment, Vertical Alignment, Intersection Design, Parking and Other Facilities, Rotaries and Grade Separators. Airport Design Standards, Airport Configuration and Planning AASHO,
A Policy on Geometric Design of Rural Highways and Urban Highways.
Khanna S.K., and Arora, M.G., Airport planning and Design, Nem Chand and Bros., Roorkee.
Kadiyali, L.R., Traffic Engineering and Transport Planning, Khanna Publishers, New Delhi.

CV842 Air Transport Planning & Design **(3-0-0) 3**
Airport Planning- Aircraft characteristics related to airport planning and design, airport master plan, site selection, planning surveys etc. Classification and Standards, Capacity and Delay, Terminal Facilities and Standards, The Demand Analysis, Optimal Route Frequency planning- Measure of air travel capacity, Approach to Demand Analysis, Microanalysis of Air Travel Demand, Calibration of Macromodels, Microanalysis of Air Travel Demand, Disaggregate Models of Air Travel Demand, Air travel Choice Models, Simultaneous Models of Demand and Supply. Optimal Route Frequency Planning, Air Traffic Controls.
Horonjeff, R and Mckelvey., The Planning and Design of Airports, McGraw Hill.
Kanafani, A., Transport Demand Analysis, McGraw Hill Book Company.

CV843 Infrastructure Development: Policies, Planning, Engineering, and Appraisal **(3-0-0) 3**
Overview on infrastructure development policies of central and state governments in India. Programmes and initiatives for development of roads, railways, airports, and urban infrastructure in India. Planning of infrastructure projects contexts, perspectives, and objectives. Project-wise studies and development of alternatives. Screening of alternatives and Master planning. Overview of various planning tools. Project appraisal by financial analysis, economic analysis, environmental and societal impact assessments. Concept of sustainable infrastructure development. Considerations to uncertainty and risk assessments.
Alvin S. Goodman and MakarandHastak, Infrastructure Planning, Engineering, and Economics, Second Edition, McGraw-Hill Education, 2015.
Transport Notes by the Transport Economics, Policy and Poverty Thematic Group, World Bank, 2005.
Relevant Standards, Guidelines, and Other Publications from the Indian Roads Congress, New Delhi.

CV844 Railway Track Engineering **(3-0-0) 3**
Introduction to railway track structure. Indian Railways (IR): Past, present, and future plan, organizations associated with the IR, policies and programmes of IR. Track structure of IR: Rails, sleepers, ballast and formation. Design of IR track: horizontal and vertical alignment, switches and crossings. Modern track construction methods. High-speed-tracks. Introduction to railway tunnels.
“Railway Track Engineering”by J.S.Mundrey, Fourth Ed., McGraw Hill Education (India) Pvt. Ltd., 2009.
“Railway Engineering”by Satish Chandra and M.M.Agarwal, Oxford University Press-India, 2013.
Standards, Guidelines, and other publications from IR’s RDSO.

CV845 Rural Roads **(3-0-0) 3**
Planning of rural roads, Location Surveys and Geometric Design, Pavement Materials: Soil Investigation, Properties and specifications of materials, Utilisation of locally available materials and waste materials in village road projects like fly ash, iron and steel slag, recycled and other waste materials etc., stabilized roads, road aggregates, materials for bituminous construction, cement concrete, special pavements. Pavement Design, Road Drainage, Construction and specifications, Maintenance of rural roads
“Rural Roads Manual”, IRC:SP:20-2002, by Indian Roads Congress, New Delhi.
Other relevant Standards, Guidelines, and Publications from the Indian Roads Congress, New Delhi.

CV846 Advanced Asphalt Technology **(3-0-0) 3**
Asphalt refining, asphalt types and uses, asphalt grading system, rheological properties and pavement performance, Superpave asphalt binder tests and specifications, asphalt chemistry. Role of aggregates in asphalt mixtures; Hot mix asphalt mix design methodology; characterisation of asphalt mixtures; Equipment and construction for HMA paving; Special mixtures and additives; Reuse, recycling and reclaim of asphalt pavements.

"Hot Mix Asphalt Materials, Mixture Design and Construction"by E.Ray Brown and others, Third Edition, National Asphalt Pavement Association Research and Education Foundation, Maryland, 2009.

CV847 Concrete Microstructure, Properties, and Mechanics (3-0-0) 3

Introduction to concrete and role of individual ingredients. Concrete microstructure, strength, dimensional stability, durability, properties of concrete at its early age. Concrete Mechanics: Elastic and viscoelastic behaviour of concrete. Special types of concrete: High strength concrete, high performance concrete, shrinkage-compensating concrete, fiber reinforced concrete, geopolymer concrete, use of industrial by products in concrete, pervious concrete.

"Concrete: Microstructure, Properties, and Materials", by P.K.Mehta and P.J.M.Monteiro, Fourth Edition, McGraw-Hill Education, 2014.

CV848 Characterization and Modeling of Asphalt Mixtures (3-0-0) 3

Hot mix asphalt mix design concepts, classical methods, Superpave method. Modeling of asphalt concrete-performance characteristics, future asphalt concrete modeling. Asphalt rheology –Modeling of asphalt binder rheology and its application to modified binders. Stiffness characterization –Comprehensive overview of stiffness, complex modulus characterisation of asphalt concrete. Constitutive models- viscoelastoplastic damage modeling of asphalt concrete. Models for rutting by simple shear tests, creep versus repeated loading, simple performance tests. Models for fatigue cracking and moisture damage. Models for low-temperature cracking in asphalt binders, mastics, and mixtures.

"Modeling of Asphalt Concrete" by Y.Richard Kim, ASCE PRESS, McGraw Hill, 2009.
"Mechanics of Asphalt: Microstructure and Micromechanics" by L.Wang, The McGraw-Hill Co. Inc., 2011.
"Hot Mix Asphalt Materials, Mixture Design and Construction"by E.Ray Brown and others, Third Edition, National Asphalt Pavement Association Research and Education Foundation, Maryland, 2009.
Relevant International Standards of ASTM International, AASHTO, AI

CV849 Traffic Simulation and Modeling (3-0-0) 3

Introduction to Traffic Simulation; simple Probability Concepts; Different Probability Distribution (discrete and continuous distribution); Random Number Generation; Macroscopic Traffic Simulation: concepts of macroscopic models, first order traffic flow models (LWR Model), second order traffic flow models, Macroscopic Traffic Simulator: NETSIM; Mesoscopic Traffic Simulation: Concepts of mesoscopic models, application of mezzo models. Mesoscopic Traffic Simulator: DynaMIT; Microscopic Traffic Simulation: Concepts of microscopic models, Different types of car following models, lane changing and overtaking models, Different types of traffic simulation models; Microscopic Traffic Simulator: MITSIM, VISSIM; Traffic simulation models for mixed traffic conditions.

J. Barcelo, Fundamentals of Traffic Simulation, Springer, 2010.
A. M. Law and W. David Kelton, Simulation Modeling and Analysis, 4th edition, McGraw Hill, 2006
T. Toledo, Integrated Model of Driving Behavior, VDM Verlag Dr. Müller, Saarbrucken, Germany, 2008.
M. Treiber and A. Kesting, Traffic Flow Dynamics: Data, Models and Simulation, Springer, 2013

CV850 Mass Transport Systems (3-0-0) 3

Transit Classifications: Classes of Transit Modes, Modes, Technologies, Service Types, and routing. Basic Transit Management Activities: Service, Finance, Marketing, Maintenance, Demand Analysis, Transit Subsidies. Transit Terminals: Design, Functional Aspects, and Scheduling of Transit Units. Performance Evaluation Techniques: Efficiency and Effectiveness Indicators for Transit Planning: System, Subsystem, and Route Level Analyses, Staff Utilization, Fleet Utilization and Productivity, Passengers Carried, Revenue, Operating Costs, and Break-Even Load, Capacity Utilization, Financial Performance indicators, Cost-Benefit Analysis. Techniques for reduced traffic demand: staggered hours, and vehicle restrictions. Transport System Management Actions: Traffic management techniques for improving vehicular flows, preferential treatment for high occupancy modes, promoting non-auto or high occupancy use, and transit and intermediate public transport service improvements. Bus transit operations: Planning, routing and scheduling, Location of loading and unloading platforms and transit terminals.

Vuchic A and Vukun R., Urban transit: operations, planning and economics, prentice hall, 2012 Morlok E.K., Introduction to transportation engineering and planning, McGraw hill,1978
Alvin C.Rencher and William F.Christensen,Methods of Multivariate Analysis, Wiley; 3 edition, 2012
Subhash C. Ray, Data envelopment analysis: theory and techniques for economics and operations research, Cambridge university press, 2012

Transportation Systems Management: State of the Art, UMTA, US Dept. of Transport.

CV851 Soil Mechanics for Highway Engineers (3-0-0) 3
Functions of subgrade soil, importance of subgrade soil properties in highway engineering such as Design andperformance of pavements, embankment foundations and slopes, Soil survey, Soil water, Detrimental matter in soils, Frost action in soil, Soil Compaction, Stress- Strain Relationships on Soils, Stress in Soils, Highway Embankments, Foundations, Stability Analysis.
RRL, DSIR, Soil Mechanics for Road Engineers, HMSO London Leonards, Foundation Engineering, McGraw Hill Book Co.

CV852 Traffic Engineering and Management (3-0-0) 3
Traffic Stream Characteristics; Traffic Measurement Procedures; Probability and Statistics for Traffic Engineers; Highway Capacity and Level of Service Concepts; Interrupted and Uninterrupted Flow; Capacity under Heterogeneous Traffic conditions; Intersection Manoeuvers and Operation; Design of Traffic Control Signals; Accident and Road Safety; Traffic Demand Management; Traffic Management Techniques.
Kadiyali, L.R.., Traffic Engineering and Transport Planning, Khanna Publishers, New Delhi
Roess, R. P., Prassas, E. S. and McShane, W. R., Traffic Engineering (3rd Ed), Pearson Prentice Hall, New Jersey
Pignataro, L., Traffic Engineering: Theory and Practice, John Wiley
Khisty, C, J. and Lall, B. K., Transportation Engineering (3rd Ed), Prentice Hall of India, New Delhi.

CV861 Earth & Environment (3-0-0) 3
Understanding the Earth, atmosphere and processes governing environmental conditions; the geologic, tectonic, hydrological and biogeochemical cycles. Study and significance of natural resources; renewable biological resources, wildlife conservation/management, fisheries, forestry, energy resources, energy consumption, scarcity and conservation; mineral resources, mineral availability and recycling; air, water and soil resources. World food supply; ecological impacts of modern agriculture, organic farming. Major environmental concerns.
Heijungs, R. Environmental Life Cycle Assessment of Products. Center of Environmental Science, Leiden.

CV862 Transport of Water & Wastewater (3-0-0) 3
Transport of Water: Water Storage and Transmission: pumps and pumping units, Materials for pipes: Specification for pipes, pipe appurtenances, control devices. Distribution Systems : Principles of design, analysis of distribution networks, maintenance of distribution systems, Transport of Wastewater: Concept of model based design – hydraulic fundamentals of design models - Basic properties and model formulations for the design of wastewater of collection system - transitions in flow of sewage. Storm Drainage: rainfall data analysis - hydraulics. Equipment requirement for O & M; preventive maintenance - monitoring safety requirements.
Fair G.M. Geyer, J.C., Okun, D.A. Water and Wastewater Engg. Vol.I and II, John Wiley, New York

CV863 Air Quality Management (3-0-0) 3
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, Ambient air quality and emission standards, Air pollution indices, Air Act, legislation and regulations, control principles, Removal of gaseous pollutants by adsorption, absorption, reaction and other methods. Biological air pollution control technologies; bioscrubers, biofilters, Indoor air quality
Wark Kenneth and Warner C.F, Air Pollution its Origin and Control. Harper and Row, Publishers, New York
Sincero A.P. and Sincero G.A. Environmental Engineering, Prentice Hall.

CV864 Models for Water & Air Quality (3-0-0) 3
Introduction to Mathematical Models: Modeling approaches to water quality - classification of models - considerations in selecting models, Model requirements and limitations. D.O. Models for Streams, Models for Estuary and Lakes, Air quality models. Application of available softwares in water, air and distribution networks.
Thomann, R.V., and Mueller, A.J. Principles of surface water quality modelling and control, Harper and Row, New York.

CV865 Environmental Systems Analysis (3-0-0) 3
Introduction to natural and man-made systems. Systems modeling as applied toenvironmental systems, the model

building process, addressing to specific environmental problems. Strategies for analyzing and using environmental systems models. Application of optimization methods. Integrated management strategies
Weber W.J. Jr. Environmental Systems and Processes, Wiley Interscience.

CV866 Management of Water, Waste & Sanitation Utilities (3-0-0) 3
Introduction to management of Water and Sanitation, Development programmes, Feasibility planning. The role, objectives and techniques of project management to deliver effective and efficient infrastructure services, Project Appraisal, Contract management, Strategic Management, Change Management, Financial & Marketing management for non-financial water managers, Sustainable water and material flux management, Environmentally sound technologies for fresh water and wastewater management, Water quality surveillance programmes. The Emergence of Public Services Transnational Corporations and their Strategies in the Water Sector. Concept of Water Markets and the role of national and federal governments.
Mays, Urban Water Supply Handbook, McGraw Hill.

CV867 Membrane Processes for Water & Waste Treatment (3-0-0) 3
Introduction to membrane separation processes, Membrane filtration, dead and filtration, Cake filtration, Reverse osmosis, Nanofiltration, Ultrafiltration, Microfiltration, Membranes and modules, MF/UF experimental set up, Laws of MF/UF, Limiting Phenomena, Economic study, Applications, Case studies.
American Water Works Association Research Foundation, Water Treatment- membrane processes, McGraw Hill.

CV868 Industrial Waste Treatment (3-0-0) 3
Special nature of Industrial wastes, Sources and Characteristics, equalization/neutralization, treatment - based on specific case studies of major industrial processes like Food and dairy, distillery, fertilizers, pulp and paper, textiles, petrochemicals, power generation, electronics and IT etc.
Eckenfelder, Wesley W. Jr., Industrial Water Pollution Control, McGraw Hill.

CV869 Environmental Issues based on Case Studies (3-0-0) 3
Current issues of National Importance like River basin disputes, National/Inter National Environmental Policy, Global Conflicts etc. to be discussed.

CV870 Remote Sensing & GIS Applications (3-0-0) 3
Fundamentals of Remote Sensing, Concepts, Sensors, Interpretation and Analysis Techniques, Indian Satellites, Applications of GIS.
Thomas N. Lilles and and Keifer - Remote Sensing and Image Interpretation, John-Wiley.
Anji Reddy - Remote Sensing and GIS- Anshan Pub.

CV871 Ecotechnology (3-0-0) 3
Water budgeting, crop irrigation, Ecotechnology in crop plants, Sewage farming and utilization of waste water and solid wastes, wetlands and Root zones. Waste handling by Composting, Vermi compost other degradable biomass waste handling, Ecosanitation. Biodegradation: principle and ecorestoration. Green technology and green chemistry. Case studies about solid wastes from different industries and reuse.
Eco technology for Pollution Control and Environmental Management, R. K. Trivedi, Arvind Kumar, Enviromedia, Karad.

CV872 Environmental Biotechnology (3-0-0) 3
Concepts, Definitions, criteria, Bio treatment options for soil and ground water contamination, Bio accumulation, Bio fertilizers, agro technologies, Bioremediation and eco restoration using plants and microorganisms. Role of GMO in environmental biotechnology field with different examples.
Environmental Bio technology, Geeta bali et.al. APH Publishing, New Delhi.

CV873 Industrial Pollution Management (3-0-0) 3
Concepts, benefits, waste reduction, waste audit, environmental audit, ISO 14000, ISO 18000 series standard, Total quality management Life cycle design / assessment, process industries, cost benefit analysis, EIA and EMP, Good Management Practices, problems of small industries, case studies
Industrial Pollution Prevention Handbook, Freeman H.M., McGraw Hill Inc.

CV874 Environmental Microbiology (3-0-0) 3

The Characterization, classification and identification of microorganisms, Pure cultures and cultural characteristics, Enzymes and their regulations, microbial metabolism, control of microorganismz. Microbiology of domestic water and wastewater, industrial microbiology. Epidemiology of infectious diseases, microbial agents of diseases.

Pelczar, M. J., Chan E.C. S. and Krieg, N. R. Microbiology. Tata McGraw-Hill Pub. Co. Ltd., New Delhi.

CV875 Environmental Management (3-0-0) 3

Principles of Environmental Management, Policy and Legal aspects of Environmental Management, Environmental Management Techniques, Environmental Design, Environmental Economics, Case studies.

Kulkarni V and Ramachandra T.V., Environmental Management, Capital Publishing, Banglore

North K, Environmental Management, ILO, Geneva

Sapru R.K., Environment Management in India, Ashish Publishers, New Delhi. Kumor A., and Oti, Environment Management, APH Publishers, New Delhi.

CV876 Environmental Toxicology (3-0-0) 3

Defintion branches Taxicology, role of Taxicologist, causes of toxicity, types of toxicity, occurence of toxciants, damage process and action of toxicants, factors afftecting xenobiotic action., defense responses to toxicants, aquate and environmental toxicity, aquatic toxicology tests & their types, environmental impact interpretation, some important terminologies in toxicology, recent advaces in toxicity analysis.

W.G Lands M.H Yu, Introduction to environmental toxicology, CRC press

CV877 Environmental Hydraulics (3-0-0) 3

Basic equations for fluid flow analyses, Reynolds transport theorem, Fundamental Relationships for Flow and Transport, Diffusion and dispersion, Derivation of diffusion equation, Solution of diffusion equation, Advective diffusion, Turbulent diffusion, Transport Processes in Rivers, Modelling the movement of pollutants in ground water, Treatment Plant Hydraulics, Hydraulic profiles, Distribution networks.

Martin J.L. and McCutcheon S.C. Hydrodynamics and Transport for Water Quality Modeling, CRC Press, 1999.

Singh, Vijay, Hager, Willi H. (Eds.), Environmental Hydraulics, Kluwer Academic Pub., 1996.

Tsanis, I.K., Wu, J., Shen, H and Valeo, C. Environmental Hydraulics, Elsevier Publications, 2007.

CV878 Modelling Waste Water Treatment Processes And Plants (3-0-0) 3

Basis of wastewater modeling (kinetics, stoichiometry, mass balances, hydraulics, mixing and matrix notation) – An introduction of existing International water Association Quality (IWAQ) models (ASM1, ASM2, ASM3, ASM2d) - Selection of computer programs in which the models can be built in; Procedures for characterization of wastewater and sludge and the protocol for the development of calibrated activated sludge models- Case studies on modeling wastewater treatment plants. Applications of computer programs viz. ASIM, AQUASIM, SIMBA, WEST, SCADA as a tool of modeling wastewater treatment processes.

Henze, M., Gujer, W., Mino, T and M.C.M. van Loosdrech, Activated Sludge Models ASM1, ASM2, ASM2d and ASM3, IWA publishing, 2002

D. Brdjanovic, S.C.F Meijer, C.M. Lopez-Vazquez, C.M. Hooijmans, M.C.M. van Loosdrecht, Applications of Activated Sludge Models, IWA Publishing, 2014.

Leiv Rieger, Sylvie Gillot, Guenter Langergraber, Takayuki Ohtsuki, Andy Shaw, Imre Takacs, Stefan Winkler, Guidelines for Using Activated Sludge Models, IWA Publishing, 2012

CV881 Repair & Restoration of Structures (3-0-0)3

Deterioration processin concrete structures,Construction and design defects. Diagnostic methods, Load testing and nondestructive testing. Causes and prevention of cracks in masonry structures,Corrosion in structures, process and prevention, Fire damage of buildings. Repair materials, cement, aggregate, polymer and construction chemicals. Management of concrete for durability. Damage assessment and restoration techniques,case studies of restoration works,buildings, bridges, water retaining structures, marine structures.

PeterHEmmons,ConcreteRepair and maintenance Illustrated, Galgotia Publications Pvt.Ltd., NewDelhi,2001

R.T.LAllen,S.C.Edwards,TheRepairofConcreteStructures,Blackie&SonsLtd.,Glasgow,London,1987

Tedkay,Asserssment and Renovation of Concrete Structures, Longman Scientific&Technical, Harlow,1992.

R.Jagadisa,StructuralFailures-CaseHistories,Ocford & IBH PublishingCo.Ltd., NewDelhi,1995.

R.N.Raikar,DiagnosisandTreatmentofStructuresinDistress,R&DCentreStructuralDesigners&Consultants

Pvt.Ltd.,Vashi,NewBombay,1994.

CV882 Operation Research &DecisionTheory (3-0-0) 3
Phases of OR- Classifications; Linear Programming. Formulation & Graphical solutions; Simplex Algorithm; Quality & SensitivityAnalysis; Dual Simplex method.Transportation & Assignment problems; Games and their solution by Linear Programming; Network Analysis; Queuing Theory; Basic Structure of aqueuing model. M/M/1and M/M/Smodels.
Hamdy ATaha, Operations Research
Hiller and Liberman, Introduction to Operations Research.

CV883 Maintenance & Rehabilitation of Structures (3-0-0) 3
Performance of construction materials and Components in services;Causes of deterioration; preventive Measurements and maintenance ; principles of assessment of weathering and durability;Characteristics of materials; Diagnosis of construction failures; dealing withcracks;Methods of repair in concrete,steel and timber structural components;Corrosion damage of reinforced concrete and its repair and prevention measures; Surface deterioration, Efflorescence causes,prevention and protection;Surface coating and painting;Water Proofing; Strengthening of Existing Structures; Special repairs,maintenance inspection and planning, Budgeting and management.
Peter HEmmons,Concrete Repair and Maintenance Illustrated,Galgotia Publications Pvt.Ltd.,NewDelhi,2001
R.T.L.Allenand S.C.Edwords,The Repair of Concrete Stuctures,Blacki & Sons Ltd.,Glasgow,London,1987.

CV884 Structural Systems & Design (3-0-0) 3
Structural Systems for buildings and spatial structures-concrete and steel.Analysis and design of typical grids, shells and folded platero of structures, InformationTechnology and Industrial buildings, Prefabricated Structural Systems, Design of scaffolding and form work for different types of structures including spatial and industrial structures.
N.Subramanian,Principles of SpaceStructures,A.H. Wheeler&Co.(p)Ltd.,Allahabad,1995. G.S.Ramaswamy,Design andConstruction of Concrete Shell Roofs,Tata Mc Grawhill Publishing Co.Ltd.,1995. MarkFintel, HandBook of Concrete Engineering,Reinhold,NewYork,1995. PerifovR.L.,Form Work for Concrete Structures, Tata McGraw Hill Publishing Co.Ltd.,NewYork,1975

CV885 Valuation Techniques in Engineering (3-0-0) 3
Purpose of valuation-Different forms of values.Outgoings- Municipal&Govt.Taxes,insurance,Lossofrent, collection charges,sinking fund,Annual repairs &maintenance.Depreciation –Methods of calculation.Land value, Year's Purchase, Capitalised value,Obsolescence, Amortization.Methods of valuation- Open land valuation-factors affecting intrinsic values of land,Comparative method,Abstractive method,Belting method.Rent-definition,forms. Cost of structure- BIS rules for measuring plinth area and cubical contents.Valuation of land with buildings- Rental method,Land and building method,Valuation on profit basis,Direct comparison of capital value,Residualor Development method.Rights and Liabilities of Lessor & Lessee,Lease hold properties,free hold Properties. Easements - self imposed,legally created, Dominant and servientheritage-effect of easements onvaluation.Market-Real Estate market and market value-fairmarketvalue, openmarketvalue-parameter saffecting.Investments-Bonds,debentures, capitalgains,WealthTax and IncomeTax.
Banerjee,Principles and Practices of Valuation
Rao Gopinath CH, Valuation Practices of Immovable Properties.MitraAK,Theory and Practice of Valuation.
ShahN.A, Quality Surveying andValuation.

CV886 Contract Laws & Regulations (3-0-0) 3
Construction Contracts-Elements of contracts-types of contracts-Design of contract documents-international Contract document-Standard contract document.Tenders-Prequalification-bidding-accepting-evaluation of tender-potential contractual problems-World Bank procedures.Arbitration-Actions-laws-appointment of arbitrator-powers-rules of evidence.Legal requirements-Insurance-bonding-sale-purchase-land revenue codes-taxlaws-incometax -salestax-customduties-influence on construction cost-legal requirement for planning-property law-agency law for approval-statutoryregulations.
GajariaG.T.,Laws relating tobuildings and EngineeringContractsinIndia JosephT.Bockrath,Contracts and the Legal Environment for Engineers and Architects

CV887 Quality Control & Assurance (3-0-0) 3
Construction Organization-Types-Inspection-Control-Quality ManagementSystem-Quality Assurance-Control-

Quality Circle-Architects-Engineers-contractors. Quality Policy-Objectivesand Methods-Consumer Satisfaction-Ergonomics-Completion,Time-statistical,tolerance-Concepts-Codes-Standards-Contracts-Construction programming-Inspection Procedures-Processes and Products-Total QA/QC program and cost implication. QualityAssurtance and Control-Objectives-Techniques-Needs-factors influencing-Failure Aspect, Analysis. Stabiliy Methods-Optimum Design-Reliability Testing-Reliability Coefficient and Reliability prediction.Drawings-Detailing-specification-Standardization-Bid Preparation Construction Activity-safety- Environmental-Social-Natural Causes

JuranFrank,J Mand Gryna F M, quality Planning and Analysis
Hutchins G,ISO9000
JohnLAshford,TheManagementofQualityin Construction

CV888 Management Information Systems (3-0-0) 3

Framework-business Models-Architecture of Information System- Evolution. Modern Information System-Development Life Cycle-Methodologies-Computer Based Methods-Structured Programming. Integrated Construction Management Information System-Project Management Information System-Finance-Marketing-Production-Personnel Levels-TypesofInformationSystems-Comparisons-Concepts-International Information System.ImplementationandControl-SecurityTesting-Coding-Error Detection-validating-Cost-Benefit-Risk Information System. System Audit-. System methodology-Objectives-Timeand Logic-Knowledge and human Dimension-Software Engineering Qualities-Design,Production,Service,Software Specification-SoftwareLifeCycle Models-Verification and Validation.

GordanBDavis,ManagementInformationSystem:ConceptualFoundations
JoyceJElam,CaseSeriesforManagementInformationSystem
RalphHSpragueandHugeJ Watson,decisionSupportforManagers
Michael WEvansandJohnJ Marciniah,SoftwareQualityassuranceandManagement

CV889 Functional Efficiency of Buildings (3-0-0) 3

Environmental factors;Thermalperformance of buildings;Comfort factors and measurements;climatic design;Solar Control and shading devices,Louver design,ventilation;Introduction to lighting; units of light,colourlamps, luminaries, Day light design of Generallighting schemes;Energy management and lighting; acoustical design of Auditoria and noise control in buildings.

CV890 Supervision of Field Operations (3-0-0) 3

An overview of the principles of field supervision which includes leadershipskill, problemsolving, motivation techniques, problem solving process, communication methods, and useful supervisory aids forconstruction projects.

CV891 Computer Aided Designin Civil Engineering (3-0-0) 3

Concepts of Computer Aided Design-Role of Computers in engineering process. Introduction to Hardware and Software Systems for Computer Aided Engineering. Software Tools for CAD:Programming paradigms–Object Oriented Programming-Introductionto C++ Computer modeling of engineering systems-Data Structures-pointers, arrays,structuresandclasses,Programming techniques for computer modeling of civil engineering problems. Computer Graphics-Basic principles,Transformations, Segmentation,Interactive graphics, Drafting-AutoCAD, GraphicalUser Interfaces- Windows. Graphics standards- Graphics Programming. Database Management System-Database models-Concepts of RDBMS-Engineering Database Management systems- Concepts of Database Programming.Artificial Intelligence and Expert Systems- Knowledge Representation-Rules, Frames and Semanticnet works-Inference Strategies.Processmodels-prototypes in Civil Engineering. Development of CAE systems for different civil engineering applications such as inBuilding Technology and Construction Management, Geotechnical Engineering, Hydraulics and Water Resources Engineering, Structural Engineering, Transportation Engineering and Environmental Engineering.

StephenPrata,Programming in C++.
Gary,J Bronsonenk S.and LindN.C.,Methods of Structural Safety.
C.S.Krishnamoorthy and S.Rajeev,Computer Aided Design,Software and AnalyticalTools.
G.Enderle, K.Kansy and G.Pfaff, Computer GraphicsProgramming.C.J.Date,AnIntroductiontoDatabase Management System(Vol.1).
C.L.DymandR.E.Levitt, Knowledge Based Expert Systems in Engineering.

CV892 Excavation Technology for Construction Projects (3-0-0) 3

Scope of infrastructure industry, Role of excavation in construction projects. Typical case studies including

construction of hydro- electric power projects, pipe line projects, tunneling projects, canal projects, dredging projects etc. Excavation methodology, Earth moving equipment, Production & productivity, Resources allocation, Contracting.
Chandra, P., 1995. Project planning analysis, selection, implementation and review. TMA New Delhi. Tatiya, R.R., 1995.
Surface and underground excavations, Taylor and Francis.
Proc. Rapid excavation and tunneling conferences, 2006, 2007, 2008, Gale Group, Michigan Stack, B.2008. Mining and tunneling machines, Muden Publishing Co.

CV893 Global Business Management (3-0-0) 3
Introduction to International Business - Globalization of World Economy - World Trade & Foreign Investment Trends -Technological Changes - Types of International Business - The Cultural Dimensions of International Business. The global trade and investment environment - Trading Practices - World Financial Environment - Tariff and Non-Tariff Barriers - WTO, Regional Blocks. Global financial environment - Determinants of exchange rates - International banks - Non-banking financial institutions. Global competitiveness: Export and Import Financing - Licensing and Joint Ventures - Research and Development in Global Market. Globalization with Social Responsibility - World Economic Growth and Environment - Negotiation in International Business - Multilateral settlements.
Hill Charles, International Business: Competing in the Global Marketplace, Irvin McGraw Hill. Bhalla V. K. & Shivaramu S., International Business Environment and Business, Anmol, New Delhi.

CV894 Sustainability in Built Environment (3-0-0) 3
Basic concepts: terminology, international developments, national developments, green building foundation and its systems, building assessment, building process and ecological design, sustainable sites and landscaping, building hydrologic system, indoor environmental quality, sustainable water use, economic analysis of green building, principles and practices of sustainable building design and construction, alternate building materials & technologies, energy conservation, waste utilization and waste management in construction sites.
Charles J. Kibert, Sustainable Construction: Green Building Design and Delivery, John Wiley & Sons, 2008.
Ann Marie VanDerZanden, Thomas W. Cook, Sustainable Landscape Management: Design, Construction, and Maintenance, John Wiley & Sons, 2010.
Craig, A. Langston., and Grace, K. C. Ding., Sustainability practices in Built environment, Springer, 2001. Jagadish K S et al, Alternative Building Materials and Technologies, New Age International, 2011.

CV895 Modern Concrete Materials & Technology (3-0-0) 3
Review of properties of cement, their physical and chemical properites, special purpose cements,classification and properties of aggregates, soundless of aggregates, alkali aggregate reaction , thermal peoperties of aggregates, importance of shape and surface area and grading, gap graded and aggregates. Rheological behavior of concrete , requirements of workability of concrete, Durability& Effect of environmental conditions, strength & maturity of hardened concrete microstructure of concrete , Impact Dynamic and fatigue behaviour of concrete, shrinkage and creep of concrete , behavior of concrete under fire. Admixtures& Construction chemicals, Use of fly Ash , Silica fumes, metakaolin& GGBS in concreate . Permeability and durability of concrete , Parameters of durability of concrete,chemical attack on Concrete, Production of concrete; batching, mixing, tranportation placing, compaction of concrete . Specical methods of concreting and curing, Hot weather and cold weather concreting , Guniting(shotcreting)
Concrete mix design , basic consideration and choice of mix propotions, various methods of mix designs including IS code method. Quality control and quality assurance of concrete, Non-destructive testing of concrete.Special concrete such as high strength lightweight , heavyweight, vacuum processed concrete, Mass concrete, high performance concrete, Pumpable concrete , self - compacting concrete . Air entrained concrete , ferro cement , fiber reinforced concrete, polymer impregnated concrete . Jet concrete , Recyling & re-use of industrial waste material.
Mehta P.K. & Monteiro P.J.M, Concrete-Microstructure, Properties and Materials, McGraw Hill Eduacation , 2017
Neville A.M., Properties of Concrete, Trans-Atlantic publication Inc. 2015
Sandor Popovics, Concrete Materials - Properties, Specifications and Testing , Standard publishers,2012

CV818 Selected Topics in Structural Engineering (3-0-0) 3

CV829 Selected Topics in Geotechnical Engineering (3-0-0) 3
Recent advances and current trends in Geotechnical Engineering

CV853 Selected Topics in Transportation Engineering (3-0-0) 3

CV879 Selected Topics in Environmental Engineering (3-0-0) 3

CV896 Selected Topics in Construction Technology and Management (3-0-0) 3
Recent Advances and Current Trends in Construction Technology & Management

CV830 Geo-Disaster Mitigation (3-0-0) 3
Geo-Disaster: disasters caused mainly due to geotechnical reasons, Geo-disasters triggered by earthquake, flood/rainfall and tsunami, Effects of the geo-disaster, Reason and mechanism of the damage brought by geo-disasters, Various techniques and countermeasures to mitigate the damage caused by the geo-disasters, Damage caused by earthquake and its mitigation, Seismic earth pressure theory, Hydro-dynamic pressure, Liquefaction, Lateral earth pressure due to liquefaction, Damage caused by liquefaction and its mitigation, Damage brought by the past few tsunamis, Countermeasures for tsunami-induced damage. Disasters due to flood and available mitigation techniques, World-famous case studies of geotechnical failures.
Steven L. Kramer, Geotechnical Earthquake Engineering, Prentice Hall.
Gopal Ranjan and A.S.R Rao, Basic and Applied Soil Mechanics, New Age International Publication.
B.M. Das, Advanced Soil Mechanics, CRC Press.

CV880 Environment and Climate Change (3-0-0) 3
Introduction to climate system of the earth. Greenhouse gases, global warming and its impacts on the hydrological cycle. Anthropogenic drivers of climate change.Observed changes in the global climate: temperature and precipitation and its consequences. The scenario frameworks of climate change – RCPs, SSPs and SPAs. Climate change in India. Application of models to understand the environmentaland socio-economic impacts of climate change. Future socio-economic change and climate change. Impacts, vulnerability and adaptation. Initiatives of climate change impact mitigation in India and challenges for water security.
IPCC Reports
National Action Plan on Climate Change
Global Environmental Change - Journal - Elsevier.

DEPARTMENT OF MINING ENGINEERING

MI700 Rock Excavation Technology (3-1-0) 4
Rock excavation by different methods and different machines. Mechanical cutting, Ripping, Drilling & Blasting etc. Selection of equipment and their maintenance. Material handling. Excavation in sensitive areas.
Chugh, C.P. Drilling technology hand book, Oxford &IBH, New Delhi, 1983.
Singh, B & Goel.R.K. Rock mass classification: A practical approach, Elsevier Science, 1999 Karunam, U.M.R & Misra. B. Principles of rock drilling, Oxford &IBH, New Delhi, 1998.

MI701 Geomechanics & Geotech Engg. (2-1-0) 3
Analysis of stresses and strains. Stress- strain relationships and elastic constants, physico- mechanical properties of rocks. Measurement of rock loads and displacements, Failure criteria. Stress distributions around single and multiple openings in rocks. Rock mass classifications. Field instrumentation.
Obert L. and Duvell W. I. Rock Mechanics and design of structures in rock, Johnwiely, London, 1967
Bray and Brown. Rock Slope Engineering, Word press, 1981.

MI702 Geomechanics & Geotech Engg.Laboratory (0-0-3) 2
10 to 12 experiments will be conducted

MI703 Design of Rock Structures (3-0-0) 3
Design process for excavation in rocks- site characterization, planning and execution, stability analysis. Design methods in massive, stratified and jointed rock. Rock support and reinforcement.
Kidybinski A & Kwasniewski M. (Eds); Modeling of mine structures, A.A. Balkema, Rotterdam.1988.
Obert L. and Duvell W. I. Rock Mechanics and design of structures in rock

MI704 Stress Analysis of Excavations (3-0-0) 3
Concepts and mathematical derivations of Finite Element Method, Boundary Element Method and Finite Difference Method. Solutions of problems in rock excavation engineering using the above methods using softwares *Kidybinski A & Kwasniewski M. (Eds); Modeling of mine structures, A.A. Balkema, Rotterdam.1988.*
Kidybinski A. & Dubinski J. (Eds); Strata control in mines, A.A. Balkema.1990

MI705 Project Management (3-0-0) 3
Principles of project management, project planning. Introduction to scheduling work, project breakdown structure, bar charts, applications of CPM & PERT, precedence method, updating, time cost trade offs. Resource constrained scheduling, resource leveling, project control, performance measurement, earned value. Rock engineering project and other network projects. Economics of excavation projects. Project management softwares.
Chowdary, S. Project management, TMH, New Delhi, 1993.
Joy,P.K. Total project management, MacMillan, 1993.
Chandra,P. Project planning analysis, selection, implementation and review, TMA, New Delhi, 1995.

MI706 Environmental Management in Rock Excavation Projects (3-0-0) 3
Environmental problems associated with rock excavations, air, noise, land pollution. Environmental effects of blasting, Heat and humidity in underground excavations. Ventilation, illumination in underground excavations. Environmental impact and assessment and environment management.
Dhar, B.B. Environmental management of mining operations, Ashish, New Delhi, 1990.
Chad- wick et al . Environmental impacts of coal mining and utilization, Pelgman & Oxford, 1987.

MI800 Rock Slope Engineering (3-0-0) 3
Design of slopes and waste dumps. Factor affecting slope stability, Filed data collection. Rock slope rating. Mechanics of slope failure, Slope stability analysis. Monitoring of slope movements. Slope stabilization techniques. Slope stability analysis softwares.
Hoek, E. and Bray, J.W.Rock slope engineering, Inst. of Mining &Metallurgy, London, 1981.
Giani. Rock slope stability analysis, A.A. Balkema, 1992.

MI801 Rock Fragmentation Engineering (3-0-0) 3
Explosives and initiation systems. Blast design, special techniques of blasting. Environmental effects and their

control. Mechanisms of rock fragmentation due to blasting. Fragmentation prediction models. Fragmentation assessment methods. Economic evaluation of blasting operations.
Sastry. V.R., Advances in drilling and blasting, Allied publishers, Bangalore, 1993.
Konya, C.G. Blast design, Prentice, New Jercy,1990.

MI802 Rock Reinforcement Engineering (3-0-0) 3
Rock support and interaction. Classification of supports, temporary and permanent supports, Passive and active support systems. Safety pillars, roof bolts and cable bolting as mass support systems, Design of support systems based on rock mass classification.
Biron, C. and Arioglu, E., Design of supports in mines, Wiley, NewYork, 1983.
Obert L. and Duvall W.I. – Rock mechanics and the design of structures in rocks; John Wiley & Sons, New York, 1967.

MI803 Rock Mechanics Instrumentation (3-0-0) 3
Introduction to rock mechanics instrumentation. Various types of deformation devices, strain gauges, LVDT's. Load cells. Ultrasonic monitors, geophones, seismographs, electro-magnetic velocity meters, accelerometers, high speed cameras, laser profilers. Field instrumentation for design of tunnels and underground structures. Rock slope and blast monitoring instruments.
Ervin, M.C., Insitu testing for geotechnical investigations, A. A. Balkema, 1983.
Hunt, R.E., Geotechnical Engineering investigation manual, CRC Press, 2005

MI804 Underground Space Technology (3-0-0) 3
Design and construction of large underground excavations: rock conditions and initial state of stress, dimensions, shape, structural behavior. Methods and sequence of excavations. Power stations, storage caverns, metro railway. Large diameter trenches for communication, radioactive disposal and excavations for defense purpose. Stability analysis: structurally controlled instability, influence of size, in- situ stresses. Monitoring and back analysis. Dredging. Excavation for hydel projects. Excavation for other specific works.
Vutukuri V.S. and Lama R.D. Physico - mechanical properties of rocks, Transtech, Ohio, 1974.
Sarma, V.M. Underground space utilization, ISRMTT, 1998.
Tatiya.R.R. Surface and under ground excavations, Taylor & Francis, 1995 Sarma, V.M. Underground space utilization, ISRMTT, 1998.

MI805 Tunnelling Engineering (3-0-0) 3
Types of underground excavations, methods of tunneling. Tunneling in soft ground. Tunneling by drilling &blasting, using TBMs. Excavation of large tunnels, hazards in tunneling. Ground treatment in excavation. Supports, ventilation, drainage and lighting in tunnels.
Vutukuri V.S. and Lama R.D. Physico - mechanical properties of rocks, Transtech, Ohio, 1974.
Ann Proc. 0f Rapid excavation and tunneling

MI806 Reliability Engineering (3-0-0) 3
Need for reliability evaluation of engineering systems. Concepts of Deterministic and Statistical Reliability. Statistical failure of components: failure distribution, system reliability evaluation using probability evaluation using probability distributions. Life testing. Reliability models: catastrophic failure model, stress strength model, Markov models. Reliability evaluation of maintained and non- maintained systems. Network modeling and evaluation of complex systems.
Billianton and Ronald N. Alian. Billianton and Ronald N. Alian. Reliability evaluation of engineering systems: Concepts and techniques
Klass B. Klasson and Jack C.L. Van Pepper. System reliability: concepts & applications Sinha. S.K. Life testing and reliability estimation, Wiley, New Delhi, 1980.

MI807 Safety Engineering (3-0-0) 3
Classification of accidents, causes & prevention of various types of accidents, accidental enquiry- its significance and preparation of accident enquiry report. Accidental statistics- analytical and interpretation. Accidents costs, concepts of ZAP & MAP. Risk assessment and safety management. Aspects of human behavior in accidents application of loss control in safety, workers participation for promotion of safety. Crisis management and its role in safety.

Rakesh & Prasad. Legislation in Indian mines- A critical appraisal , Ashalatha, 1992.
Ridley, J & Channing, J.; Safety at Work; Butterworth-Heinemaan, Oxford, 2001.
Rodgers, W.P.; Introduction to System Safety Engineering; John Wiley & Sons Inc., New York, 1971.
Green, A.R.; Safety in Mines Research; A.A. Balkena; Rotterdam; 1985.

MI855 Reclamation, Rehabilitation & Waste Management (3-1-0) 4

Specific environmental problems associated with mining projects. Land issues. Sociological problems, Land Acquisition laws. Rehabilitation of land losers. Backfilling of mined out pits. Reclamation principles, technologies and new developments. Waste disposal methodologies. Effluent discharge – case studies. Utilisation of mine wastes. New technologies in utilising mine wastes. *Dhar, B.B. Environmental management of mining operations, Ashish, New Delhi, 1990. Chad- wick et al . Environmental impacts of coal mining and utilization, Pelgman & Oxford, 1987.*

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

CS700 Algorithms And Complexity (3-0-2) 4

Algorithmic paradigms: Dynamic programming, Greedy, Branchandbound; Asymptotic complexity, Amortized analysis; Graph Algorithms: Shortest paths, Flow networks; NP-completeness; Approximation algorithms; Randomized algorithms and Advanced data structures.

T.H. Cormen, C.E. Leiserson, R.L. Rivest, Introduction to Algorithms, McGraw Hill, 1994. Dan Gusfield, Algorithms on Strings, trees and Sequences, Cambridge, 2005.

Sara Baase, Computer Algorithms: Introduction to Design and Analysis, Addison Wesley, 1998.

Michael T Goodrich & Roberto Tamassia, Algorithm Design: Foundations, Analysis & Internet Examples, John Wiley, 2002.

CS701 High Performance Computing (3-0-2) 4

Moore's law.Delay, Power, Energy, Temperature dependence in integrated circuits.Modern processor architecture: Instruction level parallelism: Pipelining hazards, Compiler techniques for ILP, Branch prediction, Static and Dynamic scheduling, Speculation, Limits of ILP. Memory systems: Multicore memory hierarchy: Cache tradeoffs, Basic and advanced optimizations, Virtual memory, DRAM optimizations. Parallelism: symmetric and distributed architectures, Cache coherence protocols - Snoopy and directory based, ISA support for synchronization, Parallelization basics, Basic optimizations on serial programs, Shared memory parallel programming, Distributed memory parallel programming, Heterogeneous parallel programming; Interconnection Networks: Architectures, Topologies, Performance, Routing, Flow control.

J*ohn Hennessy and David Patterson. Computer Architecture - A Quantitative Approach. 6ed. Morgan Kaufmann. 2018.*

John P. Shen and Mikko H. Lipasti. Modern Processor Design - Fundamentals of Superscalar Processors. Tata McGraw Hill.

William J Dally and Brian Towles. Principles and Practices of Interconnection Networks. Morgan Kaufmann. 2004.

Mark Hill/Margaret Martonosi (eds.). Synthesis Lectures on Computer Architecture, Morgan and Claypool, 2006 - - 2018.

CS702 Computing Lab (0-0-3) 2

Design, analyse and implement solutions to different Computer Science and Engineering problems.

MA714 Mathematical Foundations Of Computer Science (3-0-0) 3

Finite dimensional vector spaces, Algebra of transformations, Matrix algebra, Solution sets of linear system of equations, Eigenvectors, Real symmetric / Complex hermitian matrices, Algebra of polynomial matrices, Inner product spaces, Singular value decomposition, Polar decomposition; Probability &statistics: Introduction, One - dimensional random variables, Two and higher dimensional random variables, Marginal and conditional distributions, Independence of random variables, Variances and correlations, Moment generating functions-Markov' sinequality, Chebyshev'sinequality; Graphs, Euler tours, Planar graphs, Hamiltonian graphs, Euler's formula, Applications of Kuratowski's theorem, Graph colouring, Chromatic polynomials, Trees.

Gilbert Strang, Linear Algebra and Its Applications, 3 ed., Brooks/Cole, 1998

Sheldon Ross M., Introduction to Probability & Statistics for Engineers & Scientists, John Wiley K. Huffman, R. Kunze, Linear Algebra, Prentice Hall of India, 1998 D. West, Introduction to Graph Theory, Second Edition, PHI, 2003.

CS709 Seminar 2

Students will have to choose a topic in CSE's current trends or industry practices, prepare a write up, present it along with a suitable demonstration. Evaluation will be based on the relevance of topic, communication skills and the reporting / documenting procedure.

CS710 Parallel And Distributed Databases (3-1-0) 4

Distributed data processing, Distributed DBMS architecture, Distributed database design, Distributed query processing & optimization, Distributed transaction management and concurrency control, Distributed DBMS reliability and replication techniques, Multi-database systems, Parallel databases.

M. Tamer ozsu, Patrick Valduriez, "Principles of Distributed DataBase Systems", 3rd Edition, Springer, 2011.
Stefano Ceri and Giuseppe Pelagatti, "Distributed Databases – Principles and Systems", 1st Edition, Tata McGraw-Hill Edition, 2008.
Bharat Bhargava, Concurrency Control and Reliability in Distributed Systems, Van Nostrand and Reinhold Publishers, 1987
Jim Gray and Andreas Reuter, Transaction Processing: Concepts and Techniques, Morgan Kaufmann, 1992

CS711 Network Management And Operations (3-1-0) 4
Network management overview, Network management, SNMP and Network management, TMN, network management applications, Management of heterogeneous network with intelligent agents, Network security management, Internet management (IEEE Communication May, Oct. 03), QoS in IP Network, Basic methods & theory for survivable network design & operation, Network planning, Network management standards. Case study of network management tools used at NITK Central Computing Center, Use cases of software based networks for managing networks.
Subramanian, M. Network management: Principles and Practice. Pearson Education India, 2010.
Burke, J. R., Richard, B., & Burke, R. Network management: concepts and practice, a hands-on approach. London: Pearson Education, 2004.

CS712 Software Architecture (3-1-0) 4
Introduction to software architecture, An Engineering Discipline for Software, Status of S/W Arch. Architecture Business Cycle, Where do Architectures come from, Software processes and the Architecture business cycle, Features of good architecture, Architecture styles- Pipes and Filters, Data abstraction and Object oriented organization, Event-based implicit invocation, Layered systems, Registers, Interpreters, Process control, Other familiar architectures, Heterogeneous architectures, Shared information system's database integration, Interpretation in software development environments.
Len Bass, Paul Clements, and Rick Kazman, Software Architecture in Practice, 2nd ed, Addison-Wesley,
Garmus, Herros, "Measuring the Software Process: A Practical Guide to Functional Measure", PHI.
Florac, Carleton, "Meas. Software Process: Stat. Proce. Cont. for Software process Improvements", PEA.

CS713 Software Testing Techniques (3-1-0) 4
Software testing concepts & principles, Testing Strategies, Testability and Related Issues, Methods for developing the strategy, Life cycle testing, Installation phase Testing and various phases of testing; Tools and techniques for software testing, Testing object oriented software.
Glenford J. Myers, The Art of Software Testing, John Wiley & Sons, 1979.
Boris Beizer, Black Testing: Techniques for Functional Testing of Software and Systems, John Wiley & Sons, 1995,
William Perry, Software Testing: Effective Methods for Software Testing, John Wiley, 1995
Cem Kaner, Jack Falk, Hung Quoc Nguyen, Testing Computer Software, 2nd Ed, Intl. Thomson Computer Press.

CS714 Distributed Operating Systems (3-1-0) 4
Introduction to distributed systems: Distributed systems: Goals, Hardware concepts,Software - Design communication distributed systems: Layered protocol: ATM networks, Client server model - Remote procedure call – Group communication. Synchronization: Clock synchronization - Mutual exclusion - Election atomic transactions - deadlocks. Process and processors: Threads - System models, Processor allocation - scheduling fault tolerance - Real time distributed systems. Distributed file systems: File system design and implementation - Trends in distributed file systems. Shared Memory: Introduction - Bus-based multiprocessors, Ring-based multiprocessors, Switched multiprocessors - NUMA comparison of shared memory systems - Consistency models - Page based distributed shared memory - Shared variable distributed shared memory - Object based distributed shared memory. Case studies: MACH and CHORUS
Andrew S. Tanenbaum, Maarten " Distributed Operating System*, Prentice-Hall , 2005*
R. Chow and T. Johnson, Distributed Operating Systems & Algorithms*, Addison-Wesley (1997)*

CS715 Power Aware Computing (3-1-0) 4
Energy- efficient, Power efficient and thermal aware computing and communication, Newton's cooling model, Basic thermodynamics and Sustainability. Middleware support for green computing: Power states voltage and frequency scaling ACPI support for Linux, Voltage and frequency scaling, ACPI support for Linux and Windows, Compiler optimization, Virtualization and server consolidation. Tools for monitoring: Sensor networks, Cooling equipment and

their behavior. HPC computing: Hadoop, Map-reduce, Dynamic thermal-aware scheduling, Resource management in virtualized environment. Green mobile, Embedded computing and networking: Optimizing for minimizing battery consumption, Safe and sustainable cyber-physical systems (Medical devices). Management frameworks, Standards and metrics for green computing.
Kant, Data center evolution - a state of the art issues and challenges, Elsevier Computer Networks.
Barraso and Holzl, Case for Energy Proportional Computing, IEEE Computer, Dec 2007.

CS716 Topics In Image Processing (3-1-0) 4
Introduction and fundamentals, Image enhancement in spatial and frequency domains, Image filtering and restoration (Conventional as well as state of the art methods like NLM, BM3D), Image analysis, Morphology, Color image processing, Practical applications of image processing, Discussions on recently published papers in image processing/ medical imaging.
Rafael C. González, Richard E. Woods, "Digital Image Processing", 3rd Ed., PHI, 2007.
Anil K. Jain, "Fundamentals of Digital image Processing", Prentice Hall, US Ed., 1989.
Rafael C. González, Richard Richard Eugene Woods, Steven L. Eddins, *"Digital Image Processing using MATLAB", Pearson Education India, 2004.*
AL Bovik (Editor), "Handbook of Image and Video Processing", Academic Press.

CS717 Topics In Speech Processing (3-1-0)4
Mathematical foundations of signal processing, Speech production and perception, Speech signal analysis: Short-time speech analysis, Time-domain analysis, Frequency-domain analysis, LPC (linear predictive coding) analysis; Issues in in speech processing: Speech synthesis, Speech recognition, Speaker identification, Emotion analysis, Language identification; Introduction to advanced topics in speech processing: Pattern classifiers.
Douglas O'Shaughnessy, Speech Communications Human and Machines (Second Edition)
Rabiner and Juan, Fundamentals of speech recognition

CS718 Data Science (3-1-0)4
Data collection and integration, Data presentation, Experimentation, Longitudinal analysis, Data products. Introduction to statistical inference, Linear and logistic regression, Variance and smoothing, Analysis of variance, Predictive modeling. Data types, Statistical graphs, Visualization of multidimensional data, Maps and text, Distance, Clustering and dimensionality reduction. Managing Big Data, Map-Reduce, the Map tasks, Grouping by key, the Reduce tasks, Combiners, Extensions to Map-reduce, Workflow systems, Recursive extensions to Map-reduce. Statistical inference, Statistical modeling, Design of experiments, Statistical graphics. Classification, Decision trees, Naive-Bayes classifier, Support vector machine, Clustering, Hierarchical clustering, K-means clustering, Distribution-based clustering, Ensemble learning and Performance evaluation. Building the data pipelines, Map-Reduce, Graph visualization, and Storytelling.
Michael Manoochehri, Data Just Right: Introduction to Large-Scale Data & Analytics, Addison-Wesley Data & Analytics Series, 2013.
Foster Provost, Tom Fawcett , Data Science for Business: What you need to know about data mining and data analytic thinking, O'Reilly, 2013.
Eric Siegel, Predictive Analytics, 2013, Wiley, 2013.
Drew Conway, John Myles White, Machine Learning for Hackers, O'Reilly, 2012 Ivan Idris, Python Data Analysis, Packt Publishing, 2014.
Wes McKinney, Python for Data Analysis, O'Reilly, 2012.

CS719 Mobile Computing Systems (3-1-0) 4
History and evolution of different generations of cellular networks, Radio propagation characteristics: Models for path loss, Shadowing and multipath fading, Jakes channel model, Digital modulation for mobile radio, Channel coding techniques, Multiple access techniques used in wireless mobile communications. Frequency reuse: Basic theory of hexagonal cell layout: Spectrum efficiency, FDM / TDM cellular systems: Channel allocation schemes, Handover analysis, Erlang capacity comparison of FDM / TDM systems and cellular CDMA. Discussion of GSM and CDMA cellular standards, Signaling and call control: Mobility management, Location tracking. Wireless data networking, Packet error modeling on fading channels, Performance analysis of link and transport layer protocols over wireless channels: Mobile data networking (Mobile-IP), Use cases of SDN and NFV in cellular network.
Rappaport, T. S. Wireless Communications: Principles and Practice (Vol. 2). New Jersey: Prentice Hall PTR, 1996.

Murthy, C. S. R. Ad hoc wireless networks: Architectures and Protocols. Pearson Education India, 2004.
Kumar, A., Manjunath, D., & Kuri, J. Communication networking: an analytical approach. Elsevier, 2004.

CS720 Wireless Networks And Applications (3-1-0) 4
Different types of wireless technologies such as: Cellular networks, Wi-Fi, Underwater acoustic networks.
Different versions of 802.11 such as: Wireless access for vehicular environments, Gigabit Wi-Fi, and others. Rate adaptation algorithms such as: Auto rate fallback, Adaptive auto rate fallback, ONOE, Sample rate, Minstrel and others. Performance problems in wireless networks, Introduction to wireless TCP, Importance of explicit congestion notification in wireless networks. Different types of wireless routing protocols such as: Ad-hoc on demand distance vector, Ad-hoc on demand multipath distance vector, Destination sequenced distance vector, Dynamic source routing and others.
Grigorik, Ilya. High Performance Browser Networking: What every web developer should know about networking and web performance. " O'Reilly Media, Inc.", 2013.
Murthy, C. S. R. Ad hoc wireless networks: Architectures and Protocols. Pearson Education India, 2004.
Online Resources: Technical papers in course related topics and IEEE Standards documents.

CS721 Advanced Algorithms (3-1-0) 4
Advanced data structures: Self-adjustment, Persistence and Multidimensional trees. Randomized algorithms: Use of probabilistic inequalities in analysis, Geometric algorithms: Point location, Convex hulls and Voronoi diagrams, Arrangements applications using examples. Graph algorithms: Matching and flows. Approximation algorithms: Use of linear programming and primal dual, Local search heuristics. Parallel algorithms: Basic techniques for sorting, searching, merging, list ranking in PRAMs and Interconnection networks.
Kleinberg and Tardos, "Algorithm Design", Pearson, 2005.
Cormen, Leiserson, Rivest, and Stein," Introduction to Algorithms", MIT Press, Third Edition, 2009. Vijay Vazirani, Approximation Algorithms
Alexander Schrijver, A course on Combinatorial Optimization, https://homepages.cwi.nl/~lex/files/dict.pdf

CS722 Optimization Algorithms (3-1-0) 4
Basic OR techniques, Requirements, Networks, Design, Role and methods, Databases, Compilers, Optimization and performance in web computing, Internet application, Performance measurement tools, and Case studies.
K Kanth, Introduction to computer system performance evaluation, McGraw Hill, 1992.
David K smith, Network Optimization in Practice, Ellis Horwood publications, 1982

CS723 Distributed Algorithms (3-1-0) 4
Transition systems and Algorithms, Routing algorithms, Election algorithms, Termination detection, Synchronous network algorithms, asynchronous network algorithms, Snapshots, Fault tolerance, Failure detection.
Nancy & Lynch, Distributed Algorithms, Harcour Asia, 2001.
Gerard Tel. Introduction to Distributed Algorithms. Cambridge University Press, Cambridge, UK, 2nd edition, 2000.

CS724 Internet Of Things And Applications (3-1-0) 4
Internet of Things (IoT) Enabling Technologies, IoT and M2M, IoT System Management with NETCONF-YANG-IoT Platforms design methodology, IoT architecture, IoT protocols, Building IoT with Raspberry Pi & Arduino, Data Analytics for IoT, Cloud for IoT, Case studies and Real world applications.
Arshdeep Bahga, Vijay Madisetti, —Internet of Things – A hands-on approach, Universities Press, 2015
Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), —Architecting the Internet of Things, Springer, 2011.
Honbo Zhou, —The Internet of Things in the Cloud: A Middleware Perspective, CRC Press, 2012.
Jan Ho¨ ller, Vlasios Tsiatsis, Catherine Mulligan, Stamatis, Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence", Elsevier, 2014.

CS725 Network Optimization (3-1-0) 4
Introduction, Mathematical preliminaries, Comparison of label setting and label correcting shortest path algorithms, Single origin/Single destination and Multiple origin/Multiple destination shortest path methods. The max-flow problem: cuts in a graph, The max-flow/min-cut theorem, The maximal and minimal saturated cuts, Price-based augmenting path algorithms, Multicommodity flow problems. Auction algorithms for min-cost flow: The auction algorithm for the assignment problem, Extensions of the auction algorithm, The preflow-push algorithm for max-

flow, The auction/sequential shortest path algorithm, and Simplex methods for min-cost flow.
Ravindra K Ahuja, , Thomas L. Magnanti, James B. Orlin, Network Flows: Theory, Algorithms, and Applications, Prentice Hall, 1993
Eugene Lawler, Combinatorial Optimization – Networks and Matroids, Dover Publication 2002
William J. Cook, William H. Cunningham, William R. Pulleyblank, Alexander Schrijver, Combinatorial Optimization, Wiley 1997
Michal Pioro, Deepankar Medhi, Routing, Flow, and Capacity Design in Communication and Computer Networks, The Morgan Kaufmann Series in Networking.

CS726 Compiler Optimization (3-1-0) 4
Review of compiler fundamentals - Lexical analysis, Parsing, Semantic analysis, Error recovery and intermediate code generation; Runtime storage management; Code generation; Code improvement - Peephole optimization, Dependence analysis and Redundancy elimination, Loop optimization, Procedural and inter-procedural optimization, Instruction scheduling, Optimization for memory hierarchy; Compilation for high performance architecture; Portability and retarget ability; Selected topics from compilers for imperative, object-oriented and markup languages, Parallel and distributed programming and concurrency.
Alfred V. Aho, Ravi Sethi, Jeffrey D. Ullman, Compilers: Principles, Techniques and Tools, Addison-Wesley.
Michael L. Scott, Programming Language Pragmatics, Elsevier.
Andrew W. Appel, Modern Compiler Implementation in C/Java, Cambridge University Press

CS727 Service Oriented Computing (3-1-0) 4
SOA reference model and service models, SOA business case, Service design principles, BPEL, Modeling SOA with CPN and OPNET, SOA, SOAP and REST, SOA infrastructure, SOA governance, Web services, identity and security, Technologies, Tooling and Vendors.
Thomas Erl, Service-Oriented Architecture: Concepts, Technology and Design, 2006.
Mark Hansen. SOA Using Java Web Services

CS728 Virtualization And Cloud Computing (3-1-0) 4
Introduction to cloud computing, Cloud computing Delivery models, Open source and Industry case studies of cloud (Apache VCL, Amazon, IBM and Eucalyptus), Introduction to map/reduce and Apache hadoop programming models for cloud computing and examples/applications, Virtualizations as an enabler for cloud computing infrastructure.
George Reese Cloud Application Architectures", O'Reilly Publications, 2009 Tim Mather, Subra Kumaraswamy, Cloud Security and Privacy, O'Reilly, 2009 Tom White, The Hadoop – Definitive Guide, O'Reilly, 2009

CS729 Social Media Mining (3-1-0) 4
Different sources of network data, Types of networks, Tools for visualizing network data, Review of graph theory basics. Structural properties of networks: Notions of centrality, Cohesiveness of subgroups, Roles and positions, Structural equivalence, Equitable partitions, Stochastic block models. Cascading properties of networks: Information/influence diffusion on networks, Maximizing influence spread, Power law and heavy tail distributions, Preferential attachment models, Small world phenomenon. Mining Graphs: Community and cluster detection: Random walks, Spectral methods; Link analysis for web mining
Wasserman, Stanley, & Faust, Katherine. Social Network Analysis: Methods and Applications. Cambridge: Cambridge University Press, 1994.
Scott, John. Social Network Analysis: A Handbook. 2nd Ed. 1994. Newberry Park, CA: Sage.
Robert Hanneman and Mark Riddle. Introduction to Social Network Methods, 2004

CS730 Big Data Analytics And Tools (3-1-0) 4
Big Data Characteristic Features, Structure of Big Data, Best Practices for Big data Analytics, Lambda calculus and data analysis, Analytics process, methods and tools, Predictive analytics and visualization, Mining data streams, Big data frameworks, Modern data analytic tools,.
Anand Rajaraman and Jeffrey David Ullman, "Mining of Massive Datasets", Cambridge University Press, 2014.
Michael Berthold, David J. Hand, "Intelligent Data Analysis", Springer, Second Edition, 2007.
Bill Franks, Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics, Wiley and SAS Business Series, 2012.
David Loshin, "Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph", 2013.

Michael Minelli, Michelle Chambers, and Ambiga Dhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.

CS731 Software Defined Networking (3-1-0) 4

Traditional IP Control Plane and Router Implementation, History and Evolution of Software Defined Networking, Data and Control plane separation: Concepts, Advantages and Disadvantages. OpenFlow Protocol and Applications. Data plane: programmable network hardware, programming SDN using Pyretic, Frenetic or P4. Control plane: Open Network Operating System (ONOS), Floodlight and OpenDayLight projects. Network Function Virtualization: Network Middleboxes, Introduction to Virtualization: VMs and Containers, Introduction to Network Function Virtualization (NFV), Enhancing the Data Plane: Flow Tags, Function Placement and Routing.

Goransson, P., Black, C., & Culver, T. Software defined networks: a comprehensive approach. Morgan Kaufmann, 2016.

Nadeau, T. D., & Gray, K. SDN: Software Defined Networks: An Authoritative Review of Network Programmability Technologies. "O'Reilly Media, Inc.", 2013.

Gray, K., & Nadeau, T. D. Network function virtualization. Morgan Kaufmann, 2016.

CS732 Topics In Information Centric Networking (3-1-0) 4

Introduction to Information Centric Networking (ICN), Different types of ICN: NDN and CCN, Autonomous System (AS) Architecture and AS types, Domain Name System (DNS), Name resolution methods in ICN, Intra-AS routing protocols - Open Shortest Path First (OSPF), Intra-AS routing methods in ICN, Locating content and caching content, ICN applications: Case study.

Amin, K. Computational Intelligence for Security in Named Data Networking Lambert Academic Publishing, 2015.

Ahmed, S. H., Bouk, S. H., Kim, D., & Sarkar, M. Bringing Named Data Networks into Smart Cities. Smart Cities: Foundations, Principles, and Applications, 275-309, 2017

CS733 Natural Language Processing (3-1-0) 4

Natural Language Processing, Mathematical Foundations, Pos tagging, n-gram Models, Word Sense Disambiguation, Lexical acquisition, Probabilistic Context Free Grammars, Parsing, Semantic analysis, NLP based Information Retrieval, Named entity recognition and relation extraction, Text mining, Machine Translation *Christopher D.Manning and Hinrich Schutze, "Foundations of Statistical Natural Language Processing ", MIT Press, 1999.*

Daniel Jurafsky and James H. Martin, "Speech and Language Processing", Pearson, 2008.

Ron Cole, J. Mariani, et.al "Survey of the State of the Art in Human Language Technology", Cambridge University Press, 1997.

Michael W. Berry, "Survey of Text Mining: Clustering, Classification and Retrieval", Springer Verlag, 2003.

CS734 Parallel Programming Techniques (3-1-0) 4

Introduction to Parallel Computers, Message-Passing Computing and Programming, Shared Memory Computing and Programming. Communication Costs in Parallel Machines, Routing Mechanisms for Interconnection Networks, Process- Processor Mapping and Mapping Techniques, Parallel Algorithm Design - Decomposition Techniques, Tasks and Interactions, Mapping Techniques for Load Balancing. Communication Operations in Parallel Computers. Analytical Modeling of Parallel Programs - Overheads, Performance Metrics, Scalability, Asymptotic Analysis. Dense Matrix Algorithms, Graph Algorithms, Search algorithms for discrete optimization problems, Sorting Algorithms, FFT, Image Processing algorithms. Programming Paradigms: Shared Address Space (OpenMP), Message Passing (MPI), GPGPU (CUDA), Heterogeneous Parallel Computing (OpenCL and Intel MIC programming).

Maurice Herlihy, Nir Shavit, The Art of Multiprocessor Programming, MK, 2008.

Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar, Introduction to Parallel Computing, Second Edition, Addison Wesley, 2003.

Barbara Chapman, Gabriele Jost, Ruud van der Pas, Using OpenMP - Portable Shared Memory Parallel Programming, The MIT Press, 2008.

David B. Kirk and Wen-mei W. Hwu, Programming Massively Parallel Processors - A Hands-on Approach, MK. 2nd edition, 2014.

Wen-mei W. Hwu, GPU Computing Gems - Jade and Emerald Editions, MK, 2011.

CS735 Data Mining Techniques (3-1-0) 4

Data Mining Functionalities, Issues in Data Mining, Data Warehouse and OLAP Technology for Data Mining,

Association rule mining, sequential pattern mining, Classification and Prediction, Cluster Analysis, Outlier Analysis, Text mining, Applications in Data mining
Jiawei Han, Micheline Kamber, "Data Mining: Concepts and Techniques", Morgan Kaufmann, Third edition, 2011.
Alex Berson, Stephen J. Smith, "Data Warehousing, Data Mining & OLAP", Tata McGraw Hill, Tenth Reprint, 2007.
G. K. Gupta, "Introduction to Data Mining with Case Studies", Eastern Economy Edition, Prentice Hall of India, Third Edition, 2014.
Ian.H.Witten, Eibe Frank and Mark.A.Hall, "Data Mining: Practical Machine Learning Tools and Techniques", Morgan Kaufmann, Third edition, 2011.

CS736 Machine Learning And Applications (3-1-0) 4
Goals and applications of machine learning, Types of learning, Inductive Classification, Linear regression, Decision trees, Probability and Bayes learning, Experimental Evaluation of Learning Algorithms, Logistic Regression, Support Vector Machine, Kernel function and Kernel SVM, Artificial neural networks (Perceptrons, Multilayer neural networks, Back propagation algorithm, Different activation functions), Computational learning theory, Clustering and Unsupervised Learning.
Tom M Mitchell, "Machine Learning", McGraw Hill Education, 2017.
Alpaydin, E. "Introduction to machine learning", MIT press, 2014.
Marsland, S. "Machine learning: an algorithmic perspective", CRC press, 2015.
Christopher M Bishop, "Pattern recognition and machine learning" Springer Science Business Media,2006 Richard O. Duda, Peter E. Hart, David G. Stork, *"Pattern Classification" Second edition John Wiley,* 2001

CS737 Deep Learning (3-1-0) 4
Introduction to deep learning, Math review (Linear algebra, probability, calculus), Machine learning basics, Basic neural network models [McCulloch-Pitts Model of Neuron, Perceptron], Adaline, linear and nonlinear activation functions, loss functions, gradient descent method, back propagation algorithm, Deep feed forward networks, Regularization for deep learning, Optimization for training deep models, Convolutional neural networks, Sequence modelling, Applications (image and speech processing).
Goodfellow, I., Bengio, Y., Courville, A., & Bengio, Y. (2016). Deep learning (Vol. 1). Cambridge: MIT press.
Martin T haganetc, Neural network design (2nd edition), 2014
Taqiq Rashid, Make your own Neural Network, 2016
Tom Mitchell, Machine Learning, McGraw-Hill, 1997

CS738 Topics In Computer Networks (3-1-0) 4
Different types of optimizations proposed for improving the performance of TCP/IP: TCP Fast Open, Window Scaling, Slow Start Restart, Proportional Rate Reduction, Increasing initial congestion window. Problems of UDP and Peer to Peer applications with NAT, Linux queue disciplines such as Random Early Detection, Proportional Integral controller, Controlled Delay and Explicit Congestion Notification (ECN). Differences between the Internet architecture and Data Center Network architecture, Performance problems in Data Center Networks and existing solutions, the need for Software Defined Networks in Data Center Networks, and the importance of Network Function Virtualization.
James F. Kurose & Keith W. Ross, Computer Networking: A Top-Down Approach, 6/E. Pearson Education India, 2012.
Ilya Grigorik, High Performance Browser Networking: What every web developer should know about Networking and Web Performance. "O'Reilly Media, Inc.", 2013.
Khan, S. U., & Zomaya, A. Y. (Eds.). Handbook on Data Centers. Springer, 2015.
Larry L. Peterson, Bruce S. Davie, Computer Networks: A Systems Approach, Elsevier, 2007.

CS750 Distributed Data Management (3-0-2) 4
Data Management Issues in Data-intensive Computing, Data Management for Enterprise Applications and Internet Applications, cloud Data Management, Parallel data management, Data management for sensor networks, Streaming data management, Web data management, MapReduce-based distributed data management, Distributed Data Mining, Trends in Computing Infrastructures
M.T. Özsu and P. Valduriez, Principles of Distributed Database Systems, 3rd Edition, Springer, 2011
J. Lin, C. Dyer, Data-Intensive Text Processing with Map Reduce, Morgan and Claypool, 1st ed., 2010
P. J. Sadalage, M. Fowler, NoSQL Distilled, Addison-Wesley, 2012

Tiwari, S. , Professional NoSQL. John Wiley & Sons, Inc., Indianapolis, 2011
T. White, Hadoop – The Definitive Guide, O'Reilly, 3rded., 2012

CS751 Network Engineering **(3-0-2) 4**
Internetworking: Architectural principle, Layering, Names and addresses. Advanced topics in Transport Protocol, Congestion Control, Fair Queuing, Router design and Router protocols. Network topologies, Peer-to-Peer networks. Application level protocols. Network management and access control.
Larry L. Peterson, Bruce S. Davie, Computer Networks: A Systems Approach, Elsevier
Richard Stevens, TCP/IP Illustrated, Volume 1: The Protocols PHI, 2001.
Behrouz Forouzan, TCP/IP Protocol Suite, 3/e, McGraw Hill

CS752 Mini Project **2**
Experimental Design/ Implementation tasks of relatively minor intensity and scope as compared to the Major-project and in line with the guidelines formulated by DPGC (CSE).

CS753 Practical Training **2**
(to be completed during vacation Between 2nd & 3rd sem)
The Student has to undergo a training programme or any equivalent programme fixed by the DPGC of department. This will be done during vacation period of first year (6 to 8 weeks). A report will be submitted by the student. Evaluation is based on the seminar and report.

CS754/ CS755 Major Project (3rd & 4th sem) **4/8**
The students individually will select a project work based on a topic of interest under the supervision of project guide. This work started in 3rd semester continues through 4th semester. The project work will be evaluated periodically.

CS800 Number Theory & Cryptography **(3-0-2) 4**
Elementary number theory, Finite fields, Arithmetic and algebraic algorithms, Secret key and public key cryptography, Pseudo random bit generators, Block and stream ciphers, Hash functions and message digests, Public key encryption, Probabilistic encryption, Authentication, Digital signatures, Zero knowledgeinteractive protocols, Elliptic curvecrypto system, Formal verification, Hard problems, Randomness and Pseudo randomness & Testing.
Koblitz, N. Course on Number Theory and Cryptography, Springer Verlag, 1986
Menezes, A,et.al. Handbook of Applied Cryptography, CRC Press,1996
Ivan Niven, Herbert S. Zukerman, HughL. Montgomery, An Introduction to the Theory of Numbers.

CS801 Computing Lab **(0-0-3) 2**
Design, analyse and implement solutions to different Computer Science and Engineering problems.

CS809 Seminar **2**
Students will have to choose a topic in CSE's current trends or industry practices, prepare a write up, present it along with a suitable demonstration. Evaluation will be based on the relevance of topic, communication skills, and the reporting / documenting procedure.

MA714 Mathematical Foundations Of Computer Science **(3-0-0) 3**
Finite dimensional vector spaces, Algebra of transformations, Matrix algebra, Solution sets of linear system of equations, Eigenvectors, Real symmetric / Complex hermitian matrices, Algebra of polynomial matrices, Inner product spaces, Singular value decomposition, Polar decomposition; Probability &statistics: Introduction, One - dimensional random variables, Two and higher dimensional random variables, Marginal and conditional distributions, Independence of random variables, Variances and correlations, Moment generating functions-Markov'sinequality, Chebyshev'sinequality; Graphs, Euler tours, Planar graphs, Hamiltonian graphs, Euler's formula, Applications of Kuratowski's theorem, Graph colouring, Chromatic polynomials, Trees.
Gilbert Strang, Linear Algebra and Its Applications, 3 ed., Brooks/Cole, 1998
Sheldon Ross M., Introduction to Probability & Statistics for Engineers & Scientists, John Wiley K. Huffman, R. Kunze, Linear Algebra, Prentice Hall of India, 1998
D. West, Introduction to Graph Theory, Second Edition, PHI, 2003.

CS810 Security Architecture–Design & Analysis (3-1-0) 4

Secure systems–hardware, Software and communication systems–design issues and analysis, Secure software architecture–models and principles, Hardware design related security–smart cards and other security solutions, Communication protocols and application systems associated with security.

Asoke Talukder, Manish Chaitanya, Architecting Secure Software Systems, CRC Press

CS811 Secure Coding (3-1-0) 4

Buffer Overrun, Format String Problems, Integer Overflow, and Software Security Fundamentals, SQL Injection, Command Injection, Failure to Handle Errors, and Security Touchpoints, Cross Site Scripting, Magic URLs, Weak Passwords, Failing to Protect Data, Weak random numbers, Improper use of cryptography, Information Leakage, Ace Conditions, Poor Usability, Not Updating Easily, Executing with too much privilege, Failing to protect network traffic, Improper use of PKI, Trusting network name resolution.

Howard, LeBlanc and Viega, 24 Deadly Sins of Software Security, ISBN: 978-0-07-162675-0,2010 John Viega and Gary McGraw, Building Secure Software, Addison Wesley Gary McGraw, Software Security: Building Security, Addison-Wesley

CS812 Formal Analysis And Verification (3-1-0) 4

Automata and temporal logics, Computational Tree Logic (CTL) model checking, Timed computational tree logic (TCTL) model checking, Probabilistic computational tree logic (PCTL) model checking, Markov decision processes, Program verification, Verification of deterministic and recursive programs, Verification of object-oriented programs, Verification of parallel programs, Verification of non-deterministic programs, Verification of distributed programs

C. Baier, J.-P. Katoen, and K. G. Larsen, "Principles of Model Checking", MIT Press, 2008.
E. M. Clarke, O. Grumberg, and D. A. Peled, "Model Checking", MIT Press, 1999.
M. Ben-Ari, "Principles of the SPIN Model Checker", Springer, 2008.
K. R. Apt, F. S. de Boer, E.-R. Olderog, and A. Pnueli, "Verification of Sequential and Concurrent Programs", Third Edition, Springer, 2010.

CS813 Cyber Laws And Ethics (3-1-0) 4

Cyber laws and rights in today's digital age; IT Act, Intellectual Property Issues connected with use and management of Digital Data The similar Acts of other countries Information Warfare: Nature of information warfare, including computer crime and information terrorism; Threats to information resources, Including military and economic espionage, Communications eavesdropping, Computer break-ins, Denial-of-service, Destruction and modification of data, Distortion and fabrication of information, Forgery, Control and disruption of information How, Electronic bombs, and sops and perception management. Countermeasures, including authentication, Encryption, Auditing, Monitoring, Intrusion election, and Firewalls, and the limitations of those countermeasures. Cyberspace law and law enforcement, Information warfare and the military, and Intelligence in the information age. Information warfare policy and ethical Issues.

Hon C Graff, Cryptography and E-Commerce - A Wiley Tech Brief, Wiley Computer Publisher, 2001.
Michael Cross, Norris L Johnson, Tony Piltzecker, Security, Shroff Publishers and Distributors Ltd.

CS814 Principles of Information Security (3-1-0) 4

Introduction to Information Security, Design Principles, Complete Mediation. Access Control Matrix, Security Policies, Confidentiality Policies, Integrity Policies, Hybrid Policies, Role-Based Access Control, Fine-grained role based access control - Temporal role based access control, Spatio-Temporal Role based access control, Attribute based access control.

Matt Bishop, Introduction to Computer Security, Addison Wesley, 2005.
R. Sandhu, E. J. Coyne, H. L. Feinstein and C. E. Youman. Role-based Access Control Models. IEEE Computer, pages 38-47, February 1996.
E. Bertino, P. A. Bonatti, and E. Ferrari. TRBAC: A temporal role-based access control model. ACM Transactions on Information and System Security, volume 4, issue 3, pages 191-233, August 2001.
S. Aich, S. Mondal, S. Sural, and A. K. Majumdar. ESTARBAC: Role based access control with spatiotemporal context for mobile applications. Transactions on Computational Science IV, pages 177-199, March 2009.
C. Hu. Vincent, D. F. Ferraiolo, R. Kuhn, A. Schnitzer, K. Sandlin, R. Miller, and K. Scarfone. "Guide to attribute based access control definition and considerations," National Institute of Standards and Technology, 2014.

CS815 Web Application Security **(3-1-0) 4**
Web safety and browser vulnerabilities, Privacy concerns, Issues with java, Java script, ActiveX, and all things Web and security related. Various protocols and approaches, web services security, digital certificates SSL (Secure Socket Layer), TLS (Transport Layer Security), Host security, Server access methods and secure CGI/API.
D.Stuttard and M.Pinto. The Web Application Hacker's Handbook. Wiley.2008.
Ivan Ristik. Mod Security Handbook. Feisty Duck, Ltd. 2010.
Open Web Application Security Project. A Guide to Building Secure Web Applications and Web Services.
http://www.owasp.org/index.php/Category:OWASP_Guide_Project

CS816 Biometrics Security **(3-1-0) 4**
Security via biometrics. Spaced domain based biometric and recognition techniques; Correlation based biometric, filters. Basic theory or correlation filters; Design of advanced correlation fillers that offer tolerance to expected impairments; Methods to implement digital correlations; Applications of correlation filters.
Reid, Biometrics for Network Security, Pearson Education, 2004.
James L. Wayman, Anil K. Jain, DavideMaltoni, Dario Maio, Biometric Systems: Technology, Design and Performance Evaluation , Springer
Anil K. Jain, Ruud Bolle, Sharath Pankanti , Biometrics: Personal Identification in Networked Society, Kluwer Academic Publishers

CS817 Security Policies **(3-1-0) 4**
Definition of a system; System concepts, Type of system; Continuous & discrete systems; Modeling process verification & validation, Markov chains- Weak law of large numbers; Central limit theorem; Strong law of large numbers; Queuing models; Little's Theorem, M/M/1, M/M/m, M/M/', M/M/m/m, M/G/1,and M/M/1/J queuing systems. Introduction to simulation models; Classification of simulation models; Advantages and disadvantages of simulation; Discrete system simulation: Monte carlo method, Random number generators, Probability distributions. Element of inventory theory, More complex inventory models, Finite & infinite delivery rate model with and without back ordering; Simulation of inventory systems.
Scott Barman , Writing Information Security Policies

CS818 Cyber Crime And Information Warfare **(3-1-0) 4**
Cybercrime, Industrial espionage and cyber-terrorism, Computer forensic investigation, Elements of personnel security and investigations, Conspiracy in computer crime and computer fraud investigation. Cyber forensics, Computer forensics and the law, Private & public sector workplace practices, Cybercrime examples, Computer forensic tools, Information warfare, Threats to information resources, military and economic espionage, Communications eavesdropping, Computer breakins, Denial-of-service, Destruction and modification of data, Distortion and fabrication of information, Forgery, Control and disruption of information flow, Electronic bombs and perception management, Countermeasures including authentication, Encryption, Auditing, Monitoring, Intrusion detection and fire walls and the limitations of those countermeasures. Open Source Intelligence (OSINIT), Web intelligence and social media intelligence; Cyberspace law and law enforcement, Information warfare and the military and intelligence in the information age.
John Wiley & Sons, Information Warfare, Ventre, 15-Feb-2016
J. Wiles and A.Reyes, The Best Damn Cybercrime and Digital Forensics Book Period, Syngress, 2007.

CS819 Malware Analysis **(3-1-0) 4**
Introduction to malware, Basic static and dynamic analysis, Overview of windows file format, PEView.exe, Patching binaries, Disassembly(objdump, IDA Pro), Introduction to IDA, Introduction to reverse engineering, Extended reverse engineering using GDB and IDA, Advanced dynamic analysis - debugging tools and concepts, Malware behavior - malicious activities and techniques, Analyzing windows programs – WinAPI, Handles, Networking, COM, Data encoding, Malware countermeasures, Covert launching and execution, Anti analysis- anti disassembly, VM, Debugging, Packers – packing and unpacking, Kernel basics, Windows kernelAPI, Windows drivers, Kernel debugging, Rootkit techniques- Hooking, Patching, Kernel object manipulation ,Rootkit anti-forensics, Covert analysis
Michael Sikorski and Andrew Honig, " Practical Malware Analysis", No Starch Press,2012
Jamie Butler and Greg Hoglund, "Rootkits: Subverting the Windows Kernel", Addison-Wesley, 2005 Dang, Gazet, Bachaalany, "Practical Reverse Engineering",Wiley,2014
Reverend Bill Blunden, "The Rootkit Arsenal: Escape and Evasion in the Dark Corners of the System"

SecondEdition, Jones & Bartlett, 2012.

CS820 Digital Watermarking And Steganalysis **(3-1-0) 4**
Watermarking: Applications, Techniques, Models, and Detection techniques. Visible and invisible watermarks. Embedding. Robust watermarking, Watermark security. Video analytics: Introduction to digital image and Video processing, Background modeling, Shadow removal, Invariant image representation, Object detection and recognition, Image and motion features, Multi object tracking, Trajectory analysis, Recognition of human biometrics, Activities and events, Anomaly detection, Compressed domain video analytics, Multi camera surveillance, Camera coordination, Distributed Multi-sensor surveillance, Video indexing, Mining and retrieval. Steganography – Least bit, DCT, Spread spectrum. Audio steganography, Stegananalysis techniques.
Ingemar J. Cox, Matthew L. Miller, Jeffrey A. Bloom, Jessica Fridrich, Ton Kalker, Digital Watermarking and Steganography, Morgan Kauffman
Ingemar J. Cox, Matthew L. Miller, Jeffrey A. Bloom, Digital Watermarking principles, Morgan Kauffman

CS821 Game Theory & Its Applications **(3-1-0)4**
Game theory and its application: Basics of game theory; Different types of games: two party, Multi-party games, Coalition games on graphs; Nash equilibrium; Walsarian and other equilibrium, Analysis of optimal strategies; Applications of game theory (Network economics, Bandwidth allocations, etc.)
Martin Osborne , An Introduction to Game Theory (2003) , Oxford University Press Avinash Dixit and Susan Skeath, Games of Strategy, 2nd Ed.

CS822 Cryptanalysis **(3-1-0) 4**
Modern cryptography, Steganography, One- way functions; Pseudo-randomness and random number generators; Encryption; Authentication, Symmetric cryptography, Asymmetric cryptography: Public-key cryptosystem; digital signatures, Message authentication codes, Remote user authentication, Notions of security; Zero knowledge /interactive proofs, Multi-party crypto graphic protocols, Key exchange and applications; Crypt analysis of cryptographic primitives and protocols, Such as by side- channel attacks, Differential cryptanalysis, Or replay attacks; and crypt analytic techniques on deployed systems . Lattices in cryptography and cryptanalysis: Algorithmic aspects of the theory of point lattices and their applications to cryptography and cryptanalysis. Differential and linear crypt analysis, Side channel crypt analysis.
Spillman & Richard J, Classical and Contemporary Cryptology, PHI International, 2004.
Han & Helmutt, Introduction to Cryptography: Principles and Applications, Springer Verlag 2002.

CS823 Advanced Cryptography **(3-1-0) 4**
Objectives of cryptography, Symmetric key encryption-stream ciphers &block ciphers, Public- key cryptography: RSA, Hash-functions, Discrete logarithm, Modular squaring, Cryptographicprotocols: Key exchange & entity authentication, Identification schemes, Commitment schemes, Electronic elections, Probabilistic algorithms, Probably secure encryption & Digital signatures. Mathematical models for internet: Design and control communication networks that respond to: randomly fluctuating demands and failures by adapting rates, By re-routing traffic and by re-allocating resources, Stability and fairness of rate control algorithms for the internet; economic issues, Scalable models of simulation of such networks, Quantum cryptography
Wenbo Mao, Modern Cryptography- Theory and Practice, Prentice Hall, 2004.
Susan Loepp & William K. Wooters, Protecting Information (Quantum Cryptography) Cambridge, 2005.
Hans DelFs & Helmutt Knebl, Introduction to cryptography: Principles & Application, Springer Verlag.

CS824 Applied Cryptography **(3-1-0) 4**
Privacy- Enhancing technologies, Privacy- Preserving data collection and data publishing, Privacy- Preserving data mining, K- Anonymity, Anonymous communications, Anonymous credentials, Group signatures, Privacy and anonymity in peer-to-peer architectures, Privacy-enhanced access control or authentication/certification, Advanced crypto algorithms and protocols, Zero-knowledge proof, Oblivious transfer, Secure multiparty computation digital cash, Secret sharing, Threshold cryptography, Identity- based encryption, Attribute- based encryption *B.Schneier, Applied Cryptography, John Wiley & Sons.*
Alfred J.Menezes, Paul C. Van Oorschot, Scott A. Vanstone Handbook of Applied Cryptography, CRC Press
Jonathan Katz and Yehuda Lindell, Introduction to Modern Cryptography, Chapman & Hall/ CRC Press

CS825 Advanced Topics In Security **(3-1-0) 4**
Design and implementation of advanced cryptosystems for high-performance applications, Cryptographic protocols for secure online computation applications, Advanced hacking techniques, complete computer system penetration testing and defences, Advanced wireless network security, Enterprise security architectures, Malicious code detection and prevention systems, Defence systems in depth, Advanced software security, Virtual system and cloud computing security and emerging technologies such as quantum computing and cryptography.
D. Boneh , Topics in Cryptography, , Stanford University
J. Katz, Advanced Topics in Cryptography, Univ. of Maryland
R. Cramer, Number Theory/Cryptology course, University of Ultrecht
U. Maurer, Current Topics in Information Security, ETH Zurich
Y. Lindell, Foundations of Cryptography, Bar Ilan University

CS826 Quantum Cryptography **(3-1-0) 4**
Quantum computing models, Quantum algorithms, Quantum tree search, Quantum wavelets, quantum information theory, Quantum cryptography, Breaking RSA system, Quantum teleportation, Circuit design, Quantum error correction finite dimensional hilbert spaces – Tensor products and operators on hilbert space –Hermitian and trace operators - Basic quantum mechanics necessary for the course. Quantum gates and operators and Measurement: Quantum computational model –Quantum complexity – Schemes for physical realization (Only peripheral treatment expected), Shor's algorithm – Application to integer factorization – Grover's algorithm – Quantum cryptography: Encryption and decryption schemes
Christian Kollmitzer, Mario Pivk, Applied Quantum Cryptography, Springer Science & Business Media, 28-Feb-2010
Gilles van Assche, Quantum Cryptography and Secret-Key Distillation, Cambridge University Press, 29-Jun-2006

CS827 Cloud Security **(3-1-0) 4**
Introduction to cloud computing, Modular arithmetic background, Concepts of security, How to assess security of a system, Information theoretic security v/s computational security, Data security and storage in cloud, Data dispersal techniques, High-availability and integrity layer for cloud storage, Encryption and key management in the cloud, Cloud forensics, Data location and availability, Data security tools and techniques forth cloud, Data distribution and information dispersal techniques Data encryption/decryption methodologies, Trustworthy cloud infrastructures, Cloud related regulatory and compliance issues
Mather, T.,Kumaraswamy S., and Latif, S. Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance.
O'ReillyMedia. Stallings, W. Cryptography and Network Security: Principles and Practice, 5th Edition. Prentice Hall. Menezes, A., Oorschot, P.,Vanstone, S .Handbook of Applied Cryptography. CRC Press, Edition 1st.

CS828 Wireless Network Security **(3-1-0) 4**
Wired /wireless networks; Effect of mobility on networks, & systems; Impact on IP stack from MAC layer and up; Ad- hoc and sensor networks; Wireless broadcast. II* broadcast. Satellite broadcast; Issues of information capacity; Distinction between wired and wireless networks from information theory; Issues of security in wireless; Issues of 802.11 protocols; Routing in wireless networks, Design of secure protocols: Keydistribution for access control, Source authentication of transmissions, and non-repudiation; Power management and selfishness issues, Attacks in wireless networks; DOS and DDOS attacks, Reaction to attacks, Information processing for sensor networks.
Perrig, Adrian; Tygar J. D., Secure Broadcast Communication in Wired and Wireless Networks, Allied Publishers, 2004.
Makki, S.K.; Reiher, P.; Makki, K.; Pissinou, N.; Makki, S. (Eds.), Mobile and Wireless Network Security and Privacy, Springer.

CS829 IoT Security **(3-1-0) 4**
Sensors and actuators in IoT, Communication and networking in IoT, Real-time data collection in IoT, Data analytics in IoT, IoT applications and requirements, Security threats and techniques in IoT, Data trustworthiness and privacy in IoT, Balancing utility and other design goals in IoT, Programming IoT applications using Arduino or Raspberry Pi.
Francis daCosta, Rethinking the Internet of Things: A Scalable Approach to Connecting Everything, ISBN: 978-1-4302-5740-0, 2013
Dieter Uckelmann, Mark Harrison and Florian Michahelles, Architecting the Internet of Things, ISBN: 978-3-642-19157-2, 2011

"Internet of Things: IoT Governance, Privacy and Security Issues" by European Research Cluster

CS830 SCADA Security (3-1-0) 4

Critical infrastructure and ICS, ICS processes & roles types of ICS systems, Fundamental principles and concepts of SCADA, ICS lifecycle challenges physical security, ICS network architecture, Network models, Design example, Industrial Control Systems (ICS) characteristics, Threats and vulnerabilities, PLC and role in automation, PLC - SCADA communications, SCADA architecture, SCADA control and next generation SCADA systems, Visualization tools, Protocols, TCP/IP communication, Inter-Master station communication, ICCP SCADA reliability, Redundancy and fault tolerance. ICS/SCADA security, Firmware, Attacks, Security standards & mitigation, Security, Defending ICS servers and workstations, Defending ICS networks and devices, ICS/SCADA security, Building domain specific models in process control and automation using SCADA.

Eric D. Knapp, "Industrial network security: Securing critical infrastructure networks for smart grid, SCADA, and other industrial control systems", O'Reilly, 2014

Robert Radvanovsky and Jacob Brodsky, "Handbook of SCADA/Control systems security", second edition, 2016

Jack Wiles and Ted Claypoole, "Techno security's guide to securing SCADA: A comprehensive handbook on protecting the critical infrastructure", 2008

CS831 Cyber Forensics (3-1-0) 4

Industrial espionage and cyber-terrorism,Principles of criminal law, Computer forensic investigation, Elements of personnel security and investigations, Principles of risk and security management, Conspiracy in computer crime and Computer fraud investigation. Introduction to cyber forensics: Computer forensics and the law, Private &public sector workplace practices, Cyber crime examples: Defacements, DoS, Credit card theft, Silent intrusion, Internal attacks, Investigative actions, Forensics analysis investigative action, Computer forensic tools.

Jennifer Bayuk, Cyber forensics: Understanding information security investigations, Springer Bill Nelson, Amelia Phillips, Christopher Steuart, Guide to Computer forensics and investigations

CS832 Social Network Security (3-1-0) 4

Online social networks, Data collection APIs,Cybercrime,Trust, Credibility,and Reputations in social systems,Privacy setting and policies, Profile linking, Anonymous networks, Privacy disclosure threats and Attacks, Detection of spam, Phishing, Frauds, Hate crime, Abuse, Extremism, Cyber-bullying, Abuse and Harassment detection, Defense and prevention strategies, Legal and ethical issues.

Yaniv Altshuler, Yuval Elovici, Armin B. Cremers, Nadav Aharony, Alex Pentland, Security and privacy in Social networks, Springer 2013.

Toby Segaran, Programming Collective Intelligence: Building Smart Web 2.0 Applications Paperback, O'Reily Pubs 2007

Michael Cross, Social Media Security: Leveraging Social Networking While Mitigating Risk, Syngress, I Ed 2014

Dafydd Stuttard , Marcus Pinto , The Web Application Hacker's Handbook: Finding and Exploiting Security Flaws 2nd Edition, Kindle Edition

CS833 Information Security and Risk Management (3-1-0) 4

Development of concepts required for risk-based planning and risk management of computer and information systems(Risk analysis, Risk perception, Communicating risk, Risk mitigation); Objectives and methods for vulnerability assessment for natural disaster, Technological hazards and terrorist threats; implications for emergency response, Vulnerability of critical infrastructures;

A. Calder and S. G. Watkins, Information Security Risk Management for ISO27001/ISO27002, IT Governance Ltd, 2010.

S. Snedaker, Business Continuity and Disaster Recovery Planning for IT Professionals, Elsevier Science & Technology Books, 2007.

H. F. Tipton and M. Krause, Information Security Management Handbook, Volume 1, Sixth Edition, Auerbach Publications, 2003.

CS834 Computer Security Audit and Assurance (3-1-0) 4

Basic cryptography theoretical aspects, Algorithms &Computations and cryptanalysis, Analytic number theory; Group theory; Elliptic curves; Probabilistic methods in combinatorial analysis; Computational complexity; Arithmetical and algebraic algorithms; Integer factoring- Group order, Quadratic congruence methods; Discrete logarithms- Index calculus; Algebraic cryptanalysis for block and stream ciphers; one-way functions; Hard-core predicates; Hash collisions; Emerging areas- Identity, Attribute based encryption; Homomorphic encryption; Block chains; End-to-end encryption; Side-channel attacks and resistance; Security engineering; Post-quantum crypto algorithms based on hard primitives;

Niels Ferguson, Bruce Schneier, and Tadayoshi Kohno, Cryptography Engineering: Design Principles and Practical Applications, John Wiley & Sons, 2010.

H. James, Tommie Singleton, Information Systems Auditing and Assurance (2nd Edition), Cengage Learning, 2004.

R. Weber, Information Systems Control and Audit, Prentice Hall, 1999

J. A. Hall, Information Technology Auditing and Assurance, 4th Edition, Cengage Learning, 2011

CS850 Database Security (3-0-2) 4

Security architecture, Database Security, Operating system security, Application security models, Access control models, Statistical DB security, Database auditing, Compliance storage, Data privacy, Steganographicfile systems, Privacy preserving data mining, Database as a service, Searchable encryption techniques.

Hassan A. Afyouni, "Database Security and Auditing", Third Edition, Cengage Learning, 2009. Alfred Basta, Melissa Zgola, Database Security , Cengage Learning, ISBN 1435453905, 2011

Charu C. Aggarwal, Philip S Yu, "Privacy Preserving Data Mining": Models and Algorithms, Kluwer Academic Publishers, 2008.

Ron Ben Natan,"Implementing Database Security and Auditing", Elsevier Digital Press, 2005.

David C. Knox: Effective Oracle Database 10g Security by Design, McGraw-Hill, 2004.

Ron Ben-Natan , HOWTO Secure and Audit Oracle 10g and 11g , Publisher: Auerbach Publications; 1 edition (March 10, 2009)

CS851 Network Security (3-0-2) 4

Introduction to network security, Network security concepts, Attacks to networks and Countermeasures, World wide web and Internet security, Security protocols, Wireless security protocols, Intrusion detection and Prevention systems, Organizational security issues, Security policies for network operations, Disaster recovery and business continuity.

Kaufman, Perlman and Speciner. Network Security: Private Communication in a Public World. Prentice Hall, 2nd edition. 2002.

Mark Ciampa, "Security+ Guide to Network Security Fundamentals", 2nd Edition, Cengage Learning, 2012.

William Stalling, Network Security Essentials - Applications and Standard, Pearson Education, 2004.

CS852 Mini Project 2

Experimental design/ implementation tasks of relatively minor intensity and scope as compared to the Major-project and in line with the guidelines formulated by DPGC(CSE-IS).

CS853 Practical Training 2

(to be completed during vacation Between 2nd& 3rd sem)

The student has to undergo a training programme or any equivalent programme fixed by the DPGC of department. This will be done during vacation period of first year (6 to 8 weeks). A report will be submitted by the student. Evaluation is based on the seminar and report.

CS854/ CS855 Major Project(3rd &4th Sem) 4/8

The students individually will select a project work based on a topic of interest under the supervision of project guide. This work started in 3rd semester continues through 4th semester. The project work will be evaluated periodically.

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

EC701 CMOS VLSI (4-0-0) 4

MOSFET - Review of current equation, regions of operation, MOSFET logic circuits. MOSFET logic gates. Interfacing CMOS and Bipolar logic families. Circuit characterization and performance estimation, Switching characteristics, Delay models, Power dissipation, Packaging, Scaling of MOS transistor dimensions, Yield and Reliability, CMOS subsystem design, Datapath operations, Addition, Multiplication, Counters, Shifters, Memory design. Interconnect design, Power-grid and clock design. Simulation exercises on MOSFET.

Jan M. Rabaey, Anantha Chandrakasan, and Borivoje Nikolic Digital Integrated Circuits – A design perspective, Pearson, 2003
S. M. Kang & Y. Leblebici, CMOS Digital Integrated Circuits, McGraw Hill, 1999.
David A Hodges, Horace G. Jackson and Resve Saleh, Analysis and Design of Digital Integrated Circuits, Mc GrawHill, 2003
Neil H. E. Weste, David Money Harris, Integrated Circuit Design, Fourth Edition, 2011
NPTEL Video Lectures

EC702 Analog Integrated Circuit Design (4-0-0) 4

MOSFET - Review of current equation, regions of operation, small signal model. Current mirrors, Single-ended amplifiers, Differential amplifiers, Two-stage amplifiers – analysis, frequency response, stability, compensation; Band gap references, Constant–Gm biasing; Types of Noise, Introduction to switched capacitor circuits, switched capacitor amplifiers, noise analysis, Distortion, current and voltage references, Oscillators and PLL.

Behzad Razavi, Design of Analog CMOS Integrated Circuits McGraw-Hill International Edition 2016
Behzad Razavi, Fundamentals of Microelectronics, Second edition, Wiley, 2013
Sedra and Smith, Microelectronics Circuits, Oxford Univ. Press, 2004
David A. Johns and Ken Martin, Analog Integrated Circuit Design, John Wiley, 2002
Phillip E. Allen and Douglas R. Holberg, CMOS Analog Circuit Design, Oxford University Press, 2003.
NPTEL Video Lectures

EC703 VLSI Data Converters (4-0-0) 4

Sample and Hold Circuits: Basic S/H circuit, effect of charge injection, compensating for charge injection, bias dependency, bias independent S/H. D/A Converter – General considerations, Static non-idealities and Dynamic nonidealities; Current-steering DAC – Binary weighted DAC, Thermometer DAC, Design issues, Effect of Mismatches. A/D converter – General considerations, static and dynamic non-idealities. Flash ADC – Basic architecture, Design issues, Comparator and Latch, Effect of non-idealities, Interpolative and Folding architectures. Successive Approximation ADC; Pipeline ADC. Over sampling ADC – Noise shaping, Sigma-Delta modulator.

Behzad Razavi, Design of Analog CMOS Integrated Circuits McGraw-Hill International Edition 2016
David A. Johns and Ken Martin, Analog Integrated Circuit Design, John Wiley, 2002
Phillip E. Allen and Douglas R. Holberg, CMOS Analog Circuit Design, Oxford University Press, 2003.
Behzad Razavi, Principles of Data Conversion System Design, Wiley-IEEE Press, 1995
Rudy J. van de Plassche, CMOS Integrated Analog-to-Digital and Digital-to-Analog Converters, Springer, 2003
NPTEL Video Lectures

EC704 VLSI Design Automation (4-0-0) 4

Introduction to VLSI design automation: VLSI design methodologies, use of VLSI EDA tools, Algorithmic Graph Theory, computational Complexity; Partitioning, Simulated Annealing. Floor planning and placement, Routing, High Level Synthesis, operation scheduling, Static Timing Analysis, Topological vs logical timing analysis, False paths, Arrival time, Required arrival Time, Slacks.Advanced VLSI Design Automation: Physical Synthesis, Optical Proximity correction, Interconnect issues.

Naveed Sherwani, Algorithms for VLSI Physical Design Automation, 3rd ed., Kluwer Academic Pub., 1999
Majid Sarrafzadeh and C. K. Wong, An Introduction to VLSI Physical Design, McGraw Hill, 1996.
Sabih H. Gerez, Algorithms for VLSI Design Automation, John Wiley, 1998
Sung Kyu Lim, Practical Problems in VLSI Physical Design Automation, Springer, 2008
Sadiq M. Sait & Habib Youssef, VLSI Physical Design Automation: Theory and Practice, World Scientific Publishing, 1999
NPTEL Video Lectures

EC705 IC Design Lab **(0-0-3) 2**
Design, Simulation and layout of basic digital blocks, performance comparison, Design project Tools to be used: CADENCE, MAGIC, SPICE, ELECTRIC, Mentor Graphics

EC731 Wireless Communication & Networks **(4-0-0) 4**
Introduction to Wireless Communication Systems, Channel Modeling- Pathloss, large-scale fading, small-scale fading; Power budget of mobile links - Doppler spread and coherent time, delay spread and coherent bandwidth; flat fading and frequency selective fading. Digital Modulation and its various aspects, Channel Coding- forward error correction (FEC) coding, Network Architectures, Medium Access Schemes, Communication Protocol Layers, Routing Strategies, Network Reliability, Congestion Issues, Advanced Topics in Wireless Research-MANETs, Sensor Networks, Cellular Network Concepts, SDN, Existing Wireless Systems –GSM and its evolution.
A. Goldsmith, Wireless Communications, Cambridge University Press, 2005.
T. S. Rappaport, Wireless Communications Principles and Practice (2nd edition) Pearson, 2010.
Haykin & Moher, Modern Wireless Communications Indian Edition, Pearson, 2011.
James F.Kurose, Computer Networking: A Top own Approach, 5th Ed., Pearson, 2012
A. Kumar, D. Manjunath and Joy Kuri, Communication Networking: An Analytical Approach, Morgan Kauffmann, 2004.

EC732 RF Circuit Design **(4-0-0) 4**
Review of Basic Transmission Line Theory, Planar Transmission Lines Microwave Network Analysis - Microwave network representation, Impedance Matching Techniques, Binomial and Chebyshev approximations, Basic Passive Components, Analysis and design of stripline/ microstrip components- Equivalent circuit and Characteristics, Basic series and shunt switches in microstrip; SPST and SPDT switches, Switched line, branch line coupled and loaded line phase shifters in microstrip. Applications in phased arrays. MIC Filters, Examples-Realization of lumped elements and filters in MMIC, Realization of planar transmission lines and filters in MEMS.
D.M. Pozar, Microwave Engineering, 2 Edition, John Wiley & Sons, 1998.
Michael Steer, "Microwave and RF Design: A Systems Approach", First Edition, Yes Dee Publishing 2012.
Peter Rizzi, Microwave Engineering-Passive Circuits, Pearson Education, 1988..
R. Ludwig and G. Bogdanov, "RF Circuit Design: Theory and Applications", 2nd Edition, Pearson Education India, 2009.
Behzad Razavi, "RF Microelectronics", Second Edition, Pearson Education India, 2012.

EC733 Optical Networks and Switching **(4-0-0) 4**
Introduction to basic optical communications and devices. Optical multiplexing techniques. Optical Networks: Conventional optical networks, Multiple access optical networks, Optical amplification in all optical networks. All-optical subscriber access networks. Design issues. Optical switching: Motivation, Spatial light modulator, Relational and non-relational switching devices, Fundamental limits on optical switching elements, Switching architectures, Free-space optical switching. Wavelength routed networks and other special topics. Soliton based networks, Optical networks management issues.
Rajiv Ramaswami, Kumar Sivarajan, Galen Sasaki, Morgan Optical Networks: A Practical Perspective, Kauffman Publishers, ELSEVIER, 2010.
Hussein T. Mouftah, Jaafar M. H. Elmirghani, Photonic Switching Technology: Systems and Networks, Wiley, 1999.
Ray T. Chen, Joseph C. WDM and Photonic Switching Devices for Network Applications, Volume 4653, Chon SPIE, 2002 - Technology & Engineering
Martin Maier, Optical Switching Networks, Cambridge University Press, 2008.
A. Selvarajan, Subrat Kar, T. Srinivas, Optical Fibre Communication: principles and systems, TMH, 2002.

EC734 Signal Detection and Estimation **(4-0-0) 4**
Hypothesis Testing, Neyman Pearson Lemma, UMP test, Decision Theoretic framework, Multiple-Decision Problem. Parameter Estimation - Unbiasedness, Consistency, asymptotic normality, sufficient statistics, minimax estimation, decision theoretic framework, Rao-Blackwell theorem, Cramer – Rao inequality. Estimation: Minimum mean square linear estimation, Wiener filter, Kalman filter, Levinson – Durbin and innovation algorithms.
H. L. Van Trees Detection, Estimation and Modulation Theory, Part I, John Wiley, 1968.
Srinath, Rajasekaran and Viswanathan, Introduction to Statistical Signal Processing with applications, PHI, 1995.
Steven M. Kay, Fundaments of Statistical Signal Processing, Vol. I:Estimation Theory, Vol. II: Detection Theory, Prentice Hall International, 1993

Papoulis A., Probability Random Variables and Stochastic Processes, McGraw Hill, 2002
H. Stark and J. W Woods, Probability and Random Processes with applications to signal processing, Pearson Education, 2002.

EC736 Communication and Networking Lab (0-0-3) 2
Design experiments to reflect the contents of core courses in the curriculum. Exposure to hardware design of communication systems and simulation using tools such as MATLAB, ADS, HFSS, SystemVue, Network Simulator and GNU Radio etc.

EC761 Information Processing and Compression (4-0-0) 4
Introduction to Information theory, Entropy and Inference. Mathematical preliminaries for Lossless compression, Shannon's Source Coding Theorem Huffman coding, Arithmetic Coding, LZW coding. Mathematical preliminaries for lossy compression, quantization and the Lloyd-Max Algorithm, rate-distortion theory, Scalar and vector quantization, Transform coding, Subband coding.
Khalid Sayood, Introduction to Data Compression, Morgan Kaufman, 5th Ed. 2018.
David McKay, Information Theory, Inference and Learning Algorithms, Cambridge University Press, 2003.
David Solomon, Handbook of Data Compression, Springer, 2010.

EC762 Pattern Recognition and Machine Learning (4-0-0) 4
Statistical foundations, Different Paradigms of Pattern Recognition, Probability estimation, Proximity measures, Feature extraction, Different approaches to Feature selection, Nearest Neighbor Classifier and variants, Bayes classification.
Linear models, regression, logistic regression, neural networks, objective function and learning, back propagation. Kernel based methods, support vector machines. Dimensionality reduction, principal component analysis, reconstruction, discriminant analysis. Clustering, K-means algorithm, distance measure, objective function, initialization. Anomaly detection, recommender systems. Scaling of algorithms.
R. O. Duda, P. E. Hart and D. G. Stork Pattern Classification, Wiley Publications, 2001.
D. McKay, Information Theory, Inference, and Learning Algorithms, Cambridge University Press 2003.
C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.

EC763 Optimization (4-0-0) 4
Convex sets and Convex functions, Level sets and Gradients. Unconstrained Optimization: Search methods, Gradients Methods, Newton Method, Conjugate Direction Methods, Quasi-Newton Methods. Linear Programming: Standard Form Linear Programs, Simplex method, Duality and Non Simplex Methods. Nonlinear Constrained Optimization: Problems with equality constraints, Problems with Inequality Constraints, Convex Optimization Problems. Algorithms for Constrained Optimization: Projected Gradient Methods and Penalty Methods.
Lieven Vandenberghe and Stephen P. Boyd, Convex Optimization, Cambridge University Press, 2004.
Dimitris Bertsekas, John N. Tsitsiklis, Introduction to Linear Optimization, Athena Scientific Series, 1997.
Aharon Ben-Tal and Arkadi Nemirovski, Lectures on Modern Convex Optimization: Analysis, Algorithms, and Engineering Applications, SIAM, 2001.

EC764 Signal Processing Laboratory (0-0-3) 2
Signals and spectral analysis, Transform domain analysis of systems, Sampling and Quantization effects, Digital Filter Design, Applications in Image and Speech – Compression Schemes, Denoising, Real Time DSP experiments.
D G Manolakis, V K Ingle, Applied Digital Signal Processing, Cambridge University Press, 2012
Donald Reay, Digital Signal Processing using ARM Cortex-M4, John-Wiley, 2015.

EC791 Linear Algebra and Stochastic Processes (3-1-0) 4
Vector Spaces, Subspaces, Linear Independence, Span, Basis, Dimension, Linear Transformations, Orthogonal Transformations, Orthogonal projections, Matrix subspaces and orientation, Eigen decomposition, SVD, Least Squares , Pseudo inverse.
Review of Probability theory and Random variables, Random vectors and moments, Stochastic Processes and Examples, stochastic processes and linear systems, Gaussian random process, spectral analysis of stationary processes, Power Spectral Densities, Stationarity and Ergodicity.
Gilbert Stran, Linear algebra and its applications, Thomson Brooks, 2006.
P Halmos, Finite Dimensional Vector Spaces, Springer, 1993.

Edgar G. Goodaire, Linear Algebra: Pure & Applied, World Scientific, 2014.
Dimitris P. Bertsekas, John N. Tsitsiklis, Introduction to Probability, 2nd Ed, Athena Scientific, 2008.
Alberto Leon-Garcia, Probability, Statistics, and Random Processes for Electrical Engineering, 3rd Ed, Addison-Wesley, 2008.

EC792 High Performance Computing Architectures (4-0-0) 4
Instruction Level Parallelism: Pipelining, Hazards, Instruction Level Parallelism, Branch prediction, Static and Dynamic Scheduling, Speculation, Limits of ILP. Multicore Memory Hierarchy: Cache trade-offs, Basic and Advanced optimizations, Virtual Memory, DRAM optimizations. Multiprocessors: Symmetric and Distributed architectures, Cache coherence protocols - Snoopy and Directory based, ISA support for Synchronization, Memory Consistency Models. Interconnection Networks: Architectures, Topologies, Performance, Routing, Flow control, Future of NoCs.
John Hennessy and David Patterson, Computer Architecture - A Quantitative Approach 6th Edition, Morgan Koufmann, 2017
John Hennessy and David Patterson, Computer Architecture - A Quantitative Approach 5th Edition, Morgan Koufmann, 2011
John Paul Shen and Mikko H. Lipasti, Modern Processor Design: Fundamentals of Superscalar Processors, Tata McGraw Hill, 2013
D. A. Patterson and J. Hennessy, Computer Organization and Design, Harcourt Asia, 1998.
Behrooz Parhami, Computer Arithmetic Algorithms and Hardware Design, Oxford, 2000.
NPTEL Video Lectures

EC793 Signal Analysis and Processing (4-0-0) 4
Review of Time domain analysis of discrete-time signals & systems, Transform domain analysis of discrete time signals & systems: Z transforms, application of Z transforms to discrete-time systems, Frequency domain analysis of discrete-time signals and systems, Sampling in time and frequency domain, linear convolution using DFT, Fast Fourier Transform algorithms.
Digital Filter Design: Filter Structures; FIR filter design, IIR Filter Design, Filter design using Butterworth, Chebyshev and elliptic approximations, Spectral transformation technique for HP, BP and BS filter design. Direct design of IIR filters, Introduction to multirate Signal Processing, Upsampling, Downsampling, Sample rate conversion.
D G Manolakis, V K Ingle, Applied Digital Signal Processing, Cambridge University Press, 2012
Oppenheim, Schaffer, Discrete Time Signal Processing, Prentice Hall,
Ashok Ambardar, Digital Signal Processing – A Modern Introduction, Thomson, 2007
Sanjit K. Mitra, Digital Signal Processing: A computer based Approach, TMH, 2006

EC801 Logic Synthesis Techniques (4-0-0) 4
Introduction to Computer aided synthesis and optimization. Hardware Modeling. Advanced Boolean Algebra and Applications, Shannon co-factors, satisfiability and cover, Binary Decision Diagrams, Representing Boolean functions, ROBDD, ITE operator, Variable ordering- choice of variables, application of BDD to synthesize Boolean functions, Two level combinational logic optimization, Multiple level combinational optimization. Sequential logic optimization. Cell Library Binding. Algorithms for Technology mapping – Structural and Boolean matching, Simulation & Static Timing analysis - Event driven simulation – zero delay, unit delay and nominal delay simulation, Timing analysis at the logic level, Delay models, Delay graph, static sensitization, State of the art and future trends: System level synthesis and hardware software co-design.
Giovanni De Micheli, Synthesis and Optimization of Digital Circuits, McGraw Hill, 1994.
Srinivas Devadas, Abhijith Ghosh and Kurt Keutzer, Logic Synthesis", Kluwer Academic, 1998.
G. D. Hachtel and F. Somenzi, Logic Synthesis and Verification Algorithms, Kluwer Academic Publishers, 1996.
S. Hassoun and T. Sasao, (Editors), Logic Synthesis and Verification, Kluwer Academic publishers, 2002
NPTEL Video Lectures

EC802 Low Power VLSI Design (4-0-0) 4
Introduction to Low Power VLSI. Modeling and Sources of Power consumption. Power estimation at different design levels. Power optimization for combinational circuits and sequential circuits Voltage scaling Approaches. Low energy computing using energy recovery techniques. Low Power SRAM architectures. Software design for low power. Computer Aided Design Tools. Case studies Recent trends in low-power design for mobile and embedded

application.
Kaushik Roy, Sharat Prasad, Low-Power CMOS VLSI design, John Wiley, 2000.
K.-S. Yeo and K. Roy, Low-Voltage Low-Power Subsystems, McGraw Hill, 2004.
L. Benini and G. De Micheli, Dynamic Power Management Design Techniques and CAD Tools, Springer, 1998.
S. G. Narendra and A. Chandrakasan, Leakage in Nanometer CMOS Technologies, Springer, 2005.
Edgar Sánchez-Sinencio, Andreas G. Andreou, Low-Voltage/Low-Power Integrated Circuits and Systems: Low-Voltage Mixed-Signal Circuits IEEE Press Series on Microelectronic Systems 1999
NPTEL Video Lectures

EC803 Microelectronic Devices (4-0-0) 4
Review of basic device physics, Electronic structure of semiconductors, Diodes, MOS capacitor. Transistor theory. Scaling - Moore's law on technology scaling, MOS device scaling theory, Short channel effects, sub threshold leakage, Punch through, DIBL, High field mobility, Velocity saturation and overshoot. Reliability. Various definitions of channel length, Performance metric of digital technology, Transistor design trade-offs, Technology case studies, Silicon on Insulator (SOI) devices, Partially depleted and fully depleted SOI, Floating body effects, SOI for low power, Interconnects in sub-micron technology, Foundry technology, International Technology Roadmap for Semiconductors (ITRS)
J. A. del Alamo Integrated Microelectronic Devices: Physics and Modeling, Pearson, 2017
Yaun Taur, Tak H. Ning, Fundamentals of modern VLSI devices, Cambridge university press, 1998.
B. G. Streetman & S. Banerjee, Solid State Electronic Devices, Prentice Hall, 1999.
M. K. Achuthan and K. N. Bhat, Fundamentals of Semiconductor Devices, McGraw Hill, 2006
Nandita Dasgupta, Amitava Dasgupta, Semiconductor Devices: Modelling And Technology, Phi, 2009
A. K. Dutta, Semiconductor Devices and Circuits, Oxford Univ. Press, 2008.
ITRS Road map - http://public.itrs.net/
NPTEL Video Lectures

EC804 Digital VLSI Testing & Testability (4-0-0) 4
Overview of testing and verification, Defects and their modeling as faults at gate level and transistor level. Functional V/s. Structural approach to testing. Complexity of testing problem. Controllability and observability. Generating test for a signal stuck-at-fault in combinational logic. Algebraic algorithms. Test optimization and fault coverage. Logic Level Simulation – Delay Models, Event driven simulation, general fault simulation (serial, parallel, deductive and concurrent). Testing of sequential circuits. Observability through the addition of DFT hardware, Adhoc and structured approaches to DFT – various kinds of scan design. Fault models for PLAs, bridging and delay faults and their tests. Memory testing, testing with random patterns. LFSRs and their use in random test generation and response compression (including MISRs), Built-in self-test.
M. Abramovici, M. A. Breuer, and A. D. Friedman, Digital Systems Testing and Testable Design, IEEE Press, 1994.
M. L. Bushnel and V. D. Agarwal, Essentials of Testing for Digital, Memory and Mixed – Signal VLSI Circuits, Kluwer Academic Publishers, 2000.
Ajai Jain, Learning Module for the course - VLSI Testing and Testability, IIT, Kanpur, 2001.
NPTEL Video Lectures

EC805 Embedded Systems (2-0-3) 4
Introduction: Overview of embedded systems, embedded system design challenges, common design metrics and optimizing. Survey of different embedded system design technologies & trade-offs. Embedded microcontroller cores, embedded memories, Examples of embedded systems. Architecture for embedded system, High performance processors – strong ARM processors, programming, interrupt structure, I/O architecture, Technological aspects of embedded systems: interfacing between analog and digital blocks, signal conditioning, Digital signal processing, Subsystem interfacing, interfacing with external systems. Software aspects of embedded systems: real time programming languages and operating systems for embedded systems – RTOS requirements, kernel types, scheduling, context switching, latency, inter-task communication and synchronization, Case studies.
Jack Ganssle, The Art of Designing Embedded Systems, Elsevier, 1999.
R. Gupta, Co-synthesis of Hardware and Software for Embedded Systems, Kluwer 1995.
Steve Furber, "ARM System Architecture", Edison Wesley Longman, 1996.
Andrew N. Sloss, Dominic Symes, Chris Wright, "ARM System Developer's Guide: Designing and Optimizing System Software", Elsevier, 2004.
NPTEL Video Lectures

EC806 Digital Design Using FPGAs (2-0-3) 4

Digital system design options and trade-offs, Design methodology and technology overview, High Level System Architecture and Specification: Behavioral modeling and simulation, Overview of FPGA architectures and technologies, Logic block architecture, Input and Output cell characteristics, clock input, Timing, Power dissipation, Programmable interconnect, Applications, Embedded system design using FPGAs, Dynamic architecture using FPGAs, reconfigurable systems, application case studies, Simulation / implementation exercises of combinational, sequential and DSP kernels on Xilinx / Altera boards.

M.J.S. Smith, Application Specific Integrated Circuits, Pearson, 2000
Peter Ashenden, Digital Design using VHDL, Elsevier, 2007
Peter Ashenden, Digital Design using Verilog, Elsevier, 2007
Clive Maxfield, The Design Warriors's Guide to FPGAs, Elsevier, 2004
NPTEL Video Lectures

EC807 Active Filter Design (4-0-0) 4

Butterworth, Chebyshev & Inverse-Chebyshev filter response and pole locations; LC ladder filter – prototype & synthesis; Frequency transformation of lowpass filter. Impedance converters; Gm-C filters – Gm-C biquad, Q enhancement, Automatic Tuning; Active-RC filters – Comparison with Gm-C filter, Issues in realizing high frequency active-RC filters; Characterization of on-chip integrated continuous time filters.

R. Schaumann and M.E. Van Valkenburg, Design of Analog Filters, Oxford University Press, 2003.
P. V. Ananda Mohan, Current-Mode VLSI Analog Filters - Design and Applications, Birkhauser, 2003
NPTEL Video Lectures

EC808 CMOS RF Integrated Circuits (4-0-0) 4

Basic concepts in RF Design – harmonics, gain compression, desensitization, blocking, cross modulation, intermodulation, inter symbol interference, noise figure, Friis formula, sensitivity and dynamic range; Receiver architectures – heterodyne receivers, homodyne receivers, image-reject receivers, digital-IF receivers and subsampling receivers; Transmitter architectures – direct-conversion transmitters, two-step transmitters; Low noise amplifier (LNA) – general considerations, input matching, CMOS LNAs; Down conversion mixers – general considerations, spur-chart, CMOS mixers; Oscillators – Basic topologies, VCO, phase noise, CMOS LC oscillators; PLLs – Basic concepts, phase noise in PLLs, different architectures.

Behzad Razavi, RF Microelectronics, Prentice Hall PTR, 1997
Thomas H. Lee, The design of CMOS radio-frequency integrated circuit, Cambridge University Press, 2006
Chris Bowick, RF Circuit Design, Newnes, 2007
NPTEL Video Lectures

EC809 Heterogeneous and Parallel Programming (3-0-2) 4

Heterogeneous platform and GPU architecture. Introduction to OpenCL. OpenCL device architecture. Concurrency and execution model. Programming examples like vector addition, convolution and matrix multiplication. Application case studies.

Benedict R. Gaster, Lee Howes, David R. Kaeli, Perhaad Mistry, Dana Schaa, "Heterogeneous Computing with OpenCL" - Revised OpenCL 1.2 Edition, Morgan Kaufmann, 2013.
Aaftab Munshi, Benedict R. Gaster, Timothy G. Mattson, James Fung, Dan Ginsburg, "OpenCL Programming Guide", Addison-Wesley, 2012.
David B. Kirk and Wen-mei W. Hwu, "Programming Massively Parallel Processors - A Hands-on Approach", Second Edition, Morgan Kaufmann, 2013.
AMD Accelerated Parallel Processing OpenCL User Guide, AMD, 2014.
NPTEL Video Lectures

EC810 Selected Topics in VLSI Design (4-0-0) 4

Current advances in VLSI Design as defined by the instructor.

Current literature from IEEE and other quality journals and recent books in the field.

EC831 Spread Spectrum Communication Systems (4-0-0) 4

Direct sequence spread spectrum, Frequency hop spread spectrum, Hybrid direct sequence/frequency hop spread spectrum, Complex envelope representation of spread spectrum systems. Binary Shift Register Sequences for Spread

Spectrum Systems: Maximum length sequences, Gold Codes, Synchronization of Spread Spectrum Signals: Acquisition, Tracking, Code tracking loops for frequency hop systems, Synchronization using matched filter, Performance of Spread Spectrum Systems in Jamming Environments, CDMA System Design Concepts, Direct Sequence Ultra-wideband Communications, Ultra Low Power, Short Range system optimization and trade-offs.

Roger L.Peterson, Rodger E.Ziemer, David E.Borth, "Introduction to Spread Spectrum Communications", Prentice Hall, 1995.
Gordon Stuber, "Principles of Mobile Communication", Fourth Edition, Springer, 2017.
Don Torrieri, "Principles of Spread Spectrum Communications", Springer, Third Edition, 2015.
Marvin Simon, Jim Omura, Robert Scholtz, Barry Levitt "Spread Spectrum Communication Handbook", McGraw - Hill Inc., 2002.
Jack K. Holmes, "Spread Spectrum Systems for GNSS and Wireless Communications", First Edition, Artech House, 2007.

EC832 MIMO Communication Systems (4-0-0) 4

Overview of MIMO communications: Introduction to MIMO, Introduction to Spatial Diversity and Spatial Multiplexing, MIMO capacity formula, MIMO System Model. Application of MIMO Capacity, Phenomenology of multipath channels, Power law propagation, Impulse response of a multipath channel, Intrinsic multipath channel parameters, Classes of multipath channels, Statistics of small-scale fading, MIMO channels in LOS geometry, Antenna spacing and scattering angle,. Alamouti Coding and Space-time Coding: Maximal ratio receive combining (MRRC), Maximum likelihood decoding in MRRC and Alamouti receivers, Performance results, Space-time coding. Spatial Multiplexing: Overview of spatial multiplexing, BLAST architecture, Broadband MIMO, Narrowband and Broadband MIMO channel estimation,

Jerry R. Hampton, "Introduction to MIMO Communications", Cambridge University Press, 2014.
Bliss and S. Govindasamy, "Adaptive Wireless Communications: MIMO Channels and Networks", Cambridge University Press, 2013.
Simon Haykin, Michael Moher, "Modern Wireless Communications", First Edition, Pearson, 2004.
Andrea Goldsmith, "Wireless Communication", Cambridge University Press 2005.
Jafarkhani, "Space-Time Coding: Theory and Practice", Cambridge University Press, 2005.

EC833 Internet of Things (4-0-0) 4

The IoT Networking Core , Technologies involved in IoT Development, Overview of IoT supported Hardware, Network Fundamentals: Overview and working principle of Wired Networking equipment, Linux Network configuration Concepts, IoT Architecture, Applications, Back end Application, Case Study & advanced IoT Applications, IoT applications in home, infrastructures, buildings, security, Industries, Home appliances, other IoT electronic equipment. Use of Big Data and Visualization in IoT, Industry 4.0 concepts. Sensors and sensor Node and interfacing.

Ovidiu Vermesan, Peter Friess, Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems, River Publishers, 2013.
Jean-Philippe Vasseur, Adam Dunkels, Interconnecting Smart Objects with IP: The Next Internet, Morgan Kuffmann, 2010.
Lu Yan, Yan Zhang, Laurence T. Yang, Huansheng Ning, The Internet of Things: From RFID to the Next Generation Pervasive Networked, Auerbach Publications, 2008.
Arshdeep Bahga, Vijay Madisetti, Internet of Things (A Hands on Approach), VPT, 2014.
Adrian McEwen, Hakim Cassimally, Designing the Internet of Things, Wiley, 2013.

EC834 Error Control Coding (4-0-0) 4

Coding for reliable digital transmission and storage. Groups, Rings, Vector Spaces, Galois Fields, Polynomial rings, Channel models, Linear Block codes, Cyclic codes, BCH codes, Reed Solomon Codes, Berlekamp-Massey and Euclid decoding algorithm, Applications of Reed-Solomon codes, Convolutional codes, Decoding algorithms for Convolutional codes, Viterbi, Trellis coded modulation, Turbo Codes, LDPC codes.

Shu Lin and Daniel J. Costello Jr., Error Control Coding: Fundamentals and Applications, Prentice Hall, 2003.
S. B Wicker, Error Control Systems for Digital Communication and Storage, Prentice Hall International, 1995.
Blahut R.E., Algebraic codes for Data transmission, Cambridge University Press, 2003.

EC835 Algorithms for Parameter and State Estimation (4-0-0) 4

Maximum likelihood (ML) estimation, Maximum a posteriori (MAP) estimation, Least squares (LS) estimation,

Minimum mean square error (MMSE) estimation, Linear MMSE (LMMSE) estimation. LS estimation for linear and nonlinear systems, modeling stochastic dynamic systems, the Kalman filter for discrete time linear dynamic systems with Gaussian noise. Steady state filters for noisy dynamic systems, adaptive multiple model estimation techniques. Nonlinear estimation techniques, computational aspects of discrete time estimation.
Y. Bar-Shalom, X. Rong Li and T. Kirubarajan, Estimation with Applications to Tracking and Navigation, John Wiley & Sons, 2001.
F. L. Lewis, Optimal Estimation, John Wiley & Sons, 1986.
R. G. Brown and P. Y. C. Hwang, Introduction to Random Signals and Applied Kalman Filtering, John Wiley & Sons, 1992.

EC836 Radar Signal Processing (4-0-0) 4
Radar and its composite environment, Review of Radar range performance computations, Detection Processes, Sequential and adaptive processes, Atmospheric effects, Sea and land Back scatter, Signal Processing concepts and waveform designs MTI & CW radars, phase coding techniques, FM pulse compression waveforms, Mateorogical radar and system performance analysis.
R.J Sullivan, Radar Foundations for imaging and Advanced Concepts, PMI, 2004.
F.E Nathanson, Radar Design Principles, Signal Processing and the Environment, PMI, 2004.
J.C. Toomay, Principles of radar, PMI, 2004.

EC837 Advanced Radiating Systems (4-0-0) 4
Planar Antennas - Microstrip rectangular and circular patch antennas- Analysis and design, Feeding methods; circularly polarized microstrip antennas, Broadband techniques. Array Theory, Planar array- Array factor, beamwidth, directivity. Electronic scanning,. Broadband Antennas, Yagi array of linear elements and printed version, Log-periodic dipole array. Frequency Independent Antennas Aperture Antennas- Field equivalence principle, Babinet's principle, Antennas for mobile communication - Active and smart microstrip antennas, Design and analysis of microstrip antenna arrays.
C. A. Balanis, Antenna Theory and Design, John Wiley & Sons, 1997.
J.D. Kraus, Antennas, McGraw-Hill, 1988.
R.A. Sainati, CAD of Microstrip Antennas for Wireless Applications, Artech House, 1996.
R. Garg, P. Bharhia, I. Bahl, and A. Ittipiboo, Microstrip Antenna design Handbook, Artech House.
J. R. James, P.S. Hall and C.Wood, Microstrip Antennas: Theory & Design, Peter Peregrinns , UK.

EC838 Multi Target Tracking and Multi-Sensor Information Fusion (4-0-0) 4
Target tracking, performance evaluation techniques, data association. Tracking with multiple sensors, out - of - sequence measurement, track initialization, track management. Probabilistic Data Association Filter (PDAF), adaptive gating for PDAF. Maximum Likelihood - PDA (ML - PDA). Joint Probabilistic Data Association Filter (JPDA). Multiple Hypothesis Tracking (MHT). Performance prediction, sensor management, track - to - track fusion. Nonlinear filters.
Y. Bar-Shalom, X. Rong Li, Multi Target Multi Sensor Tracking-Principles and Techniques, YBS Publishers, 1995.
Y.Barshalom, P K Willet and X Tin, Tracking and Data Fusion: A Hand book of algorithms, Yaakov Bar-Shalom, 2011.
Y.Barshalom, Multitarget-Multisensor Tracking: Applications and Advances v.2, Yaakov Bar-Shalom, 2000.
Y.Barshalom, Multitarget-Multisensor Tracking: Applications and Advances v.3, Artech House, 2000.
S.Blackman and R.Popoli, Design and Analysis of Modern Tracking systems published by Artech house, 1999.

EC839 Nano-Photonics (4-0-0) 4
Fundamentals, Maxwell's equations, light-matter interaction, dispersion, EM properties of nanostructures, etc. Photonic crystals and photonic crystal fibers, Photonic and plasmonic nanocircuits, Metal optics Manipulating light with plasmonic nanostructures, Plasmonic nano-sensors, Near-field optics, Metamaterials: artificial magnetism and negative refractive index, Metamaterials: superlens and hyperlens, Transformation optics and cloaking, Metasurfaces, Nanolasers, Tunable and active plasmonic materials, Refractory plasmonics, Plasmonics for energy conversion, data storage and biomed applications, Silicon photonics, Diamond photonics, Graphene photonics, Intro to quantum photonics.
W. Cai and V. Shalaev, Optical Metamaterials: Fundamentals and Applications, Springer, 2009.
Surface plasmons on smooth and rough surfaces and on gratings," Raether (Springer-Verlag, New York, 1986)
Principles of Nano-Optics," Lukas Novotny and Bert Hecht, Cambridge, 2006.

S. Maier, Plasmonics: Fundamentals and Applications, Springer (2007). Photonic Crystals: Molding the Flow of Light ," J. D. Joannopoulos, R. D. Meade, J. N. Winn (Princeton University Press, 1995).

EC840 Millimeter Wave Communications (4-0-0) 4

Millimeter wave characteristics, Radio wave propagation for mm wave, emerging applications of millimeter wave communications. Millimeter wave generation and amplification, Analog mm wave components, Consumption factor theory, Modulation for millimeter wave communications, Millimeter wave link budget, Transceiver architecture, Millimeter wave calibration, Millimeter wave design considerations. Massive MIMO Communications, Noise coupling in MIMO system, Dynamic spatial, frequency and modulation allocation. Antenna beam width, polarization, advanced beam steering and beam forming, mm wave design consideration, Implementation for mm wave in adaptive antenna arrays, Device to Device communications over 5G systems.

K.C. Huang, Z. Wang, "Millimeter Wave Communication Systems", Wiley-IEEE Press, March 2011.
Robert W. Heath, Robert C. Daniel, James N. Theodore S. Rappaport, Murdock, "Millimeter Wave Wireless Communication", Prentice Hall, 2014.
Jonathan Wells, "Multi-Gigabit Microwave and Millimeter-Wave Wireless Communications", Artech House, 2010.
Xiang, W; Zheng, K; Shen, X.S; "5G Mobile Communications: Springer, 2016.

EC841 Cryptography (4-0-0) 4

Elementary Number Theory, Finite series, Arithmetic and Algebraic Algorithms, Secrete key and Public key Cryptography, Pseudo Random bit generators, Block and Stream Ciphers, Hash functions and Message digests, Public key encryption, Authentication, Digital Signatures, Zero Knowledge Interactive Protocols, Elliptic curve cryptosystems, formal verification, Crypt analysis, Hard Problems.

Koblitz N., A Course on Number Theory and Cryptography, Springer Verlag, 1986.
Menezes A. et. all, Handbook of Applied Cryptography, CRC Press, 1996.

EC842 Information Theory (4-0-0) 4

Communication systems and Information Theory, Measures of Information, Coding for Discrete sources, Discrete memory-less channels and capacity, Noisy channel coding theorem, Techniques for coding and decoding, Waveform channels, Source coding with Fidelity criterion, Network Information Theory.

Thomas M Cover & Joy A Thomas, Elements of Information Theory, Second Edition, John Wiley,2006.
R.G.Gallagher, Information Theory and Reliable Communication, Addison Wesley, 1987.
A.J.Viterbi & J.K. Omura, Principles of Digital Communications and Coding, McGraw Hill, 1979.

EC843 Broadband Communications (4-0-0) 4

Introduction, Internet-based Networks, Networking Technologies, Multiple Access Techniques, Timing Synchronization, Delay Lock Loop, ISDN Physical Layer, ISDN Data Link Layer, Signaling System Number 7, BISDN and SONET, ATM Switch and Protocols, UWB, specialized video (DBS) and wireless networks; CATV architecture; and the role of the Internet in the broadband environment, Access Networks, Cable Modem Systems, PONs, Personal Communication Systems, VPNs, VSATs, CLOS Network Switch, OFDM Concept, OFDMA System, Multi-Carrier CDMA, WiMAX.

Introduction to Broadband Communication Systems, Cajetan M. Akujuobi, Matthew N.O. Sadiku, Scitech Publishing Inc, CRC Press, 2007.
Balaji Kumar, Broadband Communications, McGraw-Hill, 1998.
Robert Newman, Broadband Communications, Prentice Hall, 2002.

EC844 Electromagnetic Interference and Compatibility (4-0-0)4

Introduction to EMI/EMC to circuit designer, Biological effects of EMI. Sources of EMI/EMC-noise paths Measurement of RE/CE interference. EMI in analog and digital circuits, power circuit case studies, Grounding, Shielding-cut-off frequency, effectiveness calculation, common mode choke design, radiation emission reduction. Power distribution issues in PCB using different converters, filtering techniques. Reflection and cross talk in PCB for high-speed circuits. Signal integrity-propagation on multi-conductor lines and cross talk, PCB design for signal integrity, EMI/EMC standards.

Ott. H.W. Noise reduction techniques in Electronic system, 2nd edition, John Wiley Interscience, New York (1988).
Clayton R.Paul, Introduction to electromagnetic compatibility, John Wiley and Sons, Inc. 1991.
Dr.V.P.Kodali, "Engineering EMC", IEEE Publications, S. Chand., New Delhi, 2000.

EC845 Principles of Communication Systems Simulation (4-0-0)4

The role of simulation and simulation methodology. Sampling and Quantization. Low pass Simulation models for Band pass Signals and systems, Complex envelope representation of band pass signals, multi carrier signals, nonlinear and time variant systems. Filter Models and Simulation Techniques, Phase Locked Loops and Differential Equation Methods, Generating and Processing random Signals, Stationary and ergodic processes, PN sequence generation and processing. Monte Carlo Simulation of Communication Systems: Fundamental concepts, AWGN channel, Fading channel, examples, Semi analytic techniques.

Tranter, Sam Shanmugan, Rappaport and Kosbar, "Principles of Communication Systems Simulation with Wireless Applications", First edition, Prentice Hall, 2004.
Jeruchim, "Simulation of Communication Systems", Second Edition, Springer, 2011.
Won Y Yang, "MATLAB/Simulink for Digital Communication", Second Edition, YesDee Publishers, 2014.

EC846 Computer Communication Networks (4-0-0)4

Introduction to common networks such as the Internet, WiFi, Cellular networks, Ad hoc and Sensor networks; Introduction to ISO/OSI Layers; Deterministic and Stochastic Network Calculus, Introduction to Network Simulators, Medium Access Control Layer, ARQ protocols; Random access, Backoff algorithms; WFQ implementations, Introduction to Queueing theory, Routing Layer and algorithms, Buffer management; Transport Layer, Cross-layer Design; Network Monitoring; Performance Measures.

Communication Networking: An Analytical Approach, Anurag Kumar, D Manjunath and Joy Kuri, Morgan Kauffmann, 2004.
Data Networks, 2nd Edition, Dimitri P Bertsekas and R Gallager, Pearson, 1992.
Wireless Networking, Anurag Kumar, D Manjunath and Joy Kuri, Morgan Kauffmann, 2004.
Resource Allocation and Cross-Layer Control in Wireless Networks, Leonidas Georgiadis, Michael J. Neely and Leandros Tassiulas, NOW Publishers, 2006.
Computer Networking: A top-down approach, James F Kurose, Pearson Education, 5th Edition, 2012.
Various research publications

EC847 Selected Topics in Communication Engineering (4-0-0) 4

Current advances in Communication Engineering as defined by the instructor

Current literature from IEEE and other quality journals and recent books in the field.

EC848 Signal Processing Techniques for Software Defined Radios (4-0-0) 4

Multirate Signal Processing: M-fold decimator and L-fold expander, sample rate conversion, noble identities. polyphase representations, interpolated FIR technique, CIC filters.
An Overview of Transceiver Systems: Baseband PAM transceiver, Eye patterns in PAM systems, QAM transceiver, Eye patterns in QAM systems, the impact of frequency offset and phase offset on the baseband equivalent of passband channels.
Adaptive Systems: Wiener filter, The LMS algorithm, The standard RLS algorithm, Sarnpling with AGC.
Phase Locked Loop: Continuous time PLL, Discrete tirne PLL, Maximum likelihood phase estirnation. PLL with extended lock range.
Carrier Acquisition and Tracking: Non-data aided carrier recovery techniques, Coarse carrier acquisition, Fine Carrier acquisition and tracking, Costas loop, Pilot aided carrier acquisition method, Data aided carrier tracking method.
Timing Recovery: Non data aided timing recovery methods and algorithms, Data aided timing recovery techniques, Muller and Muller's method, Decision directed method.
Channel Equalization: Continuous time channel model, Discrete time channel rnodel, Symbol spaced equalizer. Fractionally spaced equalizer, Performance study of equalizers (Wiener- Hopf Equations), Adaptation algorithms, Cyclic equalization.

Behrouz Farhag, Signal Processing Techniques for Software Radios, Second Edition, Lulu Publications,2010
Michael Rice, "Digital Communications: A Discrete Time Approach", First Edition, Pearson Education, 2009.
Richard Johnson, William Sethares, and Andrew Klein, Software Receiver Design, First Edition, Cambridge University Press, 20 I l.

EC849 RF TRANSCEIVER SYSTEMS DESIGN FOR WIRELESS COMMUNICATION (4_0_0)4
An overview of wireless systems: Mobile communication systems, WLANs, Bluetooth, GPS, OFDM. MIMO. And UWB. Converge of system design.
System design fundamentals: Linear systems and transformation, Non-linear system representation and analysis approaches, Noise and random processes: Noise Figure, Noise Temperature, Noise PSD. Narrowband noise representation.
Elements of Digital Baseband Systems: Sampling theorem and sampling process, Jitter effect. pulse shaping and ISI. BER, SNR, CNR, EVM, eye diagram, scatter plot.
Radio Architectures and Design Considerations: Super heterodyne architecture, Direct conversion (or Zero IF architecture), Low IF Architecture, Band-pass sampling radio architecture. Discuss merits and demerits.
Receiver system analysis and design: Sensitivity, selectivity and Noise figure of receiver. Intermodulation characteristics, Single tone desensitization, Adjacent/Alternate channel selectivity and blocking characteristics, Receiver dynamic range and AGC system, System design and performance evaluation, Examples
Transmitter system analysis and design: Transmission power and spectrum, Modulation accuracy, Adjacent and Alternate channel power, Noise emission calculation, Some important considerations in system design, Examples.

Qizheng Gu, "RF Systent Design of Transceivers for Wireless Communications", First Edition, Springer publication, 2005.
Behzad Razavi, "RF Microelectronics", Second Edition, Pearson India, 2013.
Cornell Drentea, "Modern communications Receiver Design and Technology", First Edition, Artech House, 2010.
Kevin McClaning, "Wireless Receiver Design for Digital Communications", Second Edition, SciTech publications, 2012.

EC85O DESIGN OF INTEGRATBD CIRCUITS FOR WTRELESS COMMUNTCATTON (4-0-0)4
Introduction and Basic Concepts in RF IC Design: Some popular radio systems, The big picture of RF transceiver architecture, Time variance, Non-linearity Harmonic distortion, Gain compression, Cross Modulation, Irrter rnodulation, Cascaded nonlinear stages, Stochastic characterization of noise, Device noise, Representation of noise in circuits, Sensitivity and dynamic range.
Oscillators: Design criteria, Topologies, Large-signal transconductance and harmonic tuned amplifiers, Analysis of large-signal loop gain of an oscillator, MOS Oscillator with differential gain stage, VCO.
PLL and Frequency Synthesizers: Phase detector, Gilbert cell as a phase detector, Design and analysis of first and second order PLLs, PLL as frequency synthesizers, Applications.
Mixers, Modulators and Demodulators, Limiters and ACC: Mixer Concept, Passive and active mixers, switching circuits, linearization methods in mixers, Analog and digital modulator and dernodulator circuits, AGC and limiter circuits analysis.
Narrow band and Wideband Amplifier Design: Transmission lines and impedance matching, S-parameters. Specification of amplifiers, Power gain contours, Constant noise figure contours, design of single stage and rnulti stage amplifiers, Design of narrow band and wide band RF amplifiers. Power Amplifier Design: PA specification, PA topologies, and Linearization techniques in power amplifiers.

Forouhar Farzaneh, Ali Folowat, et al., "Introduction to Wireless Communication Circuits", River publishers.2018.
Behzod Razavi, "RF Microelectronics", Second Edition, Pearson India, 2012.
Richard Chi-Hsi Li, " RF Circuit Design", Second Edition, John Wiley & Sons, 2012.
Bosco Leung, "VLSI\for Wireless Communication", Second Edition, Springer International, 2011.
Thomas H. Lee, "The Design of CMOS RF ICs", Second Edition, Cambridge University Press, 2003.

EC861 Image Processing and Computer Vision (4-0-0) 4
Overview of image processing systems, image formation and perception, continuous and digital image representation, image quantization, image contrast enhancement, histogram equalization, 2D signals and systems, 2D sampling, linear convolution in 2D, continuous and Discrete Fourier transform in 2D, image filtering in the DFT domain, color representation and display; true and pseudo color image processing, image compression, imaging geometry, model of image degradation/restoration process, texture analysis, motion analysis, geometric camera models, stereopsis, structure from motion, tracking, robot vision, object identification.
Anil K. Jain, Fundamentals of digital image processing, Prentice Hall, 1989.
Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing, 2nd Ed, Prentice Hall, 2002.

Forsth D. A. and Ponce J., Computer Vision: A Modern Approach, Prentice Hall, 2003.
Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2010.
Hartley and Zisserman, Multiple Geometry in Computer Vision, Cambridge University Press, 2004.

EC862 Time Series Analysis and Data Science (4-0-0) 4
Identifying patterns in time series data, inference, estimation, prediction, general properties of time series models, systematic pattern and random noise, trend and seasonality analysis, time domain and frequency domain analysis, data visualization, linear and mixed models, AR models, ARMA models, ARIMA models, identification and parameter estimation, model estimation and forecasting, Akaike information criterion, mixed models, single spectrum and cross spectrum analysis, higher order statistics, state space models, Kalman filter, non-Gaussian linear models, Generalized autoregressive conditional hetereoskedastic (GARCH) models, stochastic volatility models, extreme value theory, nonlinear time series models, applications in data science.
Peter J. Brockwell, Richard A. Davis, Introduction to Time Series and Forecasting, Springer, 2001.
George E. P. Box, Gwilym M. Jenkins, Gregory C. Reinsel, Time Series Analysis: Forecasting and Control 4th Ed, Wiley, 2008.
Andrew C. Harvey, Forecasting, Structural Time Series Models and the Kalman Filter, Reprint Ed, 2001.
Box-Steffensmeier, Janet M., John R. Freeman, Matthew P. Hitt, Jon C. W. Pevehouse, Time Series Analysis for the Social Sciences, Cambridge University Press. 2014.
James Fahl, Data Analytics, Paperback, 2017.

EC863 Statistical Signal Processing (4-0-0) 4
Introduction to Adaptive Filters: General properties, filtering, prediction and smoothing, Applications in Communications, Optimal Signal Processing, Principles of orthogonality, minimum square error, Wiener Hopf equations, state space model, innovations process, Kalman filter equations. Linear Adaptive Equalisation, Gradient search and steepest descent adaptation algorithms, Transient and Steady state properties including convergence rate and mis-adjustment, least square estimation, Recursive Least Squares (RLS) algorithms, Introduction to Fast Recursive Algorithms for Equalization, lattice filtering for RLS. Tracking time-varying systems.
S.J. Orfanidis, Optimum Signal Processing, McGraw Hill, 1989.
S. Haykin, Adaptive FilterTheory, Pearson, 1996.
Mayson H. Hayes, Statistical Digital Signal Processing and Modeling, Wiley, 1996.

EC864 Speech and Audio Processing (4-0-0) 4
Speech Production–human speech production mechanism, digital models for speech production, Speech perception, Speech Analysis–Time and frequency domain analysis of speech, Linear prediction, Speech compression, Audio processing–characteristics of audio signals, sampling, Audio compression techniques, Standards for audio compression in multimedia applications, MPEG audio encoding and decoding, audio databases and applications. Speech synthesis–text to speech synthesis, letter to sound rules, syntactic analysis, timing and pitch segmental analysis. Speech recognition.
Douglas O'Shaugnessy, Speech Communication–Human and Machine, IEEE Press, 2000
L R Rabiner, Digital Processing of Speech Signals, Pearson,1978.
T.F Quatieri , Discrete-time speech signal processing: Principles and Practise Pearson,2002.
Zi Nian Li, Fundamentals of Multimedia, Pearson Education, 2003.

EC865 Multimedia Systems (4-0-0) 4
Computer information representation through text, graphics, images, sound, audio, animation, video, processing, storage, generation, manipulation, rendition, transmission of multimedia information, psycho acoustic models, synthesis and recognition, color models for video, television, video formats, text in multimedia and internet, image compression, video indexing and content based image/video retrieval, audio coding, storage, retrieval and presentation of media, multimedia annotation and indexing, multimedia recommendation and summarization, multimodal translation between language and vision, DLT for audio, multimedia synchronization, multimedia databases, multimedia communications, network applications, distributed multimedia systems, multimedia system integration.
Ze-Nian Li, Mark S. Drew, Fundamentals of Multimedia. Prentice-Hall/Pearson Education, 2004.
P. K. Andleigh, Kiran Thakrar, Multimedia Systems Design, 1/e, Prentice Hall, 1995.
R. Steinmetz, K. Nahrstedt, Multimedia Fundamentals, Volume 1: Media Coding and Content Processing, Prentice Hall, 2002.

F. Kuo, J. J. Garcia Luna-Aceves, W. Effelsberg, Multimedia Communications: Protocols and Applications, 1/e 1998.
Milovanovic, Zoran S. Bojkovic, Dragorad A. Milovanovic, Kamisetty Ramamohan Rao: Multimedia Communication Systems: Techniques, Standards, and Networks, Prentice Hall, 2002.

EC866 Deep Learning and Applications (3-0-2) 4
Linear Regression , Logistic regression, Basic neuron structure, Perceptron, error functions, optimization – gradient descent, Multilayer perceptron, transfer function, nonlinearities, learning, backpropagation, function approximations, overfitting, underfitting, Deep networks, challenges, regularization techniques – Norm penalties, early stopping, drop outs, dataset augmentation, bagging and ensemble methods, Convolutional Networks – Convolution, pooling, variants, transfer learning, Sequence Modeling – Recurrent neural networks, Bidirectional RNNs, architectures, LSTM, Application examples – Computer Vision, Speech recognition, NLP.
Simon S. Haykin, Neural Networks and Learning Machines, 3rd Ed, Pearson, 2009.
José C. Principe, Neil R. Euliano, W. Curt Lefebvre, Neural and Adaptive Systems: Fundamentals through Simulations, John Wiley and Sons, 2000.
Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press, 2016.
EC867 Fourier and Wavelet Analysis (4-0-0) 4
Hilbert Spaces, Review of sequences and discrete time systems, functions, DTFT, convergence, multi rate systems, polyphase representation, stochastic processes and systems. Continuous time systems, Fourier transform, definition, existence, spectral decay, Fourier series. Sampling and Interpolation–finite dimensional vectors, sequences, functions, periodic functions, approximation and compression polynomial and spline approximation. Localization and uncertainity, Filter banks–Localization, two channel orthogonal filter banks, design, biorthogonal filter banks, design, Local fourier bases–N channel filter banks, exponentially modulation filter banks, cosine modulated filter banks. Wavelet bases on sequences, Tree structured filter banks, orthogonal, biorthogonal bases, wavelet packets, frames. Wavelet bases on functions–local Fourier transforms.
Martin Vetterli Jelena Kovacevic & Vivek K. Goyal, Foundations of Signal Processing, Cambridge University Press, 2015.
J. Kovacevic, V. K. Goyal and Martin Vetterli, Fourier and Wavelet Signal Processing, Cambridge University Press, 2013.

EC868 Time Frequency Analysis (4-0-0) 4
The need for Time-frequency analysis: introduction, Time and Frequency Description of Signals, Instantaneous Frequency and the Complex Signal, Densities and Characteristic functions: one and two dimensional density functions and their characteristic functions, Fundamentals of Time-Frequency Distribution (TFD), Different Types of TFD, Generation of TFD Using Kernel Methods. Kernel design for reduced interference in TFD. Positive Distributions Satisfying the Marginals. Applications of TFD in the fields of Radar, Speech, Sonar Signal Processing.
Leon Cohen, Time-Frequency Analysis, Prentice-Hall PTR, Upper Saddle River, 1995.
S. Mallat, A wavelet tour of signal processing - The sparse way, Elsevier, Third Edition, 2009.
D. Gabor, Theory of communication, Proceedings of IEE, pp. 429-457, 1946.

EC869 Medical Imaging and Biosignal Analysis (4-0-0) 4
Bio-electromagnetism, bioelectric sources and conductor modeling, image formation in modern medical imaging modalities, radiography, fluoroscopy, and computed tomography, magnetic resonance imaging, ultrasound, acoustic and photoacoustic imaging, X-Ray tomography, radiation measurements, safety issues, and physiological signals and responses, Bioelectrical signals, Evoked potentials, Electromyogram, respiration and heart rate variability, mathematical modeling and techniques for image and bio-signal analysis and diagnostic decision-making, detection, segmentation and classification techniques, Computational Bio-imaging, data interpolation, registration, acquisition and compression.
Jaakko Malmivuo, Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields, Oxford University Press, 1995.
John L. Semmlow, Benjamin Griffel, Biosignal and Medical Image Processing, 3rd Ed, CRC Press, 2014.
E. Russell Ritenour and William Hendee, Medical Imaging Physics, 4th Ed, 2002.
Rangaraj M. Rangayyan, Biomedical image analysis, CRC Press, 2004.
B.H Brown, R.H Smallwood, D.C. Barber, P.V Lawford, D.R Hose, Medical Physics and Biomedical Engineering, CRC Press, 1998.

EC870 Architectures for Signal Processing and Machine Learning **(4-0-0) 4**
Representation of digital signal processing systems: block diagrams, signal flow graphs, data-flow graphs, dependence graphs; pipelining and parallel processing for high-speed and low power realizations; iteration bound, algorithms to compute iteration bound, retiming of data-flow graphs; unfolding transformation of data-flow graphs; systolic architecture design, architectures for real and complex fast Fourier transforms; stochastic logic based computing, computing digital filters, arithmetic functions and machine learning functions using stochastic computing; Neural Network architectures.
K.K. Parhi, VLSI Digital signal processing systems: Design and implementation, John Wiley, 1999.
Lars Wanhammar, DSP Integrated Circuits, Academic Press, 1999.
Sen M. Kuo Bob H. LeeWenshun Tian, Real-Time Digital Signal Processing: Implementations and Applications, John Wiley & Sons, Ltd, 2006.
Roger Woods, John McAllister, Gaye Lightbody, Ying Yi, FPGA Based Implementation of Signal Processing Systems, John Wile, 2017.
U. Meyer-Baese, Digital Signal Processing with Field Programmable Gate Arrays, 4th Ed. Springer, 2014.
Recent literature

EC871 Selected Topics in Signal Processing **(4-0-0) 4**
Current advances in Signal Processing as defined by the instructor.
Current literature from IEEE and other quality journals and recent books in the field.

EC872 Nonlinear Dynamics, Chaos and Fractals **(4-0-0) 4**
Review of linear systems; discrete and continuous, difference and differential equation modeling and solution, dynamics of linear and nonlinear systems, maps and flows, phase-plane analysis, bifurcations, limit cycles, attractors, chaotic behavior, strange attractors, chaotic systems and their analysis, fractals, Mandlebrot and Julia sets, iterated function systems, fractal dimension, stable and unstable manifolds, multifractals, applications.
Steven H. Strogatz, Nonlinear Dynamics And Chaos: With Applications To Physics, Biology, Chemistry, And Engineering, Addison-Wesley, 1994.
MW Hirsch, S. Smale, RL Devaney, Differential equations, dynamical systems, and an introduction to chaos, Academic Press. 2012.
Drazin, P. G. Nonlinear systems. Cambridge, UK: Cambridge University Press, 1992.
Peitgen, H-O., H. Jurgens, and D. Saupe. Chaos and Fractals: New Frontiers of Science, Springer, 2004.
M. Barnsley, Fractals everywhere, Academic Press, 1993.

EC873 Computational Imaging and Physics **(4-0-0) 4**
Imaging methods and modalities, computational aspects of analysis, theoretical and applied; modalities in medical imaging, geophysics, applied physics, biology, astronomy, remote sensing and optics; methods and applications in nuclear medical imaging physics and radiology, image guided radiotherapy; computational photography, inverse problems and reconstruction, modeling, analysis; use of optimization, compressed sensing and pattern recognition and machine learning theory; applications of deep learning and artificial intelligence.
Kedar Khare, Fourier Optics and Computational Imaging, Wiley, 2015.
B.H Brown, R.H Smallwood, D.C. Barber, P.V Lawford, D.R Hose, Medical Physics and Biomedical Engineering, CRC Press 1998.
S Webb, The Physics of Medical Imaging, Institute of Physics, 1988.
Paul Suetens, Fundamentals of Medical Imaging, Cambridge University Press, 2009.
Thayalan K, The Physics Of Radiology And Imaging, Jaypee Brothers 2014.
Tetsuo Asano, Geometry, Morphology, and Computational Imaging, Springer 2002.

EC874 Detection, Estimation And Statistical Learning Theory **(4-0-0) 4**
Non-Bayesian Detection: Hypothesis test, Neyman-Pearson lemma, Likelihood ratio test, Kullback-Leiblerdivergence, Matched filter, Sequential test; Minimum mean square-error (MMSE), Linear MMSE, Minimum probability of error (MAP), Stationarity and power spectral density, Wiener filter, Kalman filter, Non-Bayesian Estimation: Sufficient Statistic, Bias, Minimum variance unbiased estimator. Cramer-Rao bound. Maximumlikelihood, Expectation maximization, Bayesian inference, empirical risk minimization, concentration inequalities, PAC learning, nonparametric inference.
HV. Poor, AnIntroduction to Signal Detection and Estimation, 2nd Ed., Springer-Verlag, 1994.
HL. Van Trees, Detection, Estimation and Modulation Theory, Parts 1and 2, John WileyInter-Science.

SM. Kay, Fundamentals of Statistical Signal Processing, vol 1and vol 2, Prentice Hall, 1993.
Kailath, sayed, and Hassibi, Linear Estimation, Prentice Hall, 2000.
MD,Srinath and PK. Rajasekharan, An Introduction to Statistical Signal Processing with Applications, John Wiley & Sons, 1979.
LL. Scharf, Statistical Signal Processing; Detection, Estimation, and Time Series Analysis, Addison-Wesley, 1991.

EC875 Probabilistic Models In Machine Learning (4-0-0) 4

Probabilistic graphical models, belief networks, decision making, Bayesian linear models, linear Gaussian state space models, Expectation Maximization, Markov models, Bayesian networks, Markov random fields, Markov networks, variational inference, latent variable models, Markov chain Monte Carlo, Kalman Filtering, Particle Filters, Dynamic Bayesian Networks.

David Barber, Bayesian Reasoning and Machine Learning, 1st Ed, Cambridge University Press, 2012.
Jerome H, Friedman, Robert T'ibshirani, Trevor Hastie, TheElements of Statistical Learning; Data Mining, Inference, and Prediction, Springer, 2nd Ed, 2009.
Kevin P. Murphy, Machine Learning; A Probabilistic Perspective, MIT, 2012.
Zoubin Ghahramani,Probabilistic Modelling,Machine Learning and the Information Revolution, MIT Tutorial 2012.

EC876 System Identification And Control (4-O-O)4

Dynamic Systems and Models, mathematical models of systems from observations of their be6av,ior: time series. state-space' and input-output models; model structures, parametrization, and identifiability; non-parametric methods; prediction error methods for parameter estimation, convergence., consistency, and asymptotic distribution: relations to maximum likelihood estimation; recursive estimation; relation to Kalman filters; structure determination: order estimation; parametric identification by linear regression (least squares method, instrumental variables method, recursive algorithms); Subspace identification methods; Prediction' error methods (ARX. ARMAX, OE and BJ structures). Practical aspects of identification (input design, order estimation, model validation): Identification of Linear-Parameter Varying (LPV) models, Nonlinear system- identification, control, Adaptation and learning; Adaptive control: certainty Equivalence, Stability Issues in Time-varying Systerns, stability of Adaptive Systerns; Learning and Adaption Based Control; Direct and indirect adaptive control, model reference control (MRC), rnodel reference adaptive control (MRAC), pole placement control (PPC) and adaptive pole placernent control (APPC).

Ljung, L. System identification; Theory for the user. 2nd ed. PTR Prentice Hall, 1999.
Toffner Clausen, Steen, System Identification and Robu.st Control, Springer, 1996.
Ljung, L and T. Glad. Modeling of Dynamic systems. PTR Prentice Hall, 1994.
Soderstrom,T., and P. Stoica. System identification. Prentice Hall Inrernational, London, 1989.
NS Nise, Control Systems Engineering, 6th Ed., Wiley, 2011

EC877 Inverse Problems: Theory And Applications (4-0-0)4

Introduction and Basic Concepts: Ill-Posedness in inverse Problems, linear inverse problems, Classical Regularization Methods, Tikhonov Regularization, SVD, Projection Methods, Inverse Eigenvalue Problems, Besov space regularization, Inverse Scattering Problem, Variational Regularization Methods, Convex Regularization, Non-convex Regularization, Statistical Inversion Theory, Nonlinear inverse problems, Inverse problems in imaging modalities and radar, applications in remote sensing, geoscience, biomedical, Computational inverse problems.

Jennifer L. Muller, Samuli Siltanen, Linear and nonlinear inverse problems with practical applications-Society for Industrial and Applied Mathematics 2012.
Per Christian Hansen, Discrete Inverse Problems; Insight and Algorithms, Society for Industrial and .4pplied Mathematics 2010.
Aster, Richard C. Borchers, Brian Thurber, Clifford H, Parameter estimation and inverse problem.Elsevier 2019.
J. C. Santamarina, Dante Fratta, Discrete signals and inverse problems: an introduction for engineers and scientists, Wiley 2005

EC727 / EC757 / EC787	**Seminar**	**2**
EC728 / EC758 / EC788	**Minor Project**	**2**
EC729 / EC759 / EC789	**Major Project – I**	**4**
EC730 / EC760 / EC790	**Major Project – II**	**8**

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

EE700 Computer-Aided Protection of Power Systems (4-0-0) 4

Simulation methodologies of complex energy systems and transducers, Basic hardware scheme of a microprocessor based relay. Signal processing algorithms for energy system protection. Microprocessor- based protection of generators, transmission line, power transformer, and induction motors. Automatic testing of protective relays.

IEEE PES, Tutorial Course on Computer Relaying, IEEE Catalog 79EHC 148-7PWR, 1979.

IEEE PES, Tutorial Course on Microprocessor Relays and Protection Systems, IEEE Catalog 88EHO 269-1 PWR , 1988.

IEEE PES, Tutorial Course on Advancement in Microprocessor-Based Protection and Communication, IEEE Catalog 97TP120- 0, 1997.

A T Johns, S K Salman, Digital Protection of Power Systems, IEE.

EE701 Power Electronics: Modeling and Design (4-0-0) 4

Review of basics, modeling of devices, review of ac to dc converters, modeling and design of switch mode power converter circuits with hard switching such as dc to dc converters, isolated dc to dc converters, dc to ac converters and ac to ac converters. Design of magnetic circuits. Introduction to soft switching circuits, multilevel inverter topology and SVPVM algorithm. Applications to power systems and power quality issues.

Ned Mohan, Undeland, Robbins, Power Electronics 3rd edition, Part II & III, John Wiley.

M H Rashid, Power Electronics, Chapters 8, 6, 9 &10 , 3rd edition, PHI (EEE) or Pearson Education.

EE702 Power System Modeling and Analysis (4-0-0) 4

Introduction to generalized theory of machines. Modeling of transformers, synchronous machines and induction machines to carryout dynamic analysis. Modeling and computational issues pertaining to power system stability analysis such as generator-driven and load-driven stability, and SSR analysis.

Charles V Jones, The Unified Theory of Electrical Machines, Butterworth and Co. Ltd.,1967. P.W.Sauer, M.A. Pai, Power System Dynamics and Stability, Prentice Hall, NJ, 1998. K.R.Padiyar, Analysis of SSR in Power Systes, Kluwer Academic Publishers, 1999 A.R.Bergen and V.Vittal, Power System Analysis, Pearson Education Asia, India, 2001

K.N. Shuhanga, Power System Analysis –A Dynamic Perspective , Pearson Education , India 2018

EE703 Power System Modeling and Analysis Lab (0-0-3) 2

Solution of differential-algebraic equations. Performance study of different numerical integration techniques and eigenvalue analysis in MATLAB®/SIMULINK® . Case studies: small and large signal stability analysis of power systems. EMTP-based simulation. Exercises and assignments to support EE702.

EE750 Computer Control of Energy Systems (4-0-0) 4

Optimal control of Power Systems: Economic load dispatch. Hydrothermal Co-ordination, Algorithms for Unit Commitment, Optimal Power flow. Load frequency Control: Issues related to operation of Multi-Area systems, Automatic Generation Control and Tie- line Control. Sources of Reactive power and Reactive power control. Study of algorithms for Security assessment, AC State Estimation algorithms. Operation of Power Systems under De-Regulated Environment.

S S Rao, Optimization Theory and Applications. Wilay Esatern Ltd 1979

Allen J Wood, Bruce F Wollenberg , Power Generation Operation and Control , Second Edition , John Wiley and Sons, 1996.

A Monticelli, State Estimation in Electric Power Systems :Generalized Approach, Kluwer Academic Publishers ,1999.

Leon K Kirchmayer, Economic Operation of Power Systems. John Wiley and Sons, 1958. Leon K Kirchmayer, Economic Control of Interconnected Systems, John Wiley and Sons, 1959. Current Literature from relevant technical journals.

EE751 Control Systems (4-0-0) 4

Linear Systems, Dynamics, modeling of linear systems, state- space theory, state, state variables. Discrete systems, extension of state-space theory to discrete systems, stability theory. Review of control system analysis using state variable methods. Digital control - concepts of signal processing. Discrete time signals. Z-domain description of sampled continuous time plane. Implementation of simple digital controllers. Z- plane specifications of control

system design. Digital compensator design using root locus plots and frequency response plots. State variable analysis of digital control systems - state description, solution of state difference equations, controllability and observability.
W Brogan, Modern Control Systems, Prentice-Hall, NY 1991.
Thomas Kailath, Linear Systems, IEEE Press.
G Gopal, Digital Control and State Variables, Tata McGraw-Hill, 1997.

EE800 Fuzzy-Neural Control (4-0-0) 4
Fuzzy Sets, Fuzzy Logic, Fuzzy Rule-Based Systems, Fuzzy Control Systems, Learning Processes, Single/Multi Layer Perceptrons; Neuro-Fuzzy Modeling and Control. Unified Approximate Reasoning Approach, BNN Network Based Fuzzy Controller with Self-Learning.
Junhong Nie , Derek Linkens, Fuzzy-Neural Control: Principles, Algorithms and Applications, PHI, 2005.
Timothy J Ross, Fuzzy Logic with Engineering Applications, McGraw-Hill, 1997.
Simon Haykin, Neural Networks - A Comprehensive Foundation, Second Edition, Prentice-Hall, 1999.

EE801 EMI Testing and Design for Compatibility (4-0-0) 4
Electromagnetic emissions: systems and appliances, Circuit model, Noise characteristics, Effects of Interference. Amplifier nonlinearity, modulation. Transients in power supply lines. Electromagnetic Interference: Radiation coupling, Conduction coupling. Open area testing and measurements: Test sites, Test Antennas, Anechoic chamber, TEM Cell, Reverberating Chamber, GigaHertz TEM Cell. Grounding: Principles and practice of Earthing, System grounding for EMC. Shielding: Shielding integrity and discontinuities, cable shielding, Electrical Bonding. EMC Components: EMI suppression cables, EMC connectors, EMC Gaskets. EMC Filters: Characteristics of filters, Power Line Filter Design. EMC Standards.
H W Ott, Noise Reduction techniques in Electronic Systems, Wiley Interscience.
C R Paul, Introduction to Electromagnetic Compatibility, Wiley Interscience.
R Morrison, W H Lewis, Grounding and Shielding in Facilities, John Wiley and Sons.
V P Kodali, Engineering Electromagnetic Compatibility, S Chand and Company, New Delhi.

EE802 Energy Management (3-0-0) 3
Principles of energy management, energy utilization. Energy conversion and thermodynamic principles. Semiconductor basics. Solar cells and photovoltaic systems. Electrochemical effects and fuel cells. Thermionic and thermoelectric systems. MHD generation. Energy Auditing: purpose, methodology, case studies of few selected industries, analysis of results and inference, different standards, instruments used in energy auditing.
S L Soo, Direct Energy Conversion, Prentice-Hall.
S W Angrist, Direct Energy Conversion, Allyn and Bacon.

EE803 Microcontroller Based System Design (3-0-0) 3
Introduction to embedded systems, Microcontroller architecture, programming and interfacing: Study of 8-bit / 16-bit / 32-bit Microcontrollers / DSP Controllers. PWM, Timer, ADC interfacing, Interrupt processing, Communication interfaces, Development environments, Embedded / Real time O.S.
John Peatman, Design with Microcontrollers, McGraw-Hill, 1995.
Microcontroller / DSP controller User Manual / Reference Manual.
H Kopetz, Real-time systems, Kluwer, 1997.
Goman, Software Design Methods for Concurrent and Real Time Systems , Addison-Wesley, 1993.

EE804 Electric Power Quality (3-0-0) 3
Definition, Causes of Distortion, Quantification of Disturbance, Voltage Flickering, Frequently varying load, Measuring Devices, Voltage sensitive loads, Accepted standards of Power quality, Mathematical analysis of power Quality, effect of dynamic and static load, Minimization of disturbance, Voltage instability, Effect of OLTC, remedial measures.
G T Heydt, Electric Power Quality, Stars in a Circle Publication, 1991.
R C Dugan, Mark F McGranaghan, Surya Santoso, H W Beaty, Electrical Power Systems Quality, McGraw-Hill, Second Edition, 2002.
Math H J Bollen, Understanding Power Quality Problems , IEEE Press, 2000.
Recent publications in relevant journals and conferences

EE805 Discrete Fourier Transforms and Digital Filter Design (4-0-0) 4
Fourier transform: Discrete Time Fourier transform, Methods of obtaining DFT: Algorithms for obtaining FFT and DCT. Data Compression using DCT. Window functions: Their Properties, Application of windows in DFT computation. Digital filters: Designing techniques, IIR and FIR Filters: Different methods, Design of Digital Controllers. DSP architecture, Floating point and fixed point DSPs. Applications of Digital Signal Processing. Power Spectrum Analysis: Significance and Methods.
Roman Kuc, Introduction to Digital Signal Processing. Mcgraw-Hill, 1988 A V Oppenheim, R W Schafer, Discrete Time Signal Processing, PHI, 1994. R G Lyons, Understanding Digital Signal Processing Prentice Hall, 2004

EE806 Sensor Technology and Instrumentation Design (3-0-0) 3
Sensor types and classification, Mechanical, Electrical, Acoustic, Magnetic, Thermal and Bio-sensors. Introduction to MEMS Technology, Modeling and simulation of Micro-sensors and actuators. Interfacing with digital controllers. Design of instrumentation using MEMS sensors.
Ristic L (Ed), Sensor Technology and Devices, Artech House, London, 1994.
Tai Ran Hsu, MEMS and Microsystems - Design and Manufacturing, Tata McGraw-Hill.
Wise K D (Guest editor), Integrated Sensors, Micro-actuators, and Micro-systems (MEMS), Special Issue of Proceedings of the IEEE, Vol.86, No.8, Aug 1998.

EE807 Optimization Techniques (4-0-0) 4
Linear Programming: Simplex method and extensions. Network models: Shortest path, maximum flow and minimum cost problems. Dynamic programming: resource allocation, production scheduling and equipment replacement problem. Non-linear programming: selected unconstrained and constrained non-linear programming algorithms like quasi Newton, reduced gradient and gradient projection methods. Penalty function methods, Quadratic programming.
Lueneburger, Linear and Non linear Programming, McGraw-Hill.
Fletcher, Optimization techniques, John Wiley and Sons.

EE808 Finite Element Methods and Applications (3-0-0) 3
Introduction, magnetic circuits, review of electromagnetic theory, application of finite element method to magnetic circuit design. CAD tools - SPEED™, MAXWELL™ and applications to magnetic circuit design.
SPEED™ Lab, Design Notes on Electric Machine Design, Glasgow University.
Chary, Finite Elements and Applications to Electromagnetics, John Wiley and Sons.

EE809 DC-AC System Interaction (3-1-0) 4
Introduction to HVDC transmission systems, General aspects and comparison with AC transmission systems, HVDC configurations, components of HVDC transmission system, Converter and inverter circuit operation for HVDC system, Line Commutated and Capacitor commutated converters, HVDC control, Harmonic generation and their elimination, Converter faults and protections of HVDC systems, filter design, AC/DC load flow and stability analysis, Interaction between AC-DC systems, HVDC light system, Multi-terminal HVDC, Multipulse VSC/CSC based HVDC systems, New developments and recent trends in HVDC systems.
J Arrillaga, "High Voltage Direct current Transmission", Peter Peregrinus Ltd, UK.
E W Kimbark, "Direct Current Transmission", Wiley-Interscience, New York.
K R Padiyar, "HVDC Power Transmission Systems", Willey Eastern Limited, Second edition.
N Singh, "Electric Power Generation, Transmission and Distribution", PHI, New Delhi 2nd edition, 2008.

EE810 Power System Transients and Overvoltages (3-0-0) 3
Transients in power systems, Overvoltages, current chopping, capacitor switching, 3-phase capacitor bank switching, traveling waves, Bewley's lattice diagram, attenuation, distortion of waves, two-conductor system, multi-conductor system, Computation of transients. Transients in transformers: initial voltage distribution, winding oscillations. Protection form surges: ZnO arrestors. Insulation coordination principles and applications.
Allan Greenwood, Electrical Transients in Power Systems, Wiley Interscience.
Relevant IS Codes.

EE811 Distribution System Automation (3-0-0) 3
Introduction and Historical development of Distribution System Automation, Distribution Networks and Protection, Remote Control and Intelligent systems, Data Communications and Communication Protocols, SCADA systems,

Distribution System Automation Architectures, Practical applications and market overview.
H Lee Willis, Electrical Power Distribution Planning Reference Book , 2 Edition, Marcel Dekker Inc, 2004. Cobus Strauss, Practical Electrical Network Automation and Communication Systems, Newnes Publications, 2003.

EE812 Energy Management Lab (0-0-3) 2
Laboratory exercises and assignments to provide additional support to EE802.

EE813 Electric Power Quality Lab (0-0-3) 2
Simulation of Electric Power Quality Problems, Familiarisation with the handling of Power Quality Instruments. Measurement of Power Quality Parameters . Report Preparation. To provide additional support to EE804.

EE814 Discrete Fourier Transforms and Digital Filter Design lab (0-0-3) 2
Application of Discreet Fourier Transforms for Power System Problems : Laboratory Exercises to design systems for the control of Active Power Filters, Implementation of Protection Algorithms. Design and implementation of Digital Filters and Controllers. To provide additional support to EE805.
MATLAB Signal Processing Toolbox Users Guide, Mathworks Inc.

EE815 Power Electronics Design Lab (0-0-3) 2
Laboratory experiments on design of power electronic circuits and systems, Hardware and simulation experiments to provide additional support to EE701.
Ned Mohan, Undeland, Robbins, Power Electronics, 3 Edition, John Wiley.
M H Rashid, Power Electronics, $2^{nd}/3^{rd}$ edition, PHI (EEE) or Pearson Education .

EE816 Distribution Automation Lab (0-0-3) 2
Algorithms for Distribution Automation, Database Management for Automation. Exercises and assignments to provide additional support to EE811.

EE817 Power System Operation under Deregulation (4-0-0) 4
Fundamentals of Deregulation, Restructuring Models and Trading Arrangements, Different Models of Deregulation, Operation and control, Wheeling charges and pricing, Role of FACTS Controllers and Distributed Generation in Restructured Environment, Developments in India, IT applications in restructured markets.
K. Bhattacharya,MH J Bollen and J.E. Daalder,"Operation of Restructured Power Systems", Kluwer Academic Pub, USA, 2001.
L. Philipson and H.L. Willis, "Understanding Electric Utilities and Deregulation", Marcel Dekker Inc. 1999.
M. Shahidehpour and M. Alomoush,"Restructured Electrical Power Systems:Operation, Trading and Volatility", Marcel Dekker Inc. 2001
Steven Stoff, "Power System Economics: Designing Markets for Electricity", John Wiley & Sons, 2002.
M. Ilic, F. Galiana and L Fink, "Power System Restructuring: Engineering and Economics", Kluwer Academic Pub., 1998.
L. L. Lie, "Power System Restructuring and Deregulation", John Wiley & Sons, UK, 2002.
S. Hunt and G. Shuttleworth, "Competition and Choice in Electricity", John Wiley & Sons, 1996.
Relevant research papers published in reputed journals and Conferences in India and aboard.

EE818 Advanced Semiconductor Devices (3-0-0) 3
Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); Device selection strategy – On-state and switching losses – EMI due to switching - Power diodes - Types, forward and reverse characteristics, switching characteristics – rating. BJT's – Construction, static characteristics, switching characteristics; Negative temperature co-efficient and secondary breakdown; Power darlington - Thyristors – Physical and electrical principle underlying operating mode, Two transistor analogy – concept of latching; Gate and switching characteristics; converter grade and inverter grade and other types; series and parallel operation; comparison of BJT and Thyristor – steady state and dynamic models of BJT & Thyristor. Power MOSFETs and IGBTs – Principle of voltage controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs - Basics of GTO, MCT, FCT, RCT and IGCT. Necessity of isolation, pulse transformer, optocoupler – Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT. - Over voltage, over current and gate protections; Design of snubbers. Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for hear sink

selection – Thermal resistance and impedance -Electrical analogy of thermal components, heat sink types and design – Mounting types.
B.W Williams 'Power Electronics Circuit Devices and Applications'.
Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004.
MD Singh and K.B Khanchandani, "Power Electronics", Tata McGraw Hill, 2001.
Mohan, Undcland and Robins, "Power Electronics – Concepts, applications and Design, John Wiley and Sons, Singapore, 2000.

EE820 Analysis of Faulted Power Systems (4-0-0) 4
Unsymmetrical faults on normally balanced 3-phase systems, simultaneous faults on symmetrical 3-phase systems. Ground faults and open conductors. Unsymmetrical 3-phase circuits.
Clarke E., "Circuit Analysis of AC Power Systems", Volumes I & II, John Wiley and Sons, 1943 & 1950.
Anderson P.M., " Analysis of Faulted Power Systems", Wiley/IEEE Press, 1995.

EE850 FACTS and Custom Power Devices (3-0-0) 3
Overview of Power Transfer issues in Transmission Systems and Power Quality issues in Distribution systems. Multilevel VSI configurations, modulation and control techniques, high-power, medium-voltage applications. FACTS Devices - Series, Shunt and Unified configurations and applications. Custom Power Devices - DVR, DSTATCOM and UPQC.
Math H J Bollen, Understanding Power Quality Issues, IEEE Press, 2005 N G Hingorani , L Gyugyi, Understanding FACTS, IEEE Press, 2001 IEEE Transactions, Proceedings and other related Journals.

EE851 High-Voltage Testing and Measurements (3-0-0) 3
Specification for High Voltage tests, Dielectric stress, Voltage stress, Insulation coordination, breakdown test of insulating oil, Transformer test with alternating voltage and impulse voltage. Insulation characteristics, types of insulation, types of stress used in high voltage testing. Laboratory test procedures. Testing with power frequency voltage. Partial discharge measurements, the basic PD test circuit, PD currents, PD measuring systems within the PD test circuit.
Dieter Kind, An Introduction to High-Voltage Experimental Techniques, Wiley Eastern Limited.
E Kuffel, W S Zaengal, J Kuffel, High Voltage Engineering Fundamentals, Newnes Publishers.
Kamaraju, Naidu, High Voltage Engineering, TMH.

EE852 PV Power Systems (3-0-0) 3
Large PV power systems, village power supply systems, PV-powered agricultural facility, micro-irrigation systems, remote applications, portable applications, PV power for domestic use. Design and economic considerations, cost analysis of PV power, issues in developing countries. Thermophotovoltaic system, satellite power system, photoelectrolytic cell, multi-cell systems.
C E Backus, Solar Cells. IEEE Process, 1976
P D Maycock, E N Stirewatt, Photovoltaics: Sunlight to Electricity in One Step, Brickhouse Publishers.

EE853 Renewable Energy Systems (3-0-0) 3
Energy Scenario. Solar, thermal and photovoltaic systems. Biomass and biogas. Wind energy systems. Geothermal, tidal and wave energy resources. Micro and mini hydros. Integrated renewable energy systems. Energy storage techniques.
R H Taylor, Alternative Energy Sources, Adam Hilger Limited.
Gary L Johnson, Wind Energy Systems, Prentice-Hall.

EE854 Distributed Generation (3-0-0) 3
Various technologies for distributed generation: Wind, Photovoltaic, Fuel cell based generation, Principles of reciprocating, stirling engines, Variable speed generators, doubly-fed generators, control and protection. Deregulation Policies, Economic issues of Distributed generation.
N Jenkins, R Allen, P Crossley, D Kirschen, G Strbac, Embedded generation, IEE, 2000.

EE855 Communication Networks for Power Systems (3-0-0) 3
Historic Developments in Data communication over Power lines, Remote energy metering protocols,

Communication systems in Power stations, Modulation schemes for PLC, Communications in Power distribution grid.
Klaus Dostert, Power Line Communications, Franzis Verlag IEC 62056, International Electricity Metering Protocol.

EE856 Application of Digital Signal Processing Techniques to Power Systems (4-0-0) 4
Time frequency analysis, Time frequency distribution, Short time Fourier Transform. Multirate Signal Processing: Decimation, Interpolation, DFT filter banks, QMF filter banks. Multiresolution Signal analysis. Wavelet theory of sub-band decompositions, Sub-band coding and wavelet transforms, application of wavelet transforms. Homomorphic Signal Processing : Homomorphic system for convolution, properties of complex spectrum, Applications of homomorphic deconvolution. Multi Dimensional Signal Processing : Review of convolution and correlation. 2- D signals and systems. Linear estimation of Signals and applications : Random Signals , Linear prediction and applications (deconvolution, least square filters). Recursive estimation and Kalman filters. Adaptive signal processing: Adaptive filters and applications.
P P Vaidyanathan, Multirate Systems and Filter Banks, Prentice-Hall, 1993.
S J Orfanidis, Optimum Signal Processing, McGraw-Hill, 1989
Proakis, Manolakis, Introduction to DSP, PHI, 1994/ Pearson, 2002.
E C Ifeachor, B W Jervis, Digital Signal Processing: A Practical Approach.
Barrus, Gopinath, Guo, Introduction to Wavelet Transforms-- APrimer, Prentice hall A K Jain, Image Processing. Prentice hall
A V Oppenheim, R W Schafer, Discrete Time Signal Processing, PHI, 1994.

EE857 Design of Embedded Controllers (3-0-0) 3
Review of Digital circuits fundamentals, Combinational and sequential circuits. Review of VHDL, Modeling of digital systems, synthesis and simulation,. Design of data acquisition circuits. Selection of A/D converters, minimum system requirements for the design of DSP/16bit processor based embedded controllers, Minimum system requirements for design of FPGA based embedded controllers.
Charles Roth, Digital system design using VHDL, Indian Reprint , Thomson Book
P Lapsley, DSP Processor Fundamentals -Architecture and Features, Chand Publications.

EE858 Electric Drives (3-0-0) 3
Drives fundamentals:, DC drives: Control of AC drives: space vectors, modeling and control of induction motor drive, v/f, vector control and DTC drives, rotor side control of induction motor drive. PMAC motor drives: modeling and control. Switched reluctance motor drives.
W Leonhard, Control of Electric Drives, Springer Verlag .
R Krishnan, Electric Drives, Pearson Education, 2003.

EE859 Computational Methods for Large Power Systems (4-0-0) 4
Sparsity solution techniques: linear system solvers. Numerical Integration: multi step methods, solution of stiff systems. Methods to solve DAEs: application to power systems. Optimization techniques: OPF. Eigenvalue computations: small signal analysis and SSR analysis.
S A Soman, S A Khaparde, Shubha Pandit, Computational Methods for Large Sparse Power System Analysis, Kluwer, 2002.
J Arrillaga, C P Arnold, Computer Analysis of Power Systems, John Wiley and Sons, 1990.

EE860 Industrial Applications of HV and Fields (3-0-0) 3
Electrostatic precipitators and pollution controls using HV sources. Corona characteristics of precipitators. Charging, collection of dust particles. Xerography, Mineral separation using high voltages and fields, Electrostatic spray painting and applications. Testing of power systems components from the point of insulation, tests on insulators and material characteristics.
A D Moore (Ed.), Electrostatics and its Applications, John Wiley and Sons.
Dieter Kind, High Voltage Testing Techniques.
Technical papers of relevance.

EE861 LabVIEW™- based Data Acquisition and Instrumentation Lab (0-0-3) 2
LabVIEW™ Programming, Data Acquisition, Measurement and Automation, Instrument Interfacing, PXI system.

EE862 Computer Control of Energy Systems Lab (0-0-3) 2
Laboratory exercises and assignments to provide additional support to EE750. Exercises based on MATLAB®and packages such as PSCAD™ , PowerWorld™, and SKM®.

EE863 Power System Signal Processing Lab (0-0-3) 2
Laboratory exercises and assignments to provide additional support to EE856.

EE864 Embedded Controllers Design Lab (0-0-3) 2
Laboratory experiments on DSP based embedded controllers, FPGA-based controllers to provide additional support to EE857.

EE865 High-Voltage Testing Lab (0-0-3) 2
Laboratory exercises and assignments to provide additional support to EE860/EE 851.

EE866 Gaseous Insulation & Gas Insulated Systems (3-0-0) 3
Gaseous insulation fundamentals, Insulation design, Interface with solids. Gas insulated substations (GIS), Compared with AIS, Typical features GIS: Layout, design, testing, specific problems / faults, diagnostics, maintenance, gas circuit breakers, other components of the substation.
Naidu, . Gas insulated substations, IK International Publishing House, New Delhi. 2007
Fujimoto, N., Boggs, S.A. and Chu, FY. Gas insulated substation technology & practice. Pergamon Press, New York 1985
Maller, V.N. and Naidu, M.S., Advances in high voltage insulation and are interruption in SF6 and vacuum. Pergamon Press, Oxford 1982z.

EE867 Power System Simulation Laboratory (0-0-3) 2
Laboratory exercises and assignments related to EE 859-Computational Methods for Large Power System: Developing computer programs related to some of the techniques/methods and its application to power system analysis: Gauss elimination and its variants, Sparse matrix solution techniques, Load flow or Power flow analysis, Transient stability analysis, State estimation, Eigen value and modal analysis.

EE868 Switched Electric Networks – A Power Electronics Perspective (4-0-0) 4
Electric network topology, modeling, and time domain analysis of switched electric-circuits. Natural frequency and choice of state-variables. Periodically switched networks with multi-part excitations.
Norman Balabanian and Theodore A. Bickart. Electrical Network Theory, John Wiley and Sons, Inc. 1969 Louis Weinberg. Network Analysis and Synthesis, McGraw-Hill Book Company, Inc. 1962 Ernst A. Guillemin. Introductory Circuit Theory, John Wiley and Sons, Inc. 1953
Robert W. Erickson. Fundamentals of Power Electronics, Chapman and Hall, 1997

EE869 Tensors (4-0-0) 4
n-Way matrices, Generalisation postulates, Transformation Tensor, Singularity transformations, Examples of invariant transformations, Covariant and contravariant indices, geometrical interpretations, Compound tensors, Reduction formulae.
Gabriel Kron. Tensor Analysis of Networks, John Wiley and Sons, Inc. 1939

EE870 Tensor Analysis of Networks (4-0-0) 4
Review of Tensor Basics, Theory of groups, Reactance calculation of windings, Spinor transformations, Junction networks, Orthogonal networks, Interlinked electric and magnetic networks, the metric tensor, Compound networks, Symmetrical components, Multiple tensors, Analysis of networks.
Gabriel Kron. Tensor Analysis of Networks, John Wiley and Sons, Inc. 1939

EE871 Machine Learning (3-1-2) 5
Introduction, linear classification, perceptron update rule; Perceptron convergence, generalization; Maximum margin classification; Classification errors, regularization, logistic regression; Linear regression, estimator bias and variance, active learning; Active learning, non-linear predictions, kernals; Support vector machine (SVM) and kernels, kernel optimization; Model selection, Model selection criteria; Description length, feature selection; Combining classifiers, boosting, Boosting, margin, and complexity; Margin and generalization, mixture models, Mixtures and the

expectation maximization (EM) algorithm, regularization, clustering; Spectral clustering, Markov models, Hidden Markov models (HMMs), Bayesian networks, Learning Bayesian networks, Probabilistic inference. Simulation exercises covering the theory.

Bishop, Christopher. Neural Networks for Pattern Recognition. New York, NY: Oxford University Press, 1995. I
Duda, Richard, Peter Hart, and David Stork. Pattern Classification. 2nd ed. New York, NY: Wiley-Interscience, 2000.
MacKay, David. Information Theory, Inference, and Learning Algorithms. Cambridge, UK: Cambridge University Press, 2003.
Mitchell, Tom. Machine Learning. New York, NY: McGraw-Hill, 1997. ISBN: 9780070428072.
T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e, 2008.
Christopher Bishop. Pattern Recognition and Machine Learning. 2e.

EE872 Smart Grid Control and Operation (4-0-0) 4

Introduction to smart grid attributes and architecture, Traditional grid operation basics and principles, Smart grid technology, PMU, Advanced meter infrastructure, smart grid communication, smart grid control and monitoring, distributed generation resources, Grid integration of generation and storage systems, photovolataic and wind system integration to low voltage networks, smart grid operational issues, voltage regulation, islanding detection and re-closure methods, fault analysis, isolation, relay coordination, state estimation, Ac microgrid, Dc microgrid, modeling and analysis of hybrid grid, AC/DC grid interaction, microgrid control architecture, Demand side management, demand response, Smart grid standards and policies, smart grid case studies

James Momoh, Smart Grid: Fundamentals of Design and Analysis by, Wiley-IEEE Press, 2012,
N. Jenkins, R. Allan, P. Crossley, D. Kirschen and G. Strbac, Embedded Generation, The Institution of Electrical Engineers, 2000
A Keyhani, M Marwali, Smart Power Grids 2011 , Springer-Verlag Berlin Heidelberg,2012 Nikos Hatziargyriou, Microgrids Architecture and control by Wiley-IEEE Press,2014 Recent literatures and publications

EE873 Soft-switching Power Converters (3-0-0) 3

Introduction to soft switching power conversion. Resonant converter topologies. Variablefrequency and fixed frequency control. Zero-voltage and zero-current switching operation. Steady state and transient analysis of resonant converters. Zero-voltage and zero-current transition converters-Basic principle of operation and steady-state analysis. DC link commutated resonant converters.

M.K. Kazimierczuk and D. Czarkowski, “Resonant Power Converters”, John Wiley & Sons, Second Edition, 2010
Selected research papers from journals and conference records of IEEE.
Ned Mohan, T. M. Undeland, W. P. Robbins, Power Electronics, 3rdedition, John Wiley.
M. H. Rashid, Power Electronics, 4th edition, PHI (EEE)/Pearson Education.
K. Kit Sum (Editor), "Recent Developments in Resonant Power Conversion", Intertec Communications Press, California, 1988

EE874 Soft-switching Power Converters Laboratory (0-0-3) 2

Design and performance verification of soft-switching converters studied in course PS871 through simulations/experiments.

M.K. Kazimierczuk and D. Czarkowski, “Resonant Power Converters”, John Wiley & Sons, Second Edition, 2010
Selected research papers from journals and conference records of IEEE.
Ned Mohan, T. M. Undeland, W. P. Robbins, Power Electronics, 3rdedition, John Wiley.
M.H. Rashid, Power Electronics, 4thedition, PHI (EEE)/PearsonEducation.
K. Kit Sum (Editor), "Recent Developments in Resonant Power Conversion", Intertec Communications Press, California, 1988

DEPARTMENT OF INFORMATION TECHNOLOGY

IT700 Advanced Algorithms (3-0-2) 4

Review of algorithm analysis. Stable Matching Problem, Algorithm design techniques: recursion, branch-and-bound, divide and conquer, greedy, dynamic programming; integer linear programming; polynomial and matrix multiplications: Fast Fourier Transforms (FFT), FFT Algorithms, Amortized analysis, Advanced Data Structures to implement Disjoint Sets, Priority Queues and other Dynamic Sets. Randomized algorithms to solve fundamental problems like sorting, MST, min-cuts, geometric problems, caching, load balancing, etc. Reductions and theory of NP-complete problems, Approximation algorithms, Local Search heuristics and On-line algorithms.

Jon Kleinberg and Eva Tardos, Algorithm Design, 1st Edition, Pearson Education India, 2013.
S Dasgupta, C Papadimitriou, U Vazirani, Algorithms, McGraw-Hill Education, 2006.
T H Cormen, C E Leiserson, R L Rivest, C Stein, Introduction to Algorithms, 3rd Edition, PHI, 2010.
Steven S Skiena, The Algorithm Design Manual, 2nd Edition, Springer-Verlag, 2nd Edition, 2013.
Michael T. Goodrich and Roberto Tamassia. Algorithm Design, Wiley, 1st Edition, 2006.
Horowitz and Sahni, Fundamentals of Computer Algorithms, Galgotia Publications, 2nd Edition, 2009.

IT701 Advanced Database Systems (3-0-2) 4

Design of database kernels, Schema integration, Data warehousing, Distributed database design, Distributed query processing, Distributed transaction processing, Object-Relational databases, Emerging database technologies and applications, Application of conceptual and physical design to the real world database problems, Research Trends.

M. Tamer Özsu, Principles of Distributed Database Systems, Prentice Hall, 2011.
Ceri S and Pelagatti G, Distributed Databases: Principles and Systems, McGraw Hill, 2009.
T Connolly and C Begg, Database Systems: A Practical Approach to Design, Implementation and Management, Pearson, 2015.
R. Elmasri and S. B. Navathe, Fundamentals of Database Systems, Addison-Wesley, 3rd ed., 2011.
R. Ramakrishnan and J. Gehrke, Database Management Systems, McGraw-Hill, 3rd ed., 2014.
M. Stonebraker and J. Hellerstein, Readings in Database Systems, Morgan Kaufmann, 4th ed., 2005.
M. Stonebraker, Dorothy Moore, Object-Relational DBMSs, Morgan Kaufmann, 2nd ed., 1998.
J. Han, M. Kamber and J. Pei, Data Mining: Concepts and Techniques, 3rd ed., 2012.

IT702 Deep Learning (3-0-2) 4

Basics of Applied Math and Machine Learning: Linear Algebra for Machine Learning, Probability and Information Theory, Numerical Computation, Machine Learning Basics.

Deep Networks: Deep Feed Forward Networks, Regularization for Deep Learning, Optimization for Training Deep Models, Convolutional Neural Networks, Sequence Modeling - Recurrent and Recursive Nets. Practical Methodology, Applications of Deep Learning, Deep Generative Models,Research Trends

Josh Patterson and Adam Gibson, "Deep learning: A Practitioner's Approach", O'Reilly, 2017 Ian Goodfellow, Y. Bengio and A. Courville, "Deep Learning", MIT Press, 2016.
Michael A. Nielsen, "Neural Networks and Deep Learning", Determination Press, 2015 Li Deng and Dong Yu, "Deep Learning: Methods and Applications", 2013 Koller, D. and Friedman, N. Probabilistic Graphical Models . MIT Press. 2009

IT750 Cyberse Curity (3-0-2) 4

Basics of Network Security: Cryptography, Terminology, Mathematics (One way functions, Discrete Log problem, Integer Factorization), Background (App developers, Hosters, Listers, payloads, Attack life cycle), Authentication and Authorization, Defensive and Secure Programming, Threat Modeling and changes to SDL; Intranet Security: SPAM, Virus and Worms, Social Engineering, Network Management, Vulnerable Applications, Uneducated Users vs Spies, Firewall and DMZ, Piracy; Penetration Testing: Ethics, Moral, Legal values and repercussion, Procedures, Tools, Metasploit and Exploit db; Internet Security: Server side security (Webserver, Database server, Appserver, Compromised user accounts), Client side security (Browser security, Malicious Webserver and Victim Webserver, Malware and terms), Ecommerce (Internet Banking, E-shopping, Mobile Banking – Transactions/Reporting, Trading), Identity Theft (Password Stealing - Phishing / Keyloggers / Malware / Tab nabbing/Social Engg, Tools, Best Practices), Privacy (Introduction, Rights, Legal Issues, Online Services, Facebook, Google, Social Web and Virtual Worlds), Cloud Security, Mobile Security (Challenges and Malware); Provable Security, Secure Multi-party Computation,Recent Trends.

"Information Assurance – Dependability and Security in Networked Systems", Yi Qian David Tipper, Prashant Krishnamurthy, James Joshi, (Morgan Kaufmann Series in Networking), 2008.
"Network Security Essentials", William Stallings, 4th Edition, Pearson Education, 2008.
"Internet and Intranet Security", Rolf Oppliger, 2nd Edition, Artech House, 2007.
"Computational Intelligence in Information Assurance and Security", Nadia Nedjah et al, Springer 2007.
"Security in Distributed and Networking Systems", Yang Xiao and Yi Pan, World Scientific Publishing, 2007.
"Network Security Private Commn. in a Public World", C. Kaufman, R. Perlman, M. Speciner, Prentice Hall, 2002.
"Applied Cryptography, Code Complete, Secure Programming", Articles and papers from http://securityresearch.in.
"Fundamental Problems in Provable Security and Cryptography", Alexander W. Dent (Research Paper).
"Cryptography: An Introduction", Nigel Smart, 3rd Edition, Mcgraw-Hill, 2013.
"Secure Multiparty Computation and Secret Sharing An Information Theoretic Approach", Ronald Cramer, Ivan Damgard and Jesper Buus Nielsen, 1st Edition, Cambridge University Press, 2015.
"Cryptography and Network Security", Behrouz A Forouzan/Debdeep Mukhopadhyay, 3rd Ed., McGraw-Hill, 2015.

IT751 Distributed Computing Systems (3-0-2) 4
Basic concepts - Computer networks, Distributed systems models and architectures, Design goals, Fundamental issues and transparencies in DCS, Ordering of events, Ordering of messages and concerned protocols, Global state detection, Process synchronization, Process communications, Distributed deadlock handling, Distributed scheduling, Load balancing techniques
Mukesh Singhal and Niranjan G. Shivaratri, Advanced Concepts in Operating System, Tata McGraw Hill, 2014.
Ajay .D. Kshemkalyani, Mukesh Singhal, Distributed Computing, Cambridge University Press, 2008 A.S Tanenbaum and M.V. Steen, Distributed Systems – Principles and Paradigms, PHI, 2015.
Randy Chow, Distributed Operating Systems and Algorithms, Addison Wesley, 1997.
G.F. Coulouies et al., Distributed Systems: Concepts and Design, Addison Wesley, 5th Ed., 2012.

IT752 Web and Social Computing (3-0-2) 4
The Web as a graph: structure and coverage concepts, Web graph analysis; Link structure and link analysis algorithms; The problem of Web Search: Handling unstructured, semi-structured, structured data on the Web; Search Engines and search issues; Web as a Distributed computing platform: Service oriented Architecture and REST based web services (Resource Oriented Architecture); Micro-services; Social computing on the Web: The Social Web, Mining Social-network Graphs: graph centrality concepts, clustering, partitioning, community detection, overlapping community detection techniques; Applications of Large-scale Machine Learning to Social Media analysis, Current trends and research problems.
Christopher Manning et al., "Information Retrieval", Cambridge University Press, 2008.
Alonso, G et al., "Web Services - Concepts, Architectures and Applications", Springer, 2004.
Cioffi-Revilla, Claudio. Introduction to Computational Social Science, Springer, 2014.
Jennifer Golbeck, Analyzing the Social Web, Morgan Kaufmann, 2013.
Pascal Hitzler et al., "Foundations of Semantic Web Technologies", Chapman & Hall, 2009.

IT800 Mobile Computing (3-0-0) 3
Evolution of Wireless and Cellular Systems;Wireless Propagation: Encoding, Modulation, Multiplexing, and Error Handling Techniques; MAC Layer: Channel Allocation Techniques; Study of Mobile Communication Systems: Infrastructure, Registration and basic Call Establishment & Termination, Hand off, Roaming Support;Threat, Security & Privacy Issues; Ad-Hoc & Sensor Networks: Basic architecture/structure, terminology and Nomenclatures, Routing Protocols; IEEE802.11 & 802.15; Recent Trends: Ultra-Wideb and Technology, Sensor Networks, and Bluetooth;
Joschen Schiller,Mobile Communications, Pearson Education, 2003 Dharma Prakash Agarwal & Qing-AnZeng, Wireless & Mobile Systems,CENGAGE, 2ndEdition, 2006. William Stallings ,Wireless Communication & Networks, Prentice HallofIndia, 2ndEdition,2004.

IT801 Genetic Algorithms (3-0-2) 4
Robustness of traditional optimization and search techniques, Simple Genetic Algorithms, Similarity templates, goals of optimization, SchemaTheorem of John Holland, Computer Implementation of genetic algorithms; Applications of genetic algorithms, advanced operators and techniques in genetic algorithms; Recent research Trends. *David Goldberg,Genetic Algorithms in search ,optimizations and machine learning, Addition Wesley, 1999 Charles L Karr and L Michael Freeman, Industrial applications of Genetic Algorithms, CRC Press 1998.*

IT802 Artificial Intelligence (3-0-0) 3
Problem Solving: Solving Problems by Searching, heuristic search techniques, constraint satisfaction problems, stochasticse archmethods. Game Playing: minimax, alpha-beta pruning. Knowledge and Reasoning: Building a Knowledge Base: Propositional logic, first order logic, situation calculus.Theorem Proving in First Order Logic. Planning, partial order planning. Uncertain Knowledge and Reasoning, Probabilities, Bayesian Networks.Learning: Overview of different forms of learning,Learning DecisionTrees, Neural Networks. Introduction to Natural Language Processing, Applications and Research Trends.
Nilsson, Nils, ArtificialIntelligence:A NewSynthesis.MorganKaufmannPublishers,1998. Russell, StuartJ andNorvigPeter, ArtificialIntelligence:A ModernApproach,PrenticeHall,2003. NPTELVideos: ArtificialIntelligence

IT803 Software Architecture (3-0-0) 3
Definition and overview of software architecture, The architecture business cycle: what influences software architects, Different Architectural styles, Architecture description language, Understanding and achieving quality attributes, Attribute-driven design, Documenting software architecture, Evaluating software architecture, Architecturere use, Case studies and Recent Research Trends.
Mary Shaw, David Garlan,"Software Architecture", Prentice HallIndia,2000 Bass, Len; Paul Clements, Rick Kazman,. Software Architecture In Practice, Second Edition, Addison- Wesley,2003. Clements Pauletal, Documenting Software Architectures: Views and beyond, Addison-Wesley,2003.

IT804 Artificial Neural Networks (3-0-2) 4
Introduction to Artificial Neural Networks, Artificial Neuron Model and Linear Regression, Gradient Descent Algorithm, Nonlinear Activation Units and Learning Mechanisms, Associative Memory Model, Statistical Aspects of Learning, Single-Layer Perceptions, Least Mean Squares Algorithm, Perceptron Convergence Theorem,Bayes Classifier, Back Propagation Algorithm, Multi-Class Classification Using Multi-layered Perceptrons,Radial Basis Function Network, Principal Component Analysis, Independent Component Analysis, Self Organizing Maps, Applications and Research Trends.
Simon Haykin,“NeuralNetworks- A comprehensiv e foundations”,Pearson,2004.
Laurene Fausett:“Fundamentals of Neural Networks:Architectures, Algorithms, and Applications”,Prentice Hall.
J A.Freeman, D M. Skapure:Neural Networks Algorithms, Applications & Programming Techniques, Addison-Wesley. James A. Anderson,“An Introduction to Neural Networks”,Prentice Hal lof India.
Yegnanarayana:“Artificial Neural Networks”,Prentice Hall of India,2004.

IT805 Topics n Web SIemantics (3-0-2) 4
Semantics vs. Syntax, Structure, Formal Languages, Semantic Web Architecture, Vocabularies (Dublin Core, RSS, FOAF); Taxonomies – Descriptive Taxonomies, Navigational Taxonomies, Data Management Vocabulary, Roles of taxonomy in Content Management, Building and Maintaining taxonomies; Structured Web Documents and Resource Description Framework – metadata standards, RDF and metadata processing; Knowledge Organization Systems; Classification of organization systems; Relationship Models; Programming with RDF/XML; Web Ontology Language (OWL) - Ontology, Domain Modeling - Logic, Inferencing, Context; Programming with Ontology; Logic Reasoning for the Semantic Web - Classification and semantic metadata extraction using statistical, statistical learning/AI, lexical and natural language, knowledge based techniques; Linked Data, Role of Agents, Semantic Web and Intelligent Agents; Semantic Applications, Review of some of active projects and W3C initiatives, Contributions of IR, AI, Logic, and NLP to Semantic Web and Research Trends.
Pascal Hitzler et al, Foundations of Semantic Web Technologies, Chapman & Hall, 2009. Karin Breitman et al, Semantic Web: Concepts, Technologies and Applications, Springer, 2010. Grigoris Antoniou and Frank van Harmelen, A Semantic Web Primer, The MIT Press, 2nd Edition, 2008. John Hebeler, Matthew Fisher, Ryan Blace, Andrew Perez-Lopez, Semantic Web Programming, Wiley, 2009. Semantic Web – W3C https://www.w3.org/standards/semanticweb/

IT806 Perceptual Audio and Speech Processing (3-0-0) 3
Fundamentals of Audio and Speech Processing; Speech and Audio Analysis: Transforms–STFT, DCT, Waveletsand Gammatone Filterbanks; Audio and Speech Compression Standards:MPEG, AC-3, EAC-3 and AAC; Human Auditory Perception; Perceptual Audio Quality Metrics, Perceptual Audio Coding and Processing of Digital Speech; Speech and Audio Storage, Retrieval and Communication; Applications and Research Trends.
Jacob Benesty, M.Mohan Sondhi and Yiteng Huang, Handbook of Speech Processing, Springer-Verlag,2008.
Andreas Spanias et al.,“Audio Signal Processing and Coding”,Wiley-Interscience,2007.

Soren Bech and Nick Zacharov,"Perceptual Audio Evaluation- Theory,Method and Application",Wiley,2006.
HugoFastland Eberhard Zwicker,"Psychoacoustics:FactsandModels",Springer,3rd edition,2006.
Marina Bosiand Richard E.Goldberg,"Introduction to Digital Audio Coding Standards",Springer,2002.
BenG.and Nelson M.,"Speech and Audio Signal Processing: Perception of Speech and Music", Wiley,1999.

IT807 Enterprise Resource Planning and Systems **(3-0-0) 3**
Enterprise Resource Planning and Systems (ERP) – Introduction, ERP & Related Technologies, Customer Relationship Management (CRM), Human Resource Management (HRM), ERP Implementation Life Cycles, ERP Case Studies.
Alexis Leon-Enterprise Resource Planning.
V.K.Garg & N.K.Venkitakrishnan, ERPWare:ERP Implementation Framework.
Garg&Venkitakrishnan,ERP:ByLeon,ERP-ConceptsandPlanning.
VinodKumarG&N.K.Venkitakrishna,ERP - ConceptsandPractice,PHI,1998
SunilC&Peter-SCM-StrategyandPlanningandoperation,PearsonEducation,LPE,2002

IT808 Cyber Law and Intellectual Property Issues **(3-0-0) 3**
The Right to Access, Anonymity, Data Protection, Malicious Code, Spam, Cyber-Hooliganism, Cyber-Stalking, Identity Theft, Cyber-Terrorism, Cyber-War, Distance Contracting, Obscene Publications, Digital Signatures, Civil Liberties, Civil Liability, Civil Remedies,Criminal Liability,Criminal Penalties,Sovereignty and Jurisdiction; Controlling Digital Goods: Copyright, Protection of Online Commercial Identity (TradeMark, DomainName), Controlling Online Business Methods: Patent, ICANN Dispute Resolution Policy and WIPO, Legal Positionon Database protection in U.S, E.U and India,Protection of Multimedia works in cyber space,Copyright In fringement & Liability of Network Service provider.
AhmedKamal, TheLawofCyberSpace,United Nations Institute of Training and Research, October2005
Intellectualpropertyissuesinsoftwarepublishedby NationalAcademyPress,Washington D C1991
Hahn,Robert W.,IntellectualPropertyRightsinFrontierIndustries:SoftwareandBiotechnology,AEIPress,2005.

IT809 Data Mining **(3-0-0) 3**
Basic concepts, KDD process, OLAP, Mining frequent patterns, Classification, Clustering, Database based mining, Graph mining, Web mining and Research Trends..
J. HanandM. Kambar, DataMining: Concepts and Techniques,Morgan Kaufmann Publishers(Elsevier),2008.
OdedMaimon, LiorRokach, The Data Mining and Knowledge Discovery Handbook, Springer,2005.
G.Piatetsky–Shapiroand W.J.Frawley (Editors),Knowledge Discovery in Databases,AAAI/MITPress,1991.
Sushmita Mitra and Tinku Acharya,Data Mining,Wiley-Interscience,2004.

IT810 E-Commerce **(3- 0-0) 3**
Infrastructure and Tools for E-Commerce, Current Trends in E-Commerce applications development,The Business of Internet Commerce,Enterprise level E-Commerce, Security and encryption, Electronic payment systems,Search engines, Intelligent agents in E-Commerce, On-lineauctions, Data mining for e-commerce, Webmetrics, Recommender systems, Knowledge management, Mobilee-commerce, Legal, ethical & social issues and recenttrends.
Henry Chanetal.,E-Commerce-Fundamental and applications,John Wiley & Sons,2002
G.Winfield Treese and Lawrence C.S,Designing Systems for Internet Commerce,Pearson Education, LPE,2002
Fensel, Dieter, Brodie M.L.,Ontologies:A Silver Bullet for Knowledge Management & E-Commerce, Allied Publishers,2004.
Zimmermann, Olaf;Tomlinson, MarkR.;Peuser,Stefan, Perspectives on Web Services, Allied Publishers,2004.

IT811 Web Services **(3-0-0) 3**
Basic concepts, Enabling Infrastructure, Core functionality and standards, Service semantics, Web service composition,Servicedevelopment,applicationsandresearchtrends.
Alonso,G etal,WebServices-Concepts,ArchitecturesandApplicationsSeries:Data-CentricSystemsand Applications2004.
SanjivaWeerawaranaetal,WebServicesPlatformArchitecture:SOAP,WSDL,WS-Policy,WS-Addressing,WS-BPEL,WS-ReliableMessaging,andMore,PrenticeHall,2005.
ThomasErl,Service-OrientedArchitecture:Concepts,Technology,andDesign,PrenticeHall,2005.
J2EEWebServices,RichardMonson-Haefel,Pearson(LPE),2005.

IT812 Virtual Reality **(3-0-0) 3**

Introduction toVirtualReality Technology and its effectiveness in Real-Time Applications, Scientific Visualization, Input Devices: Trackers, Navigation and Gesture Interfaces; Output Devices: Graphics, 3D Sound and Haptic Displays; Computing Architectures for Virtual Reality, Modeling, Virtual Reality Programming, Human Factors in Virtual Reality; Virtual Humans: Overview of Virtual Humans, Face Cloning & Face Motion Capture/Analysis, Body Cloning & Body Motion Capture, Body Gesture Recognition and Action Response, Cloth Simulation and Research Trends.

Gerard Jounghyun Kim, Designing Virtual Reality Systems–The Structured Approach, Springer-Verlag,2005.
NMagnenat-
Thalmannand D Thalmann, Handbook of Virtual Humans,Wiley,2004.
L J. Hettinger, M W.Haas,Virtual & Adaptive Environment:Apps /Human Performance,Lawrence Erlbaum,2003.
GrigoreCBurdea and Phillippe Coiffet, Virtual Reality Technology, John Wiley,2003.

IT813 Computer Vision **(3-0-2) 4**

Introduction to Computer Vision, Color + Math basics, Linear Algebra, Pixels and filters, Edge detection, Features and fitting, Feature descriptors, Resizing, Semantic segmentation, Clustering, Object recognition, Dimensionality reduction, Face identification, Visual Bag of Words, Detecting objects by parts, Image classification, Motion Tracking, Introduction to Deep Learning.

Sonka M., Hlavac V., Boyle R., Image Processing Analysis and Machine Design. PWS Publishers Ballard D., Brown C., Computer Vision, Prentice Hall, 1982.
R. C. Gonzalez and R. E. Woods, Digital Image Processing, Addison Wesley, 1992.
Digital Image Processing and Computer Vision";; John Wiley and Sons, 1989.
Robert J. Schallkoff , Pattern Recognition: Statistical. Structural & Neural Approaches, John Wiley and Sons, 1992.
D. A. Forsyth and J. Ponce, Computer Vision: A Modern Approach, Pearson Education, 2003.
Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag, 2011.

IT814 Cloud Computing **(3-0-2) 4**

Introduction to Cloud Computing, Cloud Computing Delivery Models, Open Source and Industry case Studies of Cloud (ApacheVCL, Amazon, IBM and Eucalyptus) Introduction to Map/Reduce and Apache Hadoop Programming models for cloud computing, examples/applications, Virtualizations as an enabler for cloud computing infrastructure, Cloud Application Design & Development, Containers and Dockers.

GeorgeReese,CloudApplicationArchitectures,O'ReillyPublications,2009 Tim Mather,Subra Kumaraswamy, Cloud Security and Privacy,O'Reilly,2009 Tom White,The Hadoop–Definitive Guide,O'Reilly,2009.
Arshadeep Bagha and Vijay Madisetti, Cloud Computing: A Hands on Approach, Universities Press, 2014.

IT815 System Integration **(3-0-0) 3**

Enterprise Integration Drivers, Requirements and Strategies: The Business Imperative for Enterprise Integration, Business Drivers and Requirements, Enterprise Integration Strategy; Enterprise Integration Architecture: Overview, Current Integration Architecture Assessment, Technical Integration Architecture, Service Integration Architecture, Information Integration Architecture, Process Integration Architecture; Enterprise Integration Solutions: Application Integration, Information Integration, Composite Application Integration, Process-Driven Integration, Best Practices for Enterprise Integration; Currenttrends.

B.G-Bernstein, W.Ruh. Enterprise Integration: Essential Guideto Integration Solutions, Addison-Wesley, 2005.
C.Britton, P.Bye, ITArch &Middleware: Strategies for Building Large Integrated Systems, Addison-Wesley,2004

IT816 Mobile Adhoc Networks **(3-0-2) 4**

Mobile adhoc networking; imperatives, challenges and characteristics, Bluetooth networks, Routing approaches, Proactive and reactive protocols. Clustering and hierarchical routing, Multipath routing, Security aware routing, Energy efficient communication in adhoc networks, Measuring energy consumption, Power save protocols, Maximum life time routing, Secure routing protocols, Intrusion detection, Security considerations in adhoc sensor networks, Key management, Characterization of IP traffic, QOS classification, Self similar processes, Statistical analysis of non–real time traffic and real–time services and Recenttrends.

C.S.Murthy & B.S.Manoj, AdHoc Wireless Networks, Pearson, 2006.
T.Janevski, Traffic Analysis and Design of Wireless IP Networks, Artech House, 2003.
Ozan K.Tonguz & Gianluigi, Adhoc Wireless Networks,Wiley, 2006.

IT817 Wireless Sensor Networks (3-0-2) 4
Introduction to wireless communication networks and wireless sensor networks, Network architecture and design principles, MAC and Link-layer protocols, Topology controlin WSN, Routing protocols, information aggregation, information storage and query, localization, Security issues, Recenttrends: multimedia sensor networks etc.
F. *Zhaoand L. Guibas, Wireless Sensor Networks, Elsevier/Morgan- Kaufmann,2004 William Stallings, Wireless Communications and Networks, PrenticeHall,2004. P.Nicopolitidis,M.S.Obaidat, G.I.Papadimitria, A.S.Pomportsis, Wireless Networks,John Wiley & Sons,2003. K.Pahlavan, P.Krishnamoorthy, Principles of Wireless Networks,- A united approach-Pearson Education,2002.*

IT818 Intelligent Information Systems (3-0-0) 3
Emerging Technologies and applications with latest knowledge applied to customized logic systems, agent based Approaches to modeling, and human-based models, multi-mobile agent systems, the product development process, fuzzy logic systems and ambient intelligent environment such as development of information and communication technologies, multimedia data hiding and watermarking algorithms for real world audio and video applications.
XuanF.Zha, Artificial Intelligence and Integrated Intelligent InfoSystems: EmergingTech. & Apps,IGI Global, 2006 Jialie Shen, Intelligent Music Information Systems: Tools and Methodologies, Idea Group Publishers, 2007 Pan, J.-S; Huang, H.-C; Jain, L.C.;Fang,W.-C; Intelligent Multimedia Data Hiding, Springer,2007.

IT819 Blind Signal and Image Processing (3-0-0) 3
Introduction to Blind Signaland Image Processing: Principal Component analysis (PCA), Blind Source Separation (BSS) and Independent Component Analysis(ICA), BSS of Instantaneous and Convolutive Mixtures, Sequential Blind Signal Extraction, Robust BSS/ICA with noisy data; Learning Algorithms for Estimation of Sources; Applications: Audio, Speech, Image and Biomedical Signals; Research Trends.
A.*Cichocki,S.Amari, Adaptive Blind Signal and Image Processing:Learning Algorithms & Apps, John Wiley,2002.*
Hyvarinen, J. Karhunen, E.Oja, Independent Component Analysis, John Wiley, 2001
C S.Roberts, R. Everson, Independent Components Analysis: Principles & Practice, Cambridge Univ. Press,2001.
A.S. Bregman, Auditory Scene Analysis",MIT Press, 2nd Edition,1999 Handbookon Speech Processing and Speech Communication, Springer, 2007.

IT820 Information Technology for Health Care (3 -0-0) 3
Evolution of IT Enhanced Healthcare, Internet Technologies in Telemedical Systems, Wireless Systems in E-Health, Decision Support Systems in Medicine, Health Telematics Networks, Computer Aided Diagnosis and Recent Trends.
Krzysztof Zielinski, Mariusz Duplaga and David Ingram, IT Solutions For Healthcare, Springer,2006
Robert E Hoyt, Nora Bailey, Ann Yoshihashi, *Health Informatics, 5thEdition, Lulu Publishers, 2012 Kevin Beaver, Healthcare Information Systems, Auerbach Publications, 2nd Edition, 2002.*

IT821 Perceptual Image and Video Processing (3-0-0) 3
Fundamentals of Image and Video Processing; Image and Video Analysis: Image Transforms-DCT, Hadamard, Haar, K L and Wavelets; Image and Video Compression Standards: JPEG, JPEG2000, MPEG1, MPEG2, MPEG4 & MPEG7, H.264 and AVC; Image and Video Rendering and Assessment; Human Visual Perception; Perceptual Video Quality Metrics, Perceptual Coding and Processing of Digital Pictures;Image and Video Storage, Retrieval and Communication; Applications Image and Video Processing and Research Trends.
Perceptual Based Image Processing, Morgan & Claypool,2009
Al Bovik,"Hand book of Image and Video Processing",Elsevier Academic Press,2005
H.R.Wuand K.R.Rao,"Digital Video Image Quality and Perceptual Coding",C R C Press,2005
R. C.Gonzalez and R E Woods,"Digital Image Processing",Pearson Education,2002

IT822 Advanced Computer Networks (3-0-2) 4
Overview of computer networks, seven-layer architecture,TCP/IP suite of protocols etc.MAC protocols for high-Speed LANS, MANs, and wireless LANs. (For example, FDDI, DQDB, HIPPI, Gigabit Ethernet, Wireless Ethernet, etc.) Fast access technologies. (Forexample, ADSL, Cable Modem, etc.) IPv6:WhyIPv6, basic protocol, extensions and options, support for QoS, security, etc., neighbor discovery, auto-configuration, routing. Changes to other protocols. Application Programming Interface for IPv6. Mobility in networks. Mobile IP. IP Multicasting. Multicast routing protocols, address assignments, session discovery, etc. TCP extensions for high-speed networks, transaction-oriented applications.OthernewoptionsinTCP.

W.R.Stevens,TCP/IPIllustrated,Volume1:TheProtocols,AddisonWesley,1994.
G.R.Wright,TCP/IPIllustrated,Volume2:TheImplementation,Addison Wesley,1995.
W.R.Stevens, TCP/IPIllustrated,Volume3:TCPforTransactions,HTTP,NNTP,andtheUnixDomainProtocols, AddisonWesley,1996.
R.Handel,M. N.Huber,S. Schroeder,ATMNetworks:Concepts,Protocols,Applications,AddisonWesley,1998.
C.E.Perkins,B.Woolf,andS. R.Alpert.MobileIP:DesignPrinciplesandPractices,AddisonWesley,1997.

IT823 Topics in Natural Language Processing (3-0-2) 4

Introduction to Language Modeling, History and Applications, Text Processing Systems and architectures, N-grams, Lexical semantics and word-sense disambiguation, part of speech tagging, spelling correction, Text Classification – basics and process, tools, learning algorithms, Probabilistic Similarity Measures and Clustering, Sentiment Analysis, Generating and developing sentiment lexicons, learning lexicons, Information Retrieval models, Information Extraction - Maximum Entropy models, Relation Extraction, Stochastic Tagging, and Log-Linear Models, Semantics in NLP - Question Answering Models, passphrase analysis and answer generation, Summarization, Emerging trends, research issues, challenges, interesting applications in various domains.

Daniel Jurafsky and James H. Martin. "Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition". Second Edition. Prentice Hall, 2008
C.D. Manning and Hinrich Schütze, "Foundations of Statistical Natural Language Processing" MIT Press, 1999
Steven Bird. "Natural Language Processing with Python". O'Reilly, 2009
James Allen, "Natural Language Understanding". Benjamin/Cummings, 2Ed., 1995

IT824 Topics in Soft Computing (3-0-2) 4

Fuzzy logic: Classical sets and Fuzzy sets, Fuzzy sets operations, Fuzzy relations, Membership functions, Defuzzification, Fuzzy rule based systems. Fuzzy implications. Artificial neural network: Model of a neuron, Learning rules, Activation functions, Single layer perceptron networks, Multilayer feed forward networks, Back-propagation algorithm,. Solving optimization problems, Concept of Genetic algorithm -Fitness function, Genetic operators: selection, crossover, mutation. Swarm optimization techniques: Particle swarm optimization and Global swarm optimization. Hybrid of soft computing and machine learning methods: GA-Kmeans, GA based wrapper feature selection method, Fuzzy clustering, Fuzzy classifier, Integration of genetic algorithms with neural networks, Integration of genetic algorithms with fuzzy logic; Multi objective evolutionary algorithm approaches

Vojislav Kecman, Learning and Soft Computing , Pearson Education (Asia) PTE, 2004 Ross T.J., Fuzzy logic with engineering applications-McGraw Hill, 1995
J. M. Zurada, Introduction to artificial neural networks, Jaico publishing, 1997.
Goldberg D., Genetic algorithms- Addison-Wesley, 1st edition,1989.
S. N. Sivanandam, S. N. Deepa, Principles of Soft Computing 2nd edition, Wiley, 2011.
Shishir K. Shandilya et al., Handbook of Research on Soft Computing and Nature-Inspired Algorithms, IGI Global, 2017.
Evolutionary Algorithms for Solving Multi-Objective, Optimization Problems, 2nd Edition, Collelo, Lament, Veldhnizer, Springer
J. Han and M. Kambar, Data Mining: Concepts and Techniques, Morgan Kaufmann, 2008.

IT825 Designing Internet of Things (3-0-2) 4

Introduction to Internet of Things: Technology drivers, Business drivers, Applications of IoT. Sensors and sensor nodes: sensing devices, sensors modules, nodes and systems. Connectivity and networks: Wireless Technologies for IoT, Edge connectivity and protocols, Wireless Sensor Networks.Communication technology for IoT, Design Principles for Connected Devices, Internet principles, Prototyping embedded devices, Prototyping the physical design, Prototyping Online Components, Business models. Design of Semantic IoT, Cloud analytics and applications.

Olivier Hersent, David Boswarthick, Omar Elloumi, The Internet of Things: Key applications And protocols,Wiley publications2015
Adrian McEwen And Hakim Cassimally, Designing Internet of Things, John Wiley and Sons2014
Karin Breitman, Marco Antonio Casanovaand Walter Truszkowski, Semantic Web: Concepts, Technologies, and Applications, Springer2007
Charles Bell, Beginning Sensor Networks with Arduino and Raspberry Pi, Apress, 2013
Zhong,N.,Ma,J.,Liu, J., Huang,R., Tao,X.Wisdom Web of Things, Web Information Systems Engineering and Internet Technologies Book Series, 2016 Rajkumar Buyya Amir Vahid Dastjerdi, Internet of Things- Principles and

Paradigms, Morgan Kaufmann, 2016 Kai Hwang, Jack Dongarra, Geoffrey C Fox,Distributed and Cloud Computing: From Parallel Processing to the Internet of Thing, Morgan Kaufmann, 2012

IT826 Cyber Physical Systems (3-0-0) 3

Cyber physical system(CPS) Introduction, Industry standards, applications of CPS, CPS components : hardware platform, CPS networks, Software stack, scheduling real time control stacks. Principles of Automated Control Design: dynamical systems and stability, controller design techniques, stability analysis, performance under packet drop and noise. CPS implementation, Safety assurance of Cyber-Physical systems, Secure deployment of CPS, Mobile Cyber physical systems.

Andr´e Platzer. Logical Foundations of Cyber-Physical Systems. Springer, 2018
Raj Rajkumar, Dionisio de Niz, Mark Klein, Cyber- Physical Systems, Pearson Education, 2017 Rajeev Alur, Principles of Cyber-Physical Systems, MIT Press, 2015.

IT827 High Performance Computing (3-0-2) 4

High performance computing architectures, Fundamentals of Superscalar processors, Vector processors and Accelerators architecture – GPGPU, Xeon-Phis and FPGAs. Programming for HPC clusters – OpenMP and MPI programming. Programming for accelerators – OpenCL/CUDA/Xeon-PHIs. Domains for HPC (Microbiology, Engineering, Physics, Chemistry). HPC Benchmarks – LINPACK/HPL. Recent, relevant high-performance computing advances from literature from Supercomputing and other sources. Programming projects in the area of open source HPC applications. Introduction to Deep Learning frameworks like Caffe, Tensorflow. Implementation of HPC techniques in DNN frameworks incl. TPUs.

Dennis Abts, John Kim, High Performance Datacenter Networks - Architectures, Algorithms, and Opportunities.
Mark Hill/Margaret Martonosi (Eds.). Synthesis Lectures on Computer Architecture,Morgan and Claypool, 2011.
David B. Kirk, Wen -mei W. Hwu, Programming Massively Parallel Processors: A Hands-on Approach (Applications of GPU Computing Series) Elsevier-2014
David j. Kuck, "High Performance Computing", Oxford Univ Press, 1996 Gary W. Sabot, "High Performance Computing", Addison-Wesley, 1995
John L Hennessy, David A Patterson, Computer Architecture - A Quantitative Approach, 5th Edition, Morgan Kaufmann, 2011.

IT828 Modern Cryptography (3-0-2) 4

Symmetric Key Cryptography: The notion of a symmetric key cryptography, Data Encryption Standard (DES), Double DES, Triple DES and cryptanalysis. Advanced Encryption Standard (AES). Public Key Cryptosystems: Fundamentals of Public-key Cryptography, RSA public key cryptosystem, ElGamal public key cryptosystem and Elliptic Curve Cryptosystems. Integer Factorization Problem: Trial division, Pollard' s rho factoring algorithm, Pollard's p-1 factoring algorithm, Elliptic Curve Factoring, Random Square Factoring methods, Quadratic sieve Factoring, Number Field Sieve Factoring. Digital Signatures: RSA based signature scheme, ElGamal based signature scheme, Schnorr signature scheme, Digital Signature Algorithm (DSA). Key Distribution and Key Agreement Protocols: Key Pre-distribution, Diffie-Hellman key Exchange. Authentication: simple authentication protocol and possible attacks, Strong password protocols, Key Distribution Centers based authentication protocols.

"Cryptography and Network Security: Principles and Practices", 4th Edition, W. Stallings, Prentice Hall, 2005.
"Cryptography and Network Security", 6th Edition, William Stallings, pearson, 2013.
"Applied Cryptography", 2nd Edition, Bruce Schneier, Wiley, 1996.
"Handbook of Applied Cryptography", A. Menezes, P. Van Oorschot, S. Vanstone, CRC Press, 5th Printing, 2001.
"Understanding Cryptography A Textbook for Students and Practitioners", Christ of Paar, Jan Pelzl, Springer.
"Cryptography, Theory and Practice", 3rd Edition, Douglas R. Stinson, CRC Press, 2006.
"Network Security Private Communication in a Public World", C. Kaufman et al., Prentice Hall, 2002.
"Cryptography & Network Security", Behrouz A Forouzan & Debdeep Mukhopadhyay, 3rd Ed., McGraw-Hill, 2015.

IT829 Advanced Computer Architecture (3-0-0) 3

Flynn's Classification, RISC Vs CISC, Data and control flow, Pipelining: Linear and non linear, pipeline hazards, instruction scheduling, Branch handling techniques, Dynamic Branch prediction, Arithmetic pipeline, VLIW architecture, Superscalar processors: Architecture, shelving, score boarding, Multiple issue and speculation, Limits of Instruction level parallelism. Software pipelining and global scheduling. Hardware assisted software ILP and IA64/Itanium case study. Instruction level Data-Parallel architectures: SIMD architectures, Systolic and Vector architecture; MIMD architectures, Systems interconnect architecture: Network properties/routing, Static/dynamic

interconnection networks. Multiprocessor architectures, models of memory consistency, cache coherence/directory protocols. Multicore architecture. Performance evaluation. Design of simple computer architecture.
J. Hennesy and D. Patterson, Computer Architecture –A Quantitative Approach, 6th Ed., Morgan Kaufmann, 2017
Yan Solihin, Fundamentals of Parallel Multicore Architecture, Chapman and Hall/CRC Press, 2015
Dezso Sima, Peter Karsuk, Advanced Computer Architectures: A Design Space Approach, Addison- Wesley, 2002

IT830 Multimedia Information Retrieval (3-0-2) 4
Introduction to multimedia information retrieval, Characteristics of MM data; similarity-based retrieval model-retrieval framework; Benchmarking of multimedia information systems; Color- based Retrieval: color models; histogram model; indexing and retrieval; relevance feedback; histogram refinement; color cluster technique; Texture-based Retrieval: texture models; statistical models; combined color-texture representation; Shape-based Retrieval: shape matching; contour-based method (Fourier descriptors); region-based method (moment invariants); Audio Retrieval: characteristics of audio data; spectrum analysis; pitch tracking; techniques for audio feature extraction, similarity matching and retrieval; Video Retrieval: key-frame extraction; video retrieval techniques; Multimedia applications; Research Problems.
R. Jain, R. Kasturi, B.G. Schunck (1995), Machine Vision, McGraw-Hill.
B. Furht, S.W. Smoliar, H.J. Zhang (1995), Video and Image Processing in Multimedia Systems, Kluwer, Boston.
Roberto Raieli, "Multimedia Information Retrieval- Theory and Techniques", Elsevier, 1st Edition, 2013 Mark T Maybury, "Intelligent Multimedia Information Retrieval", AAAI Press, *MIT Press*
C. D. Manning, P. Raghavan and H. Schütze, Introduction to Information Retrieval, Cambridge Univ. Press, 2008.
Baeza-Yates & Ribeiro-Neto, Modern Information Retrieval, Pearson Education, 2010

IT831 Game Theory (3-0-0) 3
Introduction to Game Theory, Strategic Games and Nash Equilibrium, Illustrations of Nash Equilibrium, Mixed Strategy Nash Equilibrium, Extensive Games and Nash Equilibrium, Illustrations of Extensive Games and Nash Equilibrium, Evolutionary and Correlated Equilibrium - Evolutionary Game Theory.
Osborne, M.J, An Introduction to Game Theory, Oxford University Press, International Edition, 2009.
Mas-Colell, A., M.D. Whinston and J.R. Green Microeconomic Theory, Oxford University Press, 2012.
Roger B. Myerson, Game Theory: Analysis of Conflict, 1st Paperback Edition, Harvard University Press, 1997.
Gibbons, R, A Primer in Game Theory, Pearson Education, 1992.

IT832 Blockchain Technologies and Applications – Decentralization and Smart Contracts (3-0-0) 3
Theories of Cryptocurrency, Block chain and Distribution Systems. Understanding the emerging abstract models doe Block chain and Bitcoin Security, Application of block Chain, Byzantine fault tolerance, Security of Blockchain and decentralized schemes, attacks on Block Chain systems, Light weight protocols and algorithms based on block chain, block Chain Based IoT solutions, Block chain in crowdsourcing and crowdsensing, Block chain in Cyber Physical Systems, Block chain in Social Networking, block chain in 5G, Block Chain in edge and Cloud Computing, Block chain and Trust managements, Business Model destruction/creation caused by Block chain, Business value of blockchain.
Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder. Bitcoin and cryptocurrency technologies: a comprehensive introduction. Priceton University Press 2016.
Dac-Nhuong Le, Gulshan. Cryptocurrencies and Block Cahin and Applications, Decentralization and Smart Contracts, Wiley Publications.
Joseph Bonneau et al, SoK: Research perspectives and challenges for Bitcoin and cryptocurrency, IEEE Symposium on security and Privacy, 2015 (article available for free download) {curtain raiser kind of generic article, written by seasoned experts and pioneers}.
J.A. Garay et al, The bitcoin backbone protocol – analysis and applications EUROCRYT 2015 LNCS VOL 9057, (VOLII), pp 281-310. Serious beginning of discussions related to formal models for bitcoin protocols.
R. Pass et al, Analysis of Blockchain protocol in Asynchronous networks, EUROCRYPT 2017, A significant progress and consolidation of several principles.
R. Pass et al, Fruitchain, a fair blockchain, PODC 2017.

IT833 Advanced Time Series Analysis (3-0-2) 4
Stationary processes, ensemble, random walk Vs trend, periodicity, linear process; Estimators mean, ACF, PACF, variogram; Properties covariance, normality; Regression, models for trend, differencing, backshift operator; Harmonic regression, periodogram, signal processing; Nonparametric regression, smoothing, periodic functions;

Model selection, AIC, BIC, SIC, bias-variance trade-off; ARMA models; Estimation, MLE, LS, forward-backward; State-space models, Kalman filter, hidden state, HMM, Switching models, hidden Markov models (HMM), GARCH, stochastic volatility, financial models; Heteroscedasticity, Wavelets, Vector Autoregressive (VAR) Models, Integrated Variables and Cointegrated VAR Models, Time-varying parameter and Bayesian VARs, Multivariate GARCH models.

Shumway, R.H and Stoffer, D.S., Time Series Analysis and its Applications: With r Examples, Springer.
Pole A., West M. and Harrison P.J., Applied Bayesian Forecasting and Time Series Analysis. Chapman-Hall.
Tsay, R.S. Analysis of Financial Time Series, John Wiley and Sons.
West, M. and Harrison, P.J. (1997), Bayesian Forecasting and Dynamic Models, Springer-Verlag.

IT834 Performance Evaluation of Computer Systems and Software (3-0-2) 4

Operational Laws: Little's Law, response-time law, asymptotic bounds, modification analysis, performance metrics; Markov Chain Theory: discrete-time Markov chains, continuous-time Markov chains, renewal theory, time-reversibility; Poisson Process: memorylessness, Bernoulli splitting, uniformity, PASTA;
Queueing Theroy: open networks, closed networks , time-reversibility, RenewalReward, M/M/l, M/M/k, M/M/k/k, burke's theorem, Jackson networks, classed networks, load-dependent servers, BCMP result and proof, M/G/l full analysis, M/G/k, G/G/l, transform analysis (Laplace and z-transforms);
Simulation: time averages versus ensemble averages, generating random variables for simulation, Inspection Paradox;
Modeling empirical Workloads: heavy-tailed property, Pareto distributions, heavy-tailed distributions, understanding variability and tail behavior, Matrix analytic methods;
Management of Server Farms: capacity provisioning, dynamic power management, routing policies;
Analysis of Scheduling: FCFS, non-preemtive priorities, preemtive priorities, PS, LCFS, FB, SJF, PSJF, SRPT, etc.

Mor Harchol-Balter, Performance Modeling and Design of Computer Systems: Queueing Theory in Action, Cambridge University Press.
A.Papoulis and S.U. Pillai, Probability, Random Variables, and Stochastic Processes, McGraw-hill.
A.Leon-Garcia, Probability and Random Processes for Electrical Enginering, Prentice Hall.
Michael Pinedo, Scheduling Theory, Algorithms and Systems, Prentice Hall.

IT890 Professional Practice / Seminar 2

This is a 2 credit mandatory learning course to be completed during the 2nd semester. Each student will make technical presentation with suitable demonstration and Professional (Industry) Practices on a topic of academic interest as per recommendations and evaluation criteria of the DPGC of IT department.

IT891/IT897 Practical Training / Minor Project 2

Each Student has to undergo a practical training programme or any equivalent minor project fixed by the DPGC of IT department. This practical training/minor project will be done during the summer vacation (10-12 weeks) before the evaluation semester. Final evaluation is based on the report/seminar by the student.

IT898 Major Project-I 4

The students individually will select a project work based on a topic of interest under the supervision of project guide. This project work will be commencing in the 3rd semester and will be continued in 4th semester. At the end of each semester, the project will be evaluated internally and externally as per the evaluation criteria decided by the DPGC of IT department.

IT899 Major Project-II 6

The students individually will select a project work based on a topic of interest under the supervision of project guide. This project work will be commencing in the 3rd semester and will be continued in 4th semester. At the end of each semester, the project will be evaluated internally and externally as per the evaluation criteria decided by the DPGC of IT department.

DEPARTMENT OF CHEMICAL ENGINEERING

CH701 Molecular and Turbulent Transport **(3-1-0) 4**

Phenomenological description of the continuum approach, Introduction to general transport equations for momentum, energy and mass transfer in Cartesian, cylindrical and spherical coordinates. Reynolds transport theorem. Equations of change for isothermal systems, Velocity distributions with more than one independent variable, Velocity distributions in turbulent flow, Interphase transport in isothermal systems, Macroscopic balances for isothermal systems.Temperature distributions in solids and in laminar flow, Equations of change for non-isothermal systems, Temperature distributions with more than one independent variable, Temperature distributions in turbulent flow, Interphase transport in non isothermal systems. Macroscopic balances for non-isothermal systems, Concentration distributions in solids and in laminar flow, Concentration distributions with more than one independent variable, Concentration distributions in turbulent flow. Interphase transport in multi-component systems, Macroscopic balances for multicomponent systems.

1. R.S.Brodkey and H.C.Hershey, Transport Phenomena - A unified approach, McGraw Hill, 1988.
2. R.B.Bird, W.E.Stuart and E.W.Lightfoot, Transport Phenomena - John Wiley, 1960.

CH702 Process system analysis and Control **(3-1-0) 4**

Review of Stability analysis and controller design for linear time invariant systems. Advanced control techniques, cascade ratio, feed forward, adaptive control, Smith predictor, selective control, inferential control, internal model control, model based control systems. Analysis of distributed parameter system dynamics. Multivariable process control. Sampled - data systems. Nonlinear control, Application of Artificial intelligence in control, introduction to digital process control.

1. *D.R. Coughanowr, Process Systems Analysis and Control, , McGraw Hill, 1995,*
2. *D.E. Seborg, T.F. Edgar and D.A. Mellichamp, Process Dynamics and Control, Jonh Wiley, 1989.*
3. *W.L.Luyben, Process modelling, simulation and control for chemical engineering, 2nd Edn, McGraw Hill.*

CH704 Instrumentation Analysis Lab **(0-0-3) 2**

Separation and quantification of components in liquid sample by HPLC; Quantification of components in a volatile mixture by GC; Deduction and identification of molecules based on m/z ratio by LC-MS; Elemental composition analysis by ICP/OES; Thermo gravimetric analysis technique - change in physical and chemical properties of material as a function of temperature; Quantitative analysis of chemical elements using absorption of optical radiation by AAS; particle size and zeta potential analysis of colloidal solutions; Quantitative determination of different analytes by UV-Visible spectroscopy; Determination of total organic carbon of given sample by,
TOC analyser; purification of analyte based on affinity by Ion-exchange chromatography; Linear shrinkage and shrinkage rate behaviour of a pellet by Dilatometer studies.

1. *D.A.Skoog, F.J.Holler and S.R.Crouch,Instrumental Analysis, Brooks/ Cole, 2001*
2. *Wilson and Walker, Principles and techniques of biochemistry and molecular biology. Seventh edition, 1986*
3. *Nakra B.C and Chaudhry K Instrumentation, Measurement and Analysis, Tata McGrow Hill Co., New Delhi. 1985*
4. *LiptakB.G ,Encyclopadia of Instrumentation,.,Vol.l, and supplement Chelton Book Co., New York, 1969.*
5. *R.K.Jain, Mechanical and Industrial Measurements, Khanna Publishers. New Delhi. 1982.*

CH705 Process Modelling and Simulation **(3-0-2) 4**

Introduction to process modelling - a systematic approach to model building, classification of models, Conservation principles of formulation of mathematical models, thermodynamic principles of process systems. Development of steady state and dynamic lumped and distributed parameter models based on first principles. Solution strategies for lumped parameter models. Solution methods for initial value and boundary value problems, Solution strategies for distributed parameter models, Simulation of chemical processes.

1. *W.L. Luyben, Process Modeling, Simulation and Control for Chemical Engineers, 2nd Edn., McGraw Hill Book Co., New York, 1990.*
2. *K. M. Hangos and I. T. Cameron, Process Modeling and Model Analysis, Academic Press, 2001.*

CH706 Statistical and Irreversible Thermodynamics **(3-1-0) 4**

Fundamental concepts of classical and statistical thermodynamics, thermodynamic properties of multicomponent multiphase systems from equation of state, Intermolecular forces and potential energy functions, molecular theory of corresponding states, fugacities in liquid mixtures, theories of solution, solubilities of gases in liquids, solubilities of solids in liquids, high pressure equilibria, generation of multicomponent phase equilibria data by computer calculations. Introduction to irreversible thermodynamics: evaluation of thermodynamic properties by classical and empirical methods.

1. *J. Richard Elliott; Carl T. Lira, "Introductory Chemical Engineering Thermodynamics, 2nd Edition", 2nd edition, Prentice Hall, 2012*
2. *O. A. Hougen, K.M. Watson & R. A. Ragatz, Chemical process principles, Part II, Wiley, 1960*
3. *S. M. Walas, "Phase Equilibria in Chemical Engineering", Butterworths, 1985.*
4. *J. M. Prausnitz, T. F. Andersons, E.A Grens, C. A. Eckert, R. Hsieh and J. P. OÇonnell, Computer calculations for vapour liquid equilibria, Prentice Hall, 1980*

CH707 Chemical Reactor Design **(3-1-0) 4**

Review of non-ideal reactor analysis. Non Isothermal reactor Design. Design of gas-liquid and liquid-liquid reactors. Design of plug flow type reactors-reactors for carrying out isothermal, adiabatic and non-isothermal operations involving homogeneous, heterogeneous, catalytic. Analysis of Non-catalytic fluid solid reaction: Kinetics of non-catalytic fluid-particle reactions, various models, application to design. Introduction to multiphase reactors design concept for slurry reactors, trickle bed reactors, fluidized bed reactors. Physical adsorption and chemical adsorption: Fluid-fluid reactions different regimes, identification reaction regime, application to design.

1. *Foggler,H.S., Elements of Chemical Reaction Engineering, Prentice Hall of India, 2008.*
2. *Levenspiel O., Chemical Reaction Engineering, Wiley, 1998.*
3. *Froment G.F. and Bischoff K.B., Chemical Reactor Analysis and Design, John Wiley, 2010*

CH801 Chemical Process Optimization **(3-0-0) 3**

Nature and organization of optimization problems, formulation of single and multi-objectiveproblems. Optimization theory and methods. Non -traditional optimization methods. Applications of Optimization in chemical process.

1. *T.F.Edger and D.M.Himmelblau, Optimization of Chemical Processes, McGraw Hill, 1989.*
2. *S.S. Rao, Engineering Optimization: Theory and Practice, John Wiley & Sons, 1996*
3. *Kalyanmoy Deb, Optimization of Engineering Design, Prentice Hall of India, 1995.*

CH802 Process Equipment Design **(3-1-0) 4**

Process design of Shell and Tube exchangers, condensers and reboilers, evaporators, Single and Multi -component absorption and distillation, Liquid-Liquid extraction, Leaching and adsorption.

1. *D.Q.Kern, Process Heat Transfer, McGraw Hill, 1950*
2. *R.E.Treybal, Mass Transfer Operations, McGraw Hill, 1981.*
3. *Coulson and Richardson, Chemical Engineering, Volume 6, Butterworth Heinemann, 1996.*

CH803 Biochemical Engineering and Bioreactor Design **(3-0-0) 3**

Microbiology: Characterization, Classification and enumeration of microorganisms, environmental and industrial microbiology, ecology, microbiology of soil and air, Laboratory techniques in microbial operations. Control of microorganisms by physical and chemical methods, biochemistry. Microbial metabolism. Mechanism and kinetics
Of enzyme catalyzed reactions. Enzyme technology. Bioreactor design.

1. *J.E.Bailey and D.F. Ollis, Biochemical Engineering Fundamentals, McGraw Hill, 1977.*
2. *S. Aiba, Biochemical Engineering, Acadmic Press, 1965.*

CH804 Advanced Separation Processes **(3-0-0) 3**

Fundamentals of Separation Processes, Ion Exchange, design of microfiltration, ultra-filtration, reverse osmosis, nano filtration, dialysis and electrodialysis, Fundamentals of various colloid separation, Cloud Point Extractor, Micellar enhanced separation processes, Supercritical fluid extraction, Other non-conventional extraction processes.

1. *Handbook of Separation Process Technology , R W Rousseau, John Wiley & Sons((1987).*
2. *Supercritical Fluid Extraction , M AMchugh and V J Krukonis , Butterworth Heinmann(1987).*
3. *Large Scale Adsorption and Chromatography , W C Wankat , CRC Press Inc , (1986).*
4. *Advanced Membrane Technology and Applications, Norman N Li, Anthony G. Fane , W. S. Winston Ho , Takeshi Matsuura , Wiley(2008).*

CH805 Computational Methods in Chemical Engineering **(3-0-0) 3**

Introduction to computational methods - matrix algebra. Finite difference methods. Partial differential equations-classification, solution of elliptic, hyperbolic and parabolic partial differential equations by finite difference equations, stability of different schemes. Variational methods.

1. *D. Potter, Computational Physics, John Wiley, 1973.*
2. *C.A. Brebbia& A.J. Ferranta, Computational Methods for Solution of Engineering Problems, Pented Press., 1978.*

CH806 Risk & Safety Management in Process Industries (3-0-0) 3

Hazard identification methodologies, PHA, HAZOP, MCA, ETA, FTA, Consequence analysis, Probit Analysis. Hazards in work places. Workers' exposures to hazardous chemicals. Guidelines for safeguarding personnel. Safety managements, legal aspects of industrial safety, safety audits, on site and off site emergency, inherently safer design, Transportation of hazardous materials, fire-explosion and toxic releases.

1. *F.P.Lees, Loss prevention in process industries, 2/e, Butterworth-Heinemann,. 1996*
2. *W.Handley, Industrial Safety hand book, 2/e, McGraw-Hill, 1977*

CH807 Process Energy Integration (3-0-0) 3

Introduction and role of Thermodynamics. Heat exchanger Networks. Heat and Power Integration. Economic Evaluation. Applications and Problems.

1. *B.Linnhoff, A User Guide on Process Integration for Efficient Use of Energy, UMIST.*
2. *Robin Smith, Chemical Process Design, McGraw Hill.*

CH808 Cavitation and its Applications in Chemical Engineering (2-1-0) 3

Cavitation physics; hydrodynamic and acoustic cavitation; cavitation bubble dynamics–
Rayleigh–Plesset equation; Cavitation assisted physicochemical and biological transformations – mixing, leaching and extraction, dyeing, wastewater treatment, atomization, crystallization, coal washing, enzyme harvesting by cell disruption; Cavitation in nanotechnology – Production of nanomaterials; precision cleaning of surfaces.

1. *Brennen Christopher, Cavitation and Bubble Dynamics, Oxford University Press, New York, 1996. ISBN:0195094093*
2. *T.J. Mason, J.P. Lorimer, Applied Sonochemistry: Uses of Power Ultrasound in Chemistry and Processing, Wiley - VCH Verlag, 2002.ISBN: 3-527-30205-0*
3. *HaoFeng, Gustavo Barbosa - Cánovas, Jochen Weiss (Editors) Ultrasound Technologies for Food and Bioprocessing, Springer, 2011. ISBN -13:978 -1441974716*

CH809 Multiphase Flow (3-0-0) 3

Homogeneous flow; Separated flow; Drift-flux model. Practical applications: Bubbly flow, Suspensions of particles in fluids, Slug flow, Annular flow, Drop flow, Bubble formation and bubble dynamics, hydrodynamics of solid –liquid and gas-solid flow, hydrodynamics of three phase flows, measurement techniques in multiphase flow

1. *G. B. Wallis, "One-dimensional two-phase flow" , McGraw-Hill Book Company (1969).*
2. *R. Clift, J. R. Grace, M. E.Weber, "Bubbles, Drops and Particles", Dover Publications, US(2005).*
3. *G.F. Hewitt," Measurement of two phase flow parameters", Academic Press Inc (1978)*
4. *D.Butterworth and G.F Hewitt ,"Two phase flow and Heat transfer", Oxford University Press (1977)*
5. *G.Hetsroni , "Handbook of multiphase flow systems", Hemisphere Pub. Corp ,McGraw-Hill(1982), New York.*

CH810 Mathematical Methods in Chemical Engineering (3-0-0) 3

Vector and Vector spaces; Matrices, operators and transformations; Applications to Chemical Engineering Systems (homogeneous and non-homogeneous); Partial Differential equations; Strum -Louiville Theory; Separation of variables and Fourier Transforms; Greens Functions; uniqueness conditions for linear and non-linear systems, Applications to models in Chemical Engineering.

1. *S.Pushpavanam, "Mathematical Methods in Chemical Engineering", Prentice Hall of India Pvt Ltd(2004).*
2. *E.Kreszig, "Advanced Engineering Mathematics", Wiley, New York (2011).*

CH811 Computational Fluid Dynamics (3-1-0) 4

Governing equation of fluid dynamics , nature of PDE and boundary conditions, Turbulence and its modelling, Finite Volume discretization method for steady and transient flow problems, Numerical solution of the incompressible flows using Explicit, Implicit time marching schemes, Implicit Pressure correction algorithms, Fundamentals of grid generation.

1. *J. H. Ferziger and M. Peric , "Computational Methods for Fluid Dynamics", Springer, Germany (2002).*
2. *H. Tennekes and J.L Lumley, "A first course in turbulence". The MIT Press (1972).*
3. *David C. Wilcox ," Turbulence Modeling for CFD", DCW Industries, Inc.(2006).*

4. *Versteeg, H. K. and Malalasekara, W. (2008). Introduction to Computational Fluid Dynamics: The Finite Volume Method. 2nd Edition, Pearson Education.*
5. *Jr., John D. Anderson (2017). Computational Fluid Dynamics the Basics with applications, McGraw Hill Education*

CH812 Mechanical Design of Process Vessels (3-0-0) 3
General considerations in design of process vessels. Design of thin walled vessels under internal pressure. Compensation for openings and branches. Design of vessels subjected to external pressure. Design of vessels subjected to combined loadings. Design of vessels supports. Design of flanged joints and welded joints. Fatigue assessment of vessels and pressure tests.
1. *Coulson and Richardson, Chemical Engineering, Volume 6, Butterworth Heinemann, 1996.*
2. *Brownwell and Young, Process equipment design-Vessel design, Wiley Eastern Limited., 1951.*

CH813 Integrated Process Design Flow Sheeting & Synthesis (3-0-0) 3
Flow sheet synthesis.- Structural optimization of process flow sheets. Process synthesis concepts. Design and scheduling of batch processes - single product batch plants, multiple product batch plants, sizing of vessels in batch plants, inventories, synthesis of flowshop plants, optimal design and scheduling of multi product batch plants.
1. *L.T.Biegler. I.E.Grossmann and Westerberg, Systematic methods of chemical process design, Prentice Hall Inc., 1997.*
2. *Robin Smith, Chemical process design, McGraw Hill Inc. 1995*

CH814 Polymerisation Reaction Engineering (3-0-0) 3
Classification of polymerization reactions. molecular weight distribution in batch and continuous reactors, average molecular weight and experimental determinations based on viscosity, osmotic pressure etc., semi-batch reactor operation, design of batch and continuous reactors. Heterogeneous poly -addition reactors. Polycondensationreactions.
1. *Mechanism of Reactions, G.M.Burnett, 1954, Interscience.*
2. *Emulsion Polymerization, F.M.Bovey, A.J.Medalia, E.J.Meachan and I.M.Kolthoff, 1955, Interscience.*

CH815 Molecular Simulations (3-0-0) 3
Introduction on electronic, atomic, molecular and mesoscale modelling of soft materials, interaction potentials; statistical ensembles, thermodynamic averages, fluctuations, structural quantities, time correlation functions and transport coefficients. Molecular dynamics (MD): Hamilton's equations of motion (EOM), numerical techniques to solve EOM. Application of thermostats and barostats to simulate MD under constraints. Monte Carlo schemes to predict equilibrium properties. Applications of molecular simulation tools: determination of transport properties in polymers/polymer nanocomposites, studies on adsorption of simple and macromolecules, studies on Self-assembly of patchy particles and surfactants, studies on free energy calculations and phase-equilibria.
Computer Simulation of Liquids, M. P. Allen., D. J. Tildesley, Oxford University Press, 1989.
Understanding Molecular Simulation, D. Frankel, B. Smit, Academic Press, 2001.
Thermodynamics and Statistical Mechanics An Integrated Approach, M.Scott Shell, Cambridge University Press, 2015
Molecular Modeling: Principles and Applications, 2nd Ed., A. Leach, Prentice Hall, 2001.
The Art of Molecular Dynamic Simulation, 2nd Ed., D. C. Rapaport, Cambridge University Press, 2004.
Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987.
Introduction to Computational Chemistry, 2nd Ed., F. Jensen, Wiley, 2007.
Molecular Modeling Basics, J. H. Jensen, CRC Press, 2010.

CH730 Industrial & Domestic Wastewater Treatment (3-1-0) 4
Introduction- Wastewater sources and Characterization, components of wastewater flows, estimation of wastewater flows. Wastewater treatment methods, primary, secondary and tertiary methods, Design of equipment for wastewater treatment, EPA models for assessing water quality.
Metcalf and Eddy, Wastewater Engineering-Treatment, disposal & reuse, Tata McGraw Hill,1991
H.E.Babbilt and R.Baumann,Sewage and Sewage Treatment, 1986.

CH731 Solid Waste Management (3-1-0) 4
Introductionto solid waste management and SWM rules 2016, Generation and characterization of solid waste,solid waste collection, transport, processing, recovery and disposal.Processing techniques and equipment.Recovery of resources- Conversion, Chemical and Biological methods.Disposal of solid waste.Hazardous waste and their management. Case studies on major industrial solid waste generation units, E-waste management.

Martell, Solid Wastes, John Wiley, NY, 1975.
George Tchobanuglour, H.Theisen and R.Eliassen, Solid Wastes

CH732 Air Pollution Control & Design of Equipment (3-1-0) 4
Introduction.Air pollution laws and standards.Meteorological aspects of air pollution dispersion.Air pollution sampling and measurements.Air pollution control methods and design of equipment.Particulate emission control.Control of gaseous emissions.Air pollution control in specific industries. Acid rain, green house effects, important air pollution episodes, noise quality assessment and control.
Martin Crawford, Pollution Control Theory, McGraw Hill, NY.1976. Joe Ledbetter, Air Pollution Part A&B, Marcel Dekker, NY, 1972.

CH733 Environmental Impact Assessment & Management Plan (3-0-0) 3
Introduction and need for impact assessment, Methodologies, Application of Impact assessment methods in specific developmental projects, Ranking of impacts, environmental management plan, Legislation and pollution control acts and notifications, Environmental audits, waste audit, life cycle assessments, Industrial symbiosis, Clean Technology - options.
Peter Wathern, Environmental Impact Assessment-Theory and practice, Unwin Hyman Ltd, 1988.
Environmental Health and Safety Auditing Hand Book, McGraw Hill Inc, NY, 1994,

CH734 Mathematical Modeling of Environmental Systems (3-1-0) 4
Introduction to modeling of Environmental systems, surface and ground water.Air pollutants- Modeling of dispersion of pollutants in air. Water Quality modeling-basic theory, models of treatment processes-thickening process, anaerobic digestion, activated sludge process, trickling filter process. Modeling of transport of pollutants in subterranean media.
J. L. Schnoor, Environmental Modeling: Fate and transport of pollutants in water, air and soil, J. Wiley & Sons, NY, 1996
B.E. Logan, Environmental Transport processes, Wiley, 2012.

CH735 Environmental Quality Analysis Lab-I (0-0-3) 2
Sampling and analysis of water quality parameter, Use of all water testing and measurement equipment’s, characterisation of solid waste, use of water quality model.

CH736 Environmental Quality Analysis Lab-II (0-0-2) 1
Stack and ambient air quality measurement, noise measurement, use of air quality models
Elective Cources:

CH803 Biochemical Engineering & Bioreactor Design (3-0-0) 3
Microbiology.Characterization, Classification and enumeration of microorganisms, environmental and industrialmicrobiology, ecology, microbiology of soil and air, Laboratory techniques in microbial operations.Control ofmicroorganisms by physical and chemical methods, biochemistry.Microbial metabolism. Mechanism and kinetics ofenzyme catalysed reactions. Enzyme technology.Bioreactor design.
J.E.Bailey and D.F. Ollis, Biochemical Engineering Fundamentals, McGraw Hill, 1977. S.
Aiba, Biochemical Engineering, Acadmic Press, 1965.

CH 804 Advanced Separation Processes (3-0-0) 3
Fundamentals of Separation Processes, Ion Exchange, design of microfiltration, ultra-filtration, reverse osmosis, nano filtration, dialysis and electro-dialysis, Fundamentals of various colloid separation, Cloud Point Extractor, Micellar enhanced separation processes, Supercritical fluid extraction, Other non-conventional extraction processes.
Handbook of Separation Process Technology , R W Rousseau, John Wiley & Sons((1987).
Supercritical Fluid Extraction , M AMchugh and V J Krukonis , Butterworth Heinmann(1987).
Large Scale Adsorption and Chromatography , W C Wankat , CRC Press Inc , (1986).
Advanced Membrane Technology and Applications, Norman N Li, Anthony G. Fane , W. S. Winston Ho , Takeshi Matsuura , Wiley(2008).

CH806 Risk &Safety Management in Process Industries (3-0-0) 3
Hazard identification methodologies, risk assessment methods-PHA, HAZOP, MCA, ETA, FTA, Consequenceanalysis, Probity Analysis. Hazards in work places.Workers' exposures to hazardous chemicals.Hazards peculiar

inindustries.Guidelines for safeguarding personnel.Safety education and training-Safety managements, fundamentalsofsafety tenets, measuringsafety performance, motivating safety performance, legal aspects of industrial safety,safety audits.
F.P.Lees, Loss prevention in process industries, 2/e, Butterworth-Heinemann,. 1996
W.Handley, Industrial Safety hand book, 2/e, McGraw-Hill, 1977

CH807 Process Energy Integration (3-0-0) 3
Introduction and role of Thermodynamics.Heat exchanger Networks.Heat and Power Integration.EconomicEvaluation.Applications and Problems.
B.Linnhoff, A User Guide on Process Integration for Efficient Useof Energy, UMIST. Robin Smith, Chemical Process Design, McGraw Hill.

CH808 Cavitation and its Applications in Chemical Engineering (2-1-0) 3
Cavitation physics; hydrodynamic and acoustic cavitation; cavitation bubble dynamics–Rayleigh–Plesset equation;Cavitation assisted physicochemical and biologicaltransformations–mixing, leaching and extraction, dyeing, wastewater treatment, atomization, crystallization, coal washing, enzyme harvesting by cell disruption; Cavitation innanotechnology–Production of nonmaterial; precision cleaning ofsurfaces.
BrennenChristopher,Cavitation and Bubble Dynamics,Oxford University Press, New York, 1996. ISBN:0195094093
T.J. Mason, J.P. Lorimer, Applied Sonochemistry: Uses of Power Ultrasound inChemistry and Processing, Wiley-VCH Verlag, 2002.ISBN: 3-527-30205-0
HaoFeng,GustavoBarbosa-Cánovas,JochenWeiss(Editors) Ultrasound Technologies for Food and Bioprocessing,Springer,2011.ISBN-13:978-1441974716.

CH 809 Multiphase flow (3-0-0) 3
Homogeneous flow; Separated flow; Drift-flux model. Practical applications: Bubbly flow, Suspensions of particlesin fluids , Slug flow, Annular flow, Drop flow, Bubble formation and bubble dynamics, hydrodynamics of solid-liquidand gas-solid flow, hydrodynamics of three phase flows, measurement techniques in multiphase flow
G. B. Wallis, "One-dimensional two-phase flow" , McGraw-Hill Book Company (1969).
R. Clift,J. R. Grace,M. E.Weber, "Bubbles, Drops and Particles", Dover Publications, US(2005).
G.F. Hewitt," Measurement of two phase flow parameters", Academic Press Inc (1978)
D.Butterworth and G.F Hewitt ,"Two phase flow and Heat transfer", Oxford University Press (1977)
G.Hetsroni , "Handbook of multiphase flow systems", Hemisphere Pub. Corp ,McGraw -Hill(1982), New York.

CH811 Computational Fluid Dynamics (CFD) (3-1-0) 4
Governing equation of fluid dynamics , nature of PDE and boundary conditions, Turbulence and its modelling, Finite Volume discretization method for steady and transient flow problems, Numerical solution of the incompressible flows using Explicit, Implicit time marching schemes, Implicit Pressure correction algorithms, Fundamentals of grid generation.
J. H. Ferziger and M. Peric , "Computational Methods for Fluid Dynamics", Springer, Germany (2002).
H. Tennekes and J.L Lumley, "A first course in turbulence". The MIT Press (1972).
David C. Wilcox ," Turbulence Modeling for CFD", DCW Industries, Inc.(2006).
Versteeg, H. K. and Malalasekara, W. (2008). Introduction to Computational Fluid Dynamics: The Finite Volume Method. 2nd Edition, Pearson Education.
Jr., John D. Anderson (2017). Computational Fluid Dynamics the Basics with applications, McGraw Hill Education

CH831 Environmental Biotechnology (3-0-0) 3
Concepts, Definitions, Criteria, Potable water quality, Bio-treatment options for ground and water contamination, Bioaccumulation of trace materials, Biodegradation of organic pollutants, bio-fertilizer, Immuno-contraceptivebiotechnology, agro technologies,phyto-remediation and use of remote sensing technology.
Geetabali et al., Environmental biotechnology, APH Publishing Corporation, New Delhi, 2002.

CH832 Industrial Pollution Prevention (3-0-0) 3
Concepts, Benefits, waste Reduction, Waste Audit, Environmental Audit, ISO 14000, ISO 18000 series standards,Total quality management, Life Cycle design/Assessment, Product labelling, Examples in Chemical ProcessIndustries, Cost benefit Analysis, Role ofBiotechnology.
Harry M. Freeman, Industrial Pollution Prevention Handbook, McGraw Hill Inc., 1995

CH833 Bioremediation Techniques (3-0-0) 3

Case Histories, Constraints and Priorities of Bioremediation, Bio-augmentation for Bioremediation, Bioreactors for Remediation Processes, Types of Bioremediation, Applications-Examples, Biotechnology and Oil Spills. Biotechnology for Hazardous Waste Management, Xenobiotic Compounds, Recalcitrance, Hazardous Wastes, Biodegradation of Xenobiotics, Biological Detoxification, Biotechnology toHazardous Waste Management, Pesticide Industry: Tannery Industry and Biotechnology. Paper Industry and Biotechnology. Waste Treatment of Food and Allied Industries: Biological Treatment Methods, Air Pollution Abatement and Odour Control. Solid Waste Management. Novel Methods for Pollution Control: Vermitechnology, Waste Water Treatment Using Aquatic Plants, Root Zone Treatment. Aiming for Biodegradable and Ecofriendly Products.

Biodegradation and Bioremediation Martin Alexander, Academic Press ,1999
Handbook of Bioremediation Robert, Hinchee, Brown, McCarty, Semprini, Wilson,Lewis Pubs, Inc. ,1993
Bioremediation : Principles and Applications (Biotechnology Research) Ronald L. Crawford, Don L. Crawford, James Lynch,Cambridge University Press ,1996
Bioremediation Katherine H. Baker, Diane S. Herson, McGraw-Hill Professional,1993

CH810 Mathematical Methods in Chemical Engineering (3-0-0) 3

Vector and Vector spaces; Matrices, operators and transformations; Applications toChemical Engineering Systems(homogeneous and non homogeneous); Partial Differential equations; Strum-Louiville Theory; Separation of variablesand Fourier Transforms; Greens Functions; uniqueness conditions for linear and non-linear systems, Applicationstomodels in Chemical Engineering.

S.Pushpavanam, "Mathematical Methods in Chemical Engineering", Prentice Hall of India Pvt Ltd(2004).
E.Kreszig, "Advanced Engineering Mathematics", Wiley, New York (2011).

CH834 Sustainable Technologies (3-0-0) 3

Environmental implications of fossil fuels, air pollution, greenhouse gas emissions and land degradation. Renewable energy technologies, solar, wind, biomass, hydro etc.Biological conversion techniques and devices for Bioenergy.Socio-Environmental and Economic Implications. Integrated (systemic) Sustainability Assessment, Modelling and Fore-casting; Integrated Life-Cycle Studies; Identification and Selection of Appropriate Design/Technologies.

Renewable Energy - Sources for fuels and electricity: Eds. Johansson T B, Kelly H, Reddy AKN and Williams, RH, Island Press, 1993.
Solar energy - Fundamentals and Applications, H P Garg and J P Prakash, Tata McGraw-Hill, New Delhi, 1997.
Boyle G, Renewable Energy Power for a sustainable Future, Oxford Univ Press, 1996
Cassidy E and P Grossman, Introduction to Energy Resources, Cambridge Univ Press, 1998
Bell, Simon and Stephen Morse (1998) Sustainability Indicators: Measuring the immeasurable; Earthscan, London.

CH835 Economics for Pollution Control (3-0-0) 3

The Economic Approach: The Human–Environment Relationship, Environmental Problems and Economic Efficiency. Ethics, Economics and the Environment: Naturalist & Libertarian moral philosophies, Utilitarianism. Evaluating Trade-Offs: Benefit–Cost Analysis. Recyclable Resources: Disposal Cost and Efficiency. Economics Of Pollution Control: Pollutant Taxonomy, Stock & Fund Pollutants, The Single & Many-Receptor Cases, The Revenue Effect, Price Volatility, Instrument Choice under Uncertainty, Product Charges.

Dixon, J., Economic Analysis of Environmental Impacts, Earthscan Publications, 1994
Tietenberg Tom and Lyne Lewis, Environmental Economics and policy, Pearson Higher Education, 2009
Tietenberg Tom and Lyne Lewis, Environment and Natural Resources Economics, Prentice Hall, 2011
Turner, R.K., Pearce, D., and Batman, I, Environmental Economics, The Johns Hopkins University Press, 1993

CH836 Environmental Management System (3-0-0) 3

Environmental Management Standards: National policies on environment, abatement of pollution and conservation of resources, Environmental quality objectives & standards, measuring performance evaluation. Preventive Environmental Management: Cleaner production and technology. Environmental Management System: EMAS, ISO 14000 - EMS as per ISO 14001. Environmental Audit and Applications: Pollution Prevention opportunities in Textile, Sugar, Pulp & Paper, Electroplating, Mining, petroleum refining, Tanning industry, Dairy, Cement, Chemical industries, etc.

Hillary, R., Environmental Management Systems and Cleaner Production, Wiley Publishers, 1997
ISO 14001/14004: Environmental management systems – Requirements and Guidelines – International Organisation for Standardisation, 2004

Environmental Management Systems, Second Edition, NSF International, Ann Arbor, Michigan, January 2001

CH837 Industrial Waste Management and Audit (3-0-0) 3
Industrial Wastes: Nature and characteristics, Prevention and Control, Tools for clean processes: reuse, recycle, recovery, source reduction, raw material substitution, process modification, Flow sheet analysis, Energy and resources audit, Waste audit, emission inventory and waste management hierarchy for process industries, Zero discharge, Environmental indicators, Industrial ecology and eco-parks, rules and regulations, Case studies: Dairy, Fertilizer, Distillery, Pulp and Paper, Iron and steel, Metal plating, Refineries, Thermal power plants, etc.
EPA Guide for Industrial Waste management
C. Visvanathan, Industrial Waste Auditing, Wiley 2013
Ram Chandra, Environmental Waste Management, CRC Press 2015

CH838 Sustainable Technologies (3-0-0) 3
Environmental implications of fossil fuels, air pollution, greenhouse gas emissions and land degradation. Renewable energy technologies, solar, wind, biomass, hydro etc.Biological conversion techniques and devices for Bio-energy.Socio-Environmental and Economic Implications.Integrated (systemic) Sustainability Assessment, Modelling and forecasting; Integrated Life-Cycle Studies; Identification and Selection of Appropriate Design/Technologies.
Renewable Energy - Sources for fuels and electricity: Eds. Johansson T B, Kelly H, Reddy AKN and Williams, RH, Island Press, 1993.
Solar energy - Fundamentals and Applications, H P Garg and J P Prakash, Tata McGraw-Hill, New Delhi, 1997.
Boyle G, Renewable Energy Power for a sustainable Future, Oxford Univ Press, 1996
Cassidy E and P Grossman, Introduction to Energy Resources, Cambridge Univ P

CH760 Transport Phenomena (3-1-0) 4
Introduction to transport phenomena to biological systems, general transport equations for momentum, heat and mass transfer and their analogies; cylindrical and spherical coordinates; boundary layer concepts; Convective transport; Transport in turbulent condition; Multiphase systems and transport coefficients; Non-steady state transport; microscopic balances for isothermal, non-isothermal multi component systems; diffusion in biofilm-floc; transport coefficients and mass transfer in bioprocesses and biosystem; case studies of application of the concept to biological systems.
Heat and Mass Transfer: A Biological Context, Second Edition, Ashim K. Datta, CRC Press, 2017
Transport Phenomena in Biological Systems, 2nd Edition, By George A. Truskey, Fan Yuan, David F. Katz, Pearson publishers, 2008

CH761 Bioprocess Engineering (3-1-0) 4
Introduction: history, time line; Microbial growth kinetics: Batch, continuous and Fed-batch cultures; Microorganism: Isolation, preservation and strain improvement; Media for industrial fermentations: nutrient sources, design & optimization by Design of experiments; Sterilization: Design of batch and continuous sterilization of medium, bioreactor, filter sterilization of process streams; Inoculum development;Sold state fermentation; Bioprocess monitoring and measurement.
Fundamentals of enzymology: classification, chemical mechanisms of enzyme catalysis; kinetics of single-substrate and multi-substrate enzyme catalysed reactions; enzymatic production of valuable molecules in batch operation;Process technology for the production of: Baker's yeast, ethanol, organic acids, antibiotics and high fructose corn syrup.
Principles of Fermentation Technology by Stanbury&Whataker, ,2nd edition,Elsvier,2005.
Comprehensive biotechnology by Murray Moo-Young, ,1st Edition, Pergamon , 1985
Bioprocess technology, Kinetics & Reactors by A.Moser, Springer Verlag 1981
Enzymes by Trevor Palmer, Affiliated East-West Press Ltd.
Biocatalysis-Biochemical fundamentals and applications by Peter Grunwald, Imperial College Press.

CH762 Environmental Biotechnology (3-0-0) 3
Qualitative and Quantitative characterization of wastes; Waste disposal norms and regulations; Waste water treatment-aerobic & anaerobic processes; Biological means of stabilization and disposal of solid wastes; Treatment of hazardous and toxic wastes; Biodegradation of xenobiotic substances; Bioremediation; Phytoremediation; Bioaugmentation; Biostimulation; Sampling of air and water pollutants.
Environmental Biotechnology by C.F.Froster&D.A.J.Wase, PHI 1987
Environmental Biology for engineers and Scientists by DA Vaccari et al. Wiley Interscience 2006.
Waste water Engineering, Treatment, Disposal & Reuse by Metcalf & Eddy,.

Martin Alexander, Biodegradation and Bioremediation, 2nd Edition, Academic Press, 1999.
Bruce Rittman, Perry L. McCarty. Environmental Biotechnology: Principles and Applications, 2nd Edition, McGraw-Hill, 2000.

CH763 Downstream Process Technology (3-1-0) 4
Downstream Processing in Biotechnology; Selection of unit operation with due consideration of physical, chemical and biochemical aspect of biomolecules; Basic review of downstream process designing;Cell disruption methods: Mechanical & enzymatic methods;Insoluble removal: Filtration, centrifugation; Extraction: Solvent, aqueous two-phase, supercritical; Precipitation; Crystallization; Membrane separations: Ultra filtration, microfiltration, electro dialysis, Reverse osmosis, pervaporation; Chromatographic separations processes; electrophoretic separations;Quality control and quality assurance in biopharmaceutical industry; Good manufacturing practices.
Separation Process Principles by J. D. Seader& Ernest J. Henley, John Wiley & Sons; 2nd Edition. 2006
Separation processes in Biotechnology by Juan Asenjo,, CRC Press, 1990
Bioseparations Downstream Processing for Biotechnology by Paul A. Belter, E.L. Cussler , Wei-Shou Hu, Wiley India Pvt Ltd. 2011
Biotechnology-Quality assurance and validation by Kenneth E. Avis, Carmen M.Wagner, Vincent L.Wu, CRC Press, 1999.

CH764 Bioreactor Engineering (3-1-0) 4
Background of bioreactors; Classification & configuration of bioreactors: bioreactor designs for microbial processes, mammalian cell culture, plant cell culture & environmental applications; ideal and non-ideal bioreactors, Sources of non-ideality; non-ideal parameters, continuous flow bioreactors, mean residence time, optimum feed flow rates, Bioreactor operations for industrial-important biological products and for biological treatment of wastewater Bioreactor system components and specifications: material of construction, valves, seals, septum, sampling ports; Agitation system design: impellers, spargers, baffles; Oxygen transfer: measurement and control; Bioreactor support system: sterilization and containment, system supplies. Instrumentation and control: measurement of process variables; Scale-up and scale-down strategies.
Bioprocess Engineering Principles by Pauline M. Doran, 2nd edition, Elsevier Publishers, 2012
Bioreactors: Analysis and Design by T. Panda, First edition, McGraw Hill Publishers, 2011

CH765 Bioprocess Lab (0-0-4) 2
Qualitative and quantitative methods of proteins and metabolite estimation, characterization of enzymes, isolation of pure culture, preservation of cultures, Fermenter preparation & operation, determination of kinetic constants of bacterial batch process, measurement of OTR & OUR, HPLC, GC, FPLC etc.

CH861 Bioanalytical Techniques (3-0-0) 3
Basics of analytical chemistry; Qualitative and quantitative analysis of proteins, nucleic acids, polysaccharides and small molecules such as antibiotics, vitamins, natural products etc. Spectroscopic methods-UV, Vis, IR, Fluorescence, ORD, CD, & PAS), Chromatography: HPLC (including ELSD, RI and UVD detectors), GC, Ion chromatography; Mass spectrometry:atomic absorption spectrometry, atomic emission spectrometry, Recent developments in applications to proteomics and metabolomics (SELDI, MALDI, Q-TOF, Triple Quad and Ion trap mass analyzers), SEM, TEM and their application in bioprocessing and bioproduct characterizations. Introduction to methods and concepts of statistical analysis, errors, precision, accuracy, analysis of variance, confidence interval.
Instrumental methods of Analysis Willard and Merit, CSS Publishers 2004
Principles of Instrumental Analysis, 7th edition by DA Skoog, FJ Holler and TA Nieman, 2017
Handbook of analytical separations, vol. 4, by Ian Wilson, 2003

CH864 Enzyme Technology (3-0-0) 3
Fundamentals of enzymology; Single substrate and multi-substrate enzyme kinetics; Enzyme Inhibition kinetics; Characterization of enzymes (optimum pH & temperature, stability, molecular weight, kinetic constants, effect of additives, specificity etc.); Enzyme assay: methods & design; Immobilization- methods, characterization; Enzyme modifications; Non-aqueous enzymology; Commercial applications-case studies.
Enzymes by Trevor Palmer, Affiliated East-West Press Ltd.
Biocatalysis-Biochemical fundamentals and applications by Peter Grunwald, Imperial College Press.
Enzyme Biocatalysis by Andres Illanes, Springer
Advances in Biotechnology by Pratyoosh Shukla & Brett I.Pletschke, Springer

CH862 Genetic Engineering (3-0-0) 3

Introduction to r-DNA Technology, Fundamental methods: precipitation of nucleic acids, determination of concentration of nucleic acids, purification of nucleic acids, Restriction enzymes, electrophoresis gels, blotting techniques, Polymerase chain reaction and its applications, Basics of cloning, introduction to cloning process, Vectors for cloning: plasmids, bacteriphages, cosmids, P1 vectors, PAC, BAC, YAC, MAC, DNA sequencing techniques, Methods for analyzing DNA for mutations, Expression systems: bacterial, yeast, baculoviral, mammalian, Advances in r-DNA technology

Molecular Biology and Genomics, CORNEL MÜLHARDT, The Experimenter series, Academic press,
Gene cloning and DNA analysis, T.A. Brown, sixth edition ,Wiley- Blackwell
Principles of Gene manipulation and genomics, S. Primrose, Wiley, second edition

CH863 Industrial and Environmental Epidemiology (3-0-0) 3

Basic principles and concepts of epidemiology relating to the design, analysis and interpretation of epidemiological studies. Epidemiologic methods for studying industrial and environmental determinants of disease. Estimating industrial workplace and environmental exposure, design experiments to understand the effects of exposure, analyse data from health reports and epidemiological studies. Specific health outcomes, including: cancer, non-malignantrespiratory diseases. Introduction to statistical software (“R”) for epidemiological studies.

Checkoway H, Pearce N, and Kriebel D. Research methods in occupational epidemiology. Oxford University press, 2nd eidition-2004.
Rothman J J. Epidemiology: An introduction. Oxford University press. 1st edition-2002.
Rothman J J, and Greenland S. Modern epidemiology. Lippincott Williams & Wilkins, 3rd edition-1998.

CH865 Quality Control in Biopharmaceutical Industries (3-0-0) 3

Introduction to GMP, General considerations in quality of bioproducts (enzymes/vaccines/insecticides/r-DNA product etc.) such as molecular identity, potency, purity and stability, toxicity, immunogenecity and consistency. Physical and biological containment, facilities for experiments dealing with recombinant cells and viruses. General scientific considerations for assessing possible risks of viral/bacterial insecticides and recombinant organisms in large scale particles.

Total Quality Environmental Management : An ISO 14000 Approach Vasanthakumar N. Bhat, Quorum Books, 1998
ISO9000 for Better Business: Using ISO 9000 As a Foundation for Total Quality management Jack E. Small,Lanchester Press Inc, 1996
Bioprocess Monitoring and Control (Hanser Series in Biotechnology) Marie-Noelle Pons,John Wiley & Sons Inc 1993

CH866 Biosensors (3-0-0) 3

Introduction to biosensors, biological sensing elements and transducer systems, classification of biosensors, enzyme and whole cell based biosensors, affinity biosensors, amperometric biosensors, immuno sensors, ELISA, plant cell based biosensors, pesticide biosensors, flow injection analysis based biosensors, stability of biosensors, signal amplification, stabilisation and measurement, luminescence based biosensors.

Biosensors and Their Applications. Yang, V.C. and T.T. Ngo. 2000. Kluwer Academic/Plenum Publishers, New York,
Optical Biosensors: Present & Future. Ligler, F.S. and Rowe Taitt, C.A. 2002.Elsevier, The Netherlands
Biosensors: Fundamentals and Applications A.P.F. Turner, I. Karube, and G.S.Wilson, s.; Oxford Science, Publications: Oxford, 1987.
Enzyme and Microbial Biosensors: Techniques and Protocols Ashok Mulchandani and Kim R. Rogers, Eds.; Humana Press, Totowa, NJ, 1998.
Affinity Biosensors: Techniques and Protocols. Ashok Mulchandani and Kim R. Rogers, Eds.; Humana Press, Totowa, NJ, 1998

CH867 Bioremediation Techniques (3-0-0) 3

Introduction to Bioremediation. Case Histories, Constraints and Priorities of Bioremediation, Bioaugmentation for Bioremediation, Bioreactors for Remediation Processes, Types of Bioremediation, Applications - Examples, Biotechnology and Oil Spills. Biotechnology for Hazardous Waste Management, Xenobiotic Compounds, Recalcitrance, Hazardous Wastes, Biodegradation of Xenobiotics, Biological Detoxification, Biotechnology to Hazardous Waste Management, Pesticide Industry: Tannery Industry and Biotechnology. Paper Industry and Biotechnology. Waste Treatment of Food and Allied Industries: Biological Treatment Methods, Air Pollution Abatement and Odor Control. Solid Waste Management. Novel Methods for Pollution Control: Vermitechnology, Waste Water Treatment Using Aquatic Plants, Root Zone Treatment. Aiming for Biodegradable and Eco-friendly Products.

Biodegradation and Bioremediation Martin Alexander, Academic Press ,1999

Handbook of Bioremediation Robert, Hinchee, Brown, McCarty, Semprini, Wilson,Lewis Pubs, Inc. ,1993
Bioremediation : Principles and Applications (Biotechnology Research) Ronald L. Crawford, Don L. Crawford, James Lynch,Cambridge University Press ,1996
Bioremediation Katherine H. Baker, Diane S. Herson, McGraw-Hill Professional ,1993

CH868 Animal Cell Biosystems and Immunotechnology (3-0-0) 3
Characteristics of animal cells and their implication on process design Nutritional requirements and serum free cultureof mammalian cells Kinetics of growth and product formation. Reactor systems for large-scale production using animal cells. Production of Polyclonal antibodies with different types of antigens: antigen preparation and modification, adjuvants does and route of antigen administration, collection of sera, purification of antibodies. Hybridoma technology – production and applications of monoclonal antibodies for diagnosis and therapy. Production of virus vaccines, specific vaccines. Production of cellular chemicals like Interferons, Interleukin, etc. Immunoassay procedures.
Essential Immunology by Ivan M Roitt, Blackwell Scientific Publication, 4th Edition, 1980
Basic Concepts in Immunology : A Student's Survival Guide. par John Jr. Clancy (Editor), James Morgan McGrawHill Text
Textbook of Immunology. 2nd ed. Constantin A. Bona, Francisco A. Bonilla. Harwood Academic Pub. 1996.
Fundamental Immunology. 4th ed. Livre & CD edition. William E. Paul (Editor). Lippincott-Raven Pub.

CH869 Protein Engineering (3-0-0) 3
Introduction: Design and construction of novel proteins and enzymes, Conformation of proteins in general and enzymes in particular, Effect of amino acids on structure of proteins, Energy status of a protein molecule, Structure function relations of enzymes, Physical methods such as x-ray crystallography for determination of protein structure, Site directed mutagenesis for specific protein function, Basic concepts for design of a new protein/enzyme molecule, Specific examples of enzyme engineering, -Tryesyl t RNAsynthetase, Dihydrofolate reductase, Subtilisin.
Protein Engineering : Principles and Practice Jeffrey L. Cleland, Charles S. Craik,Wiley-Liss Hardcover,1996
Introduction to Proteins and Protein Engineering Barry Robson, Jean Garnier, Elsevier Science Ltd,1988

CH870 Cell Signaling and Systems (3-0-0) 3
Introduction to cell signaling pathways and networks, Components of signaling pathways-receptors-protein phosphorylation-cyclic nucleotides-G-proteins-Inositol phosphate-reactive oxygen species-nitrogen species-toll like receptors-cytokine-receptors-apoptosis-innate immunity receptors. Systems biology-modeling of signalling networks-network motifs-feedback and feedforward systems.
Cell Signaling J.T. Hancock, Oxford university press, 2nd edition, 2005.
Signal transduction B.D. Gomperts, Academic press, 1st edition, 2003.
An introduction to systems biology: design principles of biological circuits U. Alone, Chapman and Hall/CRC, 1st edition, 2006.

DEPARTMENT OF MECHANICAL ENGINEERING

ME700 Machining Processes **(3-0-0) 3**

Mechanism of chip formation, Determination of shear plane angle, forces on the chips, forces in orthogonal cutting, Merchant circle diagram and analysis, Theory of Lee & Shaffer, co-efficient of friction, power & energy relationship, velocity relationship, shear-strain, forces and power, Tool Materials and their properties, Friction in metal cutting, Mechanisms of tool wear, tool failure criteria, tool life equations, effect of process parameters on tool life, tool life tests, machinability index, Machining with controlled contact tools, shear angle in controlled contact machining, Thermal Aspects in metal cutting, temperature in chip formation, temperature distribution and analysis, Economics of Machining, element of total production cost, optimum cutting speed and tool life for minimum cost, optimum cutting speed and tool life for maximum production.High speed machining abrasive processes, machining of polymers, ceramics, glasses and composites. Difficult to machine materials, Dry machining.

References:

Metal Cutting Principles: M.C Shaw, Oxford Publication.
Metal Cutting by Edward.W. Trent.Butterwork.
Fundamentals of Metal Machining & machine tools by Boothroyd. McGraw-Hill.
Manufacturing Technology: Metal cutting and machine tools, P N Rao, Mc Graw Hill.
Manufacturing Science, Amitabha Ghosh, East-West Press.
Metal Cutting: Theory and Practices, Bhattacharya A, New Central Book Agency.

ME701 Computer Integrated Manufacturing **(3-0-0) 3**

Introduction to Automation, Industrial Control Systems, Discrete Control Using Programmable Logic Controllers and Personal Computers, Introduction to Material handling, Material Transport systems, Group Technology and Cellular Manufacturing, Flexible Manufacturing Systems.

References:

Computer Integrated Manufacturing, Alan Weatherall, Elsevier
Mikell P. Groover, "Automation, Production Systems, and Computer Integrated Manufacturing", Prentice hall.
Computer Integrated Manufacturing, A W Scheer, Springer

ME702 Metal Forming Processes **(3-0-0) 3**

Brief introduction to the Theory of Elasticity, Elastic stress-strain relations, Plasticity, Plastic stress-strain relations, Yield conditions, Graphical representations of yield criteria, Work hardening. Forming – fundamentals, classification, flow stress, flow curves, effect of parameters such as strain rate and temperature, workability, anisotropy Deformation zone geometry, uniform deformation energy method and slab analysis, Theory of slip lines, Upper and Lower bound theorems, friction and lubrication, residual stress. Forging: Mechanics and Operations. Rolling: Mechanics and Operations. Extrusion: Mechanics and Operations Wire Drawing: Mechanics and Operations. Deep drawing of sheet metals: Mechanics and Operations.

References:

Mechanical Metallurgy, S.I. Metric edition, George E. Dieter,McGraw Hill Book Company.
Metal Forming: Mechanics and Metallurgy , William F. Hosford and Robert M.Caddell, PTR Prentice-Hall,USA
Metal Forming Analysis, R.H.Wagoner and J.L.Chenot Cambridge University Press, New York, U.S.A.
Metal Forming Practice, Heinz Tschaetsch, Springer-Verlag Berlin Heidelberg.
Elementary Mechanics of Plastic Flow in Metal Forming,Samuel H. Talbert and BetzalelAvitzur, John Wiley and Sons, New York.
Fundamentals of Metal Forming Processes, B.L. Juneja, New Age International Publishers, New Delhi.

ME703 Manufacturing Systems Lab-I **(0-0-2) 2**

CAD Modeling, Assembly, Drafting of production drawing, Tolerance analysis of machine components like Screw jack, Drill Jig etc.

ME704 Metal Casting Processes **(3-0-0) 3**

Introduction to Casting technology; Technology of patternmaking, study of molding sands and their testing methods; Technology of mould making and core making, Special sand moulding processes; Pouring(Gating design) Aspiration effect, Effects of friction and velocity distribution; Principles of risering design for castings; Special casting methods, Cooling and solidification of pure metals and alloys; Solidification considering various interfacial resistances; effect of solidification on casting properties; Defects in castings; Fettling and Heat treatment of castings, Casting defect and its diagnostic methods. Melting and pouring practices for production of Cast Iron family, steel and non-ferrous metals and alloys; Analysis of casting quality using numerical methods. Parting line design, Yield analysis in investment casting, Introduction to micro-casting.

References:

M C Fleming, Solidification processing, McGraw-Hill.
Heine, R.W., Loper, C.R., and Rosenthal, P.C., "Principles of Metal Casting", TMH.
Ghosh, A., and Mallik, A.K., "Manufacturing Science", Affiliated East-West Press Pvt. Ltd.
Jain P. L., "Principles of Foundry Technology", TMH.
Chakrabarti, A. K., "Casting Technology and Cast Alloys", PHI.
John Campbell, Complete Casting Handbook, Metal Casting Processes, Techniques and Design, Elsevier.

ME705 Micro Manufacturing **(3-0-0) 3**

Micromanufacturing: An Introduction, Microturning, Microgrinding, Micro and Nanomanufacturing by Focused Ion Beam, Magnetorheological and Allied Finishing Processes, Magnetic Abrasive Finishing, Abrasive Flow Finishing (AFF) for Micromanufacturing, Laser Microwelding, Microextrusion, Microbending, Dimensional Metrology for Micro/Mesoscale Manufacturing, Micromolding, Fabrication of Microelectronic Devices, Introduction to Biomachining.

References:

Electrochemical machining, Debarr& Oliver, Elsevier
Micromanufacturing processes by V. K. Jain, CRC press
Ghosh & Mallick, Manufacturing science, East West Press.
Modern Machining technology, J PualoDavim, Elsevier.

ME706 Additive Manufacturing **(3-0-0) 3**

Introduction and basic principles, Process Chain, Data Processing and File Formats, Software Issues, Liquid-Based, Solid-Based and Powder-Based Systems, Post processing, Design for AM, Energy and Material Delivery, Materials and Characterization Techniques, Mechanics and Materials Issues, Process Monitoring and Control, Analytical and Numerical Modeling, Supply Chain, Applications in Biomedical, Aerospace, Automotive and Tooling Industries.

References:

Li Yang, Keng Hsu, Brian Baughman, Donald Godfrey, Francisco Medina, Mamballykalathil Menon, Soeren Wiener, "Additive Manufacturing of Metals: The Technology, Materials, Design and Production", Springer, 2017.
Rasheedat Modupe Mahamood, "Laser Metal Deposition Process of Metals, Alloys, and Composite Materials", Springer, 2018.
Milan Brandt, "Laser Additive Manufacturing: Materials, Design, Technologies and Applications, Woodhead Publishing, 2017.
D.T. Pham, S.S. Dimov, "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling" Springer 2001.
Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: 3-D Printing, Rapid Prototyping and Direct Digital Manufacturing", Springer, 2015.

ME707 Manufacturing Systems Lab-II **(0-0-2) 2**

CNC programming Manual and automated, Tool path generation and verification using CAM software Insight to simple structure analysis using FEA softwares

ME800 Metal Joining Processes **(3-0-0) 3**

Classification and characteristics of Welding. Characteristic features of welding arc, metal transfer in welding, Ultrasonic welding, Plasma Welding, Under Water Welding, Laser Welding, Electron Beam welding, Friction welding, Physics and Metallurgy of Welding. Inspection and testing of welds. Welding defects, residual stresses, welding distortion, Economics of Welding.

References:

Parmar, R.S, Welding processes and Technology, Khanna Publishers, 1997.
Richard L. Little, Welding & Welding Technology, McGraw Hill, 1973.

ME801 Surface Engineering **(3-0-0) 3**

Plating Processes, Diffusion Processes, Thin Film Coatings: Thermal evaporation, Sputter deposition, Ion plating, Pulsed laser deposition, CVD processes and systems, Plasma enhanced CVD, Laser enhanced CVD, Metal organic

CVD, Advanced Thermal spray Coatings: Plasma spray, Detonation gun and High velocity oxy-fuel process, Bonding mechanisms, Characterization and Testing of Coatings-Film thickness measurements, coating adhesion, Residual stresses, Nano-indentation, Microstructure characterization, High-energy Surface Modifications, Heat Treatment of Superalloys, Heat Treatment of Titanium and Titanium alloys.

References:

K.G. Budinski, Surface Engineering for Wear Resistances, Prentice Hall, Englewood Cliffs, 1988. M. Ohring, The Materials Science of Thin Films, Academic Press Inc, 2005

ASM Handbook, Surface Engineering, Vol. 5, ASM Publication, Materials Park, Ohio, 2001.

ASM Handbook, Heat Treating, Vol. 4, ASM Publication, Materials Park, Ohio, 2001.

ASM Handbook, Materials Characterization, Vol. 10, ASM Publication, Materials Park, Ohio, 2001. Jamal Takadoum, Materials and Surface Engineering in Tribology, John Wiley & Sons, Inc., 2008. Rointan F. Bunshah, Handbook of Hard Coatings, Noyes Publications, U.S.A.,2001

ME802 Composite Mechanics and Processing (3-0-0) 3

Introduction to Composites, Classification of composite materials, Matrix Materials, Dispersed Phase, Dispersion strengthened, particle-reinforced and fiber-reinforced composites, Micro and Macro mechanics of Laminates, Classical Laminated theory, ABD Matrix, Design, Joining and Testing of composite materials, Failure modes, laminates, Self healing composites, Processing of Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites, Carbon Carbon Composites, Nanocomposites, Injection molding, Compression molding and 3D printing of advanced composites, Laboratory Practice, Testing methodologies. Fatigue and environmental effects. 3D, 4D composites.

References:

F.L.Matthews and R.D.Rawlings, Composite materials: Engineering and science, Wood head publishing limited RoberM.Jones, Mechanics of composite Materials, McGraw Hill Kogakusha Ltd.

Krishnan K Chawla, Composite material science and Engineering, Springer Publishing P.C.Mallik, Fibre reinforced composites, Marcel Decker

M M Schwartz, Composite Materials Hand book, McGraw Hill.

ME803 Artificial Intelligence in Manufacturing (3-0-0) 3

Computational Techniques for representing and solving problems; Semantic Networks; Perceptions; Representation, production system & search; Heuristics, Case Studies; Fuzzy Logic and control, Artificial Neural Networks: Back propagation Algorithm, Adaptive Resonance Theory, Recurrent Neural Networks, Deep Learning applications; Expert Systems; Case studies in the field related to manufacturing.

References:

George F. Luger, Artificial Intelligence, Pearson Pub.6th edition (2009)

VVS Sharma, B.Yajnanarayan and Deekshitalu, Artificial Intelligence & Expert System Technologies, Tata McGraw Hill.

Bart Kosko, Neural Networks and Fuzzy Systems.Prentice-Hall; Har/Dis edition (23 May 1991) Stuart Russell, Peter Norvig Artificial Intelligence: A Modern Approach, 3rd Edition, Prentice Hall.

ME804 Modeling and Simulation of Manufacturing Processes (3-0-0) 3

Review of Manufacturing Processes, Different Approaches to Modeling – Analytical and Numerical Techniques (Finite Difference (FDM) and Boundary Element Methods (BEM)), Modeling of Manufacturing Processes – Casting, Forming, Machining, Welding and Additive Manufacturing, Typical Case Studies Covering Different Manufacturing Processes

References:

J N Reddy, "Introduction to the Finite Element Method", 2nd Edition, Tata McGraw Hill, 2005.

P.M. Dixit and U.S. Dixit, "Modeling of Metal Forming and Machining Processes by Finite Element and Soft Computing Methods", Springer, 2008.

Kuang-Oscar Yu, "Modeling for Casting and Solidification Processing", CRC Press, 2001 J. A. Goldak and A. Mehdi, "Computational Welding Mechanics", Springer, NY, 2005.

Gouge M and Michaleris P, "Thermo-Mechanical Modeling of Additive Manufacturing", Butterworth-Heinemann, 1st edition, 2017.

ME805 Lean Manufacturing (3-0-0) 3

Role of Inventory in Production, Principles of Production systems, Production System Models; Market

Characterization: Forecasting systems, Extrapolative & Casual Models of forecasting, Combining Forecasts; Manufacturing Strategy & Supply Chain: Dimensions of manufacturing Strategy, Supporting Decisions, Multifacility Location-Allocation Models, Synthesing the concepts; Single Stage Inventory Control; Decentralized Pull Systems; Multistage Models; JIT for Lean Manufacturing; Shop Scheduling; Shop Floor Control, Systems& Extensions

References:

Ronald G Askin& Jeffrey B.Goldberg[2002], "Design and Analysis of Lean Production Systems", Wily Publ.,Singapore

Ronald G Askin, Standridge [1993], "Modeling & Analysis of Manufacturiing Systems", Wiley Publ,New York

Montgomery, D.C. &Johnson[1976],"Forecasting and Tiime Series Analysis", McGrawHillPubl,New York

Canada JR &Sullivan[1989],"Economic7 Multiattribute Evaluation of Advancec Manufacturing Technologies", Prentice Hall, NJ.

ME806 Precision Manufacturing (3-0-0) 3

Introduction: size scales, scaling analysis, technology change, Lithographic Processes- Optical and X-ray, Precision Engineering: sources of error, machine tool variables - accuracy, stiffness, spindle vibration, flatness, straightness, and smoothness of motion, 1-2 dof systems, feedback variables, cutting tool parameters and surface finish, workpiece variables, environment effects and thermal errors, geometry of Cutting Edge, Approach angle of cutting nose, Comparison with Micro- scale Machining, Diamond Micromachining: Diamond as a Tool Material, Micro-mechanical Process, Ductile Regime Grinding, Micro-ECM, Micro-EDM, Micromilling: Micro-milling Tools, Process and Micro-milling Applications, Micro-drilling, Laser Micromachining: laser Optics, Laser Ablation, Heat Affected Zone and Laser Polymerization, Micro welding: similar and dissimilar materials, Micro casting, Photo and other lithography techniques, Thermal oxidation, CVD, Metallisation. Role of CAD/CAM in precision manufacturing, and aspects of sustainable manufacturing and design for sustainability

References:

David Dornfeld and Dae-Eun Lee, Precision Manufacturing, Springer, 2008

Tlusty, J., Manufacturing Processes and Equipment, Prentice-Hall, Upper Saddle River NJ, 2000 H. Nakazawa, Principles of Precision Engineering, 1994, Oxford University Press.

P. Seyfried, H. Kuntzmann, P. McKeown and M. Weck, eds., Progress in Precision Engineering, Springer-Verlag, 1991.

Jain V. K., Introduction to micromachining, Narosa Publishers

R. L. Murthy, Precision engineering manufacturing, New Age International.

ME807 Fluid Power Automation (3-0-0) 3

Introduction, Distribution of fluid power, ISO symbols, energy losses in hydraulic systems. Applications, Basic types and constructions of Hydraulic pumps and motors. Pump and motor analysis. Performance curves and parameters. Hydraulic actuators, types and constructional details, lever systems, control elements – direction, pressure and flow control valves. Valve configurations, General valve analysis, valve lap, flow forces and lateral forces on spool valves. Series and parallel pressure compensation flow control valves. Flapper valve Analysis and Design. Proportional control valves and servo valves. Design and analysis of typical hydraulic circuits. Regenerative circuits, high low circuits, Synchronization circuits, and accumulator sizing. Intensifier circuits Meter-in, Meter-out and Bleed-off circuits; Fail Safe and Counter balancing circuits, Components of pneumatic systems; Direction, flow and pressure control valves in pneumatic systems. Development of single and multiple actuator circuits. Valves for logic functions; Time delay valve; Exhaust and supply air throttling;, Program Control, Electro-pneumatic control and air-hydraulic control, Ladder diagrams. Applications in Assembly, Feeding, Metalworking, materials handling and plastics working.

References:

Blackburn,J. F.,G.Reethof, and J. L.Shearer, Fluid Power Control, New York: Technology Press of M. I. T. and Wiley.

Anthony Esposito,"Fluid Power with applications",Pearson Education.

Ernst, W., Oil Hydraulic Power and its IndustrialApplications, New York: McGraw Hill.

Lewis,E.E., and H.Stern, Design of Hydraulic Control Systems, New York: McGraw Hill.

Morse,A.C.,Electro hydraulic Servomechanism,New York: McGraw Hill.

Pippenger, J.J., and R.M.Koff, Fluid Power Control systems, New York: McGraw Hill.

ME808 Laser Processing of Materials (3-0-0) 3

Laser fundamentals – Operation Mechanism, Properties, Types of Industrial Lasers, Fundamentals of Laser Material

Interactions: Absorption, Thermal Effects, Materials science, Lasers in Manufacturing (Cutting, Drilling, Machining, Forming, Welding, Surface Alloying, Cladding), Laser Additive Manufacturing – Classification, Processing Philosophy and Metallurgical Mechanisms, Analytical and Numerical Modeling.

References:

W M Steen and J Mazumder, "Laser Material Processing", 4th Edition, Springer, 2010.

Gennady G. Gladush and Igor Smurov, "Physics of Laser Materials Processing: Theory and Experiment", 1st Edition Springer, 2011.

Dowden J.M., "The Mathematics of Thermal Modeling: An Introduction to the Theory of Laser Material Processing", Chapman and Hall/CRC 2001

Principles of Laser Materials Processing, E Kannatey-Asibu, Wiley, 2009.

John C Ion, "Laser Processing of Engineering Materials: Principles, Procedure and Industrial Applications", Elsevier, 2005.

ME809 Tool Engineering (3-0-0) 3

Tool Making practices: hole location, jig boring practice, punch & die manufacture, EDM for cavity applications; Tooling materials and heat treatment; Locating & Clamping methods: basic principles, locating methods and devices; Drill Jigs: chip formation, drill bushings, methods of construction, drill jigs & modern manufacturing; GD& T, Fixtures: Fixtures & economics, types of fixtures; Sheet metal blanking & piercing dies: Die cutting operations, die-design fundamentals; Sheet metal blending, forming and drawing dies; construction methods of plastic tooling, metal forming operations with urethane dies and calculation of forces; Cutting tools and tool holding methods for CNC machines, Automatic Tool Changers and Tool Positioners, Tool Presetting; Automatic Screw Machines.

References:

Donaldson, Legain,Goold[2008], "Tool Deign", TMH Edition, N.Delhi.

Breding H W, [1967]"Tooling Methods and Ideas", The Industrial Press, N.York. S.Kalpakjian,StevenR.Schmid,[2007],"Manufacturing Processes for Engineering Materials", Pearson Publ. Hoffman, E G [1996], "Jig and Fixture Design", 4thEdittion , Industrial Press

Kempster, Jigs and Fixtures

ME810 Production Management (3-0-0) 3

Characteristics of Manufacturing Systems; Inventory Planning & Control; Material Requirement Planning; Operations Scheduling for Large Scale Projects; Japanese Manufacturing Systems; Product/Process Design; Waiting Line Models and Applications to Service System Design; Capacity Planning; Facility Layout and Assembly Line Balancing; Multiple Criteria Decision Methods for Production Problems.

References:

Elwood S Buffa, Rakesh K sarin[1994] "Modern Production/Operations Management", Wiley Publ, N.Delhi Chase R B & N J Aquilano[1985],"Production and Operations Management",IrwinPubl,Illinois Fitzsimmons J A & R S Sullivan[1982], "Service Operations Management", McGrawHill,New York Buffa E S & J G Miller[1979], "Production Inventory Systems: Planning & Control". Irvin, Illinois

Sarin R K[1980], "Multiple Criteria Decision Making: Theory & Applications", Springer Verlag,Berlin

ME811 Destructive and Non Destructive Evaluation (3-0-0) 3

Replication Microscopy Techniques for NDE, Electric Current Perturbation, Electromagnetic Techniques for Residual Stress Measurements, Eddy Current Inspection, Microwave Inspection, Ultrasonic Inspection, Acoustic Emission Inspection, Acoustic Emission Inspection, Neutron Radiography, Strain Measurement for Stress Analysis, Nondestructive Inspection of Forgings, Castings, Powder Metallurgy Parts, Tubular Products, Weldments, Brazed Assemblies, and Soldered Joints, Boilers and Pressure Vessels.

References:

Nondestructive Evaluation and Quality Control, Volume 17, 9th Edition Metals Handbook, ASM Handbook, 1992 L. F. Pau, Failure Diagnosis and Performance Monitoring. Marcel Dekker Inc Nondestructive Testing, Louis Cartz,ASM International

Paul E Mix, "Introduction to Non-destructive testing: a training guide", Wiley, 2nd Edition New Jersey, 2005 Charles, J. Hellier," Handbook of Nondestructive evaluation", McGraw Hill, New York 2001.

ME812 Near Net Shape Processes (3-0-0) 3

Concept of shape, size, accuracy, Tolerances and surface roughness. Economical and technological factors, Such as improved material and energy efficiency, Dimensional accuracy product integrity and reduced manufacturing costs through near net processing. Foundry processes, Such as investment casting, Ceramic moulding plaster mould process, V-process, Squeeze casting and rheo-casting. Permanent mould casting, Low pressure die casting and pressure die Casting processes. Plastic deformation processes, such as worm, Fleshless forging, Cold forging, Orbital Forging, Supper plastic forming, Powder metal forging, Liquid forging, Rheo forging and isothermal forging processes . Use of long forging machines, High energy rate forming. Electro forming, Principle of electro deposition of dies and moulds by electro forming.

References:

Boothroyd J, Dewhurst P. Design for Assembly: a designers handbook, University of Massachusetts,Dept. of Mechanical Engineering, 1983.

T ateno M. Size High Quality Steels and Their Material as 'Near Net Shape'. Trans Iron Steel Inst Japan2005.

ltan T, Miller RA. Desi gn for Forming and other Near Net Shape Manufacturing Processes.CIRP Ann Manuf Technol,

Springer 2008

Near-Net Shape Manufacturing, Kapil Gupta and Neelesh Kumar Jain, Springer, 2016

ME710 Mathematical Methods for Engineers (3-0-0) 3

Applied Linear algebra: Four special matrices, Key Ideas of Linear Algebra, Differential equations, Solving a linear system, Delta Function, Eigen values, Spring-Mass System, Solution by eigenvectors, solution by finite differences (accuracy, stability and speed), Finite Differences in time, least squares, Trusses.

Finite Elements in 1D, Quadratic/cubic elements, Element matrices; 4th order bending equations

Boundary conditions, splines, gradient and divergence, Laplace's equation, Fast Poisson Solver, Finite elements in 2D.

Fourier series, Discrete Fourier series, Examples of discrete Fourier transform, Fast Fourier transform, convolution, filtering, Filters, Fourier integral transform, Convolution equations, deconvolution, convolution in 2D, Sampling theorem.

References:

Gilbert Strang, "Computational Science and Engineering 1st Edition", Wellesley-Cambridge Press, 2007.

Tang, K. T, "Mathematical Methods for Engineers and Scientists I, 2 and 3", Springer Publishers, 2007

Alan J. Laub, "Matrix Analysis for Scientists & Engineers", SIAM Publishers, 2004

Reddy, J. N., "An Introduction to the Finite Element Method", 3rd Edition, McGraw Hill Series, 2006.

Gilbert Strang and George Fix, "An Analysis of the Finite Element Method", SIAM Publishers, 2008.

ME711 Applied Elasticity (3-0-0) 3

Introduction to tensors, Constitutive equations - piezo elasticity, Formulation of elasticity problems; Bending of symmetric and un-symmetric straight beams, effect of shear stresses, Curved beams, Shear center and shear flow, shear stresses in thin walled sections. Airy's stress function to solve two dimensional problem; Torsion of prismatic solid sections, thin walled sections, circular, rectangular and elliptical bars, membrane analogy. Plate theories.

References:

L. S. Srinath, "Advanced Mechanics of Solids", 2nd Edition, TMH Publishing Co. Ltd., New Delhi, 2003.

Wang C.T., "Applied Elasticity",Mc-Graw Hill Book Company, New York, 1953.

S. P. Timoshenko, J. N. Goodier, "Theory of Elasticity", 3rd Edition, McGraw Hill Publishing Co. 1970.

R. G. Budynas, "Advanced Strength and Applied Stress Analysis", 2nd Edition, McGraw Hill Publishing Co, 1999.

P. Boresi, R. J. Schmidt, "Advanced Mechanics of Materials", 5th Edition, John Willey and Sons Inc, 1993.

ME712 Engineering Fracture Mechanics (3-0-0) 3

History of failure by Fracture; failure of structures, bridges, pressure vessels and ships, brittle fracture, development of testing for failure, identification of reasons for failure, existence of crack, Griffith crack and experiment, energy release rate and stress for failure in presence of crack. Stress Field around Crack Tip; revision of theory of elasticity conformal mapping, Airy's stress function for crack tip stress field with crack emanating from straight boundary, stress state in crack tip vicinity, modes of crack face deformation, stress intensity factor and Irwin's failure criterion, fracture toughness. Determination of Stress Intensity Factor, different specimen configuration, numerical techniques-boundary collocation and boundary integral, finite element method, experimental method- reflection and refraction polariscopy, Determination of fracture toughness. Energy Consideration; potential energy, surface energy, plastic deformation around crack tip, energy release rate, compliance and correlation with fracture toughness, crack opening displacement (COD), COD as fracture criterion, experimental determination of COD, use of fracture toughness and COD as design criteria. Concepts of J Integral, Stress corrosion cracking, hydrogen embrittlement, leak before burst, Crack Propagation; law of fatigue crack propagation, life calculation when a crack is present and loaded, microscopic aspects of crack propagation, elastic crack and plastic relaxation at crack tip.

References:

T. L. Anderson, "Fracture Mechanics-Fundamentals and Applications", 3rd Edition, CRC Press, 2005.
S.A .Meguid, "Engineering Fracture Mechanics", Springer Publications, 1989.
KareHellan, "Introduction to Fracture mechanics", McGraw Hill Publications, 1985.
David Broek, "Elementary Engineering Fracture Mechanics", Springer, 1982.
Prashant Kumar, Elements of Fracture Mechanics, McGraw Hill Education (India) Pvt., Ltd, New Delhi, 2014
K. R. Y. Simha, K.R.V. Simha, Fracture Mechanics for Modern Engineering Design,Universities Press, 2001

ME713 Mechanical Systems Lab (0-0-3) 2

Static (stress and deflection) analysis of simple structures with and without crack under mechanical and thermal loadings.
Kinematic and dynamic analysis of planar and spatial mechanisms.
Modal analysis of simple structures and machine components.
Harmonic response analysis of machine components.
Buckling analysis of structures under thermal and mechanical loadings.
Multi-body and multi-flexible body dynamic analysis.
Multi-physics analysis (Fluid structure interaction, thermo-mechanical problem, piezoelectric).

References:

Robert D Cook, MalkusPleshaWitt, "Concepts and Applications of Finite Element Analysis", 4th Edition, Wiley Publisher, 2007.
Manish S, "Finite Element Method and Computational Structural Dynamics", Prentice Hall India, 2014.
Saeed Moaveni, "Finite Element Analysis: Theory and Application with ANSYS", 4th Edition, Pearson publications, 2015.
Ever J Barbero, "Finite Element Analysis of Composite Materials", CRC Press, 2007.
ZdravkoTerze, "Multibody Dynamics (Computational Methods in Applied Sciences) ", Springer Publications, 2014.

ME714 Advanced Mechanism Design (3-0-0) 3

Mobility Analysis – degree of freedom, mixed mobility, total, partial and fractional DOF, closed and open chain systems, structural analysis and synthesis of mechanisms. Alternative design solutions, coding, evaluation and selection of optimum mechanism, Type synthesis, number synthesis and design of mechanisms. Indexes of merit, algebraic and optimization techniques, matrix methods of design and analysis, design of function, path and motion generators.

References:

R.L.Norton-Design of Machinery,5 edition,McGraw-Hill Education,2011
Asok Kumar Mallik, Amitabha Ghosh, Gunter Dittrich- Kinematic Analysis and Synthesis of Mechanisms,CRC Press; 1 edition (1994)
Lung-Wen Tsai- Mechanism Design: Enumeration of Kinematic Structures According to Function (Mechanical and Aerospace Engineering Series),CRC Press; 1 edition (19 September 2000)
Kenneth J. Waldron, Gary L. Kinzel, Sunil K. Agrawal- Kinematics, Dynamics, and Design of Machinery, Wiley-Blackwell; 3rd Edition edition, 2016
Gordon R. Pennock & Joseph E. Shigley John J. Uicker - Theory Of Machine And Mechanisms, Oxford University Press, 4th edition (2014)
Mark W. Spong, M. Vidyasagar, Robot Dynamics and Control, Wiley,2008

ME715 Applications of FEM in Design (3-0-0) 3

Introduction to Numerical methods, Axisymmetric problems, Classical plate bending, Free vibration of elastic systems, Buckling of plates, Transient Analysis. Introduction to Non-linear Problems, Geometric and material non-linearity, Introduction to finite element programming, case studies on coupled problems.

References:

J N Reddy, "Finite Element Method", McGraw Hill International Edition 2012
S S Rao, "Finite Element Method in Engineering", 4th Edition, Elseveir, 2006.
Thomas J R Hughes, "The Finite Element Method: Linear Static and Dynamic Finite Element Analysis", Dover Publications, 2000.
R D Cook, "Concepts and Application of Finite Element Analysis", 4th Edition, Wiley & Sons, 2003.

ME716 Theory of Vibration **(3-0-0) 3**

Vibration: Review of single degree of freedom system, multi degrees of freedom system, developing stiffness and mass matrices for lumped parameter systems, natural frequencies and modes of free vibration, time harmonic forced vibration with damping, modal decomposition, time domain solutions, dynamic vibration absorber, Continuous systems, beams: equation of motion, boundary conditions, natural frequencies, mode shapes and forced vibration response. Modal analysis: solving for free and forced vibration via modal co-ordinates, FRF for multiple degree of freedom systems, modal participation factor.
Non linear and random vibrations

References:

William T Thomson, Marie Dillon Dahleh, Chandramouli Padmanabhan, "Theory of Vibration with Applications", 5th Edition, Pearson Publications, 2008.
S Graham Kelly, "Mechanical Vibrations Theory and Applications", CL Engineering, 2011
Singiresu S. Rao, "Mechanical Vibrations, 6th Edition, Pearson", 2017.

ME717 Dynamics and Stress Analysis Lab **(0-0-3) 2**

Stress Analysis:

Practicing strain gauge techniques on machine components, Use of strain gauge rosettes for combined bending and torsion measurement, Use of photo-elasticity, calibration of photo-elasticity constant, and determination of stress field in various photo-elastic models.

Dynamics:

Determination of Mass moment of inertia of Fly wheel, Axle system and compound pendulum, Motorized gyroscope, Single degree of freedom Spring Mass System – Determination of natural Frequency and verification of Laws of springs – Damping coefficient determination, Multi degree freedom suspension system – Determination of influence coefficient. Determination of torsional natural frequency of single and Double Rotor systems.- Undamped and Damped Natural frequencies, Vibration Absorber – Tuned vibration absorber. Vibration of Equivalent Spring mass system – undamped and damped vibration, whirling of shafts – Determination of critical speeds of shafts with concentrated loads, Balancing of rotating masses and reciprocating masses, Transverse vibration of Free-Free beam – with and without concentrated masses, Forced Vibration of Cantilever beam – Mode shapes and natural frequencies, Determination of transmissibility ratio using vibrating table.Non linear and random vibrations

References:

K Ramesh, "Digital Photoelasticity: Advanced Techniques and Applications", Springer, 2013.
RL Norton, "Design of Machinery", 2nd Edition, McGraw-Hill
S S Rao, "Mechanical Vibrations", Pearson Education Inc., New Delhi, 2011.
D J Ewins, "Modal Testing: Theory, Practice and Application", Research Studies Press, 2009.

ME816 Lubrication and Bearing Design **(3-0-0) 3**

Tribology and Lubrication, Surface Texture and Interactions, Bearing Materials. Fluid-Film Bearings. Fundamentals of Viscous Flow. Reynolds Equation and Applications. Thrust Bearings. Journal Bearings. Squeeze-Film Bearings. Hydrostatic, Hydrodynamic Bearings. Gas Bearings. Dry and Starved Bearings. Rolling Element Bearings. Selecting Bearing Type and Size. Principles and Operating Limits. Friction, Wear and Lubrication. Seals and Monitoring. Seal Fundamentals. Condition Monitoring and Failure Analysis.

References:

Michael M. Khonsari, E. Richard Booser . "Applied Tribology: Bearing Design and Lubrication", 2nd Edition, Wiley Publishers, 2008.
Avraham Harnoy, "Bearing Design in Machinery: Engineering Tribology and Lubrication", CRC Press, 2002.
Kenneth C Ludema, "Friction Wear Lubrication: A Textbook in Tribology", CRC Press, 1996.
B. C. Majumdar, "Introduction to Tribology of Bearings", S. Chand Publications, 2010.

ME817 Experimental Stress Analysis **(3-0-0) 3**

Photoelasticity: Behavior of Light, Polarized Light. Plane Polarizer and Wave Plates, plane and circular Polariscopic, Theory of Photoelasticity: Stressed Model in Plane Polariscope and Circular Polariscope. Analysis Techniques: Isochromatic and Isoclinic Fringes, Compensation Techniques, stress separation Techniques.
Three Dimensional Photoelasticity: Stress freezing technique, Interpretation of Fringes, Effective Stresses. Shear Difference Method. Case studies
Electrical Resistance Strain Gauges: Strain sensitivity, Gauge Construction, Temperature Compensation, Gauge Selection, Correction for transverse Strain, Semiconductor Strain Gauges. Rosette Analysis of three element

rectangular Rosette, Delta Rosettes,
Brittle Coating Method: Coating methods and stress analysis, Failure Theories, Crack Patterns produced by Direct Loading, Pattern Produced by Releasing the Load, Double Crack Pattern, Crack Detection, Bi-axial stress Field
Holography: Plane and Spherical waves, Interferometry, Holographic set up, recording and reconstruction process, Iso-patches and displacement Measurement, Applications.
References:
James W Dally and William F Riley, "Experimental Stress Analysis", McGraw Hill, 2000
Srinath, Lingaiah, Raghavan, "Experimental Stress Analysis", Tata McGraw Hill, 1991
Kuske, Albrecht and Robertson, "Photoelastic Stress Analysis" John Wiley & Sons., 1978
A S. Kobayassin (Ed), "Hand Book of Experimental Stress Analysis" - SEMNCH, II edition,1974
Sadhu Singh – "Experimental Stress Analysis", Hanna publisher, 1982

ME818 Advanced Materials for Design **(3-0-0) 3**
Design considerations in the use of materials; quality control; selecting materials to optimize multiple properties; materials failure; long-term materials properties; materials behaviour under extreme conditions; corrosion; discussion of design and materials selection strategy; processing and process selection strategy; process economics; life-cycle thinking and eco-design; special topics.
High temperature materials (super alloys) and their characteristics, Engineering plastics and polymer.
References:
M.F. Ashby, "Materials Selection in Mechanical Design", 4th Edition, Elsevier,San Francisco, 2011; ISBN 978-1-85617-663-7.
Cambridge Engineering Selector (CES EduPack), Granta Design Limited,Cambridge, UK, 2010, www.grantadesign.com.
Cases studies provided by the instructor
W.D. Callister, "Materials Science for Engineering: An Introduction", 7th Edition, Wiley, 2007. ISB 978-0-471-73696-7.
Kenneth G. Budinski, "Engineering Materials: Properties and Selection", Prentice Hall, 1996.
George E. Dieter, "Engineering Design: A Materials and Processing Approach", McGraw-Hill, 1991.

ME819 Mechanics of Polymer Composites **(3-0-0) 3**
Introduction to composite materials, Elastic behavior of uni-directional composite lamina Micro-mechanics: properties and geometric characteristics of fiber and matrix, relation to overall elastic property of lamina. Macro-mechanics: stress-strain relations for anisotropic materials; transformation of stress, strain and elastic parameters for lamina. Strength of uni-directional composite lamina Micro-mechanics: failure mechanism under longitudinal or transverse tension loading and shear loading. Macro-mechanics: failure theories for strength prediction. Elastic behavior of multi-directional laminates Lamination theory: layup arrangements for laminates and implications for elastic property of the composite Sandwich plates Failure analysis of multi-directional laminates Stress analysis for first ply failure Progressive and ultimate failure Design considerations Hygrothermal effects Thermal and moisture expansion of lamina and laminates Hygrothermoelastic stress analysis Experimental methods: Methods for mechanical and physical characterization of composites. Fatigue and impact response of composite.
References:
Vaasiliev V. V and Morozov E. V, "Mechanics and Analysis of Composite Materials", Elsevier, New York, 2001
Kaw A K, "Mechanics of Composite Materials", CRC Taylor and Francis Group, NW,USA, 2006
Jones, RM , "Mechanics of Composite Materials", Taylor and Francis, 2015.
Hull, D, "An Introduction to Composite Materials" Cambridge University Press, 1996
Agarwal, BD &Broutman, LJ, "Analysis and Performance of Fibre Composites", 3rd Edition, John Wiley& Sons, 2006.
Matthews, FL & Rawlings, RD, "Composite Materials: Engineering and Science" Chapman & Hall, 1993.
Powell, PC, "Engineering with Fibre-Polymer Laminates" Chapman & Hall, 1994

ME820 Dynamic Analysis of Rotating Systems **(3-0-0) 3**
Introduction to dynamics of rotating machinery, SDOF rotor model, Shaft whirling, Jeffcott rotor analysis, Critical speeds of rotors, Effects of internal damping and unequal moments of inertia on critical speeds, Gyroscopic effects on critical speeds, Gyroscopic effects on a spinning thin disc, Bearings and Seal systems, Influence of rolling element bearings and fluid film bearings on rotor dynamics.
Finite element modeling of rotors, System modeling, Rotor system equations, Stability analysis, Transfer matrix

method, Rotor dynamics with shaft material as composite.
Balancing of rotors, Unbalance response and Stability of rotors under various influences, including turbo machinery effects. Balancing of Rotors.
Modelling and Calculation methods in rotor dynamics for advanced applications, Active vibration control of rotors, Magnetic bearings.
Malfunction of rotor analysis, Common rotor faults, Coupling misalignment, Shaft cracks, Signal processing techniques, diagnostics and condition monitoring of rotors. Applications and Case studies.

References:

B.S.Prabhu and A.S.Sekhar,"Dynamic Analysis of Rotating Systems and Applications", Multi Science Publishing Co. Ltd, Essex, England, UK, 2008.
M.L Adams"Rotating Machinery Vibration, From Analysis to Troubleshooting", Marcel Dekker Inc.New York, 2001
E. Kramer, "Dynamics of Rotors and Foundations", Springer Verlag, Berlin, 1993
J.S.Rao, "Rotordynamics", New Age International Pvt. Ltd., New Delhi, 1996
Childs D., 1993, TurbomachineryRotordynamics: Phenomena, Modeling and Analysis. Research Studies Pub., A Wiley-Interscience Publication, NY.
J. M. Vance, "Rotordynamics of Turbomachinery", John Wiley and Sons, New York, 1998.
Rao, J. S., 2000, "Vibratory Condition Monitoring of Machines," Narosa Publishing House, New Delhi

ME821 Engineering Acoustics (3-0-0) 3

Introduction to Acoustics and Sound Perception, The human auditory system, Acoustics metrics and their uses for quantifying sound objectively and subjectively. Introduction to waves, Sound waves in fluids, Acoustic plane waves, Sound propagation, reflection, transmission, refraction and absorption. Conservation equations of compressible fluid dynamics for 3D sound fields, The Helmholtz equation and the Wave equation in three dimensions, Sound energy, sound power, radiation efficiency and sound intensity of a pulsating sphere. Sources of Sound: monopoles, dipoles, vibrating surfaces, Acoustic modes in a room with rigid walled boundaries. Modal statistics, modal overlap and the Schroeder frequency. Sound absorption and reflection co-efficient measurement using impedance tube. Introduction to noise control engineering.

References:

Frank Fahy, Foundations of Engineering Acoustics, 1st Edition, Academic Press, 2000.
Frank Fahy and David Thompson, Fundamentals of Sound and Vibration, 2nd Edition, CRC Press,2015.
Moser, Michael, Engineering Acoustics An Introduction to Noise Control, Springer-Verlag, 2009
Lawrence E Kinsler, Austin R Frey, Alan B Coppens, James V Sanders, Fundamentals of Acoustics, Wiley, 1999.
Heinrich Kuttruff, Acoustics: An Introduction, CRC Press, 2006

ME822 Design of Plates and Shells (3-0-0) 3

Preliminary, index notation, strain-displacement relation for continuum and plates, Derivation of plate equilibrium equation and boundary conditions through variational principle. Selected bending solutions for plate problems. Theory of moderately large deflection of elastic plates. Example problem with axi-symmetric plate/membrane. Buckling of plates, general formulation. Buckling of rectangular plates. Raleigh-Ritz quotient for plate buckling. Ultimate strength of plates and elastic/plastic buckling. Elastic buckling of cylindrical shells. Fundamentals of structural plasticity. Limit analysis of simple plastic structures. Energy absorption and crashworthiness of prismatic tubes. Local denting analysis of tubes and propagating buckles in pipelines. Cutting and denting of plates with application to collision and grounding of ships.

References:

Ugural, A. C, "Stresses in Beams, Plates and Shells 3rd Edition", CRC Press, 2009.
Shames, Irving H., and Clive L. Dym, "Energy and Finite Element Methods in Structural Mechanics", CRC Press, 1996.
Timoshenko, Stephen P., and S. Woinowsky-Krieger, "Theory of Plates and Shells", 2nd Edition, McGraw-Hill Companies, 1959.

ME823 Design for Fatigue (3-0-0) 3

Introduction- Fatigue Mechanisms, Overview and Examples, Fatigue Design Strategies, Uniaxial fatigue- Elastic Stress Analysis: S-N Data, Mean Stress Effect, Stress Concentration (Notch) Effect, Localized Elastic-Plastic Stress-Strain Analysis: Cyclic Stress-Strain Behavior, Strain-Life Data, Notch Stress-Strain Analysis (Neuber's Rule), Cumulative fatigue damage and life prediction for variable amplitude and irregular loadings- Miner's Rule, Cycle Counting, Rainflow Method, Load Sequence Effects. fatigue crack growth life prediction methods: Basics of Linear

Elastic Fracture Mechanics, Crack Growth Rate Data, Mean Stress Effect, Variable Amplitude and Irregular Loadings, Load Seqeunce Effects, Fatigue Microcrack Growth Behavior, Fatigue Testing Machines, residual stresses: Sources in Manufacturing and Fabrication, Effects on Fatigue Performance, Use of Manufacturing Processes to Improve Fatigue Strength, Methods to Account for Residual Stresses in Life Predictions multiaxial fatigue-Conventional Life Prediction Approaches and their Limitations, Newer Approaches (Critical Plane and Energy Approaches)

References:

Ralph I. Stephens, Ali Fatemi, Robert .R. Stephens and Henry O Fuchs, "Metal Fatigue in engineering", 2nd Edition, John Wiley, New York, 2000.
Jack. A. Collins, "Failure of Materials in Mechanical Design", John Wiley, New York, 1993.
Robert L. Norton, "Machine Design - An Integrated Approach", 5th Edition, Pearson, 2013.
S. Suresh, "Fatigue of Materials", Cambridge University Press, Cambridge, U.K, 2012.
T.L. Anderson, "Fracture mechanics : Fundamentals and applications", CRC Press, 1995.
David Broek, "Elementary Fracture Mechanics", Nijhof/Kluwers, 1986.

ME824 Design of Aircraft Structures (3-0-0) 3

Introduction, Design Philosophy (damage tolerance), Aircraft Loads, Materials used for Aircraft, Buckling and Stability of thin walled structures. Analysis of plane Truss-Method of joints-3D Truss-Plane frames-Composite beam. Strain Energy due to axial, bending and Torsional loads – Castigliano'stheorems Maxwell's Reciprocal theorem, Unit load method - application to beams, trusses, frames, rings. Columns with various end conditions, Beam column. Lug analysis, Cut-out analysis. Shear and bending moment distribution for cantilever and semi-cantilever types of beams-loads on aircraft –lift distribution-V-n diagram-Gust loads. Theories of failure and Application to aircraft Structural problems.

References:

Donaldson, B.K., "Analysis of Aircraft Structures – An Introduction", McGraw-Hill,1993.
Bruhn.E.F."Analysis and design of flight vehicle structures" Tri set of offset company, USA,1973.
Michael Chun Yung Niu."Airframe structural Design" Technical book company, Los Angeles, USA, 1989.
Timoshenko, S., "Strength of Materials", Vol. I and II, Princeton D. Von Nostrand Co,1990.

ME825 Machine Diagnostics (3-0-0) 3

Introduction, Fault diagnosis and prognosis, Model based methods, Signal driven methods, Principle of Maintenance, Vibration Monitoring, Fault Signatures, Noise Monitoring, Thermography, Wear debris analysis, Eddy current testing, Ultrasonic testing, Acoustic Emission testing, Time domain analysis, Fourier transforms, FFT, FRF, Spectrum and Cepstrum techniques, Wavelet Transform. Continuous and discrete wavelet transforms, Fault diagnosis using machine learning approach, decision tree technique, Artificial Neural Network, Support Vector Machine, Bayes classifier usage in fault diagnostics, Case studies.

References:

R. A. Collacott, Vibration monitoring and diagnosis, George Godwin Ltd London, 1979
W. T. Thomson, Theory of Vibration with application, Prentice Hall, Eaglewood cliffs, 4th edition, 1993
B. S. Prabhu, Condition monitoring and condition based maintenance ISTE New Delhi, 1997.
H. P. Garg, Industrial Maintenance, 3rd Edition, S Chand & Company ltd, 1987
Amiya R. Mohanty, Machinery condition monitoring, CRC Press, 2015.
Davies, Handbook of Condition Monitoring, Springer ltd. 1998

ME826 Mechanics of Viscoelastic Materials (3-0-0)3

Introduction to Viscoelasticity, review of the structure of viscoelastic materials such as plastics, rubbers and biological tissues. Linear viscoelasticity, constitutive equations using mechanical analogy, Maxwell model, standard linear solid and Burgers' model, generalized models, integral models, Boltzmann Superposition principle, stress relaxation and creep, relation between creep compliance, stress relaxation and complex modulus. Stress analysis examples, beam problems, elastic-viscoelastic correspondence principle, Time-temperature superposition, WLF equation, influence of temperature on stress analysis. Mechanical characterization of viscoelastic materials, experimental methods and pitfalls, dynamic measurements.

References:

M. T. Shaw and W. J. McKnight, Introduction to Polymer Viscoelasticity, 3rd Ed.,Wiley-Interscience, 2005.
A. S. Wineman and K. R. Rajagopal, Mechanical Response of Polymers: AnIntroduction, Cambridge University Press, 2000.

E. Riande, R. Diaz-Calleja, M. G. Prolongo, R. M. Masegosa, C. Salom, Polymerviscoelasticity, CRC Press, 1999.
W. N. Findley, J. S. Lai and K. Onaran, Creep and Relaxation of NonlinearViscoelastic Materials, Dover, 1989.
R. M. Christensen, Theory of Viscoelasticity, Dover, 2nd Ed., 1982.

ME720 Introduction to Mechanical Systems (3-0-0) 3

Engineering materials and their properties- structure properties and their relationship, Mechanical behaviour, stress and strain, Principal stress and Theories of failure. Principles of mechanism belt, rope, chain, gears and linkages, Manufacturing processes; casting, metal forming, machining and machine tools, press working.
Concept of system and volume, Fluid properties, Equations of mass energy and momentum balance, Flow regimes and hydrodynamics, Basic laws of thermodynamics, Enthalpy and entropy, Cycles for diesel and petrol engines, Modes of Heat transfer

References:

Yunus A Cengel, Heat Transfer: A Practical Approach, McGraw Hill, 2002
F.P.Incropera, and D.P.Dewitt, Fundamentals of Heat & Mass Transfer, John Wiley, Fourth Edition, 1998.
Arthur G. Erdman, George N, Sandor, Mechanism Design –Analysis and Synthesis, Vol. I, Prentice Hall,New Jersey, 1984
Paul Degramo, Materials and Processes in Manufacturing, 9th edition, John Wiley & Sons, 2003.

ME721 Sensors and Signal Conditioning (2-0-2) 3

Sensor classification, Sensors parameters, Selection of sensors, Proximity, Resistive sensors, Capacitive sensors, Inductive sensors, Thermal sensors, Humidity sensors, Electromagnetic sensors, Light sensing technology, Moisture sensing technology, Carbon dioxide sensing technology, Interfacing of sensors and Signal Conditioning: Change of bios and level of signals, Loading effects on sensor's output, Potential divider, Passive Filters, Op-Amp
Fundamentals, Basic op-amp configurations, Ideal op -amp circuit analysis, Negative feedback, Op- amp applications, Instrumentation amplifiers, Instrumentation applications, Analog to digital converters types and applications, digital to analog converters types and applications, Data acquisition hardware and applications.

References:

Subhas Chandra Mukhopadhyay: Smart Sensors, Measurement and Instrumentation,, Springer publication 2011
Alan S Morris, Reza Langari, Measurement and Instrumentation: Theory and Applicationc, Academic Press, Elsevier, 2015
Operational Amplifiers and Analog Integrated Circuits Francos; McGraw Hill International Edition, 1988 Randy Frank, Artech ,Understanding Smart Sensors House sensors library publications, 2010. John Marcus Analog Circuit Design, Pretance Hall, 2001
Nikolay Kirianaki, Sergey Yurish, Nestor Shpak, Vadim Deynega, Data Acquisition and Signal Processing for Smart Sensors, John Wiley & Sons Ltd, 2002.

ME722 Actuators and Control (2-0-2) 3

Solenoids, Stepping motors, DC motors, BLDC motors, Induction motors, Synchronous motors, Switched reluctance motors, Servos and synchros, Linear induction motors, Characteristics of machines : braking , four quadrant operation with power conditioners, Power amplifiers: linear and PWM , Power Operational amplifiers, Choppers, Rectifiers, Inverters and Cyclo converters.
Hydraulic and Pneumatic actuators Introduction, Circuit Symbols, Fluid Pumps and Motors types and applications, Control Valves, Servo Systems, Design consideration of Circuits, Pneumatic Compressors and their Working Principles, Principles of Pneumatic circuit design, Maintenance of Circuits, K-V Diagrams and Electrical Controls in Pneumatic Circuits, PLC control of hydraulic and pneumatic systems. Hydro-Pneumatics, Fluidics,

A.E. Fitzgerald, Charles Kingsley Jr., Stephen D. Umans : Electric machinery McGraw-Hill Publication, 6th edition, 2001
G.K Dubey : Fundamentals of Electric Drives, Narosa Publication, 2003
D.A. Bradley, D.Dawson,N.C.Burd and A.J.Loader: Mechatronics : Electronics in products and processing, Chap man and Hall,1993.
Esposito A.P., Fluid Power, Pearson Education Asia, 2005.
Text Book of Hydraulics and Pneumatics, Festo Didactic, 4th Edition, 2001.
Andrew Parr, Hydraulics and Pneumatics, Jaico Pub, 2000.

ME723 ADE and Microcontroller Lab (0-0-3) 2

Laboratory exercises related to rectifiers, choppers, power op amps etc. Exercises related to digital IC's, logic gates, flip-flops, counters and latches, registers, few digital systems. Programming and interfacing experiments on microcontroller. Exercises related to PLC programming and drive control using PLC

References:

Operational Amplifiers and Analog Integrated Circuits Francos. McGraw Hill International Edition, 1988 Randy Frank, Artech by Understanding Smart Sensors House sensors library publications, 2010. John Marcus Analog Circuit Design by, Pretance Hall, 2001

Nikolay Kirianaki, Sergey Yurish, Nestor Shpak, Vadim Deynega, Data Acquisition and Signal Processing for Smart Sensors John Wiley & Sons Ltd, 2002.

ME724 Control Engineering (3-0-0) 3

Dynamic systems, classification, linear and nonlinear systems, system modeling, state variable representation, linearization, transfer function, poles and zeros, dynamic response, time domain specification, control system, open loop and closed loop control, regulator and servo control, feedback control - classical PID control.

References:

Benjamin C. Kuo Farid Golnaraghi, Automatic Control Systems, 9ed, Wiley, 2014.

Gene Franklin et.al., Feedback Control of Dynamical Systems, Pearson, 2006

Manfred Schleicher, Frank Blasinger, Control Engineering, JUMO GmbH & Co Germany 2003 Richard Dorf and Robert Bishop, Modern Control Systems, 12th edition Pearson, 2010

K. Ogata, Modern Control Engineering, Prentice Hall International, NJ.2004

ME725 Micro Electro Mechanical Systems (3-0-0) 3

MEMS overview, working principle of sensors and actuators, materials for MEMS, processing of MEMS, scaling issues and design of MEMS micromechanical structures, CAD application in design. *References:*

Stephen D. Senturia, Microsystem Design, Springer; 1st edition . 2000. Corr. 2nd printing 2004 edition, 2004

ME726 FMS and Simulation Lab (0-0-3) 2

Exercises related to automation design using Pneumatic and Electro pneumatic systems, Exercises related to robot programming in FMS system, simulation of trajectories, interlocks, Exercises on CNC machining and simulation on factory automation related to palletizing elevators, conveyors routing using simulation packages.

References:

Esposito A.P., Fluid Power, Pearson Education Asia, 2005.

Text Book of Hydraulics and Pneumatics, Festo Didactic, 4th Edition, 2001.

Andrew Parr, Hydraulics and Pneumatics, Jaico Pub, 2000.

ME831 Smart Structures and Materials (3-0-0) 3

Sensor and actuator techniques, signal processing for control of smart structures, smart materials, models, active sensory material systems, applications of smart materials primarily for vibration control, finite element models for smart materials.

References:

Melschwartz, Encyclopedia of smart materials set,Wiley Interscience, 2001

A D Srinivasan, D Michael Mcfarland, Smart structures analysis and design, Cambridge univ press, 2000 B Culshaw, Smart structures and materials, Artec house pub, 1996

ME832 Intelligent Systems (3-0-0) 3

Concept of machine intelligence, intelligent agents, vision and image analysis, principles of decision making, fuzzy logic, decision trees, case-based reasoning, genetic algorithms, neural networks and expert systems, Deep learning techniques

References:

Junhong Nie , Derek Linkens, Fuzzy-Neural Control: Principles, Algorithms and Applications, PHI, 2005.

Timothy J Ross, Fuzzy Logic with Engineering Applications, McGraw-Hill, 1997.

Simon Haykin, Neural Networks - A Comprehensive Foundation, Second Edition, Prentice-Hall, 1999. George F Luger, Artificial Intelligence, Addison Wesley Publishing Company, 4th edition 2001

Bart Kosko, Neural networks and fuzzy systems, Prentice-Hall, Inc. Upper Saddle River, NJ, USA, 1991 Michael Negnevitsky, Artificial intelligence – a guide to intelligent systems, Addison Wesley 3rd edition, 2011

ME833 Nano Technology (3-0-0) 3

Individual nano particles, properties, carbon nano structures, bulk nano structure materials, molecular engineering, Nano machines and nano devices, Molecular machining, Manufacturing and computation.

References:

K. Eric Drexier, Nano systems, Wiley; 1st edition,1992

J. Storrs Hall, Nanofuture: What's Next For Nanotechnology, Prometheus Books, 2005. C P Poole, F J Owenf, Introduction to nanotechnology ,Wileyinterscience, 2003 Editors at scientific America, Understanding nano technology, Warner books, 2002

ME834 Digital System Design (3-0-0) 3

Review of combinational logic design using PLDs., Design of Synchronous Sequential logic systems, Introduction to VHDL, Design of system controllers, Design of systems using PLDs / FPGAs, Fundamentals of Data converters.

References:

A.S. Sedra , K.C. Smith Microelectronics Circuits, Oxford University Press, 5th edition, 2003.

J. Millman, A. Grabel, Microelectronics, McGraw Hill, , 2nd Edition 1987.

J.F.Wakerly, Digital Design -PH publications, 3rd edition, 2001 W.Fletcher, An Engineering approach to digital design -PHI publication.

M.J.Sebastian Smith, Application Specific Integrated Circuits, Addison Wesley Pub. 1999 CHRoth, Digital system design -PWS publications, 1997

ME835 Modeling and Simulation of Mechatronics Systems (3-0-0) 3

Basic component models, system model and automated computer simulation, state space equation and analysis of linear systems, transducers, amplifiers and instruments, mechanical and thermo fluidic systems, non linear system simulation.

References:

Dean C. Karnopp, Donald L. Margolis, Ronald C. Rosenberg, System Dynamics :*Modeling and Simulation of Mechatronic Systems Wiley-Interscience, 5th edition ,2012.*

Ernest O. Doebelin, System Dynamics: Modeling, Analysis, Simulation, Design Marcel Dekker 1998

Shuvradas : Mechatronic modeling and simulation using bond graph, CRC plus, 2009

ME836 Electronic Measurement and Instrumentation (3-0-0) 3

Measurement Systems, Electromechanical Instruments, Bridges, Electronic Instrumentation, Oscilloscopes, Signal Analysis, Frequency, Time interval measurements, Physical Parameter Measurements, Transducers, Data Acquisition Systems.

References:

Rajput R.K.,. Electronic Measurements and Instrumentation, S Chand & Company, 2008

U.A.Bakshi, A.V.Bakshi., Electronics Measurements And Instrumentation, Technical Publications, 2008 B.H. Oliver and J.M. Cage, Electronic Measurements and Instrumentation, McGraw-Hill, 1975

Albert D. Helfrick, William D. Cooper, Modern Electronic Instrumentation and Measurement Techniques, PHI, 2001

ME837 Embedded System Design (3-0-0) 3

Embedded controllers, basic requirements, design of embedded systems, system on chip concept. VLSI CAD application, Case study: DSP/microprocessor based or FPGA based system design

References:

Jack Ganssle, The Art of Designing Embedded Systems, Elsevier, 1999.

J.W. Valvano, Embedded Microcomputer System: Real Time Interfacing, Brooks/Cole, 2000 C.H. Roth Digital system design using VHDL,PWS 1998 User manual of Microprocessor /DSPs

Arnold. S. Berger, "Embedded Systems Design - An introduction to Processes, Tools and Techniques", Easwer Press, 2001

Dr. K.V.K. Prasad, "Embedded / Real-Time Systems: Concepts, Design and Programming Black Book" , New ed (MISL-DT) Paperback 2003

ME838 Modern Control Engineering (3-0-0) 3

State variable analysis of dynamic systems, System classification: SISO and MIMO Systems, Linear and nonlinear systems, Autonomous and non autonomous systems, time variant and time invariant systems. State space model of physical systems: Signal flow graphs, Relation between transfer function and state space equation. Time Response:

State transition matrix, Feedback control: Controllability, and Observability, Stability analysis – linear and nonlinear Systems:. Linearization: SISO and MIMO (State Space) Linearised model

References:

K. Ogata, Modern Control Engineering, Prentice Hall International, NJ.2004 Gene Franklin et.al., Feedback Control of Dynamical Systems, Pearson , 1998

C.L Phillips, R.D Harbor Feedback Control Systems, Prentice Hall International, NJ.2000 R C Dorf and R H Bishop, Modern Control Systems, Prentice Hall International, NJ.2001 Burns R.S., Advanced Control Engineering, Butterworth Heinemann, 2001.

ME839 Smart Sensors and Actuators (3-0-0) 3

Smart Sensor and Actuator Technologies, Fabrication and manufacturing of smart material for sensors and actuators, Performance and behaviors, Modeling of smart sensors and actuators, Control and Applications Future Development

References:

Ristic L (Ed), Sensor Technology and Devices, Artech House, London, 1994.

Wise K D (Guest editor), Integrated Sensors, Micro-actuators, and Micro-systems (MEMS), Special Issue of Proceedings of the IEEE, Vol.86, No.8, 1998

Kam Leang, Kwang Kim, Smart Actuator and Sensor Technologies, Butterworth-Heinemann 2018 Bob Tucker, Smart Actuators and Smart Sensors,Willfordpress Publications, 2014

Randy Frank, Understanding Smart Sensors, Artech House Remote Sensing Library, 2011

ME840 Automation System and Internet of Things (3-0-0) 3

Building blocks of automation, Mechanization of parts handling, automation of assembly Markov and queuing models, Petrinet models, various manufacturing systems, batch, mass, group, cellular systems, Process planning and CAPP. Shop floor control and automatic identification and assembly techniques, computer network for manufacturing, Integration of design and manufacturing, Design assignment and practice based on process planning and CAPP. Agent based manufacturing. IOT applications in automation.

References:

Mikell P Groover,Automation, Production systems, and computer integrated Manufacturing, Prentice Hall, 4th edition 2002

Jerome H Fuchs, The illustrated handbook of Advanced Manufacturing methods Prentice-Hall, Business and Professional Division, c1985

YorenKoren Computer control of machine tools McGraw-Hill, 1983

Bahga and V. Madisetti, Internet of Things, A hands-on approach, CreateSpace Independent Publishing Platform, 1st edition, 2014.

S. Jeschke, C. Brecher, H. Song, and D. B. Rawat, Industrial Internet of Things: Cybermanufacturing Systems, Springer, 1st edition, 2017.

ME841 Automotive Electronics (2-0-2) 3

Need for Electronics in Automotive Systems, Overview of vehicle electronic systems, Engine Control Unit, Different control strategies for cruise control, suspension control, Antilock Braking system control algorithm,

Automatic transmission system gear shift control, Communication systems like CAN, Flexray etc. X- by wire systems, Autonomous vehicle and their technology, Hybrid vehicles and their electrical systems, AUTOSAR, Telematics, Vehicle diagnostics systems. Embedded System in Automotive Applications,

Laboratory: Experiments on open loop ECU using LABCAR, embedded controllers, actuators and sensors integration

References:

Lack Erjavec Automotive Technology A systems approach, , Thomson Delmar Learning, 4th edition, 2005.

Willliam B., Ribens Understanding Automotive Electronics, , An Inprint of Elsevier Science,6th Edition., 2004.

Robert Bosch GmbH Diesel-Engine Management,, Bentley Publishers, 3rd edition. 2004.

Robert Bosch,GmbH Gasoline-Engine Management,, Bentley Publishers , 2nd edition, 2004.

Robert Bosch GmbH,Automotive Handbook, Bentley Publishers, 6th edition. 2004.

ME730 Advanced Fluid Mechanics (3-0-0) 3

Recapitulation of fundamentals: Basic concepts. Navier Stokes equations, Potential flow theory and transformation flow around bodies, cylinders and aerofoils. Transformation of circle into aerofoil. Introduction to turbulent flow. Prediction of velocity and pressure distribution, boundary layer problems, laminar and turbulent boundary layers, separation criterion. Introduction to compressible flow, velocity of sound and mach number, Isentropic flow, flow with friction and heat transfer. Analysis of flows with normal and oblique shock waves. Supersonic flows. Unsteady flows.

References;

Yuan, S. W., Fundamentals of Fluid Mechanics, Prentice Hall, India.
S. M. Yahya, Compressible Fluid Flow, IIT, New Delhi.
A. H. Shapiro, The Dynamics and Thermodynamics of Compressible flow, Ronald Press.
Nijaguna, Thermal Science/Engineering data Hand Book.

ME731 Heat and Mass Transfer (3-0-0) 3

Extended surface heat transfer with variable cross section. Finite difference method for solving two dimensional heat conduction problems. Natural and forced convection, Boundary layer analysis. Heat transfer with phase change. Two-phase flow heat transfer with pure and mixed fluids. Pressure drop in two phase flow. Boiling in two phase flow. Design of heat exchangers. Special heat transfer processes. Radiation heat transfer. Radiation properties and laws. Electrical analogy. Radiation configuration factor. Radiation through gases and absorbing media. Mass Transfer: Mechanism and fundamental concepts, definition of concentration, mass fluxes and mole fluxes, Ficks law of diffusion, temperature and pressure dependence of mass diffusivity, diffusion in a multi component system, theory of diffusion in gases and liquids, mass transfer coefficient, conservation of species for a control volume – species continuity equation, equimolar counter diffusion, simultaneous heat and mass transfer.

References;

J.P. Holman, Heat Transfer, McGraw Hill, New York, 8th Edition, 2012.
Frank Kreith, Heat Transfer, International Text Book Co, 7th edition, 2011.
NecatiOzisik M., Heat Transfer: A Basic approach, McGraw Hill Book Company, New York, 1985.
Kays W M and Crawford M E, "Convective Heat and Mass Transfer", McGraw Hill Int Edition, 3rd edition, 1993.
Spalding D B, "Introduction to Convective Mass Transfer", McGraw Hill, 1963.
Bird R. B., Stewart W. E. and Lightfoot E. N., " Transport Phenomena ", John Wiley and sons, Inc., 1960.
Nijaguna B. T, Thermal Science/Engineering data Hand Book.

ME732 Refrigeration Systems (3-0-0) 3

Principles of vapour compression refrigeration system, cascade cycles, working fluids, compressors - reciprocating, rotary, scroll compressors, screw and centrifugal compressors. Heat exchangers, condensers, evaporators, dynamics of capillary and valve expansion devices, Design criteria for pipelines, absorption and adsorption refrigeration cycles, choice of working fluids, Thermoelectric refrigeration and Hybrid cycles.

References;

R.B. Scott, Cryogenics Engineering, Van Nostrand.
R.F. Barron, Cryogenic Systems, McGraw Hill, New York.
W B Gosney, Principles of refrigeration, Cambridge University, 1982.
C P Arora, Refrigeration and air conditioning, McGraw Hill, 2009, ASHRAE Hand books

ME733 Thermal Engineering Lab (0-0-3) 2

Burning velocity measurement & Flame stability studyDetermination of flow boiling heat transfer coefficient in conventional channelEstimation of unknown parameters using inverse techniques from fin heat transfer Inverse estimation of heat fluxExperiment on pool boiling heat transferThin foil technique for film/jet cooling Determine the performance parameters of Savonius water turbine.Study of CRDI engine operated with open ECU Performance of Air conditioner test rig Thermal conductivity of liquids

References;

M.N. Ozisik, H.R.B. Orlande, Inverse Heat Transfer: Fundamentals and Applications, Taylor and Francis, New York, 2000.
Incropera F.P., DeWitt D.P., Fundamentals of Heat and Mass Transfer, fifth ed., John Wiley & Sons, Inc., New York, 2002.
Beck J. V., Blackwell B., Clair C. R., Inverse heat conduction – Ill posed Problems, Wiley, 1985.
Dwight Cooke, Satish G. Kandlikar, "Effect of open microchannel geometry on pool boiling enhancement", International Journal of Heat and Mass Transfer 55 (2012) 1004–1013.

ME734 Design of Renewable Energy Systems (3-0-0) 3

Biogas: Aerobic and anaerobic bio-conversion processes, raw materials, properties, biogas plant technology and status, Geothermal Energy: Hot springs and steam ejection, site selection, power plants, advanced concept. Solar energy: Principles, scope and applications. Wind Energy: Wind energy potential measurement, wind mill and wind electric generator. Mini and micro-hydel. Ocean energy.

References;

J.W.Twidell and A.D. Weer, Renewable energy sources, Taylor & Francis, 2nd Edition, 2006.
P.D. Dunn, Renewable energies: Sources, Conversion and Application, 1986.
S.Rao and B.B. Parulekar, Energy Technology, Khanna Publisher, 2014.
Desire LE Gourieres, Wind power plant: Theory and Design, Pergamon press, 1982.
B.T.Nijaguna, Biomass technology, New Age International Publisher, reprint, 2012.
M. M. El.Wakil, Power Plant Technology, McGraw Hill Book company, 1985.

ME735 Measurements in Thermal Systems (3-0-0) 3

Error Analysis in Experimental Investigations-Curve Fitting of Experimental Data. Methods of Measuring Temperature-Thermocouple, Error Estimation. Convective and Radiation Affects. Measurement of Unsteady Temperature-Optical Methods Shadowgraph, Schilieren and Interferometer, Spectroscopic Temperature Determination. Measurement of Pressure, Vacuum, Level etc. Heat Flux Sensors, Transient Experimental Techniques for Surface Flux Rates. Measurement- Thermal Radiation, Infra-red thermography, Volume Flow Rate, Velocity- Hot Wire and Hot Film Anemometer, Acoustic Methods. Measurement of Turbulence, Pollutants-Gas Chromatography.

References;

E.G.R. Eckert and R.G. Goldstein, Measurement Techniques in Heat Transfer.
E.O. Doebelin, Measurement Systems: Application and Design.
T.P. Holeman, Experimental Methods for Engineers.
H.D. Young, Statistical Treatment of Experimental Data.

ME736 Combustion (3-0-0) 3

Fuels and their properties, Review of basic thermodynamics and gaseous mixtures, combustion thermodynamics, stoichiometry, the First and Second Laws of Thermodynamics applied to combustion, composition of products in equilibrium, fundamentals of combustion kinetics, theory of thermal ignition, self ignition temperature, ignition delay, flame phenomena, deflagration and detonation, laminar flame propagation, flammability limits, flame quenching and minimum ignition energy, laminar burning velocity measurements, turbulent flame propagation, flame stabilization, diffusion flames: gaseous jet flames, burning of condensed phase, vaporization and combustion of liquid fuel droplet, spray combustion, combustion of solid fuels, Rocket motor systems. Combustor design, Fluidized bed combustion.

References;

Glassman I., Combustion, Academic Press, 1987
Kuo K.K. Principles of Combustion, John wiley& Sons, New York 1986
Stephen R.Turns, An Introduction to combustion, concepts and applications, 2e, McGraw Hill, 2000 Gary L. Borman and Kenneth W Ragland, Combustion Engineering, McGraw Hill,1998 R.M.Fristrom, Flame structure and processes, McGraw Hill, New York, 1995
Mukunda H.S., Understanding Combustion, Macmillan India Limited, Madras 1992 S.P Sharma and Chandermohan, Fuels and Combustion, Tata McGraw Hill

ME737 Thermal Computational lab (0-0-3) 2

1.FDM Codes for (i) 1D Parabolic PD equation -4 schemes (ii) 1D Hyperbolic PD Equation-4schemes. (iii)Convergence, stability and errors. 2. FDM computer codes for elliptic PD equation. 3. FDM computer codes for 2D steady Burgers equation. 4. FEM codes for (i) 1D steady state heat conduction/convection (ii) 1D transient heat conduction/convection (iii) 1D fluid flow between plates, ducts, annular cylinder 5. FVM codes for 1D steady and unsteady heat conduction/convection. (iv) Gaussian elimination, Jacobi method, Thomas Algorithm for solving heat transfer derived algebraic equations.

References;

Frank Krith& Bohn, Principles of Heat Transfer, Cengage Learning, 8th edition (2011).
J N Reddy, Introduction to finite Elements methods in heat transfer and fluid mechanics, CRC press, 2012.
C A J Fletcher, Springer Verlag, Computational Techniques for Fluid Dynamic,Vol-1, Springer, 2014.

ME845 Transport Phenomena in Porous Media **(3-0-0) 3**

Fluid mechanics Darcy momentum equation; Porosity; Pore Structure; Permeability; High Reynolds number flows; Brinkman superposition of bulk and boundary effects; Local volume-averaging method; Homogenization method; Semi-heuristic momentum equations; Significance of macroscopic forces; Porous plain media interfacial boundary conditions; Variation of porosity near bounding impermeable surfaces.

Conduction and convective heat transfer; Conduction heat transfer Local thermal equilibrium; Local volume averaging for periodic structures; Particle concentrations from dilute to point contact; Areal contact between particles caused by compressive force; Statistical analysis; A variational formulation; A thermodynamic analogy. Convection heat transfer-Dispersion in a tube; Hydrodynamic dispersion; Dispersion in porous media; Local volume averaging for periodic structures; Three dimensional periodic structures; Dispersion in disordered structures; Simplified hydrodynamics, particle hydrodynamics; Properties of dispersion tensor; Experimental determination of D; Dispersion adjacent to bounding surfaces.

Radiative heat transfer: Radiation heat transfer- Continuum treatment; Radiative properties of single particle; Radiative properties; Dependent and Independent; Volume averaging for independent scattering; Experimental determination of radiative properties; Boundary conditions; Solution methods for equation of radiative transfer; Scaling in radiative heat transfer; Non-continuum treatment; Monte Carlo simulations; Radiant conductivity; Modeling dependent scattering; Recent developments in the analysis of heat transfer in porous media**.**

References;

M. Kaviany, Principles of Heat Transfer in Porous Media, Springer-Verlag, New York, 1995.

R.G. Carbonell and S. Whitaker, Heat and Mass Transfer in Porous Media, in Fundamentals of Transport Phenomena in Porous Media, Bear and Corapcioglu, eds., MartinusNijheff Publishers.1984

Jacob Bear, Dynamics of Fluids in Porous Media, Dover Publications, 1988.

ME846 Automotive Pollution Control **(3-0-0) 3**

Characterization of pollution control, Primary pollutants, Air pollution and health, Air pollution and the environment, Laws and regulation, Pollutants from SI and CI engines. Methods of characterization and analysis. Mechanisms of pollutant formation in SI and CI engines, factors affecting emissions from engines engine modifications to control emissions, exhaust after treatment in SI and CI engines, influence of fuel properties, fuel specifications, alternative fuels and their emissions, emission standards and regulatory test procedures, Economic challenges, Water pollution, Legal aspects, Environmental policy.

References;

M.N Rao and H.V.N Rao, Air Pollution, Tata McGraw Hill, 2017

John B Heywood, Internal Combustion Engine Fundamentals, McGraw Hill International Edition, Singapore, 1989

Paul Degobert, Automobiles and pollution, Technip, Paris

Patterson D.J. and Henein N A. Emissions from combustion engine sand their control Ann Arbor Science Publishers, Michigan 1972

Crouse William, Automotive Emission Control,(Gregg Division check), McGraw Hill.

ME847 Design and Analysis of Solar Energy Systems **(3-0-0) 3**

Introduction to solar energy, Blackbody radiation, Relation between radiation field energy density and radiation spectrum, Planck' s formula in energy unit, Maximum spectral density, Planck's formula in wavelength unit, Wien displacement law, Stefan Boltzmann law, Photoelectric effect, Einstein's theory of photons, Einstein's derivation of the black, body formula. Solar geometry -, the structure of the Sun, the origin of solar energy, Rotation and orbital motion of the Earth around the Sun, Solar time, sidereal time, universal standard time, local standard time, Equation of time, Intensity of sunlight on an arbitrary surface at any time, Interaction with the atmosphere, Measurement of Solar Radiation, Solar collectors design and analysis, Solar air heaters, green buildings, applications of solar energy in various fields, water heating, air heating, drying etc, Thermal storage – sensible storage, latent heat storage and thermochemical storage, other methods for utilization of solar energy, Economic viability of solar systems, Thermal modeling of solar devices–Case study based assignment.

References:

Duffie J.A. and Beckman W.A., Solar Thermal Processes, John Wiley, New York, 1974.

Garg H.P, J. Prakash, Solar Energy, TMC, 1997.

Sukhatme S.P, Solar Energy Principles of Thermal Collection and Storage, 2ndEd., Tata Mc Graw-Hill, New Delhi, 1996.

C. S. Solanki, Renewable Energy Technology, Prentice Hall, New Delhi, 2008.

ME848 Nuclear Engineering (3-0-0) 3

Scope of Nuclear Power- Review of Nuclear Physics- Reactor Theory. Elements of Reaction Physics. Thermodynamics Aspects of Nuclear Power, Types of Reactors, and Economics. Steady and Unsteady State Calculation of Critical Size of Homogeneous and Heterogeneous Reactors. Elementary Idea of Reactor Instrumentation and Control. Nuclear Reactor Materials & fuels, Shielding, Thermal Aspects of Nuclear Systems. Fission and fusion, need for plasma, Lawson criterion, Confinement problem, Laser driven fusion, Magnetic confinement, Plasma concept, Single particle motions in complex magnetic field geometries, Equilibrium and stability, Cross field transport, Important heating schemes, Tokamak and magnetic mirror, Reactor concepts.

References:

Brent J. Lewis, E. NihanOnder, Andrew A. Prudil, Fundamentals of Nuclear Engineering, Wiley 2017 Charles F. Bonilla, Nuclear Engineering, McGraw Hill, 2013

A. Harms, K. F. Schoepf, G. H. Miley, and D. R. Kingdon, Principles of Fusion Energy: An introduction to Fusion Energy for Students of Science and Engineering, World Scientific, 2000.

Raymond L. Murray. Nuclear energy: an introduction to the concepts, systems, and applications of nuclear processes, Butterworth-Heinemann 2009

Samuel Glasstone and Alexander Sesonske, Nuclear Reactor Engineering: Reactor Design Basics, (Volume One) CBS Publishers and Distributors 1998

Samuel Glasstone and Alexander Sesonske, Nuclear Reactor Engineering: Reactor Systems Engineering, (Volume Two) CBS Publishers and Distributors 1998

Ram, K.S., Basic Nuclear Engineering, Wisely Eastern, Wiley Eastern Ltd., New Delhi 1990.

Jeffrey P. Freidberg, Plasma Physics and Fusion Energy, Cambridge University press, 2008.

ME849 Turbomachinery (3-0-0) 3

Classification –Specific work –Representation of specific work in TS and HS diagrams- Internal and external losses-Euler's equation of turbomachinery –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 turbomachines-Cavitation parameters, Surge and Stall. Marine turbines.

References:

Turton, R.K. , Principles of Turbomachinery, Chapman & Hall, 1996

Gopala Krishanan, G. and D. Prithvi Raj, A Treatise on Turbomachinery, Scitech Pub., 2003 Logan Earl, Jr., Hand book of Turbomachinery, Marcel Dekker, 1995 D.G. Shephard, Principles of Turbomachinery, McMillan Co., New York.

S.M. Yahya, Turbomachines, IIT, New Delhi.

H. Cohen and Rogers, Gas Turbines Theory, Longman Green Co., Ltd

Erik Dick, Fundamentals of Turbomachines, Springer, ISBN-13: 978-9402403480

ME850 Multiphase Flows (3-0-0) 3

Introduction to multiphase flows -Definition, Types, Methods of analysis, Flow patterns. Flow models - Homogeneous, separated, Drift flux models. Flow boiling and condensation: Introduction to convective boiling and condensation, flow pattern predictions, heat transfer and pressure drop in different flow patterns. Pool boiling and condensation - boiling curve. Multiphase flows with bubbles, droplets, and particles. Nanofluids. Droplet condensation.

References:

R. Clift, J. R. Grace,M.E.Weber, "Bubbles, Drops and Particles", Dover Publications, US(2005).

C.T. Crowe, John D. Schwarzkopf, M. Sommerfeld, and Y. Tsuji, "Multiphase flows with droplets and particles", CRC Press, 2012.

J.C. Collier, Convective Boiling and Condensation.

L. Strong, Boiling Heat Transfer and Two-phase Flow.

Sarit K. Das, Stephen U. S. Choi, Wenhua Yu, T. Pradeep, Nanofluids, John Wiley and Sons Inc.

ME851 Advanced Thermodynamics (3-0-0) 3

Recapitulation of classical Thermodynamics, Thermodynamics potentials and criteria of equilibrium, Thermodynamics of chemical reaction, Advanced energy systems, Kinetic theory of gases and distribution of molecular velocities. Statistical thermodynamics and quantum mechanics. Irreversible thermodynamics. Transport processes in gases.

References;
Michel M. Saad, Thermodynamics for Engineers, Prentice Hill J.P. Holman, Thermodynamics, Mc Graw Hill P.K. Nag, Basic and Applied Thermodynamics.
Lee & sears, Thermodynamics
Lee, Sears and Turcotti, Statistical thermodynamics, Addison-wasley

ME852 Theory and Design of IC Engines (3-0-0) 3
Constructional features of different engines.Combustion phenomena in SI engine.Combustion knock.Combustion Chamber designs for SI engine,combustion phenomenon in the CI engine.Combustion chamber design for the CI engine.Delay period and diesel knock,IC engine design principles.Design of engine components.Piston, connecting rod,crankcase, crankshaft, manifolds, valves. Design of cooling system, lubricating oil system and radiator fans,computer aided design of engine components. Engine balancing, recent advances.
References:
Kolchin and Demidov V, Design of Automotive Engines, Mir Publishers, Moscow, 1984 Charles Fayette Taylor, Internal combustion Engines in theory and practice. Vols 1 and 11 The MIT Press Massachusetts Institute of Technology, USA, 1996 John Fenton, Engine Design, University Press Cambridge, Great Britain, 1986 Colin R. Ferguson, Internal Combustion Engine, Applied Thermosciences, Johnwiley and sons

ME853 Design of Air Conditioning Systems (3-0-0) 3
Psychrometry. Air-conditioning calculations. Comfort scales. Solar radiation. Estimation of solar radiation from the solar angles. Cooling load and heating load calculations. Solar space heating and cooling. Passive cooling systems. Dehumidification and humidification equipment. Design of cooling towers, spray washers, air washers, cooling and dehumidifying coils. Design of air duct system. Room air distribution. Various types of air conditioning systems. Various types of system controls. Mass transfer by molecular diffusion and convection. Calculation of mass transfer coefficients. Interface mass transfer. Application of air conditioning.
References;
Arora C. P., Refrigeration and Air Conditioning, Tata McGraw Hill
Heat transfer/Refrigeration/Thermodynamics/Air conditioning data hand book.
Parker, Spitler M, Heating, Ventilating and air conditioning, Wiley India, 2011.

ME854 Cryogenic Technology (3-0-0) 3
Introduction, Applications of cryogenic systems, Properties of liquids and solids at Cryogenic temperatures, Joule Thomson expansion and isentropic expansion processes, Liquefaction of permanent gases, Methods of Air liquefaction, separation, storage and transport, Applications, cryogenic insulations vacuum technology, Cryo-pumping, Cryogenic heat pipes, Cryo engines, Cryogenic instruments, Safety in cryogenics. Materials for cryogenic engines.
References;
R.B. Scott Cryogenics Engineering - Van Nostrand
R.F. Baroon "Cryogenic Systems, McGraw Hill New York
Mamata Mukhopadhaya, Fundamentals of cryogenic engineering, PHI
Arora C P Refrigeration and Air conditioning "Tata McGraw Co. Ltd. New Delhi Refrigeration / Thermodynamics/ Heat transfer / Air conditioning Data Hand book

ME855 Gas Dynamics (3-0-0) 3
Kinetic theory of gases, molecular energies, transport phenomena, intermolecular forces, real gases, molecular collisions, introduction to compressible flow, sonic velocity, mach number, One-dimensional varying area adiabatic flow, standing normal shocks, moving and oblique shocks, Prandtl- Meyer flow, Fanno flow, Rayleigh flow, real gas effects, Boltzmann equation, simple flows induced by temperature fields, Steady state two-dimensional flow.
References;
George Turrel, Gas Dynamics: Theory and Applications, John Wiley & Sons, 1997
Robert D Zucker and Oscar Biblaz, Fundamentals of Gas dynamics, John Wiley & Sons, 2002 Yoshio Sone, Molecular gas dynamics: theory, techniques and application,Birk Hauser, Boston, 2007 EthirajanRathakrishnan, Applied Gas Dynamics, John Wiley & Sons, 2010.
V. Babu, Fundamentals of Gas Dynamics, Ane Books Pvt. Ltd, New Delhi, 2009.

ME856 Alternative Fuels for I C Engines (3-0-0) 3

Conventional liquid HC fuels. Properties of conventional fuels.Alternative engines and fuels, including for racing, Fuel measurement.Transferring the fuel from tank to metering unit.Fundamental principles of carburetion. Elements of carburetors.Constant depression and fixed venture carburetors in practice.Induction manifold design,LPG fuel and mixing systems.Gasoline injection.Combustion and combustion chambers.Emissions and their control.Sampling and analysis of emissions.Crude oil delivered diesel fuel.Fuel quality and additives, Alternative fuels. Injectors and inline and unit injection pumps. Rotary and distributor type injection pumps. Test cycles, sampling and analysis of exhaust emissions. Optimizing air induction – variable valve timing and differences in approach for diesel and gasoline engines.Optimizing air induction – induction pipe tuning.Optimizing air induction-Turbocharging and supercharging, complex pressure wave charger. Introduction to alternate fuels, biomass combustion equipment, biomass fuel supply and purchasing, processing network, fuels witching feasibility study.

References:

T.K.Garret, Automotive fuels and fuel systems Vol.1& 2,John Wiley & Sons, 2008

Thomas McGowan, Biomass and Alternate fuel systems an engineering and economy Guide, John Wiley & Sons, 2009

Ahindra Nag, Biofuels refining and performance, McGraw-Hill Professional, 2008.

AyhanDemirbas, Biodiesel: a realistic fuel alternative for diesel engines. Springer, 2008.

Lucas Reijnders, Mark A. J. Huijbregts, Biofuels for road transport: a seed to wheel perspective. Springer, 2009.

Joshua Tickell, Kaia Tickell, from the fryer to the fuel tank: the complete guide to using vegetable oil as an alternative fuel, Biodiesel America, 2000.

ME857 Sustainable Energy Technologies (3-0-0) 3

Sustainability Concept for Energy, Challenges in Energy System Design, Product innovation. Efficient Production and Use of Energy, Sustainability indicators, Biomass and Waste as Sustainable Resources, Biomass into Liquid Fuels, Significance of pyrolysis and torrefaction of biomass, Pyrolysis methods to produce Biofuels from biomass and other organic waste materials generated in Industries, Municipality, Agricultural Residues. Industrial Catalysis for fuel Production, Physical and Chemical Characterization of fuels. Torrefaction methods, process of torrefaction, pelletisation/briquetting processes, densification methods, bio coal production, gasification of biomass. Biomass and Waste Gasification, Types of Gasifiers and Bio-refineries, Plasma Arc Gasification: Garbage to Electricity, Liquid Fuels, Plasma Economics, Atmospheric Plasma, Pollution control systems for waste to energy technologies. Fuel Cell and Hybrid Systems, Fuel Cells in the Waste-to-Energy Chain, Types of Fuel Cells, Fuel Gas Clean-up and Conditioning, High-Temperature Fuel Cell Plants and Applications, Bio-methane and Natural Gas, Prospects of Hydrogen as a Future Energy Carrier. Carbon Emission Credits, Carbon Capture and Storage technology: status and future, Sustainable Nuclear Energy, Distributed Energy Generation, Multi-Criteria Decision making in Energy Systems and Environment, Simulation tools, Energy Economics, Environmental and social impacts of waste to energy (WTE) conversion plants, Lifecycle assessment (LCA) and its application to sustainable waste management.

References:

Ibrahim Dincerand Calin Zamfirescu, Sustainable Energy Systems and Applications, Springer Science+Business Media, LLC 2011

Knoef, H.A.M.,2012, Handbook of Biomass Gasification, Second edition, BTG Biomass Technology Group, Netherlands.

McPhail, Stephen J., Cigolotti, Viviana, Moreno, Angelo, 2012, Fuel Cells in the Waste-to-Energy Chain: Distributed Generation Through Non-Conventional Fuels and Fuel Cells

Ibrahim Dincerand Calin Zamfirescu, Sustainable Energy Systems and Applications, Springer Science Business Media, LLC 2011

IbonGalarraga, Mikel González-Eguino, Anil Markandya (Editors), Handbook of Sustainable Energy, Edward Elgar Publishing Limited 2011

Fausto Cavallaro (Editor), Assessment and Simulation Tools for Sustainable Energy Systems Theory and Applications, Springer-Verlag London 2013

Halime O. Paksoy (Editor) Thermal Energy Storage for Sustainable Energy Consumption Fundamentals, Case Studies and Design, 2007 Springer

Ronald E. Hester and Roy M. Harrison (Editors) Sustainability and Environmental Impact of Renewable Energy Sources, The Royal Society of Chemistry, Thomas Graham House, 2003

Bergman, P.C.A.; Kiel, J.H.A., Torrefaction for biomass upgrading", ECN report, ECN-RX—05-180,2005.

ME858 Wind Energy (3-0-0) 3

Introduction, Historical development, Current status and future prospects, Sources and characteristics of wind, Power in the wind; Wind resource assessment, Wind measurement, Classification of wind turbines, horizontal and vertical axis wind turbines, Wind turbine aerodynamics, Momentum theory, Blade element theory, Turbine airfoils and rotor wakes, Operational characteristics; Wind turbine design, Component design, Power control, Stall regulation, Pitch regulation, Siting and wind farm design, The measure–correlate–predict technique, Visual and Landscape Assessment, Electric and control systems, Economic assessment, Environmental and social issues, Understand the operation of a low-speed wind tunnel, instrumentation for measuring force, velocity, and pressure, and various aspects of the flow around an airfoil, Pressure distribution over airfoil, measurement of the lift and the drag force, static pressure distribution, and wake velocity profile for a symmetric and asymmetric airfoil; flow visualization over a symmetric airfoil using smoke generator, compare the wind tunnel measurements with theory and other experimental data. Micro wind mills.

References:

J.F. Manwell, J.G. McGowan, and A.L. Rogers *Wind Energy Explained, Theory, Design and Application, Second Edition John Wiley & Sons Inc. 2010*

Tony Burton, David Sharpe, Nick Jenkins, Ervin Bossanyi, Wind Energy Handbook, John Wiley & Sons, Ltd, 2001

Sathyajith Mathew, Wind Energy Fundamentals, Resource Analysis and Economics Springer-Verlag Berlin Heidelberg, 2006

Jewel B. Barlow, William H. Rae, Alan Pope Low-Speed Wind Tunnel Testing, 3rd Edition, John Wiley and Sons, 1999

ME859 Nanoscale Fluid Flow and Heat Transfer (3-0-0) 3

Prerequisite : Heat Transfer, Fluid Mechanics

Introduction: Fundamentals of kinetic theory-molecular models, scaling laws for micro-domains, Microscale gas flows: Wall slip effects and accommodation coefficients, flow and heat transfer analysis of microscale Couette flows, micro-Poiseuille flows, effects of compressibility, introductory concepts on gas flows in transitional and free molecular regimes. Microscale liquid flows, An introduction to biomicrofluidics. Introduction to nanofluidics, concepts of nano-fluids and their augmented transport characteristics.

References:

Suman Chakraborty, Microfluidics and Microfabrication, Springer, 2010.

Stephane Colin, Microfluidics, John Wiley & Sons, 2010

Clement Kleinstreuer, Microfluidics and Nanofluidics: Theory and Selected Applications, John Wiley & Sons, 2013.

George Karniadakis, Ali Beskok, Narayan Aluru,Microflows and Nanoflows: Fundamentals and Simulation, Springer Verlag, 2005.

Yoshio Sone, Kinetic Theory and Fluid Dynamics, Jaico Publishing House, 2004.

ME860 Applied Computational Methods in Thermal Engineering (3-0-0) 3

Mathematical modeling of simple problems, Algorithm, Approximations and errors. Roots of Equations: Bracketing and open methods as applied to thermal engineering problems. Solution of linear and non- linear algebraic equations, Statistical description of thermal data, Modeling of data, Boundary value and initial value problems of heat transfer (conduction, convection and radiation) and fluid mechanics, Numerical solution of partial differential equations of heat transfer and fluid mechanics. Eigen value problems. Tensors.

References:

William H Press, Saul A Teukolsky, William T Vellerling and Brain P Flannery, Numerical Recipes in C, 2 ed, Cambridge university press.

E.V. Krishnamurthy and S K. Sen, Numerical Algorithms, 2 ed, Affiliated east-west press.

Hoffman, K. and Kunze, R., Linear Algebra (2nd Ed.).

Herstein, I. N. and Winter, D. J., Matrix Theory and Linear Algebra, Macmillan, 1989.

Simmons G. F., Differential Equations, Tata McGraw-Hill, 1985.

Churchill, R. V., Complex Variables and Applications, McGraw-Hill, 1960.

Gupta, A. and Bose, S. C., Introduction to Numerical analysis, Academic Publishers, 1989.

Conte, S. D. and Carl de Boor., Elementary Numerical Analysis, McGraw-Hill, 1980.

Hildebrand, F. B., Introduction to Numerical Analysis, Tata McGraw-Hill, 1988.

Froberg, C. E., Introduction to Numerical Analysis, Wiley, 1965.

ME861 Finite Element Method (3-0-0) 3

Review of Applied Elasticity and Basic concepts of FEM, Finite elements formulation using elastic continuum displacement approach, Generalized finite element concepts-weighted residual and variational approaches. Element types, iso-parametric formulation,numericalintegration,Application to structural mechanics problems: Timoshenko beams, 2-D Problems, Bending of plates. Buckling and Free vibration of beam and plates. Introduction to non-linear problems.Finite element analysis of coupled problems and case studies.

References:

C Zienkiewicz, R L Taylor, J Z Zhu, The Finite Element Method: Its Basis and Fundamentals, Butterworth-Heinemann, 2013.
J. N. Reddy, An Introduction to Finite Element method, 3rd Edition, McGraw- Hill, 2005.
T R Chandupatla, A D Belegundu, Introduction to Finite Elements in Engineering, 4th Edition, Pearson, 2011.
Bathe K.J., Finite element procedures, Prentice-Hall of India, 2002
Buchanan G. R., Finite element analysis, Tata McGraw-HillPublishing, 1995

ME862 Virtual Instrumentation (2-0-2) 3

Introduction to virtual instrumentation and its evolution, Basics of graphical programming and LabVIEW, Introduction to graphical system design, Basics of Signals and Systems, Basics of Data acquisition, Basics of Digital Signal processing and signal manipulation. Application of Sensor, Actuators and DAQ systems in practical systems.

Lab component:

LabVIEW programming, Data collection from sensor inputs, Basic Digital signal processing of complex real world signals, Application of filters, Implementation of Simple controls logics. Interfacing traditional instruments with Lab VIEW, Remote triggered experiments, Mini project

References:

Sanjay Gupta, Joseph John Virtual Instrumentation Using Lab VIEW Tata MaGraw-Hill (2005)
D Patranabis, Sensors and Transducers, Phl 2nd Edition (2003)
J.P. Holman Experimental Methods for Engineers McGrawHill, 6th Edition(2000)
Academic Resources from WWW.NI.COM

ME863 Design For Manufacturing (3-0-0) 3

Selection of Materials and Shapes: Properties of Engineering Materials, Selection of Materials, Selection of Shapes, Selection of Manufacturing Processes: Design for Casting, Design for Bulk Deformation Processes, Design for Sheet Metal Forming Processes, Design for Machining, Design for Powder Metallurgy, Design for Polymer Processing, Design for Assembly: Design for Welding, Design for Brazing and Soldering, Design for Joining of Polymers, Design for Heat Treatment, Design for Reliability and Quality: Failure Mode and Effect Analysis, Design for Quality, Design for Reliability, Approach to Robust Design, Design for Optimization

References:

M FAshby and K Johnson, Materials and Design - the art and science of material selection in product design, Butterworth-Heinemann, 2003.
G Dieter, Engineering Design - a materials and processing approach, McGraw Hill, NY, 2000.
M FAshby, Material Selection in Mechanical Design, Butterworth-Heinemann, 1999. T H Courtney, Mechanical Behavior of Materials, McGraw Hill, NY, 2000.
K G Swift and J D Booker, Process selection: from design to manufacture, London: Arnold, 1997.
S S Rao, Engineering Optimization: theory and practice, John Wiley, NY, 1996.
G Boothroyd, P Dewhurst and W Knight, Product design for manufacture and assembly, John Wiley, NY: Marcel Dekkar, 1994

ME864 Computational Fluid Dynamics (3-0-0) 3

A broad review in terms of historical background, application and purpose of study. Introduction to One-Dimensional Computation by FDM, FEM, FVM. Neumann boundary condition and Dirichlet boundary condition. Governing equations of Fluid Dynamics: Derivation, Discussion, Physical meaning and Governing equation forms suitable for CFD. Partial Differential Equation their mathematical behaviour. Finite Difference Methods. Finite Volume Methods. Discretisation of governing equations by finite difference and finite volume methods. Incompressible Viscous Flow via FDM. Compressible Flows via FDM. Structured Grid Generation. Finite Element Methods: Introduction, FE Interpolation Functions. Linear Problems- Steady State problems, Transient problems. Errors and Uncertainty in CFD.Turbulence modeling. Combustion modeling.

References:

H. K. Versteeg, W. Malalasekera, An introduction to computational fluid dynamics, Pearson Printice Hall, Second edition, 2013.
Anderson John, D. Jr. Computational Fluid Dynamics-The Basics with Applications. McGrawHill International

Edition, 1995.
Chung T. J. Computational Fluid Dynamics. Cambridge University Press (South Asian Edition 2003)
Anderson Dale A, John C, Tannehill & Richard H. Fletcher, Computational Fluid Dynamics & Heat Transfer. McGraw Hill 1997.
Fletcher, C. A., Computational Techniques for Fluid Dynamics, Vol-1, Fundamental & General Techniques. Springer Verlag, Berlin 1991.

ME865 Robotics: Mechanics and Control (3-0-0) 3

Introduction, Classification of robots, mobile robots and manipulators, spatial description- transformation matrices, D-H parameters, manipulator kinematics and dynamics, workspace, trajectory generation, introduction to motion planning, manipulator control.

References:

J JCraig : Introduction to robotics: Mechanics and Control, 3rd edition, pearson Ed, 2004
AsitavaGhosal, Robotics: Fundamental concepts and Analysis, oxford University Press, 2013
Groover M P and et.al., Industrial Robotic Technology- Programming and Application, McGraw Hil, 2002 Koren Y, Robotics for Engineers, McGraw Hill,1998
Ranky P G and Ho C Y, Robots modeling control and applications with software, Springer Verlag, Berlin.2004

ME866 Optimization Techniques (3-0-0) 3

Optimization problem formulation - Design variables, constraints, objective function and variable; bounds. Single-Variable ; Single Variable Optimization Algorithm: Bracketing Melliotls Exhaustive Search Method and bounding; Phase Method. ; Region Elimination Methods: Fibonacci Search method and Golden section search method. Gradient based ; methods, Newton - Raphson method, Bisection Method, Secant Method, and Cubic Search Method. Computer programs for bounding phase method and golden section search method; Multivariable Optimization Algorithms: Direct search methods. Simplex search method and Hooke- Jeeves pattern search method. Gradient based methods, Constrained Optimization Algorithms- Kuhn- Tucker conditions, penalty function. Method, method of multipliers, cutting plane method, Generalized Reduced Gradient method, computer program for penalty function method. Integer programming - penalty function method. Global optimization using the steepest descent method, genetic algorithms and simulated annealing. ANN, FUZZY LOGIC

References:

R.L Fox, Addison -Optimization methods for Engg. Design – Wesley. Ram, 2004 Van Nostrand.-Optimization and Probability in System Eng 1980
K. V. Mital and C. Mohan- Optimization methods, New age International Publishers, 2005.
S. S. Rao – Engineering Optimization - Theory and Application, Willey Eastern.2009

ME867 Product Design and Development (3-0-0) 3

Generic process of Product Development, Concept generation, selection and Testing - CAD applications in Testing, CAD Hardware and software, Virtual Prototyping, Product Architecture, Industrial Design and Design for manufacturing, Design for assembly, Economic and Human Factors in Engg. Design for production-Metal and Plastic components, Optimum Design

References:

Karl T. Ulrich and Steven D. Eppinger, Product Design and Development, McGraw-Hill, 2000. A. K. Chitale and R. C. Gupta, Product Design and Manufacturing, PHI Pvt. Ltd., 2002 Chris McMahon and Jimmie Browne, CAD/CAM, Pearson Education Asia Pvt. Ltd., 2002

ME868 Design Of Thermal Equipments (3-0-0) 3

Design of double pipe heat exchangers. Shell and tube heat exchangers. Design of condensers, evaporators, boilers, cooling towers, selection of materials. Design of reciprocating compressor, Screw compressor, Scroll Compressor. Rotary compressor.

References:

Donald Q. Kern, Process Heat transfer, McGraw Hill.
Heat Exchanger handbook. Heat exchanger theory. Hemisphere Publishing Corporation.
Wilbert Stoecker, Design of Thermal system
Balaji C., Essential of Thermal system design and optimization.

ME869 Theory and Practice of Sensors and Actuators (2-0-2) 3

Physics of sensing, sensor specification & dynamics; experimental error analysis; measurement uncertainty, signal conditioning, Actuators and its control, modeling of sensing and actuation systems, Fundamentals of Signal processing. Lab components: Measurement of Temperature, RH, Pressure, strain, force, torque, displacement, velocity, Acceleration, rotation, and rpm – use of different sensors, signal conditioners, signal acquisition and digitization, Actuators: Solenoids, DC motor and its control, stepper motor and its control, servo motors PWM generation and control, Implementation of control systems using sensors and actuators Lab Component
Use of different kinds sensors along with open source ADC board like Arduino and Raspberry PI Open source data acquisition and remote trigger, Mini project

References:

Sanjay Gupta, Joseph John Virtual Instrumentation Using Lab VIEW Tata MaGraw-Hill, 2005.
D Patranabis, Sensors and Transducers, Phl 3nd Edition, 2013.
J.P. Holman Experimental Methods for Engineers McGrawHill, 8th Edition, 2010.
James H McClellan, DSP First A Multimedia Approach ,Printice Hall International , 1999.
Richard Crowder, Electric Drives and Electromechanical Systems: Applications and Control Elsevier, 2010.

ME870 Biomechanics and Materials (3-0-0) 3

Mechanics of the Musculoskeletal System: Structure and biomechanics of bone, cartilage, and skeletal muscle; dynamics and control of musculoskeletal system models.
Engineering of Human Work: Physics and physiology of humans at work; models of muscle strength, dynamic movements; neural control; physical work capacity; rest allocation.
Biomedical Materials: Properties and methods of processing metallic, ceramic, and polymeric materials for biomedical applications.
Artificial Organs Design: Mechanics, Basic techniques and principles of a multidiscipline approach to artificial organs design.
Bioengineering Ethics and Professional Development.

References:

Don B. Chaffin, Gunnar B. J. Andersson, Occupational Biomechanics, Wiley-Blackwell; 2nd Edition edition,1991.
Susan Hall, Basic Biomechanics, McGraw-Hill Education; 7 Edition, 2014.
Ellen Kreighbaum, Katharine M. Barthels,Biomechanics: A Qualitative Approach for Studying Human Movement, Allyn and Bacon; 4th Edition, 1995.
Nihat Özkaya, Dawn Leger , David Goldsheyder , Margareta Nordin, Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation,Springer; 4 Edition,2016
Doris I. Miller, Richard C. Nelson,Biomechanics of Sport,Lea& Febiger,U.S.,1974.
Y.C. Fung, Biomechanics: Motion, Flow, Stress, and Growth,Springer, 2013.
Ronald Huston,Principles of Biomechanics, CRC Press; 1 Edition, 2008.

ME871 Mechanical Systems and Signal Processing (3-0-0) 3

Introduction, Physical and description, data acquisition and processing techniques, Various transforms. Discrete Time Signals and Fourier Analysis; Sampling considerations, digital Fourier analysis, FFT algorithms, Wavelet Transforms, Discrete wavelet transforms and Continuous wavelet transforms, Hiberttransforms,Z Transform, Empirical Mode Decomposition, Random Processes, Probability and random variables, distributions and statistical errors, Regression analysis, Spectral density and correlation functions and their properties. System Identification Techniques. Single input/ output system, multi-input/output systems, coherence functions, Cepstral analysis, Nonlinear systems, Applications of Signal Processing Tools with artificial intelligence techniques for Fault diagnosis and Prognosis, Modern control engineering applications, State space representation of mechanical systems, Linear and nonlinear control strategies.

References:

I Nagrath,R.Ranjan, and S. Sharan, Signals and Systems, 2nd Edition, McGraw Higher Ed, 2009.
C. Sujatha, Vibration and Acoustics, Measurment and Signal Analysis, 2010.
R. A. Collacott, Vibration monitoring and diagnosis, George Godwin Ltd London, 1979
W. T. Thomson, Theory of Vibration with application, Prentice Hall, Eaglewood cliffs, 4th edition, 1993.
Robson, R.D. An introduction to random vibrations, Edinburgh University Press, Elsevier Publisher, 1963.
Katsuhiko Ogatta,Modern Control Engineering PearsonEducation,2004.

ME872 Machine Tool Design (3-0-0) 3

Electrical, Mechanical and Hydraulic Drives for the Operational Movements:

Electric Drive and Control Equipment. Mechanical and Hydraulic Drives. Drives for Producing Rotational Movements, Stepped Drives, Stepless Drives. Drives for Producing Rectilinear Movements. Backlash Eliminator in the Feed Drive Nut.

Automatic Control:

Principles and Constructional Elements. Automatic Driving of the Cutting Movements, Feed Movements, and Return Movements. Automatic control of movements for Starting, Stopping and Reversing. Automatic Clamping and Unclamping the work piece. Automatic Selection of Required Speeds, Automatic Setting of Tools. Automatic Measurement of Machined Shape and Surfaces. Transport of Components from One Machine to the Next. Applications (Examples of Automatic Machines). Control for Moving Slides into Defined, Fixed Positions. Control of Feed Movements in Producing Profiles or Surface by Continuous Path Control.

Design of Constructional Elements:

Machine Tool Structures, Structural Elements Design for Centre Lathe, Drilling Machine, Knee Type Milling Machine, Planning Machine, Boring Machine, and Grinding Machines.

Design of Slideways for Tables, Saddles and Cross-slides. Antifriction Bearings for slideways. Hydrostatically Lubricated Slideways.

Design of Cutting Drives, Feed Drives and Setting Drives.

Design of Control and Operating Devices for Machine Tools

Characteristics of positional servomechanisms in NC machines. Adaptive control. Static and dynamic deformations of the structure of the machine tool and their effects on the accuracy of the workpiece. Chatter in machining.

References:

N.K Mehta, "Machine Tool Design and Numerical Control", McGraw Hill Education, 3rd Edition, 2012.

G C Sen and A Bhattacharya, "Principle of Machine tools", 2nd Revised Edition, New Central Book Agency, 2009.

F Koenigsberger and J. Tlustry, "Machine Tool Structures", Elsevier, 1970.

F Koenigsberger, "Design Principles of Metal-cutting Machine Tools", Pergamon, 2013.

DEPARTMENT OF METALLURGICAL & MATERIALS ENGINEERING

MT700 Foundations of Physical Metallurgy **(3-1-0) 4**
Thermodynamics, phase diagrams, classification of transformation, diffusion, high diffusivity path, applications; nucleation and growth kinetics, TTT diagram, precipitation hardening, spinodal decomposition, strengthening mechanisms, dispersion strengthening, eutectoidal transformation, order-disorder transformation, recovery and recrystallisation.
D.A.Porter and K.E.Easterling, Phase transformation in metal and alloys, Chapman & Hall, 1992.
V.Raghavan, Solid state phase transformation, PHI, New Delhi, 1987.
S.H.Avner, Introduction to Physical Metallurgy, 2nd Ed (Indian edition) 1997
R E Smallman &R J Bishop, Modern Physical Metallurgy and Materials Engg, 6th Ed Kindle ed, 1999. Thomas Courtney, Mechanical behaviour of Materials, 2nd ed., Wave land Press, 2005

MT701 Materials Characterisation **(3-1-0) 4**
Basics of Crystallography; crystal systems, interplanar spacings, planes of a form, planes of a zone. X-RD Techniques: Basics of X-Rays; generation, absorption, filtering, diffraction, diffracted intensity, X-RD methods, Powder method: Specimen preparation, Selection of radiation, Background radiation, Determination of Crystal structure, lattice parameter, Chemical analysis, Particle size, Stereographic projections; Determination of texture. TEM: Electron optics, image formation, Theories of contrast in crystals, electron diffraction, indexing SAD patterns, specimen preparation. SEM: Electron-specimen interaction, signals, modes of working, Field ion and field emission microscopes.
B. D. Cullity, "Elements of X-ray Diffraction", Addison-Wesley Publishing Company Inc, 1978.
K Ramakanth Hebbar, "Basics of X-ray Diffraction and its applications", I K International, New Delhi, 2007 P. E. J. Flewitt & R. K. Wild, "Physical Methods of Materials Characterization", IOP, 1994
P. G. Grundy and G. A. Jones, Electron microscopy in study of Materials, Edward Ernold, 1976 J. I Goldstein, Scanning Electron Microscopy and X-Ray Microanalysis, 2003

MT702 Thermodynamics of Solids **(3-1-0) 4**
Laws of thermodynamics, relations between thermodynamic quantities; Thermodynamics of chemical reactions, magnetism, polarizability and elasticity; Phase transformation, partial molar and excess quantities; Multi-phase equilibria and their phase diagrams, free energy of binary systems; Electrochemical equilibria; Thermodynamics of surfaces and interfaces; Macroscopic equilibrium phenomena.
Dieter Vollath, Nanomaterials: An introduction to synthesis, properties & applications, Wiley-VCH, 2008.
R.A.Swalin, Thermodynamics of solids, John Wiley, 1972
M.F.Ashby, P.J.Ferreira, D.L.Schodek, Nanomaterials, Nanotechnologies and design, Elsevier, 2009.

MT703 Polymer Technology **(3-0-0) 3**
Physico-chemical aspects: Polymerization, classification, molecular architecture, molecular weight and molecular weight distribution, crystallinity, thermal transitions.
Mechanical behavior and viscoelasticity: Viscoelasticity, time - temperature superposition, stress-strain behavior, fracture, creep, hardness, impact behavior, toughening, dynamic mechanical analysis, theory of rubber elasticity.
Chemical and physical behavior: Environmental resistance and weathering, chemical resistance and solubility, permeability, electrical properties, optical properties, flammability.
Industrial polymers: Commodity polymers, engineering polymers, specialty polymers.
Unit operations in polymer processing: Rheology, extrusion, injection molding, blow molding, rotational molding, thermoforming, compression molding, transfer molding, rubber processing, fiber spinning.
A. Rudin, P. Choi, The Elements of Polymer Science and Engineering, 3rd Edn, Academic Press, 2012.
C.S.Brazel, S. L. Rosen, Fundamental Principles of Polymeric Materials, 3rd Edn, John Wiley, 2012.
R. J. Crawford, Plastics Engineering, 3rd Edn, Elsevier, 2006.
N. G. McCrum, C. P. Buckley, and C. B. Bucknall, Principles of Polymer Engineering, 2nd Edn, Oxford University Press, 1997.
R. O. Ebewele, Polymer Science and Technology, 1st Edn, CRC Press, Boca Raton, 2000.
J. R. Fried, Polymer Science and Technology, 2nd Edn, Prentice Hall of India, 2005.

MT704 Mechancial Behaviour & Design of Materials **(3-1-0) 4**
Atomic and molecular bonds, classification of materials, their properties with respect to the types of bonds present in

them as a class. Dislocations and plastic deformation, slip, torsion, CRSS, slip systems, strain hardening, recrystallization. Tensile behaviour and testing, temperature and strain rate effects, compression behaviour and testing, hardness testing, torsion testing, impact testing & transition temperature. Failure under combined stresses (triaxial), design against failure. Failure behaviour and fracture toughness testing. Fatigue behaviour of materials, design against fatigue failures. Creep behaviour and testing: design against creep failures. Failure analysis: a few case studies.

G. I. Dieter, Mechanical Metallurgy, Sl metric edition, McGraw Hill, 1988.
J. A. Collins, Failure of Materials in Mechanical Design, Wiley Interscience Publication, 1981.
Metals Handbook, Vol.11, 9th edition, ASM, 1986.

MT705 Materials Laboratory (0-0-3) 2

Experiments in quantitative metallography, X-ray diffraction, diffusion, phase transformations and properties of materials.

MT706 Ceramic Technology (3-0-0) 3

Structure of ceramics: bonding, Pauling's rules, oxide structures, silicate structures, structure of glasses, Zachariasen rules; Ceramic phase diagrams, microstructure of ceramics; Defects in ceramics, Kroger vink notation; Processing of ceramics: Powder processing, forming, sintering; Powder production: thermal decomposition, spray drying, sol-gel synthesis; Forming - die compaction, slip casting, tape casting; Sintering - solid state and liquid phase sintering, grain growth; Hot isostatic pressing; Properties and testing of ceramics: physical, mechanical, thermal; Brittle Fracture, Toughening mechanisms; structure, formation and properties of glasses; white ware; cements; advanced ceramics.

Michel W. Barsoum, Fundamental of Ceramics, International Edition,1997
W. D. Kingery, Introduction to Ceramics, 2nd Edition, John Wiley & Sons, 1991
Alan G. King, Ceramic Technology and Processing, Noyes Publications, New York, 2002 John B. Watchman, Mechanical Properties of Ceramics, John Wiley & Sons, 1996.
A. O. Surendranathan, An Introduction to Ceramics and Refractories, CRC Press, 2014.

MT710 Advances in Iron Making (3-1-0) 4

Different and emerging methods of Iron making, Modern developments in Iron making in the blast furnace, Preparation of inputs, Physico-chemical study of the reduction of iron ores and oxides, Deposits of coal and the developments in coke making process, Study of processes inside an iron blast furnace, Study of blast furnace slags, Heat exchange zones in blast furnace, Stoichiometry, Material and Heat Balance and introduction to Mathematical Modelling Recent trends in the operation of blast furnaces. Gas based DRI making by HyL, Midrex and fluidized bed processes, Coal based DRI making by rotary kiln, vertical retort and rotary hearth, Electric pig iron furnace; Corex and other SR processes. Production of ferro alloys.

Making, Shaping and Treating of Steel, 10th Edition, Edited by United States Steel, 1985; or 11th Edition, Edited by the Association of Iron and Steel Engineers, 1999.
A. Ghosh and A. Chatterjee, Iron making and Steelmaking; Theory and Practice, PHI Learning (P) Ltd., New Delhi, 2008.
A. K. Biswas, Principle of Blast Furnace iron making, SBA Publications, Calcutta, 1981
Strasburger, Brown, Stephenson & Dancy, B. F. Theory and Practice, Vol.I & II, Gordon & Reach, New York, 1969.
Robert L. Stephenson, Direct reduced Iron - Technology & Economics of production and use, 1980, Iron & Steel Society of AMIE.

MT711 Thermodynamics of Materials (3-1-0) 4

Review of heat capacity, enthalpy, entropy and free energy concept, fugacity, activity, activity coefficient and the equilibrium constant, Tabular representation of thermodynamic data and the free energy function. Solutions - Raoult's law and Henry law, properties of Raoultian ideal solution, non-ideal solution, binary Gibbs-Duhem equation and its application to activity and activity coefficient determination. Belton-Freuhan Treatment.

Study of thermodynamic properties of metallurgical systems with special emphasis on liquid metals and slags. Slag Theories. Quasichemical theory, excess thermodynamics functions, regular and sub regular models of metallic solutions, interaction parameter and interaction coefficient, ternary Gibbs-Duhem integration. Electrochemical Cells. Generating Phase Diagrams Using Regular Solution Theory.

Robert DeHoff, Thermodynamics in Materials Science, CRC Press, 2006 ISBN 9780849340659
D. R.Gaskell and D.E.Laughlin, Introduction to Thermodynamics of Materials, CRC Press, 2018. ISBN-13: 978-1498757003

Problems in Metallurgical Thermodynamics and Kinetics: International Series on Materials Science and Technology (Materials Science & Technology Monographs) (Volume 25) Pergamon Press, 1977 ISBN-10: 0080208649
Ahindra Ghosh, Text Book of Materials and Metallurgical Thermodynamics, Prentice-Hall, New Delhi, 2003 ISBN 81-203-2091-3

MT712 Momentum and Thermal Transport Phenomena (3-1-0) 4

Momentum Transfer in Metallurgical Processes - Viscous properties of fluids, Laminar flow and the momentum equation, Turbulent & complex flows, Energy balance applications, Problems in compressible flow, Sonic velocity and supersonic jets, production of vacuum, Differential models of turbulence for bulk convecting flows, Electromagnetically driven flows, Physical & computational models, Recent advances in metallurgical fluid dynamics: Advances resulting from physical and mathematical modeling. Heat Transfer in Metallurgical Processes - Unsteady state conduction of heat, Differential thermal energy balance in fluids, Forced and Natural convention of heat, The heat transfer coefficient, Heat Transfer Correlations, Radiant heat transfer between black - body surfaces, gray - body surfaces, radiation through emitting and absorbing media, Heat transfer in continuous casting, welding and quenching, Inverse heat conduction problem - solution and applications. Process Modeling - Introduction, types of models, similarity criteria, development of process models, model implementation.

D. R. Poirier and G. H. Geiger, Transport Phenomena in Materials Processing, TMS Warrendale, 2016, ISBN 978-3-319-48565-2 ISBN 978-3-319-48090-9 (eBook) DOI 10.1007/978-3-319-48090-9
N.J. Themelis, Transport and Chemical Rate Phenomena, Gordon Breach, 1995, ISBN-10: 2884491279 | ISBN-13: 9782884491273
R. B. Bird, W.E. Stewart and E.N. Lightfoot, Transport Phenomena, John Wiley & Sons, 2007, ISBN-10: 0470115394 | ISBN-13: 978-0470115398
R.I.L. Guthrie, Engineering in Process Metallurgy, Clarendon Press, 1992, ISBN-10: 0198563671 | ISBN-13: 978-0198563679
S Seetharaman, Fundamentals of Metallurgy (Woodhead Publishing Series in Metals and Surface Engineering) 1st Edition, ISBN-13: 978-1855739277ISBN-10: 1855739275

MT713 Mass Transfer and Metallurgical Kinetics (3-1-0) 4

Diffusion in solids, liquids, gases. Diffusion through porous media Steady state diffusion and transient diffusion, Finite system solutions, microelectronic diffusion processing, homogenization of alloys and formation of surface layers. Diffusion through a stagnant gas film, diffusion into a falling liquid film. Concentration boundary layer.

Mass transfer, General equation of diffusion with convection, concept of mass transfer coefficient, mass transfer correlations, models of mass transfer coefficient, mass transfer in chemical vapour deposition, interphase mass transfer, overall mass transfer, interfacial turbulence, enhanced vaporization.

Batch and continuous chemical reactors, F and C diagrams, eddy diffusion model, design of chemical reactors, staged operations.

Homogeneous and Heterogeneous reactions and processes, Kinetics of heterogeneous reactions in metallurgy, Transformation kinetics of a single particle and a bed of particles, ideal and non-ideal regimes, fluidized bed, heterogeneous catalyses, Langmuir adsorption isotherm.

Motion of bubbles in fluids, impinging jets and submerged jets, Droplet generation in the BOF steelmaking process, Wakelin model.

D. R. Poirier and G. H. Geiger, Transport Phenomena in Materials Processing, TMS Warrendale, 2016, ISBN 978-3-319-48565-2 ISBN 978-3-319-48090-9 (eBook) DOI 10.1007/978-3-319-48090-9
N.J. Themelis, Transport and Chemical Rate Phenomena, Gordon Breach, 1995, ISBN-10: 2884491279 | ISBN-13: 9782884491273
Ahindra Ghosh and Sudipto Ghosh, A textbook of Metallurgical kinetics, Prentice-Hall, New Delhi, 2014, ISBN-978-81-203-4828-8
L. Coudrier, D.W. Hopkins, I. Wilomirsky, Fundamentals of Metallurgical Processes
A volume in International Series on Materials Science and Technology Book , 2nd Edition, Pergamon, 1985,. ISBN 978-0-08-032536-1
R.I.L. Guthrie, Engineering in Process Metallurgy, Clarendon Press, 1992, ISBN-10: 0198563671 | ISBN-13: 978-0198563679
S Seetharaman, Fundamentals of Metallurgy (Woodhead Publishing Series in Metals and Surface Engineering) 1st Edition, ISBN-13: 978-1855739277 ISBN-10: 1855739275

MT721 Introduction to Nanoscience & Nanotechnology (3-1- 0) 4
Miniaturization of devices, need for nanoparticles; Fundamentals of structure and energetic of nanomaterials; Size effects, surface energy; Thermodynamic laws governing equilibrium properties; Relating macroscopic behavior to molecular models of materials; Heat capacities, Phase transformation, Electronic properties, Magnetic properties, diffusion; Structure of nanocrystalline, crystalline and liquid crystalline states; Tensor properties of materials; Point, line and surface imperfections; Environmental impact; Real world examples such as materials for fuel cells/batteries, engineered materials, nano-electronic and nano-photonic devices, MEMS and NEMS devices, ionic and network solids, polymers and biomaterials.
C.P. Poole and F.J. Owens, Introduction to Nanotechnology, Wiley Interscience 2003.
C.N.R. Rao, Achim Muller and A.K. Cheetham, The Chemistry of Nanomaterials,Vol I & II, Wiley VCH, 2004.
B.Rogers, S.Pennathur and J.Adams, Nanotechnology: Understanding small systems, CRC Press, 2008.
A. Nouailhat, An instriduction to nanoscience and nanotechnology, John Wiley & Sons, 2008.
Dieter Vollath, Nanomaterials: An introduction to synthesis, properties & applications, Wiley-VCH, 2008. T. Pradeep, Nano: The Essentials - Uncerstanding Nanoscience and Nanotechnology, Tata McGraw Hill H.S. Nalwa, Encyclopedia of Nanotechnology, ASP, 2011

MT722 Quantum Theory of Nanoscale Materials (3-1-0) 4
Introduction to quantum mechanics, Schrodinger equation, uncertainty principle, bound states of 3-D potential wells and periodic potentials, angular momentum, quantum statistics; perturbation theory, electronic band structures in semiconductors, metals, organic materials and nanostructures; vibrational properties of solids; light-matter interaction; electronic bonding; electronic, optical and magnetic properties of nanomaterials.
B.Rogers, S.Pennathur and J.Adams, Nanotechnology: Understanding small systems, CRC Press, 2008.
Dieter Vollath, Nanomaterials: An introduction to synthesis, properties & applications, Wiley-VCH, 2008.
M.F.Ashby, P.J.Ferreira, D.L.Schodek, Nanomaterials, Nanotechnologies and design, Elsevier, 2009.

MT723 Synthesis Techniques for Nanomaterials (3-1-0) 4
Physical Methods: Inert gas condensation, Arc discharge, RF-plasma, Plasma arc technique, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy, Chemical vapour deposition method and other variants, Electrodeposition. Chemical Methods: Metal nanocrystals by reduction, Solvothermal synthesis, Photochemical synthesis, Electrochemical synthesis, Nanocrystals of semiconductors and other materials by arrested precipitation, Thermolysis routes, Sonochemical routes, Liquid-liquid interface, Hybrid methods, Solvated metal atom dispersion, Post -synthetic size-selective processing. Sol- gel, Micelles and microemulsions, Cluster compounds. Biological Methods: Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Synthesis process and application, Role of plants in nanoparticle synthesis. Lithographic Techniques: AFM based nanolithography and nanomanipulation, E-beam lithography and SEM based nanolithography and nanomanipulation, Ion beam lithography, oxidation and metallization. Deep UV lithography, X-ray based lithography.
H.S. Nalwa - Encyclopedia of Nanotechnology, 2011.
Leon L.Shaw(Ed), Processing & properties of structural nanomaterials, 2010.
C.N.R. Rao, Achim Muller and A.K. Cheetham, The Chemistry of Nanomaterials,Vol I & II, Wiley VCH, 2004. G. Cao, Nanostructures & Nanomaterials Synthesis, Properties & Applications, Imperial College Press, 2004.

MT724 Nanomaterials Synthesis and Characterization Laboratory (0-0-3) 2
Synthesis of nanoparticles metals and metal oxides (ex. Ag, Cu, Sn, As, ZnO, SnO_2, oxides of iron, etc) by polyol, combustion, hydrolysis, high energy ball milling and ultrasonic methods under varying conditions; surface functionalization. Nanorods, Nanofibers and thin films.
Characterization of nanomaterials by powder x-ray diffraction, study of size distribution and variation, Study of morphology of nanomaterials by optical microscopy, scanning electron microscopy, Transmission electron microscopy, Differential scanning calorimetry, contact angle measurement.
Dieter Vollath, Nanomaterials: An introduction to synthesis, properties & applications, Wiley-VCH, 2008.
B D Cullity, Elements of X Ray Diffraction, Addison Wesley.
Zhou, W.Wang Z.L, Scanning Microscopy for Nanotechnology: Techniques and Applications, Springer. Reimer.L, Transmission Electron Microscopy, Springer Verlag Publishing Company, 1989 T.Gareth, Transmission Electron Microscopy of Metals, John Wiley & Sons.

MT800 Steels & Their Heat Treatment (3-0-0) 3

Iron and its solid solutions, iron - carbon equilibrium diagram, plain carbon steel, influence of alloying elements in Fe-C alloys, low alloy steels, heat treatment of steel, formation of martensite, bainite reaction, concept of hardenability, tempering of martensite, thermomechanical treatment, surface hardening, stainless steels, tool steels, embrittlement and fracture of steels, Cast irons: characteristics, applications.

R.W. K. Honeycombe, Steels - Microstructure and Properties, Edwards Arnold, 1995

W. C. Leslie, The Physical Metallurgy of Steels, McGraw Hill Book Company, New York, 1982 F. B. Pickering, Physical Metallurgy and the Design of Steels, Applied Science Publishers ,1978

T.V Rajan, C.P Sharma &A. Sharma, Heat Treatment;Principles & Techniques, PHI, New Delhi, 2007

MT801 Composite Materials (3-0-0) 3

Introduction, their characteristic features, interfaces, wettability, bonding. Important reinforcements fibers, whiskers, short fibers and particles, production. Properties, and applications of polymer matrix composites: metal matrix composites, ceramic matrix composites, carbon /carbon composites, intermetallic matrix composites, mechanics, laminate composites, short fiber composites, toughness of composites - thermal, fatigue and environmental effects, joining of composites, designing with composite materials.

K. K. Chawla, Composite materials, Springer - Verlag Press, 2001.

Mathews F. L. and Rawlings R. D., Composite Materials: Chapman Press 2010 Bryan Harris, Composite Materials, Institute of Materials, London 1996.

MT802 Electronic Properties of Materials (3-0-0) 3

Introduction: Brilluion Zone Theory; Fermi level, Band theory. Thermal Properties: specific heat, thermal expansion & thermal conductivity. Electrical properties: conductors, insulators, intrinsic semiconductors, extrinsic semiconductors. Single crystal growth, zone refining, producion of PNP, NPN transistors, intergrated circuits. Dielectrical - materials and applications, electrostriction, magnetostriction. Ultrasonic transducers: piezoelectric materials and applications, ferroelectric materials and applications. Magnetic Properties: soft magnetic materials, hard magnetic materials, ferrites, garnets, ESD magnets, magnetic tapes, films, ferromagnetic materials, antiferromagnetic materials, materials for computer memories. Neutron diffraction. Superconductivity: Type I, Type II superconductors, hard and soft superconductors, Meissener effect, high temperature superconductors, Applications of superconductors, photoconducting applications. Optical Properties: lasers, gas laser, He-Ne laser, N_2CO_2, Ar, H2-Cd lasers, liquid lasers, dye lasers, solids laser, ruby, Nd - YA glass lasers, semiconductor diode laser, applications of laser. Optical storage, optical computing, optical fibres.

R. E. Hummel, Electronic Properties of Materials, Navona, 1995. J. Wulff, Electronic Properties, Edition of 1964.

C. M. Srivastava & C. Srinivasan, Science of Engineering Materials, New Age International Pvt. Ltd., India. 1999.

MT803 Non-Destructive Testing (3-0-0) 3

Introduction to ND T techniques: visual inspection, in situ metallography, dye-penetrant inspection, magnetic particle inspection, eddy current method, computer tomography. Ultrasonic Inspection: ultrasonic waves, variables, attenuation, inspection methods, pulse echo, transmission methods, inspection standards, standard reference blocks, practical applications. Radiography Inspection: radiation sources, image quality, radiographic sensitivity, geometric unsharpness, image intensifiers, radiographic films, exposure, inspection standards.

Barry Hull & Vernon John, Non-destructive Testing, ELBS edn., Macmillan, London,1989.

R.Halmshaw, Non-destructive Testing, 2nd edn., Edward Arnold, London,1991.

McGonnagle W.J., Non-destructive testing, Gordon & Beach Science, New York, 1983.

MT804 High Temperature Materials (3-0-0) 3

Material properties at elevated temperatures. Introduction to Fe, Ni & Co base super alloys, thermal barrier coatings, titanium and alloys, refractory metals and alloys, high temperature ceramic materials, cermets, cemented carbides. Creep, fatigue, corrosion, and oxidation resistance, processing, heat treatment, and applications of wrought and cast super alloys.

Donachie, A technical guide on Super alloys, A.S.M. Ohio, 2002 C. T.Sims & N. C. Hagel, super alloys, JohnWiley Publishers, 1972

Betteridge, The Nimonic Alloys - Edward Arnold Publishers Ltd., London, 1959

MT805 Fracture Mechanics (3-0-0) 3

Stress- Strain relationships, stress concentration, conventional design concepts & its limitations, Introduction to linear elastic fracture mechanics, fracture toughness, determination of fracture toughness, stress intensity factor, strain energy release rate. Brittle and ductile fractures, fractography and fracture signature identification. Case studies in failure anaysis.

D. Boreck, Elementary Engineering Fracture Mechanics, Martinus Nijhoff, Dodrecht (1986).
E. J. F. Knott Fundamentals of Fracture Mechanics, Butterworth (1973)
S. Teteleman and A. J. Mc Evily, Facture of Structural Materials, John Wiley and Sons, (1961)

MT806 Surface Engineering (3-0-0) 3

Surface Cleaning: Classification and Selection of Cleaning Processes Finishing Methods: Classification and Selection of Finishing Processes; Topography of Surfaces; Microstructural Analysis of Finished Surfaces Plating and Electroplating: Electrodeposition Processes: Copper Plating; Nickel Plating; Zinc Plating; Zinc Alloy Plating; Selective (Brush) Plating; Electroforming. Non-electrolytic Deposition Processes: Eletroless Nickel Plating; Electroless Alloy Deposition Dip, Barrier and Chemical Conversion Coatings: Batch Hot Dip Galvanized Coatings; Phosphate Coatings; Chromate Conversion Coatings; Rust Preventive Compounds; Painting; Ceramic Coatings and Linings; Anodizing. Vacuum and Controlled - Atmosphere Coating and Surface Modification Processes: Thermal Spray Coatings; Chemical Vapor Deposition of Non -semiconductor Materials; Chemical Vapor Deposition of Semiconductor Materials; Plasma - Enhanced Chemical Vapor Deposition; Growth and Growth - related Properties of Films Formed by Physical Vapor Deposition; Vacuum Deposition, Reactive Evaporation, and Gas Evaporation; Sputter Deposition; Ion Plating; Ion-Beam-Assisted Deposition; Arc Deposition; Ion Implantation; Diffusion Coatings; Pulsed - Laser Deposition. Testing and Characterization of Coatings and Thin Films: Film Thickness Measurements Using Optical Techniques; Corrosion Testing; Evaluation of Mechanical Properties of Thin Films.

P. K. Dutta & I. S. Gray, Surface Engineering, Vol. I - III, Royal Society of Chemistry, 1993.
ASM Hand Book, Vol.5, ASM International, Metals Park, Ohio, 1999.
Kenneth G. Budinsk, Surface Engineering for wear resistance, Prentice Hall, NJ1988.

MT807 Science and Technology of Nanomaterials (3-0-0) 3

Introduction: Definitions, classification, fundamental principles, fullerenes, nanoparticles, nanoclusters, nanowires, nanotubes, nanolayers, nanopores, supramolecules. Properties: Size dependence of properties such as electrical, physical, optical and chemical. Synthesis: Top -down and bottom-up approaches, plasma arcing, chemical vapor deposition, electrodeposition, sol-gel synthesis, high energy milling/ball milling, nanolithography, self-assembly, Langmuir-Blodgett films. Characterization: Scanning tunnelling microscopy, transmission electron microscopy and atomic force microscopy. Application: Nanomachines and nanodevices, impact of nanomaterials in the areas of materials manufacturing, health care, data storage, clean energy etc. Society and nanotechnology: Challenges and fears, impact on health and environment.

D. L. Schodek, P. Ferreira and M. F. Ashby, Nanomaterials, Nanotechnologies and Design, Butterworth-Heinemann, Oxford, 2009.
G. Cao, Y. Wang, Nanostructures and Nanomaterials: Synthesis, Properties, and Applications, Imperial College Press, London, 2004.
M. Wilson, K. Kannangara, G. Smith, M. Simmons and B. Raguse, Nanotechnology: basic science and emerging technologies, CRC press, Boca Raton, 2002.
C. P. Poole, Jr., and F. J. Owens, Introduction to Nanotechnology, Wiley-Interscience, New Jersey, 2003.

MT808 Non-Equilibrium Materials and Processing (3-0-0) 3

Thermodynamics of equilibrium and non-equilibrium processes. Effect of fine structures on equilibrium, Suppressing of equilibrium structures, Melt quenching, Laser based processing, Ion based processes, High energy milling, Sputtering systems, ECAPs, Roll bonding, Friction based processes like friction welding, friction stir processing, friction surfacing. Use of shock energy for non- equilibrium processing. Metallic glasses, Quasi crystals, High entropy alloys. Atomic crystals and their reactivity. Non-equilibrium phases in Fe based, Cu based, Al based alloys. Properties of Non-equilibrium synthesized materials.

Rajiv Mishra, Friction stir processing and Applications: Elsevier publications, 2005.
D J Paulo, Tribology in manufacturing technology, Springer, 2012.
B S Yilbas, S Z Shuja, Laser surface processing and model studies, Springer, 2013.

MT809 Advanced Polymeric Materials and Technology (3-0-0) 3

Specialty Polymers: High temperature and fire-resistant polymers, Liquid crystalline polymers, Dendrimers, Drag reduction, Polymer Cement, Ion-Exchange Resins and Anchored Catalysts, Photoactive Materials, Organometallic

polymers, adhesives.
Biopolymers: Polymeric bio-implants, Contact lenses, surgical sutures, artificial organs, drug delivery biopolymers, tissue Engineering.
Polymers for Advanced Technologies: Conducting polymers, Membrane Science and Technology, Applications in Electronics and Energy, photonic Polymers, Sensor Applications.
Smart polymers: Self-healing polymers, Polymer actuators, Shape memory polymers, Magneto rheological polymers, piezoelectric polymers, Electroactive polymers.
S. Anandhan and S. Bandyopadhyay, Eds., Advances in Polymer Materials and Technology, 1st Edn, CRC Press, Boca Raton, 2016.
M. Chanda, S. K. Roy, Industrial Polymers, Specialty Polymers, and their Applications, 1st Edn, CRC Press, USA, 2009.
J. R. Fried, Polymer Science and Technology, 3rd Edn, Prentice Hall, USA, 2014.
B.D. Ratner et al., Biomaterials Science: an Introduction to Materials in Medicine, 3rd Edn, Academic press, USA, 2012.
J. Park &R.S. Lakes, Biomaterials: an Introduction, 3rd Edn, Springer, USA, 2007.
A. K. Bhowmick, Ed., Current Topics in Elastomers Research, CRC Press, USA. 2008.

MT810 Science and Technology of Biomaterials (3-0-0) 3
Introduction; Classes of materials used in medical science: metals, polymers, nanocomposites, ceramics, glasses; Biological response to biomaterials: biocompatibility, biodegradation, bio-inert; Host reactions to biomaterials: implant associated infection; Testing of biomaterials: *in-vitro*, *in-vivo* assessment, blood materials interactions; Biomedical application: Cardiovascular, orthopaedic application, dental implants, skin, ophthalmologic applications, wound healing, sutures, biomedical and biosensors; Implantation techniques for soft tissue and hard tissue replacements; Problems and possible solutions in implant fixation; Failure analysis of medical devices and implants.
Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons. Biomaterials Science: An Introduction to Materials in Medicine, Academic Press, 2004, USA
Bikramjit Basu; Biomaterials Science and Tissue Engineering: Principles and Methods; Cambridge University Press; 2017. ISBN: 9781108415156
J.B. Park and J.D. Bronzino. Biomaterials: Principles and Applications. CRC Press. 2002. ISBN: 0849314917

MT811 Advanced Welding Technology (3-0-0) 3
Introduction to conventional welding process, energy source for fusion welding, heat flow and fluid flow for fusion welding, fluxes for fusion welding, slag/metal interaction, solid state transformation, cracking phenomena, gases in welds. Special welding processes: TIG, ESW, plasma, ultrasonic, laser, electron beam welding, surface hardening, weldability of metals and alloys, stresses in welds, welding of carbon steels, low alloy steels, stainless steels. Cast iron, welding of non-ferrous and composite materials, numerical aspects of modeling the welds, weld design, weld tests. Computers in Welding.
ASM Handbook, vol.6: Welding Brazing and Soldering, 1994.
Welding Handbook: American Welding Society, 1991.
J.F.Lancaster, Metallurgy of Welding, 2007.

MT812 Corrosion Engineering (3-0-0) 3
Definition of corrosion, corrosion damage, standard expressions for corrosion rate, classification of corrosion, electrochemical aspects, electrochemical reactions, Pourbaix diagrams, mixed potential theory, polarization, Evan's diagrams, passivity, effects of environment - oxygen and oxidizers, temperature, corrosive concentration, cathode/anode area ratio, galvanic coupling using mixed potential theory. Forms of corrosion-uniform, galvanic, crevice, intergranular, pitting, selective leaching, erosion, stress corrosion, corrosion fatigue, fretting. Corrosion rate measurements-Tafel and linear polarization, AC impedance, small-amplitude cyclic voltammetry. Corrosion testing. Interpretation of results, Corrosion protection: materials selection, alternative environment, design, cathodic and anodic protection, coatings, High-temperature corrosion: mechanisms and kinetics, high-temperature materials.
Mars G. Fontana, Corrosion, McGraw- Hill Book Company 1986.
David Talbot and James Talbot, Corrosion Science and Technology, CRC Press, New York, 1998.
Denny A.Jones, Principle sand Prevention of Corrosion, Maxwell Macmillan,1992.
MetalsHandbook,Vol.13, Corrosion, ASM Metals Book, Ohio, 1987.

MT813 Advances in Steel Making **(3-0-0) 3**

Review of the development in steel making processes,Physico-Chemical and Thermodynamic Principles of important reactions in steel making,deoxidation of steel. Basic oxygen stee lmaking processes, developments in L.D.converter, Bottom oxygen process and combined blowing, energy optimizing furnace(EOF)process.Steelmaking inelectricarc furnaces, principles and practice adopted for stain less steel production, recent developments instainless steel making, recent developments in electric arc furnace practice. Steel making in electric arc furnace,recent developments. Conarc process, steel making in induction furnace. Secondary steel making processes,ladlefurnace method,injection metallurgy,vacuum treatment of liquid molten steel,Non-metallic inclusions in steel-Mechanism of formation and removal,Principles and practice adopted for stainless steel production,recent developments in stainless steel making. Electro-slagre fining and vacuum Arc Re-melting,vacuum induction melting,plasma melting,electron beam melting and microwave melting. Continuous casting of steel,fluid flow in the tundish,moulds used for continuous casting, Use of casting powder,electro-magneticstirring,defects in continuous casting products,Introduction to mathematical modelling of continuous casting process.

Making,ShapingandTreatingofSteel,10e,EditedbyUnitedStatesSteel,1985;or 11e,EditedbytheAssociationofIronandSteelEngineers,1999.
A.GhoshandA Chatterjee,Iron makingandSteel making:TheoryandPractice,PHILearning(P)Ltd.,NewDelhi, 2008.
A. K. Chakrabarti,Steel making,PHI(P)Ltd.,NewDelhi, 2007.
R.H.Tupkary,ModernSteelMaking,1982,KhannaPub.NewDelhi,2008. Longmans,Green,2nd edition,prentice
C.Bodsworth,PhysicalChemistryofIronandSteel manufacture,
HallPress:1972.
T.Rosenqvist,PrinciplesofExtractiveMetallurgy,2nd edition,McGraw-Hill,1974,McGraw-Hill,1983,Tapir AcademicPress,2004.

MT814 Mechanical Processing of Steel **(3-0-0) 3**

Review of stress and relationshipforelastic behaviour,elements of the theory of plasticity,effects of various factors on the plastic deformation of polycrystalline aggregates,fundamentals of metal working,effects of various factors on forming processes,mechanics of metal forming,work of plastic deformation,formability tests and evaluation,friction Informing operations, experimental techniques of forming analysis,detailed analysis of the various hot and cold Working processes with special reference to steels based on the following points:Classification of processes, equipment, deformation forces and geometrical relationship variables, defects, residual stresses, theories of the forming process, power requirements, lubrication problems, recent developments,heating for mechanical working, soaking pit practice,control methods and computer simulation. CAD,CAM,FEM.Numerical Problems Design Aspects.

G.E.Dieter,MechanicalMetallurgy,S. I. MetricMcGrawHill,1988.
T.Altan,S. Oh.H.Gegel,MetalForming- FundamentalsandApplications,ASM,Ohio,1983.
Making, Shaping&TreatingofSteel,10th Edition,USA,1985.

MT815 Solidification and Casting **(3-0-0) 3**

Science of Solidification, Thermodynamics of solidification, Concept of Undercooling, Homogeneous and Heterogeneous nucleation, Theory of Nucleation Rates, Growth in Pure Metals & Alloys, Constitutional Supercooling, Nucleation ahead of an advancing interface, Eutectic growth structures, Modification and Grain refinement of Al-Si Alloys.

Concept of liquid metal engineering, Solidification heat transfer, Casting & Moulding Processes, Sand Quality Control, Special Casting Techniques, Aluminium, Cast iron and Steel Foundry Practice, Melt treatment and product quality.

Flow of liquid metals in moulds, Elements of Good Gating Design, Concept of Bifilms, Campbell 's Ten Rules, Feeding of Castings, The Seven Feeding Rules, Feeding Mechanisms, Engineering Design of Castings.

Defects in Castings, Solidification simulation, Rapid Solidification.

J. Campbell, Complete Casting Handbook, 2nd Edition, Metal Casting Processes, Techniques and Design, Butterworth-Heinemann, 2015. ISBN ISBN: 9780444635099.
Peter Beeley, Foundry Technology, 2ndEdition, Butterworth-Heinemann, 2001, ISBN: 9780750645676.
D.M.Stefanescue, Science & Engineering of Casting Solidification, Second Edition, Springer Science, 2009 ISBN 978-0-387-74612-8
W.C.Winegard, Solidification of Metals, Institute of Metals, 1964.
D. R. Poirier and G. H. Geiger, Transport Phenomena in Materials Processing, TMS Warrendale, 2016, ISBN 978-3-319-48565-2.

MT816 Advanced Non-Ferrous Extractive Metallurgy (3-0-0) 3

Basics of Extractive metallurgy, Extraction of metals from oxide sources, Basic approaches and special features of Specific extraction processes, Extraction of Aluminum (Bayer process,Hall-Heroult process,modern refining processes of Alumina Production. Extraction of metals fromsulphides ore sources (Pyro-metallurgy and hydro-metallurgy) Productionofcopper,zinc(conventionalandadvancedroutes), Extractionofgold.Extractionoftitanium.

H.S.Ray, R.SridharandK.P.Abraham Extraction of nonferrous metals,Affiliated East WestPress Pvt Ltd., New Delhi(2007).

F.Habashi,Principles of Extractive Metallurgy,Vol.1-4,Gordonand Breach,NewYork,

T.Rosenqvist, Principles of Extractive Metallurgy, 2nd Ed, Tapir Academic Press, 2004.

R.D.Pehlke,Unit processes in extractive metallurgy,Elsevier,Amsterdam, 1982.

MT817 Advanced Mineral Processing (3-0-0) 3

Introduction:Economic Justification,Economic Benefits;Crushing Technique and Fine Grinding; Classification: Factors influencing settlingrates,free settling and hindered settling,air Classifiers and concentrate by classification; Metallurgical accounting and simulation:Mass balance method and mass balance on complex circuits,Particlesize analysis; Dewatering:Thickeners,Filtering, Type of Filters;Flotation:Application of flotation,wettability, bubble column concentration, celltype;Working principle of advance magnetic separator such as vertical pulsating high gradient magnetic separator, multistage magnetic separator, hybrid magnetic separator.Electro static Separator, electrodynamic separator;Gravity concentration: Shaking table, Jigs, spiral, Heavy media Separator, Particle Dynamic sinshaking table,spiral, jigs and spirals;Recycling of E-waste:Purpose of recycling,Treatment method and processing.

D.V.SubbaRao,Mineral Beneficiation:A Concise Basic Course,2011,CRC Press.

B.A.Wills Mineral Processing Technology:An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery,7 edition,2006,Butterworth-Heinemann.

Charles Burroughs Gill,Materials Beneficiation, Materials Research and Engineering,1991,Springer-VerlagNew York,Inc.

NamS, Minerals Processing and Beneficiation,2015, Daya Publishing House.

MT821 Nanophotonics (3-0-0) 3

Nanophotonics:Background,Maxwell'sequations,optical modes,1D,2D and 3D photonic crystals and light propagation in them, Photonic Properties of Nanomaterials;Photon Absorption,Emission & Scattering;Permittivity & free Electron Plasma of metals, Extinction Coefficient of Metal particles;Gold & silver particles fornanophotonic devices,band gap engineering of nanoscale devices, Thin films,Quantum wires and dots,photonic crystal fibers, Quantum Confinement based light sources and detectors, optical tweezers, photonic crystal devices,nonlinear optics in nano and microstructures.

B.Rogers,S.Pennathurand J.Adams,Nanotechnology:Understandingsmallsystems,CRCPress,2008.

H.Rigneault,J.M.Lourtioz,C.DelalandeandA.Levenson,Nano Photonics ISTELtd.,2007.

A. Nouailhat,Anintroductiontonanoscienceandnanotechnology,JohnWiley &Sons,2008.

DieterVollath,Nanomaterials:Anintroductiontosynthesis,properties&applications,Wiley-VCH,2008.

G.L.Hornyak,J.J.Moores,H.F.TibbalsandJ. Dutta,FundamentalsofNanotechnology,CRCPress,2009.

MT822 Nanoelectronics (3-0-0) 3

Semiconductors:Tuning the Band gap of Nanoscale Semiconductors,Excitons,Semiconductor nanowires-Fabrication strategies, quantum conductance effects in semiconductor nanowires, porous Silicon, nanobelts, nanoribbons, nanosprings; Quantum dot, Single electron devices, molecular electronic devices; Metal-insulator transition, Nanostructured ferromagnetism,effect of bulk nano structuring of magnetic properties, dynamics of nanomagnets, Nanocarbon ferromagnets,Giant & colossal magnetoresistance,Nanopore containment of magnetic particles.

B.Rogers,S.Pennathur and J.Adams, Nanotechnology:Understanding small systems,CRCPress,2008. A. Nouailhat,Anintroductiontonanoscienceandnanotechnology,JohnWiley &Sons,2008.

DieterVollath,Nanomaterials:Anintroductiontosynthesis,properties&applications,Wiley-VCH,2008.

G.L.Hornyak,J.J.Moores,H.F.TibbalsandJ. Dutta,FundamentalsofNanotechnology,CRCPress,2009.

MT823 Surface Phenomena (3-0-0) 3

Thermodynamics of surfaces; Reactivity of surfaces; Atomic models of crystal surfaces; Electron diffraction from surface layers; Surface diffusion; Physical and chemisorptions of gases on surfaces; Chemical reactions at surfaces; Nucleation on surfaces and bulk phases.

Dieter Vollath,Nanomaterials:An introduction to synthesis,properties & applications,Wiley-VCH,2008.
G.L.Hornyak, J.J.Moores, H.F.Tibbals and J. Dutta, Fundamentals of Nanotechnology,CRC Press, 2009.

MT824 Carbon Nanostructures & Applications (3-0-0) 3
Carbon nanostructures and types of CNTs, growth mechanisms, synthesis of CNTs by flame, CVD,laserablation and electric arc processes, purification and characterization methods, mechanical reinforcements, solid disordered carbon nanostructures, nanostructured crystals, electrical, vibrational, mechanical properties of CNTs, optical properties, Raman spectroscopy of CNTs, carbon clusters and fullerenes, decoration of CNT by nanometals/oxides,lithium and hydrogen adsorption and storage,fue cell applications and energy storage,sensor applications of CNTs.Applications to nanoelectronics, nanocomposites, nanowires and drug delivery.
C.N.R.Rao,Achim Muller and A.K.Cheetham,Th Chemistry of Nanomaterials,Wiley Interscience,2005.
A.Jorio,G.Dresselhaus and M.S.Dresselhaus,Carbon Nanotubes-Advanced Topics in the Synthesis,Structure, Properties and Applications,Springer 2008.
A.Loiseau,P.Launois,P.Petti,S.Roache and J.P.Salvetat,Understanding Carbon Nanotubes- Frombasicsto applications, Springer 2006.

MT825 Nanobiotechnology (3-0- 0) 3
Biosynthesis of nano sized materials using microbes, bioconjugation of biomaterials (enzyme) with nanoparticles, different types of inorganic materials used for synthesis of hybrid nano-bio-assemblies, nanoprobes for analytical applications-a new methodology in medical diagnostics and biotechnology,synthesis of nanomedicines and its behavior in biological systems.Synthesis of nanodrug carriers (soft, hard), applications of nanomaterials to cancer detection and treatment, Labon Chip, DNA Micro-array, Protein Micro-array, Bioelectronics, Biobatteries, Biorobotics,Molecularmotors.
A.K.Bandyopadhyay, Nanomaterials,New Age Publishers.
T.Pradeep,Nano: The Essentials-Understanding Nanoscience and Nanotechnology, Tata McGrawHill, 2007.

MT826 Polymer Nanotechnology (3-0-0) 3
Processing of Nanoparticles-Binding mechanisms in Nanoparticles, Dispersion of Nanoparticles, Stabilization of Nanoparticles. Processing and fabrication of polymer nanocomposites-Meltblending,Solvent casting, In-situ polymerization, Solution polymerization, Template synthesis,High shear mixing.Homogenoeous/heterogeneous nucleation, plasma promoted nucleation, Cold Plasma Methods, Atomic layered position fundamentals, Laser ablation, Vapour-liquid-solid growth, particle precipitation aided CVD. Polymer nanocomposites with structural, gas barrier and flame retardant properties,carbon fiber reinforced polymer composites,elastomer and thermoplastic elastomer nanocomposites fo rpropulsion systems, water bornefire-retardant Nanocomposites, hybrid composites for cosmetics, protective and decorative coatings.Polymer based optical, electronic and magnetic materials. Nanoelectronics. Molecular Electronics Components.Characterization of polyphenylene based switches and complex molecular devices. Molecular rectifying diode switches.
ChungD.L.,Composite Materials: Science and Applications, Spinger International Edition, Springer-Verlag,London(2004)-Indian Edition2006
B.T.Astrom,Manufacturing of Polymer Composites,Chapman and Hall,London,1995
T.G.Gutowski,Advanced Composites Manufacturing,John Wiley and Sons,NewYork,1997
K.Goser,Peter Glösekötter and Jan Dienstuhl,Nanoelectronics & Nanosystems:From Transistorto Molecular & Quantum Devices. Springer Berlin, 2004

MT827 Nanocomposites (3-0-0) 3
Introduction to nanocomposites, composite materials, mechanical properties of nanocomposite materials, stress-strain relationship, toughness, strength, plasticity, ceramic-metalnanocomposites, ceramic based nanoporous composites, metal matrix nanocomposites, polymer based nanocomposites, carbon nanotubes nanocomposites, natural nano-biocomposites, bio-mimetic nanocomposites and biologically inspired nanocomposites, nanocomposites for hard coatings, DLC coatings, thin film nanocomposites, modelling of nanocomposites,synthesis of various nanocomposite materials, Sputtering, mechanical alloying, sol-gel synthesis ,thermal spray synthesis, nano-indentation, processing of polymer nanocomposites, properties of nanocomposites,salt in filtration, powder mixing, intrusion method,exfoliation and interaction,gel-casting impregnation techniques.
P.M.Ajayan,L.S.Schadler and P.V.Braun, Nanocomposite Science and Technology,Wiley-VCH,2003 C.P.Poole and F.J.Owens,Introduction to Nanotechnology,Wiley Interscience 2003. H.S.Nalwa, Encyclopedia of Nanotechnology,2004

Chung;D.L., Composite Materials: Science and Applications, Springer International Edition, Springer-Verlag, London(2004)-Indian Edition 2006.

MT828 Chemistry of Nanomaterials (3-0-0) 3

Nanomaterials, size effects, general methods for preparation, sol-gel, solvo thermal, sonochemistry and othernovel methods of synthesis, properties and uses of nanomaterials, growth of nanocrystals in solutions, structure, energy bands, methods of measuring properties, particle size determination, metal and semiconductor nanocrystals, oxide nanoparticles, nanotubes and nanowires, nanostructured polymers and composites, nanoporous materials, nanocatalysis, industrial applications.

C.N.R.Rao,Achim Muller and A.K.Cheetham,The Chemistry of Nanomaterials,Vol I & II,Wiley VCH, 2004.
C.N.R.Rao,Achim Muller and A.K.Cheetham, Nanomaterials Chemistry,Wiley VCH, 2007.
C.P.Poole and F.J.Owens, Introduction to Nanotechnology, Wiley Interscience, 2003.

MT829 Advanced Characterization Techniques (3-0-0) 3

Compositional and structural characterization techniques: XPS, X-ray topography, Electron probe microanalysis, Electron diffraction, Electron probe microanalysis, SIMS and RBS, AFM, STM, Ramanspectroscopy, Photo luminescence spectroscopy,Hall measurement, dynamic and static I-V characteristics, C-V measurement, EBIC, SQUID, VSM, MFM, neutron diffraction, DSC, TGA, DMA.

C.Suryanarayana, A practical approachto X-ray diffraction analysis, 1998.
Z.L. Wang,Characterization of Nanostructured materials, 2003.
J.I.Goldstein, Scanning Electron Microscopy and X-ray microanalysis, 2003.
E.Smith and G.Dent, Modern Raman Spectroscopy: A practical approach, 2005.

MT830 Micro Structure & Mechanical Properties of Nano-Structures (3-0-0) 3

The phenomenological, mechanistic and micro-structural aspects of the mechanical properties of materials are developed, with particular emphasis on the similarities and differences among various materia lsystems including metals,ceramics and polymers.Phenomenological aspects of the three-dimensional characteristics of stress and strain, various yield criteria,elastic behavior,viscoelastic behavior, plastic behavior, statistical aspects of brittle fracture and fracture mechanics are presented. Mechanistic and micro-structural topics include edge and screw dislocation behavior, slip systems, critical resolved shearstress, dislocation multiplication and interactions, barriers to motion, polymerchain conformation and entropy.

C.P.Poole and F.J.Owens,Introduction to Nanotechnology,Wiley Interscience 2003.
H.G. Rubahn,Basics of Nanotechnology,Wiley-VCH,3rd ed.,2008.
Dieter Vollath,Nanomaterials:An introduction to synthesis, properties & applications,Wiley-VCH, 2008.
G.L.Hornyak,J.J.Moores, H.F. TibbalsandJ. Dutta, Fundamentals of Nanotechnology,CRC Press, 2009.

MT831 Nanomaterials for Energy Conversion (3-0-0) 3

Fundamentals of thermodynamics, chemistry,and transport applied to energy systems.Analysis ofenergy conversion and storage in thermal, mechanical, chemical, and electrochemical processes in power and transportation systems,with emphasison efficiency, performance, and environmental impact. Applications to fuel reforming and alternative fuels, hydrogen, fuel cells and batteries, solar cells, combustion, catalysis, combined and hybrid power cycles using fossil, nuclear and renewable resources.CO_2 separation and capture. Biomassenergy.

C.P.Poole and F.J.Owens,Introduction to Nanotechnology,Wiley Interscience, 2003.
H.G.Rubahn, Basics of Nanotechnology,Wiley-VCH,3rd ed., 2008.
Dieter Vollath,Nanomaterials: An introduction to synthesis, properties & applications, Wiley-VCH, 2008.
G.L.Hornyak, J.J.Moores, H.F.Tibbals and J. Dutta, Fundamentals of Nanotechnology,CRC Press, 2009.

MT832 Integrated Microelectronic Devices (3-0- 0) 3

Semiconductor fundamentals, p-njunction, metal-oxide semiconductor structure, metal-semiconductor junction, MOS field-effect transistor, and bipolar junction transistor. Emphasis on physical understanding of device operation through energy band diagrams and short-channel MOSFET device design. Issues in modern device scaling outlined. Includes device characterization projects and device design project.

R.S.Muller,T.I.Kamins and M. Chan, Device Electronics for Integrated Circuits,3rd Ed.,John Wiley, 2002.
S.M.Sze, Physics of Semiconductor Devices,Wiley Interscience,2nd Ed.,1981.

MT833 MEMS/NEMS Devices and Systems (3-0- 0) 3

MEMS &NEMS-overview, sensors, transducers and actuators designing, Basics of MEMS engineering, scaling laws, materials for MEMS and NEMS; microsystem manufacturing: photolithography, bulk, surface and LIGA processes,comparison of wet and dry etching, striction, methods to reduce striction, microsystem design, CAD applications in MEMS design, Applications of MEMS and NEMS in automotive, aircraft, medical electronics, and sensor systems.

Tai RamHsu,MEMS and microsystems-Design and Manufacturing,Tata McGrawHill, 2002.
M.J.Madou,Fundamentals of microfabrication-the science of miniaturization, IEEE Press,
S.D.Senturia,Microsystems Design,Kluwer Academic Publishing, 2003.

MT834 Nanotribology (3-0- 0) 3

Nanotribology, nanomechanics, surface forces, nano-rheology of molecular thin films, interfacial forces, spectroscopic study of confined fluids,friction and wear on atomic scale, nanomechanical properties of solid surfaces and thin films,computer simulation of nanometer scale indentation and friction, mechanical properties of nanostructures, scale effects in mechanical properties and tribology, nanoscale boundary lubrication studies,bio-mimetics,lotus effect,superhydrophobic surfaces, measurement techniques, scanning probe microscopy, non-contact AFM,and related topics.

Bharat Bhushan(Ed.),Nanotribology and Nanomechanics,2ndEd.,SpringerXXXIV, 2008.

MT835 Computational Materials Science (3-0- 0)3

Theory and application of atomistic computer simulations to model,understand,and predict the properties of real materials.Energy models:from classical potentials to first-principles approaches. Intermolecular forces and potentials, Density-functional theory and thetotal-energy pseudo potential method. Many body model potentials, Atomsitestress field,Errors and accuracy of quantitative predictions.Thermodynamic ensembles: MonteCarlo simulation methods, Computation for few particles, Markov process, molecular dynamics simulations, Numerical integrations of equations of motion, Systems in contact with heat bath, Free energies and phase transitions. Fluctations and transport properties. Coarse-graining approaches and mesoscale models.

G. Ali Mansoori, Principles of Nanotechnology,World Scientific, 2006.
K.Ono,K. Esfarjani and Y.Kawazoe,Computational Materials Science,From Ab-initioto Monte-Carlo,Springer Seriesin Solid State,NewYork, 1999.
D.C.Rapaport, The Art of Molecular Dynamics Simulation,CUP, 2004.
W.H.Press,S.A.Teukolsky,W.T.Wetterling and B.R.Flannery,Numerical Recipies,The Art of Parallel Scientific Computing,CUP,1996.

DEPARTMENT OF CHEMISTRY

CY701 Analytical Chemistry **(3-0-0) 3**

Electroanalytical methods: conductometry, potentiometry, Polarography and voltammetry, DC & AC polarography, Rapid scan polarography, Pulse polarography, Square wave polarography, Cylic voltammetry, Chronopotentiometry, Stripping analysis, Amperometric titrations, Coulometry, Thermal methods of analysis: TG, DTG, DTA and DSC. Nephelometry, Turbidometry. Solvent extraction, Chromatography – theoretical concepts, migration parameters, column efficiency, separation factor, Paper and thin layer chromatography, Partition chromatography, Gas chromatography, HPLC, Exclusion chromatography, Gel permeation chromatography, Super critical fluid chromatography & Extraction capillary electrophoresis.

S.M. Khopkar, Basic Concepts of Analytical chemistry, 2002.
D.A. Skoog, F.J. Holler, S.R. Crouch, Instrumental Analysis, 2008.
R.D. Braun, Introduction to Instrumental Analysis, Parma Book, 2006.
G.H. Jeffery, J. Bassett, J. Mendhem, R.C. Denney, Vogel's Textbook of quantitative Chemical analysis, ELBS, 5th Edn, 1989.

CY702 Inorganic Chemistry - I **(3-0-0) 3**

An overview of different types of bonding, energetics involved, solubility of the compounds – energetics considerations, Molecular orbital theory for polyatomic molecules, Structure of solids: Symmetry in crystal systems, radius ratio, shapes of crystals, solid state defects, physical properties of solids. Main group elements, general chracteristics, chemistry of main group elements, complexes s-block metals with cyclic and crown ethers, cryptands and calixeranes, biological significance of s-block metals. p-Block elements: Chemistry of non metals: B, Si, P & S, E-H, E-X, E-O & E-N bond types in different molecules, Intercalation compounds of graphite, Chemistry of boranes, silanes, phosphanes and sulphanes, borazine, boron and silicon nitrides. P-N & S-N rings: synthesis, structure, bonding and reactions of N3P3Cl6 & S4N4. Halogen and noble gas chemistry: Inter halogens, pseudo halogens, ionic oxy halogen species. Noble gas compounds.

F.A.Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th edn., J. Wiley. New York, 1999. D.F.Shriver, P.W. Atkins and C.H. Lingford, Inorganic Chemistry, ELBS, 1990 N.N.Greenwood and E.A. Earnshaw, Chemistry of Elements, Pergmann Press, 1984.
H. T. Huheey, 3rd edition, Inorganic Chemistry, Principles of Structure and Reactivit, 2002.
M. F. C. Ladd, Structure and bonding in solid state chemistry, Chickester, Ellis, Horwood, 1974.

CY703 Organic Chemistry - I **(3-0-0) 3**

Basic concepts: Review of bonding and electronic effects, Inclusion compounds, Crown ethers, Catenanes, Rotaxanes. Aromaticity: Huckel's rule. Organic acids and bases, factors affecting. Reaction mechanisms, Types of organic reactions and reagents. Kinetic and thermodynamic control, transition states, Hammond postulate, kinetic isotope effect. Hammett's equation. Generation, structure, stability, reactivity of carbocations, carbanions, free radicals, nitrenes, carbenes, and benzynes and their reactions. Determination of reaction mechanism. Aliphatic and aromatic nucleophilic & electrophilic substitution reactions, types & mechanisms; Additions to carbon-carbon and carbon-heteroatom multiple bonds, Elimination reactions and their types. Important named reactions and rearrangement reactions involving carbonium, carbanion, free radicals. Reactions involving carbenes and nitrenes.

F. A. Carey and R. I. Sundberg, Advanced Organic Chemistry, Parts A and B, 3rd edition, Plenum Press, New York, 1990.
Jonathan Clayden, Nick Greeves, and Stuart Warren, Organic Chemistry, 2nd edition, Oxford University Press, UK, 2012.
J. March, Advanced Organic Chemistry, Reactions, Mechanism & Structure, 4th edition, Wiley Interscience, 1994
I. Fleming, Frontier Orbitals and Organic Chemical Reactions, Wiley, London, 1976.

CY704 Physical Chemistry – I **(3-0-0) 3**

Chemical Thermodynamics: Combined form of 1st and 2nd laws, Maxwell's relations. Third law of thermodynamics, Gibbs-Duhem equation Chemical Dynamics: Transition state theory and the Arrhenius equation. Marcus theory of electron transfer. Reactivity and selectivity principles. Lindemann, Hinshelwood and RRKM theories. Fast reaction Techniques, Complex reactions, Opposing, parallel, consecutive reactions. reactions in solution: Ionic reactions-kinetic salt and solvent effects. Isokinetic temperature. An introduction to kinetic isotope effect. Theories of reaction rates: Collision theory of reaction rates, steric factor, activated complex theory and its applications to reactions in

solution. Phase equilibria. Photochemistry: Kinetics of photophysical processes, quenching, experimental methods in photochemistry, Applications in synthesis, solar energy utilization and atmospheric chemistry.
A.W. Atkins Physical Chemistry ELBS (IV Edition) Oxford University Press, Oxford 1990.
J. Rajaram and J.C. Kuriacose, Thermodynamics for Students of Chemistry, Shobanlal Nagin Chand Co. 1986.
K.J. Laidler, Chemical Kinetics. (Harper and Row) 1987.
K.K. Rohatgi Mukherjee, Fundamentls of Photochemistry, Wiley Eastern Ltd., New Delhi, 1978.

CY705 Symmetry, Group Theory and Quantum Chemistry (3-0-0) 3
Group Theory: Introduction, symmetry elements, symmetry operations and the point group of a molecule, the great orthogonality theorem, Character table, Construction of character tables for C_{2v} and C_{3v} groups, Symmetry adapted atomic basis sets, Construction of molecular orbitals. Quantum Chemistry: Photoelectric and Compton effects, de-Broglie concept, uncertainly principle, operators, Hermitian operators, Schrodinger equation, Eigen functions and Eigen values. Probabilities, normalization and orthogonality. Postulates of quantum mechanics. Solution of Schrodinger wave equation for exactly solvable problems such as particle in a box (1D and 3D), Schrodinger wave equation for harmonic oscillator, zero-point energy, Harmonic Oscillator model for diatomic molecule, anharmonicity, Morse Potential, correlation with Infrared spectrum of a diatomic molecule, rigid rotator, one-particle system, two-particle rigid rotor, Rotational spectroscopy.
F.A. Cotton, Chemical Applications of Group Theory, Wiley Interscience,1990, 3rd Ed.
R. L. Carter, Molecular Symmetry And Group Theory, Wiley Interscience, 2016.
A.K. Chandra, Introductory Quantum Chemistry (Tata McGraw Hill) 1994.
I. N. Levine, Quantum Chemistry, 5rd edition, Allyn and Bacon, Boston, 2000.

CY706 Organic Chemistry Practicals – I (0-0-6) 3
Separation and qualitative analysis of binary mixtures, Identification of functional groups in organic molecules, synthesis and identification of chemical derivatives. Quantitative estimation of organics such as acetone, phenol, and sugars. Synthesis of organic compounds involving single-step transformations such as nitration, halogenation, acetylation, condensation, cyclization, reduction, oxidation, and diazotization. Isolation techniques such as solubility and extraction, purification by crystallization and characterization of product by melting point and spectroscopic data.
D. L. Pavia, G. M. Lampman, G. S. Kriz, and R. G. Engel, A small scale approach to Organic Laboratory Techniques (4th Ed.), Centage Learning, 2015
J. Leonard, B. Lygo and G. Procter, Advanced practical organic chemistry (3rd Ed.), CRC Press, 2013 F. G. Mann and B. C. Saunders, Practical Organic Chemistry (4th Ed.), Pearson, 2009
In-house laboratory manual with detailed experimental procedure and literature

CY707 Physical Chemistry Practicals – I (0-0-4) 2
Experiments involving Thermodynamics, Kinetics, Electrochemistry and Spectroscopy techniques.
D.P. Shoemaker and C.W. Garland, Experiments in Physical Chemistry, McGraw-Hill, New York 1962.
F. Daniels, J.W. Williams, P. Bender, R.A. Alberty and C.D. Cornwell, Experimental Physical Chemistry, McGraw-Hill 1962.
J. B. Yadav, Advanced Practical Physical Chemistry, Goel Publications, 2016.

CY751 Inorganic Chemistry – II (3-0-0) 3
Chemistry of transition and inner transition metals. Co-ordination Chemistry: Theories of metal ligand bonding-crystal field theory, spectrochemical series. Jahn-Teller distortion. Molecular orbital theory. Spectral properties of complexes, term symbol of d^n ions. Orgel and Tanaber-Sugano diagrams. Charge transfer transitions. Magnetic properties - types of magnetic behavior, crystal field and M.O. interpretation, spin-orbit coupling, Gouy and Faraday methods. Kinetics and Mechanism of reactions in octahedral and square planar complexes. Coordination Chemistry of Inner transition Metals.
S.F.A. Kettle, Coordination Chemistry, ELBS & NELSON, 1969.
J.E. Huheey, Inorganic Chemistry, Principles of Structure and Reactivity, 4thEdn., Harper & Row, 1978.
H.J. Emeleen and A.G. Sharpe, Modern Aspects of Inorganic chemistry, 4th Edn.,ELBS & Roultedge of Kegan Paul, 1978.
P. Powell, Principles of Organometallic Chemistry, ELBS, Chapman and Hall, London, 1988.

CY752 Organic Chemistry - II **(3-0-0) 3**
Stereochemistry: Symmetry, optical activity, enantiomers, absolute configurations, threo & erythro isomers, resolution, diastereomers, stereospecificity, stereoselectivity, topicity, asymmetric synthesis, chiral reagents, Cram's and Prelog's rules. Optical activity in biphenyls, allenes, spiranes. Stereochemistry of N, S & P compounds. Conformational analysis of cycloalkanes and decalins, Curtin-Hammett principles, Winstein equation, Enantiomeric excess, CD, ORD, & Cotton effect. Geometrical isomerism, monocyclic & fused ring systems, Determination of configuration. Stereochemistry of important reactions. Pericyclic reactions: Woodward-Hoffmann rules, FMO approach, cycloadditon, dipolar addition and electrocyclic reactions, sigmatropic rearrangements. Photochemistry: Principles, Norrish type-I & Type-II reactions, photo-dissociation, -reduction, -isomerization, -addition & oxidation. Photochemical cells.
E.L.Eliel, Stereochemistry of Carbon Compounds, Tata McGraw Hill, New. Delhi, 1994.
D.Nasipuri, Stereochemistry of Organic Compounds-Principles and Applications, Second edition, Ch-2-6, New Age International Ltd. Publishers, New Delhi, 2007.
P.S.Kalsi, Stereochemistry, Conformation and Mechanism, Wiley Eastern, New Delhi, 2012.
R.T.Morrison and R.N. Boyd, Organic Chemistry, Prentice Hall, New Delhi, 1994.

CY753 Physical Chemistry – II **(3-0-0) 3**
Quantum Chemistry: Need of approximate methods in quantum chemistry. Approximate methods of solving Schroedinger equation for problems of chemical interest, Introduction to SCF methods. Born-Oppenheimer approximations. Statistical Thermodynamics: Concept of distribution. M-B, B-E and F-D statistics. Partition functions, Irreversible Thermodynamics.
B.C. McClelland, Statistical Thermodynamics, Chapman and Hall, London 1973.
M.C. Gupta, Statistical Thermodynamics, Wiley Eastern Limited 1993.
P.W. Atkins, Molecular Quantum Chemistry Mechanics, 2nd edition, Oxford University Press, 1983.
I. N. Levine, Quantum Chemistry, 5rd edition, Allyn and Bacon, Boston, 2000.

CY754 Spectroscopy **(3-0-0) 3**
Atomic and Molecular Spectroscopy: Basic elements of spectroscopy. Fourier Transform spectroscopy. Microwave-Spectroscopy: Spectra of diatomic & polyatomic molecules, rigid and non-rigid rotator models, isotope effects, Stark effect. IR spectroscopy: Vibrational frequency, modes of vibration, FTIR. Raman spectroscopy: Basic principles, Raman effect. Electronic Spectroscopy: Spectra of diatomic molecules, The Born – Oppenheimer approximation, Frank – Condon principle, rotational fine structures. Absorption laws –Molecular emission spectroscopy: Fluorescence, phosphorescence and chemiluminescence. AAS and AES. X – ray methods: fundamental principles and applications – qualitative and quantitative, X – ray diffraction methods – Bragg's method, rotating crystal method, powder method, applications. XRF. PES, UPS and XPS.
C. N. Banwell and E. M. Mc Cash, Fundamentals of Molecular Spectroscopy, Tata-McGraw Hill,1994.
G. M. Barrow, Introduction to Molecular Spectroscopy. McGraw-Hill, 1963.
R. M. Drago, Physical Methods for Chemists, Saunders College Pub., 1992 J. M. Hollas, Modern Spectroscopy, Wiley, 2004.

CY755 Inorganic Chemistry Practicals – I **(0-0-6) 3**
Qualitative analysis salts/salt mixture of less familiar elements – semimicro analysis. Analysis of commercially important ores, alloys, limestone, cement. Instrumental methods, pH-metry, potentiometry, polarography, amperometry, spectrophotometry, turbidimetry, flame photometry, atomic absorption spectrometry, fluorometry, coulometry, and electrogravimetry. Statistical analysis of data.
G. Srehla, Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, Orient Longman, New Delhi, 1982.
J. Basset, R.C. Denny, C.H. Jeffery and J. Mendham, Vogel's Textbook of Quantitative Inorganic analysis, including Elementary Instrumental Analysis, ELBS, London, 197

CY756 Physical Chemistry Practicals – II **(0-0-6) 3**
Experiments involving instruments such as Electrochemical work station, IR spectrometer, UV-Visible spectrophotometer, TGA and DSC, Stripping analysis, Ionometers, Cyclic voltammetry experiments, Surface area analysis and computational chemistry techniques.

D.P. Shoemaker and C.W. Garland, Experiments in Physical Chemistry, McGraw-Hill, New York 1962.

F. Daniels, J.W. Williams, P. Bender, R.A. Alberty & C.D. Cornwell, Experimental Physical Chemistry, McGraw-Hill 1962.
Journal of Chemical Education, latest issues.

CY801 Inorganic Chemistry – III **(3-0-0) 3**
Organometallic compounds: Classification, nomenclature, and characteristics. General properties, 18-electron rule, metal carbonyls, nitrosyls, cabonyl hydrides, isolobal analogy, Fluxional molecules, Organometallic compounds of main group elements: Preparative routes, structural aspects, multiple bonded silicon and arsenic organometallics, cyclopentadienyl complexes. Organometallic compounds of transition elements: Synthesis and structural properties, reactivity. Carbine complexes, Transition metal pi-complexes with unsaturated organic molecules: Preparation, properties and structural features. Applications of organometallics in oxidative addition, oxidative coupling, reductive elimination, insertion and deinsertion reactions, hydrogenation, carbonylation, hydroformylation, isomerization, aasociative substitution, dissociative substitution, activation of C-H bond, polymerization of olefins, Fischer-Tropsch process, Water Gas Shift reaction. Biological applications and environmental aspects.
J. E. Huheey,E. A. Keiter and R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Ed. Harper Collins 1993
R. C. Mehrotra and A.Singh: Organometallic Chemistry, New Age International, 1999.
J. P. Collman, L. S. Hegedus, J.R.Norton and R.G.Finke: Principles and Applications of Organotransition Metal Chemistry, University Science Books, 1987.
R.H.Crabtree: Organometallic Chemistry of Transition Metals, Wiley, 1998.

CY802 Organic Chemistry – III **(3-0-0) 3**
Heterocyclic compounds: Classification, nomenclature, structure, reactivity, synthesis and reactions of three, four, five and six membered heterocycles, fused heterocycles and bridged heterocycles. Heterocycles with two heteroatoms, azoles, synthesis and reactivity. Mesoionic compounds. Natural products: Alkaloids, Terpenoids, Carotenoids, Steroids - isolation and methods of structural determination, physiological activity. Bio-organic chemistry: Amino acids, peptides & proteins: peptide bond synthesis, solid phase peptide synthesis. Structure of proteins. Enzyme catalysis and kinetics, Enzyme inhibition and drug design, Biomemetic Polyene cyclisation, Squalene biosynthesis.
J. Joule & G. Smith, Heterocyclic Chemistry, Van-Nostrand, ELBS, 1978.
Acheson, An Introduction to the Chemistry of Heterocyclic Compounds, Wiley –Eastern, 1987.
O.P.Agarwal, Chemistry of Natural Products – Vol-I & II, Goel Gorakhpur, 1985.
I. .L.Finar, Organic Chemistry-Vol-I-II, Longmann ELBS London, 2000.

CY803 Physical Chemistry – III **(3-0-0) 3**
Electrodics-electrical double layer, electrode-electrolyte interface. Thermodynamics of electrified interfaces, electrocapillary curves, structure of electrified interfaces: Helmholtz-Perrin, Guoy-Chapman and Stern models. Mixed potential theory, Corrosion and its control, Thermodynamics and kinetics of corrosion, Types and methods of controlling corrosion, factors responsible for corrosion, theories of overvoltage polarization, exchange current density, Pourbaix diagram, Buttler-Volmer equation, kinetics of electron transfer, Stearn-Geary equation, Electrochemical methods of corrosion monitoring, Electrochemical impedance spectroscopy and its applications, Photoelectrochemistry Electrochemical Microscopy, electrochemical energy sources, primary and secondary cells, lithium and lithium ion battery, fuel cells, hydrogen energy and electrocatalysis
J. O'M Bockris and AKN Reddy, Modern Electrochemistry- Vol. I & II, Plenum Press, N.Y.(2010) Bard, A. J., and Faulkner, L. R., Electrochemical Methods, second edition, Wiley, New York (2010) Nestor Perez, Electrochemistry and Corrosion, Kluwer Academic Publishers, (2001).
Mars G Fontana, Corrosion engineering, McGraw Hill Book Co., New York, Third edition (1987).

CY804 Spectroscopy Applications in Chemistry **(3-0-0) 3**
Electronic transitions, spectra of conjugated systems, complexes. Woodward–Fieser rules, Factors affecting UV-Vis absorption. IR spectroscopy: fingerprint region, functional group analysis, H-bonding & solvent effects, overtones, Fermi resonance, analysis of organic & coordination compounds. NMR spectroscopy: ^{1}H NMR, Zeeman splitting, chemical shift, spin-spin coupling, Instrumentation & experimental techniques. J values, 1st & 2nd order patterns. AB, AX & ABX systems, stereochemical assignments. 2D NMR, MRI. ^{13}C NMR: Theory & applications. NMR of B, Si, F & P nuclei - structure and dynamics of inorganic molecules. ESR spectra of organic free radicals, metal complexes, spin traps. Mass spectroscopy: Instrumentation, molecular ions, meta-stable, isotope abundance,

fragmentation types & rules. Mc Lafferty rearrangement. ESI-MS & MALDI-MS. Introduction to single crystal analysis. Identification of structures of unknown organic compounds based on the data from UV-Vis, IR, ^{1}HNMR, ^{13}C NMR and Mass spectrometry.

Silverstein, Bassler&Monnill, Spectrometric Identification of Organic Compounds, Wiley, 1981.
W.Kemp, Organic Spectroscopy-3rd Ed. Pagrave Publishers, New York, 1991.
P.S.Kalsi, Spectroscopy of Organic Compounds-3rd Ed. New Age, New Delhi, 2000.
D.L.Pavia, G.M.Lampman, G.S.Kriz, Introduction to Spectroscopy: A Guide for Students of Organic Chemistry (3rd Ed.), Thomson. 2004

CY805 Inorganic Chemistry Practicals – II (0-0-4) 2

Preparation and analysis of metal complexes, characterization by spectroscopic, magnetic, thermal and x-ray diffraction methods. Instrumental methods, pH-metry, potentiometry, polarography, amperometry, spectrophotometry, turbidimetry, flame photometry, atomic absorption spectrometry, fluorometry, coulometry, and electrogravimetry. Solvent extraction and Chromatography.

G. Pass and H. Sutcliffe, Practical Inorganic Chemistry, Chapman-Hall, London, 1974.
D.M. Adams and J.B. Raynor, advanced Practical Inorganic Chemistry, John Wiley and Sons, New York, 1967.
G. Brauer (Ed.) Handbook of Preparative Inorganic Chemistry, 2nd Edition, Vols. I and II, Academic Press, New York, 1963.

CY806 Organic Chemistry Practicals – II (0-0-4) 2

Separation of ternary mixtures. Quantitative determination of nitrogen, carbon, hydrogen, sulphur of an organic compound. Multi-step organic synthesis involving dyes, polymers, drugs etc. Isolation and characterization of natural products like caffeine, vitamin C, casein, lipase etc. Extraction of oil from oil seed and characterization of oil. Purification of organic compounds by column and TLC, steam distillation, fractional distillation etc. Protein analysis and antimicrobial studies.

P. R. Singh et al, Experimental Organic Chemistry–Vol. I &II TMH New Delhi, 1981.
B. S. Furniss et al., Vogel's Text Book of Practical Organic Chemistry including Qualitative Organic Analysis, Longman-ELBS, London, 1989.
F .G. Mann and B. C. Saunders, Practical Organic Chemistry, ELBS, England, 2001.
Cheronis et al., Semimicro Qualitative Organic Analysis, Wiley-Eastern, New Delhi, 1964.

ELECTIVES

CY861 Advanced Instrumental Methods of Analysis (3-0-0) 3

SEM, TEM, EDX, WDXA, Scanning probe microscopy-AFM, SECM, SCM and SMFM, Principles, Instrumentation, their applications. *AFM:* Introduction, principle, Instrumentation, types of imaging, applications, advantages and its limitations. *Scanning electrochemical microscopy (SECM):* Introduction, principles, Instrumentations, applications. *Scanning capacitance microscopy*: Introduction, Principle, Instrumentation, imaging and applications. Scanning magnetic force Microscopy (SMFM), Introduction, principle, Instrumentation, types of imaging, applications, advantages and its limitations. XRD; introduction, Experimental approaches to x-ray diffraction, Single crystal XRD and powder XRD techniques and their applications. X-ray fluorescence spectrometry, principle, Instrumentation and application. XPS; Principles, Instrumentation, applications.

Ray F. Egerton, Physical principles of electron microscopy- An introduction to TEM, SEM and AEM, Springer Publications, 2005.
Azaroff, L.V., Introduction to Solids, McGraw-Hill, 1960.
Nuffield, E.W., X-Ray Diffraction Methods, Wiley, 1966.
Cullity, B.D., Elements of X-Ray Diffraction, Addison-Wesley, 1960.

CY862 Advanced Organic Synthesis (3-0-0) 3

Alkylation of enolates & other carbon nucleophiles, control of enantioselectivity, the nitrogen analogs of enols & enolates, enamines & imine anions, reductive amination. 1,3-Dipolar cycloaddition, click reactions. Modern methods of reduction & oxidation reactions. Organometallic reagents in organic synthesis: C-H activation, Pd, Rh, Ru & Ni based reagents, Suzuki, Stille, Sonogoshira, Heck & Negeshi couplings. Modern methods: Baylis-Hillman, Henry, Nef, Kulinkovich, Ritter, Sakurai, Tishchenko and Ugi reactions. Brook rearrangement. Tebbe olefination. Stereoselective & stereospecific reactions, stereochemical control in acyclic, cyclic & other bicyclic systems.

Controlling geometry of double bonds, determination of stereochemistry. Asymmetric synthesis: chiral pool strategy, chiral auxiliaries, chiral reagents and catalysts. Microwave assisted organic synthesis, solid phase synthesis.
F. A. Cary and R. I. Sundberg, Advanced Organic Chemistry, Part A and B, 5th Edition, Springer, 2009.
Advanced Organic Chemistry- Reaction Mechanisms, Reinhard Bruckner, (Academic press, USA), 2005.
Organic chemistry by Jonathan Clayden, Nick Geeves, Stuart Warren, Oxford university press.
ROC Norman and J M Coxon, Principles of organic synthesis, 3rd ed. Chapman and Hall, 200.

CY863 Advanced Polymer Membrane Technology (3-0-0) 3
Introduction, Classification of Membranes, basic principles of separation through membranes, Commonly used membrane Materials and their Selection, Types of Membrane modules, Role of additives, Molecular weight cut off, Membrane preparation methods, Membrane characterizations, Hollow fiber membranes, Transport phenomenon through Membranes, Non-porous membranes. Flow patterns in membrane modules. Concentration Polarisation., Modelling and Design considerations of various membrane processes - Reverse Osmosis, Dialysis, Electrodialysis, Ultra filtration, Pervaporation, Gas permeation Membranes. Forward osmosis membranes, Membrane Applications in Waste Water Treatment, dye rejection, heavy metal removal.
J. Mulder and M. Mulder, Basic Principles of Membrane Technology, 1991.
Seader J.D., Emest J. Henley, Separation Process Principles, John Wiley & Sons, 1998,
Judd S., B. Jafferman, Membranes for Industrial Waste Water Recovery and Re-use, Elsiever Publications, 2003.

CY864 Applied Organic Chemistry (3-0-0) 3
Organic chemical industry, petrochemicals, petrorefinery operations, production and downstream processing of ethylene, propylene, butadiene, BTX, and methanol. Chemistry of acetylene, Heterogeneous catalysis, Fixed bed and fluidized bed reactor, Production and applications of polymers like PF & UF resin, ABS polymer, polyesters and polyamides, Classification of organic dyes, synthesis and applications of various dyes, optical brighteners, chemistry of oils and fats, physicochemical properties, soaps and detergents, biodiesel, Synthesis, properties and applications of organochlorines, organophosphates, carbamates and pyrethroids, fumigants, pharmaceuticals, synthesis and properties of NSAIDS, antibiotics, sedatives, antipsychotic, antifungal, etc. Introduction to sustainable chemistry, principles of green chemistry, green matrices, greener approaches to organic syntheses.
A. El-Shekeil, Modern Petrochemicals, ISBN 978-1-490-97969-4, 2013
H. A. Wittcoff, B. G. Reuben, and J. S. Plotkin, Industrial Organic Chemicals (3rd Ed.), Wiley, 2012 R. A. Sheldon, I. Arends, and U. Hanefeld, Green Chemistry and Catalysis, Wiley-VCH, 2007
K. Weissermel and H.-J. Arpe, Industrial Organic Chemistry (3rd Ed.), Wiley VCH, 2008

CY865 Biochemistry (3-0-0) 3
Cell structure and functions: Overview of metabolic processes, ATP- the biological energy currency, ETS, metabolism of glucose, amino acids and lipids, Digestion. Biological membranes, Fluid mosaic model of membrane structure. Enzymes: Types, specificity, mechanism & conjugated proteins. Hemoglobin & its function. Carbohydrates: classification, interconversion of carbohydrates. Biochemistry of lipids, amino acids and proteins. Nucleic acids: Flow of genetic information, nature of genetic code, replication of DNA, transcription and translation, regulation of gene expression. Biochemical reactions of TPP, PLP, Lipoic acid, Vitamins: A, B, C, D, E, K. Enzymes and enzyme catalysis, Coenzyme A. Recombinant DNA technology. Brief introduction about Bioinformatics.
Jeremy M. Berg, John L. Tymoczko and Lubert Stryer, Principles of Biochemistry 6th edition, W.H. Freeman & Co., 2006.
D. L. Nelson & M. M. Cox. Lehninger, Principles of Biochemistry 5th edition, W. H. Freeman &Co. 2008. Outlines of Biochemistry 5th edition 2001- Conn, E.E., Stumpf, P. K. Bruening, G. and Doi, R.H. (John Wiley and Sons).
R.K. Murray et al., Harper's Illustrated Biochemistry, McGraw Hil.
D. Voet et al., Fundamentals of Biochemistry, 2006.

CY866 Bio- Inorganic Chemistry (3-0-0) 3
General Introduction: Essential and trace elements, function and transport: biological role of Ca^{2+}, Mg^{2+}. Na^{+} and K^{+} pump. Ca^{2+} pump, metal ion transport and storage protein: Iron protein ferritin, transferrin, siderophores, and metallothionein, photosynthesis, role of manganese in the oxygen evolution cluster of photosystem- II, Ferredoxins, Rubredoxin, nitrogenases and Cytochromes, Oxygen transport and storage protein: Hemoglobin, Myoglobin, Hemocyani, Hemerythrin, Oxygen activation protein: Cytochromes C oxidase, Cytochromes P-450, Monooxygenases, Dioxygenases, Various types of copper centers, Superoxide dismutase, Catalase and peroxidase, and ascorbic acid oxidase, Vitamin B_{12}, Vitamin B_6 and Coenzymes, Nitrosyls in bioinorganic chemistry.

M. N. Hughes, Inorganic Chemistry of Biological Porcess, 2nd edition, John-Wiley & Sons
W. Kaim and B. Schwederski, Bioinorganic Chemistry: Inorganic Elements in the chemistry of Life, John-Wiley & Sons
S. J. Lippard and J. M. Berg, Princple of Bioinorganic Chemistry, University Science Books
I. Bertini, H. B. Grey, S. J. Lippard and J. S. Valentine, Bioinorganic Chemistry, Viva Books Pvt.Ltd.

CY867 Biophysical and Photochemistry (3-0-0) 3

Bioenergetics, Biopolymer Interactions: Forces involved in biopolymer interactions-electrostatic changes and molecular expansions, hydrophobic forces, dispersion force interactions. Thermodynamic of Biopolymer solutions: Osmotic pressure, membrane equilibrium muscular contractions and energy generation in mechano-chemical system. Cell Membrane and Transport, Photochemical region and energy associated with uv-vis region, laws of photochemistry, Stem Volmer analysis, photofragmentation, photoaddition, type I and type II cleavages, photosubstitution, cycloaddition, Paterno-Buchi reaction, isomerization and rearrangement reactions, photoreduction and photooxidation reactions, singlet oxygen and chemiluminescence, Photoinduced electron transfer reactions (PET), application to solar energy conservation and artificial photosynthetic systems. Photochemical substitution in transition metal complexes.

K.K. Rohatgi Mukherjee, Fundamentls of Photochemistry, Wiley Eastern Ltd., New Delhi, 1978
N.j. Turro, Modern Molecular Photochemistry, The Benjamin Cummings Publishing Co. Ltd. Menlo Park 1978.
J. Clavert and J. Pitts, Photochemistry, John Wiley, New York 1965.
D.O. Ccowan and R.L. Drisko, Elements or Organic Photochemistry Plenum Press, New York 1976.

CY868 Chemical and Electrochemical Energy Systems (3-0-0) 3

Available energy options, their advantages and disadvantages. Fossil fuels petroleum natural gas and coal-Origin, processing and production of value added products. Nuclear Energy Principles of Fission – Fission reactors. Electrochemical power sources-theoretical background on the basis of thermodynamic and kinetic considerations. Primary electrolyte cells, Secondary electrolyte cells- classification. Fuel cells-classification-chemistry of fuel cells. Solar energy conversion devices-photovoltaic cells-photoelectrochemical cells-semiconductor electrolyte junctions photocatalytic modes for fuel conversion process-photobiochemical options. Hydrogen as a fuel production (Thermal, electrolysis, photolysis and photo-electrochemical) storage and applications of hydrogen storage. Other methods of energy conversion processes especially in the form of storage as chemical energy.

C.A. Vincent Modern Batteries, Edward Arnold, 1984.
R. Narayan and B. Viswanathan, Chemical and Electrochemical Energy systems, University Press 1998.
K. Sriram, Basic Nuclear Engineering, Wiley Easter, 1990.
D. Linden Hand book of batteries and fuel cells, McGraw Hill Book Company 1984.
T. Ohta, Solar Hydrogen energy systems, Peragamon Press, 1979.

CY869 Chemistry of Macromolecules ` (3-0-0) 3

Classification, nomenclature, molecular weights, glass transition, degree of crystallinity, morphology, and viscosity, structure-property relationship. Mechanisms and methods of polymerization – mechanism of step polymerization, reactivity. Chain polymerization, radical polymerizations (INIFERTER, ATRP, RAFT, SET). Living polymerizations. Ziegler-Natta & metathesis polymerizations. Polymer characterization. Polymer degradation. Polymer membranes. Conducting polymers. Liquid crystal polymers. Polyelectrolytes. Polymer adhesives. Hydrogels. Polymers for high temperature applications. Biodegradable polymers. Drug delivery polymers. Polymers for electronics.

R. J. Young and P. A. Lovell, Introduction to Polymers, 2nd Edition, Chapman and Hall, 2002.
F. W. Billmeyer, Textbook of Polymer Science, 3rd Edition, John Wiley, 1994.
G. *Odian, Principles of Polymerization, Fourth edition, Wiley-Interscience, 2004. L. H. Sperling, Introduction to Physical Polymer Science, Wiley- Interscience, 1986.*

CY870 Chemistry of Nano-Materials (3-0-0) 3

Nanomaterials, size effects, general methods of preparation, sol-gel, solvothermal, sonochemistry and other novel methods of synthesis, properties and uses of nanomaterials. Growth of nanocrystals in solution, structure, energy bands, methods of measuring properties, particle size determination. Characterization techniques, metal and semiconductor nanocrystals, oxide nanoparticles, nanotubes and nanowires, nanostructured polymers and composites, nanoporous materials, nanocatalysts, industrial applications.

C.N.R. Rao, A. Muller and A.K. Cheetham,(Eds.), The Chemistry of Nanomaterials, Vol I & II, Wiley – VCH, 2004.

Charles P Poole Jr and Frank J Owens, Introduction to Nanotechnology, Wiley Interscience, 2003.
G Cao, Nanostructures and nanomaterials, Imperial college press, London, 2004.
A. S. Edelstein, and R. C. Cammarata (eds.), Nano materials: Synthesis, properties, and applications, Institute of Physics, 1996.

CY871 Chemistry of Natural Products (3-0-0) 3
Alkaloids: Detailed study of structural elucidation, stereochemistry, rearrangement, synthesis & biogenesis of alkaloids - Papaverine, Adrenaline, Ephedrine, Piperine, Cinchonine, Quinine, Morphine and Reserpine. Terpenoids: Structural elucidation & synthesis of terpenoids - Geraniol, Menthol, α-pinene, Camphor; Farnesol, Zingiberene and α-Santonin.Diterpenoids: Abietic and Pimaric & Gibberillic acid;.Triterpenoids: Squalenes Steroids: Blanc's rule, Barbier-Wieland degradation. Chemistry of Cholestrol, Ergosterol, Vitamin-D & bile acids. Steroidal hormones: Oestrone, esterdiol, estriol & their relationship. Progesterone, androsterone & testosterone, Synthesis of cortisone, cortisol & aldosterone. Transformations in steroids and hormones. Porphyrins: Synthesis, structure and degradation products of Hemoglobin and Chlorophyll.
G.R.Chatwal, Natural Products Chemistry Vol-I & II. Himalaya Bomba), 1990.
O.P.Agarwal, Chemistry of Natural Products – Vol-I & II, Goel Gorakhpur, 1985.
I.L.Finar, Organic Chemistry-Vol-I-II, Longmann ELBS London, 2000.

CY872 Computational Chemistry (3-0-0) 3
Basic structure and functioning of computers. Principles of programming. algorithms and flow charts. ORIGIN, SIGMA PLOT, CHEM SKETCH etc. & solve physical/organic/polymer chemistry related problems. Plotting curves. Writing the structures, chemical equations, determining molecular parameters such as bond lengths, bond angles, dihedral angles etc. Bound-state *ab initio* quantum mechanical & density functional calculations, understanding of basis set types & sizes, computational scalability, Hartree-Fock and Post-Hartree-Fock calculations for determining electronic energies & associated molecular properties, electronic structure & thermochemical properties, geometry optimization, study of reaction mechanism, transition-state optimizations. Computer aided drug design. Molecular docking.
Franck Jensen, Introduction to computational chemistry, 2nd Ed., John Wiley & Sons Ltd. 2007.
Ramesh Kumari, Narosa, Computers and their applications to Chemistry.
Mc graw Hill, Theory and Problems of Programming with Basic, NY, 1987.
Ram Kumar, Programming with Fortran 77, Tata McGraw Hill, 1989.
K. J. Johnson, Marcel Dekker, Numerical methods in chemistry, NY, 1980.

CY873 Corrosion Science (3-0-0) 3
Introduction to corrosion, diffusion-controlled corrosion, potential-pH diagrams, passivity, different forms of corrosion, Theories of corrosion, Environmental aspects, Atmospheric corrosion monitoring methods, corrosion testing by NDT. Electrochemical AC and DC techniques, Electrochemical noise study, Corrosion control methods, Design aspects in corrosion control, corrosion resistant materials, corrosion inhibitors, Electrochemical methods – cathodic and anodic protection, protective coatings, organic, inorganic and metal coatings. Corrosion control methods in fertilizer, petrochemical and chemical industries.
S.N. Banerjee, An Introduction to Corrosion and Corrosion Inhibition, Oxonian Press Ltd., 2000.
L.L. Shrier, Corrosion Vol I & II, George Nownons Ltd, London, 2nd Edn.,1998.
M.G. Fontana, and N.D. Greens,Corrosion Engineering, McGraw Hill, New York, 3rd Edn., 2004.
H.H. Uhlig, Corrosion and Corrosion Control, Wiley-Interscience, 2002.

CY874Environmental Chemistry (3-0-0) 3
Environmental segments, Chemical and photochemical reactions in the atmosphere. Water resources, complexation in natural and waste water, microbially mediated aquatic reactions. Composition of Lithosphere, water, air, organic and inorganic components in soil. Nitrogen pathways, NPK, wastes and pollutants in the soil. Air pollutants, Tropospheric chemistry. Water pollution, Wastewater treatment. Water quality parameters and standards, sampling, monitoring techniques and methodology, pH, Conductivity, DO, NH_3, Cl^-, F^-,CN^- , S^{2-}, SO_4^{2-}, PO_4^{3-}, B, Si, metals and metalloids, hardness, COD,BOD,TOC, phenols, pesticides, surfactants, tannin, lignin and E.coli. Chemical toxicology: Toxic chemicals in the environment, Biochemical effects of As, Cd, Pb, Hg, CO, NOx, SO_2,O_3, PAN,CN, pesticides and carcinogens.
A. K. De, Environmental Chemistry, New Age Intl.(Pvt) Ltd.,1998.
C.N.Sawyer, P.L.McCarty and G.F. Parkin, Chemistry for Environmental Engineering, McGraw-Hill, 1990.

S.E.Manahan, Environmental Chemistry, Lewis Publishers, 2001.
JO'M – Bockris (ed), Environmental Chemistry, Plenum Press, New York, 1977.

CY875 Green Chemistry (3-0-0) 3

Importance, principle and scope. Green reagents-Dimethyl carbonate, polymer supported reagents, peracids, chromic acid. Green catalysts-acid catalysts-oxidation catalysts, basic catalysts, polymer supported catalysts & phase transfer catalysts. Ionic liquids: Reactions in acidic & neutral ionic liquids. Synthetic organic transformation under RT. Microwave assisted reactions in water- Hoffmann elimination, hydrolysis, oxidation, saphonification reactions, Microwave assisted reactions in organic solvents-esterification, Fries rearrangement, Deils-Alder reactions, decarboxylation. Ultrasound assisted reactions. Aqueous reactions: Aldol & Benzoin condensations, Diels-Alder & Knovenegol reactions, Solid state reactions- without solvents, solid supported synthesis.
Paul T. Anastas, John Charles Warner, Green Chemistry: Theory & Practice ISBN13:9780198506980.
V.K. Ahulwalia & M. Kidwai, New trends in green chemistry. ISBN 1-4020-1872-X Anamaya publishers.
Clark, James & Macquarrie, Duncan, Handbook of green chemistry & technology, Blackwell Publishing ISBN 0-632-05715-7.

CY876 Medicinal Chemistry (3-0-0) 3

Concept and definition of Pharmacophore, Pharmacodynamics and Pharmacokinetics, Drug targets – enzymes and receptors. Competitive, non-competitive and allosteric inhibitors, transition state analogs and suicide substrates. Nucleic acids as drug targets- reversible DNA binding agents, DNA alkylating agents and DNA strand breakers. ADMET of drugs-factors affecting absorption, distribution, metabolism, elimination and toxicity. Biochemistry of Proteins, enzymes, Lipids and Carbohydrates. Drug discovery, design and development. Structure activity relationships, strategies in drug design. QSAR and combinatorial synthesis. Optimization of drug target interactions and access to drug targets. Illustration of drug development through few specific examples. Drug resistance, drug synergism and combination therapy.
Patric G.L., An introduction to Medicinal Chemistry. 3rd Ed, Oxford University Press 2005.
Silverman R.B., The organic chemistry of drug design and drug action. 2nd Ed, Academic Press 2004.
Williams D.A., Lemke T.L. Foye's Principles of Medicinal Chemistry. 5th Ed, Wolters Kluwer Health (India) Pvt Ltd 2006.

CY877 Modern Methods and Reagents in Organic Synthesis (3-0-0) 3

Modern alkali metal reagents. Organocatalysis based on chiral Bronsted acids and NHCs. Conformational and Stereoelectronic effects on the rate of reactivity of reactions such as ester hydrolysis, substitution reactions, elimination reactions, epoxide opening etc. Different approaches towards the synthesis of three, four, five, and six-membered rings. Pauson-Khand reaction, Bergman cyclization; Nazarov cyclization, Dotz benzoannulation, cation-olefin cyclization and radical-olefin cyclization, inter-conversion of ring systems. Organometallic reagents in organic synthesis. Fischer carbenes, Schrock carbenes, Olefin metathesis, various types of metathesis and application to organic synthesis. Application of protecting groups in organic synthesis. Introduction to total synthesis. Total synthesis analysis of phytol, prostaglandins and penicillin V.
F. A. Carey and R. I. Sundberg, Advanced Organic Chemistry, Part A and B, 2009, Springer.
M. B. Smith, Organic Synthesis, Elsevier, 2011.
S. Warren, Organic Synthesis, The disconnection Approach, John Wiley & Sons, 2004.
W. Carruthers, Modern Methods of Organic Synthesis, Cambridge University Press, 1996.

CY878 Molecular Modelling and Drug Design (3-0-0) 3

Computational programming. Use of standard analysis softwares to solve chemistry problems. Structure & dynamics of bio-molecules, protein folding, free energy, molecular simulation, dielectric continuum method, empirical approaches, rate constants, docking, elucidation of enzyme structure & mechanism, kinetic, spectroscopic, isotopic & stereo-chemical studies. Molecular modelling, conformational analysis. Chemical models & mimics for enzymes, receptors, peptides, carbohydrates, nucleic acids & other bioactive molecules, catalytic antibiotics. Design, synthesis & evaluation of enzyme inhibitors. Structure based drug design, physical & chemical based factors associated with biological activities. Computer aided drug design: Captopril, substrate based drug design of protease inhibitors. Qualitative and quantitative structure-activity relationships.
Richard B. Silvermann, The Organic Chemistry of Drug Design and Drug Action, Academic Press, 1992.
O. M. Dean, Molecular Foundations of Drug-Receptor interactions, Cambridge Univ. Press, Cambridge, 1987 T. A. Clark, A Handbook of Computational Chemistry, Wiley, New York 1985.

D. DeCamp, R. Ogden, I. Kuntz and C. S. Craik in: Protein Engineering Principles and Practice (Eds J. L. Cleland and C. S. Craik) Wiley-Liss Inc New York, 1996.

CY879 Novel Inorganic Compounds (3-0-0) 3

Acylic & cyclic systems from the periodic table - Inorganic homo-& heterocycles, saturated and unsaturated ring systems, p-electron precise and rich rings, synthesis, structure and reactivity. Metallocycles - Chemistry of individual rings. Cages & clusters of Elements, structural variety, properties and implications of borides, carbides, silicides, nitrides, phosphides, oxides and sulphides of transition elements, multiple bonds and cluster variety of transition metals. Higher boranes, carboranes and metalloboranes. Inorganic polymers, definition, variety and merits, P, Si, S, N& O based polymers. Polyphosphazenes, polythiazenes, poly siloxanes and poly silanes.

D.M.P. Mingos and D.J.Wales, Introduction to Cluster Chemistry, Prentice Hall, New Jersey, 1990.
F.A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, John Wiley, New York 1988.
I. Haiduc & D.B. Sowerby (Eds,), Inorganic Homo-and Heterocycles, Vols. 1 & 2, Acad. Press, (NY), 1987.
J.E. Mark, R. West & H.R. Allcock, Inorganic polymers, Acad. Press, (NY) 1992.

CY880 Nuclear and Radiation Chemistry (3-0-0) 3

Nuclear chemistry: Basic concepts, Radioactivity and Nuclear Decay- Radioactive decay modes of natural and artificial nuclides, Radiation Detection and Measurement: Experimental techniques in the assay of radioactive isotopes. Radiation Detectors-Gas filled (ion chambers, proportional and GM counters), scintillation and semiconductor detectors (Nal-Tl and Ge(Li), HPGe solid state detectors)- important features of detectors. Nuclear Reactions and Radiosotopes ,Nuclear reactos-Power(types and basic features) and breeder reactors. Production and separation methods of radioisotopes and labeled compounds, Szilard-Chalmer process , Radiation Sources and Dosimetry-units, radiation dose, radiation chemical yield and primary dosimeters, Health and Safety Aspects: Biological effects of radiation, Hazards in radiochemical work. Radiation protection, permissible exposure doses, radioactive waste management.

Friedlander, Kennedy Macias & Miller, Nuclear and Radiation Chemistry, Wiley, 1985.
H J. Amikar, Essential of Nuclear Chemistry, Wiley Eastern, 1987.
Spinks and Woods, An Introduction to Radiation Chemistry, Wiley, New York, 1990.
Farhataziz and Rodgers, Radiation Chemistry: Principles and Applications, VCH, Weinheim.
G. F. Knoll,Radiation Detection and Measurement, John Wiley, New York, 1989.

CY881 Organic Electronics: Materials and Applications (3-0-0) 3

Introduction to organic electronics, electronic structure of organic molecules, conjugated molecules and polymers-theory and synthesis. Polyacetylene, PPV, polyaniline, polythiophenes, polypyrroles and other polyheteroaromatics, Donor-acceptor conjugated molecules and polymers. Optical and electrochemical properties: instrumental techniques. Band gap engineering in conjugated molecules. Organic light emitting diodes: theory and device configuration. Organic photovoltaic cells: theory, BHJ solar cells. Perovskite solar cells. Organic field effect transistors: Theory and device configuration. Electroactive Polymers for batteries and supercapacitors, Electrochromic devices, chemical sensors, biosensors. Organic nonlinear optics.

Hand book of conducting polymers, T.A. Skotheim, J.R. Reynolds. CRC Press, 2007.
Organic electronics. Edited by Shuichiro Ogawa, Springer, 2015.
Organic Photovoltaics. Materials, Device Physics, and Manufacturing Technologies, Chrisoph Brabec, Vladimir Dyakonov, Ullrich Scherf Eds., Wiley-VCH, 2008.
Organic Light-Emitting Devices, Synthesis, Properties and Applications, Klaus Mullen and Ullrich Scherf Eds., Wiley-VCH, 2006.

CY882 Polymer Chemistry and Catalysis (3-0-0) 3

Polymerisation mechanisms, Kinetics of Polymerisation, Polymer Molecular weights, Stereochemistry of polymers, Analysis and Identification of polymers: X-ray diffraction, thermal analysis and microscopy. Phase transitions in polymers. Polymers in solution. Catalysis: Homogeneous catalysis-equilibrium and steady state treatments, activation energies of catalysed reactions. Kinetics of enzyme catalysed reactions-Michaelis-Menten equation. Effect of pH, temperature & inhibitors. Surface reaction kinetics:BET equation and its application in surface area determination. semiconductor catalysis, n-and p-type. Mechanism of surface reactions. Uni-& bi-molecular reactions. Industrial application of catalysts.

F.W. Billmeyer, Text book of Polymer Science: (Wiley)
J.R. Fried, Polymer science and Technology, (Prentice Hall)

K.J. Laidler, Chemical Kinetics. (Harper and Row) 1987.
Puri and Sharma, Principles of Physical Chemistry, Vishal Publications, 2010.

CY883 Solid State Chemistry (3-0-0) 3

Crystal Structure: Crystalline solids, crystal systems space groups: methods of characterising crystal structure-Powder x-ray diffraction, electron and neutron diffraction; Types of close packing-hcp and ccp. Packing efficiency, radius ratios; structure types-NaCl, ZnS, Na_2O, $CdCl_2$, wurtzite, nickel arsenide, CsCl, Cdl_2, rutile and Cs_2O, perocskite ABO_3, K_2NiF_4, spinels. Thermal analysis, microscopy and spectroscopy as tools of characterization, semiconductors-extrinsic and intrinsic, Hall effect; Insulators-Dielectric, Ferroelectric, Pyroelectric and Peizoelectric properties and the relationship between them. Magnetic properties: Dia, para, ferro, ferri, antiferro and antiferri magnetic types- selected magnetic materials such as spinels, garnets and perovskites. Superconductivity, Amorphous materials-glasses and refractories. New Materials - Zeolites, Fullerenes. Defects-color centers-reactivity.

A.R. West, Solid State Chemistry and its applications John Weley & Sons, Singapore 1984.
Lesley Smart and Elaine Moore, Solid State Chemistry-An Introduction Chapman & Hall, London,1992.
H.V. Keer, Principles of the Solid State, Wiley Eastern Limited, New Delhi, 1993.
L.Azaroff, An Introduction to Solids. McGraw Hill, 1985.

CY884 Supramolecular Chemistry and Crystal Engineering (3-0-0) 3

Definition, concept, historical development, biological inspiration, classification of host-guest chemistry, cavitate, clathrate, binding constant, cooperatively, chelate effect, preorganization and complementarity. Types of non-covalent Binding interactions. Cation binding host design, Crown ethers, lariat ethers, podands, cryptands, spherands, Nitrogen and Sulphur analogue of various ligands, anion binding host: scope, challenges, types of ligands. Introduction and definition of Crystal engineering, Organic Solid state chemistry, properties of crystals, CCDC, Graph set theory, synthon/tectons. Crystal growth, crystal habit & morphology, crystallization methods, polymorphism, importance in pharma industry-reactivity of drugs, properties of Multi component crystals, solvates, hydrates, co-crystals, pharmaceutical co-crystals. Molecular electronic devices, molecular-wires, rectifiers, -switches, -logic gates, Supramolecular catalysis.

J. M. Lehn, Supramolecular Chemistry-Concepts and Perspectives Wiley-VCH, 1995.
P. D. Beer, P. A. Gale, D. K. Smith; Supramolecular Chemistry Oxford University Press, 1999.
J. W. Steed and J. L. Atwood; Supramolecular Chemistry Wiley, 2000.
G.R. Desiraju, J.J. vital and A Ramanan, Crystal Engineering A Textbook, IISc Press World Scientific

CY885 Surface Chemistry and Catalysis (3-0-0) 3

Basic concepts Surface vibrations, General aspects Surface reactions, co-adsorption, poisoning and promotion effects, model reactions, Chemistry of bimetallic surfaces, surface alloys, surface segregation and faceting. Surface modification. Techniques for surface investigation. BET theory of adsorption. Determination of surface area (BET equation). Surface films on liquids (Electro-kinetic phenomenon) Catalytic activity at surfaces. Preparation of catalyst and their behavior: Role of supports, preparation & structure of supports, silica, alumina, silica-alumina, zeolities, carbon manufacture, catalyst size & shape, pre-treatments. Deactivation process, sintering, poisoning & catalyst fouling. Definition of performance criteria of catalysts: Activity, selectivity, temperature response, catalyst life. Homogeneous and heterogeneous catalysis, mechanisms and applications ocillatory reactions, autocatalysis.

A.W. Adamson, Physical Chemistry of Surfaces, 6th ed., New York, Wiley, 1997.
John. C. Vickerman(ed.), Surface Analysis: The principal Techniques, John Wiley & Sons, New York, 1997.
G.A. Somorjai, Introduction to Surface Chemistry and Catalysis. , John Wiley, New York, 1994.
K. Christmann, Introduction to Surface Physical Chemistry, (Topics in Physical Chemistry Vol. l), Springer-Verlag, 1991.
R. Pearce and W.B. Patterson, Catalysis and Chemical Process: (Blackie & Sons.), 1981.

CY886 Synthetic Methods in Organic Chemistry (3-0-0) 3

Oxidation: oxidation of alcohols & ketonic compounds, oxygen addition at C=C, oxidative cleavage of C=C bonds, transition metal oxidants. Ozonolysis. Reduction: catalytic, metal hydride and electron transfer reductions, hydrogenolysis. Retrosynthetic analysis: Principles & terminology, disconnection approach, C-X disconnections, one group C-C & two group C-C disconnections. Protecting groups: protection & deprotection of hydroxy, carboxyl, carbonyl, amino groups & carbon-carbon multiple bonds. Organometallic reagents: Organolithium, organo magnesium, organo zinc, organo cadmium & organo mercury compounds. Sulfur, Phosphorous, Silicon and boron containing reagents. Peterson reaction. Hydroborations, organoboranes. Organotin compounds: synthesis & utility of organostannanes Asymmetric synthesis.

F. A. Cary and R. I. Sundberg, Advanced Organic Chemistry, Part A and B, 5th Edition, Springer, 2009.
S. Warren, Organic Synthesis, The disconnection Approach, John Wiley & Sons, 2004. Advanced Organic Chemistry- Reaction Mechanisms, Reinhard Bruckner, (Academic press, USA), 2005. N.Carruthers, Modern Methods of Organic Synthesis, Cambridge University, 1996.

DEPARTMENT OF PHYSICS

PH701 Mathematical Method **(3-1-0) 4**

Vector algebra in Cartesian component notation, Kronecker delta, vector notation for equation of line plane and surfaces. Vector fields, Qualitative concept of tensors, Differentiation, Line and surface integrals, Curvilinear coordinates - Spherical and Cylindrical; Gradient, Divergence, Curl, Laplacian. Matrices and their properties, Linear independence, dual vectors, Bra-Ket notation, inner product, norm, basis, orthogonality, Linear operators, Adjoint and Hermitian operators, matrix representation of operators, Change of basis, Orthogonal transformations, eigenvalue and eigenvectors, projection operator, Matrix diagonalizatoin , Function space, Hilbert space, , Fourier series and Fourier transforms, Generalized functions, Dirac delta function. Beta and gamma function. Strum-Liouville Theory, Hermitian operators, Eigen value problem of ordinary differential equation, singular points, Frobenius method, examples, Orthogonal functions. Legendre, Bessel, Laguerre and Hermite differential equations and their solutions, Legendre, Bessel, Laguerre and Hermite functions and their properties, Spherical Harmonics, Probability random walk, Probability distributions.

G. Arfken & H. J Weber -"Mathematical Methods for Physicist", Acad. Press 6th Ed (2005)
E. Kreyszig -"Advanced Engineering Mathematics, Wiley Eastern, 5th edition (1991)
P.K Chattopadhyay,-"Mathematical Physics", New Age Int. Pvt. Ltd (1990)
Mathematical methods for physics and engineering", K. F. Riley, M.P. Hobson and S. J. Bence ; Cambridge University Press. (2004)

PH702 Classical Mechanics **(3-1-0) 4**

Mechanics of a particle and a system of Particles, Constraints, D'Alembert's Principle and Lagrange' s Equation. Variational Principles and Lagrange's Equation- Hamilton's Principle, Conservation Theorems and Symmetry Properties. The Central Force Field Problem. The Virial Theorem. The Kepler Problem. Scattering in a Central Force Field. The Kinematics and Dynamics of Rigid Body, The Euler Angles, The Rigid body equations of Motion- Rigid body-Angular momentum, Kinetic energy, Inertia tensor, Coriolis force. The Small Oscillations, The Hamilton Equation of Motion, Legendre Transformations, Hamilton Equations of Motion. Principle of Least Action. Canonical Transformations. Poisson's Brackets. Hamilton – Jacobi Theory and Action Angle Variables.

Herbert Goldstein, Charles Poole and John Safco, Classical Mechanics, 3rd Edition, Pearson
David Morin, Introduction to Classical Mechanics with Problems & Solutions, Cambridge Univ. Press, 1st Ed. 2009.
R.G. Takwale & P.S. Puranik, Introduction to Classical Mech. Tata McGraw Hill, 8th reprint 1987.

PH703 Quantum Mechanics – 1 **(3-1-0) 4**

Review of empirical basis, wave-particle duality, electron diffraction. Notion of state vector. Probability interpretation. Review and relations between approaches of Heisenberg-Born-Jordan, Schroedinger and Dirac. Operators and observables, operators as matrices, significance of eigenvalues and eigenfunctions. Commutation relations. Uncertainty principle. Measurement in quantum theory. Time-dependent Schrödinger equation. Stationary states and their significance. Time-independent Schrödinger equation. Free-particle, periodic boundary condition. Wave packets. Square well potential. Numerical solution of Schroedinger equation. Transmission through a potential barrier. Gamow theory of alpha-decay. Field induced ionization, Schottky barrier. Simple harmonic oscillator: solution by wave equation and operator method. Charged particle in a uniform magnetic field. Coherent states. Separation of variables in spherical polar coordinates. Orbital angular momentum, parity. Spherical harmonics. Free particle in spherical polar coordinates. Spherical well. Hydrogen atom. Numerical solution of the radial equation in arbitrary potential.

C. Cohen-Tannoudji, B. Diu and F. Laloe, Quantum Mechanics (Vol. I), Wiley
L.I. Schiff, Quantum Mechanics, McGraw-Hill
R. Shankar, Principles of Quantum Mechanics, Springer
E. Merzbacher, Quantum Mechanics, John Wiley and Sons
A. Messiah, Quantum Mechanics (Vol. I), Dover

PH704 Electronics **(3-1-0) 4**

Current and voltage sources, KCL, KVL, Thevenin, Norton, Linearity and Superposition, Maximum power transfer theorem and their applications, Transistor basics, CB, CE and CC configurations, BJT biasing circuits, fixed bias, emitter stabilized bias, voltage divider bias, bias stabilization, Operating (Q-point), load-line analysis, two port analysis of a transistor amplifier, Analysis of CE, CB and CC amplifiers, Basics of FETs, I-V characteristics, FET small signal model, FET biasing, common-source and common drain low-frequency amplifiers, qualitative treatment

of high frequency amplifier characteristics, MOSFETs and MOSFET bias circuits, Difference amplifier, basic operational amplifier and its features, inverting and non -inverting amplifier, summer, integrator, differentiator, comparator, active filters, Schmitt trigger, Colpitts and Hartley Oscillators, Wien Bridge Oscillator, voltage controlled oscillators, 555 Timer circuits. Astable, monostable and bistable multivibrators, Boolean teorem and identities, OR, AND, NOT, NOR, NAND, Ex-OR/Ex- NOR gates, de Morgan's theorem, TTL, MOS and CMOS; Combinational Circuits: Adders, subtractors, Encoder, De-coder, Comparator, Multiplexer, De-multiplexers, Flip-flops, Registers, Counters, Memories; A/D and D/A conversion.
Electronic Devices and Circuits, David A. Bell, Oxford Univ. Press, 5th Ed (2008).
Integrated Electronics, Jacob Millman & Christos Halkias, Tata McGraw Hill, 6th Reprint.
Electronics Principles, A.P. Malvino, McGraw Hill, 6th Ed.

PH705 Electronics Lab (0-0-3) 2

PH751 Mathematical Methods – 2 (3-1-0) 4
Functions of complex variables: Limit, continuity Differentiations, Cauchy-Reimann equation, Analytic functions, power series, Taylor series, poles, Complex integrations, Cauchy's theorem, Cauchy's integral formula, Residue theorem, Calculations of Residues. Evaluation of real definite integrals, Principle values, Conformal mappings, Analytic continuations, Partial Differential Equations: Examples, chain rule, Laplace equation in Cartesian and polar form. One and two-dimensional wave equations, Green's functions, Group theory: Introduction to finite and continuous groups, Group representations and operations on them. Reducible and irreducible groups, Permutation group and its representations, Lie groups and Lie algebras, SU(2), SU(3) and SU(N) groups.
G. Arfken & H. J Weber,Mathematical Methods for Physicist, Acad. Press 6th Ed, (2005)
E. Kreyszig, Advanced Engineering Mathematics, Wiley Eastern, 5th edition (1991)
P.K Chattopadhyay, Mathematical Physics, New Age Int. Pvt. Ltd (1990)
K. F. Riley, M.P. Hobson and S. J. Bence, Mathematical methods for physics and engg., Cambridge University Press. (2004)
Jon Mathews and R.L.Walker, Mathematical Methods of Physics, 2nd Edition, , Addison-Wesley Publishing Com. (1969)

PH752 Quantum Mechanics – 2 (3-1-0) 4
Symmetry operations and unitary transformations. Conservation laws. Space and time translations; rotation. Discrete symmetries: Space inversion, time reversal and charge conjugation. Symmetry and degeneracy.Rotation operator, generators of infinitesimal rotation, angular momentum algebra, eigenvalues of J^2 and J_z. Pauli matrices and spinors. Addition of angular momenta, Clebsch-Gordon coefficients. Irreducible tensor operators and the Wigner -Eckart theorem. Indistinguishability, symmetric and anti-symmetric wave functions, incorporation of spin, Slater determinants, Pauli exclusion principle. Non-degenerate and degenerate perturbation theory. Stark effect, Zeeman effect and other examples. Variational methods. WKB approximation. Tunnelling. Numerical perturbation theory, comparison with analytical results. Schrödinger and Heisenberg pictures. Time-dependent perturbation theory. Transition probability calculations, Fermi's golden rule. Adiabatic and sudden approximations. Beta decay. Interaction of radiation with matter. Einstein A and B coefficients, introduction to the quantization of electromagnetic field.Differential scattering cross-section, scattering of a wave packet, integral equation for the scattering amplitude, Born approximation, method of partial waves, low energy scattering and bound states, resonance scattering.
C. Cohen-Tannoudji, B. Diu and F. Laloe, Quantum Mechanics (Vol. II), Wiley
L.I. Schiff, Quantum Mechanics, McGraw-Hill
R. Shankar, Principles of Quantum Mechanics, Springer
E. Merzbacher, Quantum Mechanics, John Wiley and Sons
A. Messiah, Quantum Mechanics (Vol. II), Dover

PH753 Statistical Mechanics (3-1-0) 4
Probability -Discrete and continuous probability distribution, mean, variance, random walk problem Binomial, Gaussian, Poisson distribution functions, review and statistical basis of thermodynamics: Macroscopic and Microscopic systems, Phase Space, laws of Thermodynamics, Entropy, Specific heat, Thermodynamic potentials-Helmholtz free energy, Gibbs free energy, chemical potential, Maxwell's equations. Ensembles, Partition Function and Applications. Equipartition theorem, fluctuations, Classical and quantum mechanical distribution functions: Equilibrium distribution, properties of distribution functions, Quantum statistical mechanics-postulates of Quantum

statistical mechanics, Phase space, Density matrix, Liouville's theorem. Black body thermal radiation: Bose-Einstein statistical distribution function, The density of states for photons in a cavity. Fermi-Dirac distribution function: Fermi gas in metals, Fermi energy, Application to degenerate Fermi-gas. Sommerfeld expansion, Thermalproperties of solids - Specific heat. Einstein and Debye models. Bose-Einstein condensation.

R *K Pathria, Statistical Mechanics, Butterworth-Heinemann,Indian Edition F. Rief, Fundamentals of Statistical and Thermal Physics, Tata-McGraw Hill Palash B. Pal, An Introductory Course of Statistical Mechanics, Narosa, 2008 C. Kittel and Kroemer Thermal Physics*

PH754 Electromagnetic Theory (3-1-0) 4

Electrostatics:Laplace and Poisson equations. Boundary value problems. Dirichlet and Neumann boundary conditions. Method of images. Concept of the Green function and its use in boundary value problems. Magnetostatics: Ampere's law and Biot-Savart's law. Concept of a vector potential. Maxwell equations and electromagnetic waves. Maxwell equations (both differential and integral formulations). Boundary conditions on field vectors D, E, B and H. Vector and scalar potentials. Gauge transformations: Lorentz and Coulomb gauges. Green function for the wave equation. Poynting's theorem. Conservation laws for macroscopic media. Propagation of plane waves and spherical waves in free space, dielectrics and conducting media. Reflection and refraction of electromagnetic waves. Superposition of waves. Radiation from an oscillating dipole and radiation from an accelerating charge. Electromagnetic stress tensor. Wave Guides: Modes in rectangular and cylindrical wave guides (conducting and dielectric). Resonant cavities. Evanescent waves. Energy dissipation. Q of a cavity.

J.D. Jackson, Classical Electrodynamics, Wiley Eastern, 2nd Edition (1975).
David J. Griffiths, Introduction to Electrodynamics, Prentice Hall of India, 2nd Ed, (1989).
J.R. Reitz., F.J. Milford and R. W. Christy, Foundations of Electromagnetic Theory, 3rd Edition, Narosa Pub.House (1979).
P. Lorrain and D. Corson, Electromagnetic Fields & Waves. CBS Publishers (1986).
B.H. Chirgwin, C. Plumpton and C. W. Kilmister, Elementary Electromagnetic Theory, Vols.1, 2 and 3" Pergamon Press (1972).

PH755 Computational Methods in Physics (2-1-0) 3

Basics of computers; Numbers and precision, binary arithmetic, Boolean logic; Brief introduction to Python and iPython notebooks; Computing with formula, example: trajectory of a ball, Difference equations , iterative solutions, example: population growth models, Roots of linear equation, Bisection, Newton-Raphson, Secant, and hybrid methods. Soving system of linear equations: Solving matrix equations, matrix decomposition; Gauss elimination. Example: particle in finite and infinite potential well. Numerical error, interpolation; linear and cubic spline methods, first and second order ODES, implicit and explicit schemes, numerical instabilities, Euler's method, Runge-Kutta methods, Examples: linear and nonlinear oscillators, partial differential equations: finite difference schemes, relaxation techniques, the diffusion equation; Examples: heat wave, E-M wave, Schrodingers equation: Solution of the generalized eigenvalue problem, perturbation theory and variational calculus, Integration methods, molecular dynamics simulations at different ensembles. Langevin dynamics simulations for brownian motion. Quantum molecular dynamics for hydrogen molecule, Random numbers, Distribution function, Monte carlo simulations with various ensembles. Estimation of energy and chemical potential. Ising model . Quantum Monte Carlo.

A B Downey, Think Python: An introduction to software design (available online)
D Potter, Computational Physics, Wiley Newyork NY, 1973
W.H. Press, S.A. Teukolsky, W.T. Vettering, and B.R. Flannery Numerical Recipes in C: the art of scientific programming, Cambridge University Press, Cambridge UK, 1992. Computational Physics. J. M. Thijssen , Cambridge – 2007

PH756 Physics Laboratory – 1 (0-0-3) 2

PH801 Condensed Matter Physics – 1 (3-1-0) 4

Classical and quantum (Fermi) theories for free electrons in metals -- Fermi momentum, Fermi velocity, Fermi temperature, conductivity and mobility. Lattice translation vector, primitive cell, unit cell and lattice parameters, Bravais lattice, crystal planes and Millar indices, crystal structure, packing fraction. *Reciprocal lattice:* Definition of reciprocal lattice, diffraction of X-rays by crystal planes, Laue formalism, Ewald construction, Bragg's Law, structure factor, Brillouin zones. *Crystal binding:* Crystals of inert gases, Van der Waals-London interaction, Cohesive energy, Madelung energy and Madelung constant, metallic and hydrogen bonds (qualitative). Bloch function, Kronig - Penney Model, Origin of energy bands in solids, distinction between metals, semiconductors and

insulators, velocity and effective mass of an electron in solid, nearly free electron method, tight binding approximation. Vibrations of crystals with monatomic basis, salient features of the dispersion curve, vibration of crystals with two atoms per primitive basis, acoustic and optical modes, quantization of elastic waves – phonons, *Thermal properties:* Planck distribution, density of states in one, two and three dimension, Debye T^3 law, theory of thermal conductivity, Wiedemann-Franz law.
Introduction to solid state physics – by C. Kittel
Solid state physics – by Ashcroft and Mermin

PH802 Atomic and Molecular Spectroscopy **(3-1-0) 4**
Basic Elements of Practical Spectroscopy, Signal-to-Noise Ratio, Resolving Power, Width and Intensity of Spectral Transitions. Microwave spectroscopy, Rigid and non-rigid rotator, Chemical Analysis by Microwave Spectroscopy. Infrared Spectroscopy, Anharmonic Oscillator. Raman spectroscopy, Techniques and Instrumentation. Atomic spectra hydrogen and alkali elements. LS and JJ Coupling. Photoelectron spectroscopy, Electronic spectroscopy of molecules. Nuclear magnetic resonance spectroscopy (NMR), Electron spin resonance spectroscopy (ESR). A brief outline of Techniques and Instrumentation.
Fundamentals of Molecular Spectroscopy (Fourth Edition) by Colin N. Banwell and Elaine McCash, Tata McGraw – Hill Pub. Co. New Delhi (1994)
Modern Spectroscopy (Fourth Edition) by J. Michael Hollas, John Wiley & Sons, Ltd (1996)

PH803 Physics Laboratory – 2 **(0-0-3) 2**

PH851 Nuclear and Particle Physics **(3-0-0) 3**
General properties of Nuclei-Nuclear radius, charge distribution, Deuteron problem- Nuclear force, Nuclear binding energy, Electric and magnetic moments, Nuclear models, Radioactivity and Nuclear decay-Alfa decay-Gamow's theory, Beta decay-Fermi's theory, Gamma decay, Nuclear Reactions. Scattering theory (Qualitative)-Rutherford scattering, Nucleon-nucleon scattering, partial wave analysis, Cross section, Optical theorem. Experimental Nuclear Physics-Detectors-Gas and solid state detectors, Mass spectroscopy, Particle accelerators. Particle physics-Elementary particles, classification, Quark model.
Kenneth Krane, Nuclear Physics, John Wiley and Sons, latest edition Griffith, Introduction to Elementary Particles
R.D. Evans, Atomic Nucleus
Kaplan, Nuclear Physics

PH852 Relativistic Physics **(3-0-0) 3**
Motivation. Postulates of special theory of relativity. Lorentz transformation. Space-time diagram. Time dilation and length contraction. Addition of velocities. Doppler effect. Paradoxes. Four-vectors, contra- and covariant vectors. Coordinate, velocity and momentum four-vectors. Tensors. Electromagnetic field tensor. Maxwell's equations in tensor notation. Transformation of electromagnetic field. Relativistic dynamics of charged particles in electromagnetic field with special emphasis on particle accelerators. Relativistic Lagrangian of charged particles in electromagnetic fields. Klein-Gordon equation and its plane wave solution. Dirac matrices. Dirac equation. Plane wave solutions, intrinsic spin and magnetic moment. Antiparticles. Non -relativistic limit, Pauli equation. The electron magnetic moment and gyromagnetic ratio of 2. Lorentz covariance of Dirac equation, gamma matrices and their properties. Bilinear covariants of Dirac spinors. Dirac equation for the hydrogen atom. Spin-orbit coupling and fine structure.
H. Goldstein C.P. Poole and J.F. Safko, Classical Mechanics, Addison-Wesley A.P. French, Special Relativity, W.W. Norton & Company
W. Rindler, Introduction to Special Relativity, Oxford University Press J.D. Jackson, Classical Electrodynamics, Wiley
L. Schiff, Quantum Mechanics, McGraw-Hill

PH853 Condensed Matter Physics – 2 **(3-1-0) 4**
Point defects, Schottky defects, Frenkel defects, line defects, dislocations. Intrinsic and extrinsic semiconductors, Effect of temperature on conductivity, Hall effect, experimental determination of carrier concentration, applications. Polarization in static field-Internal Field in dense dielectrics, ferro, pyro & piezoelectric materials, Behavior of Dielectrlcs in alternating fields, complex dielectric constant, Classification of Magnetic Materials Weiss molecular field theory, Landau Diamagnetism, Heisenberg model(mean field theory). Type I and Il superconductors,
Theoretical interpretation of BCS Theory,High-TcsuperconductorsandApplications. Quantum Hall Effect,

introduction to strongly correlated systems. *Introductiontosolidstatephysics—C.Kittel,WileyEasternedition,1998. Solid State Physics, Ashcroft and Mermin, latest edition. Condensed Matter Physics by M. Mardar, SolidStatephysics*—MA*Wahab2°Edition2005.*

PH860 Vacuum Technology & Thin Films **(3-0-0) 3**

Behaviour of gases at low pressures, sources of gas release into vacuum systems – adsorption and desorption, diffusion, permeation, dynamic gas balance and ultimate pressure obtainable in vacuum system. Production of vacuum – different pumps, rotary pump, diffusion pump, turbomolecular pump. Sorption pump, cryopump, getter pumps. Measurement of reduced pressures – McLeod's gauge, thermal conductivity gauges, thermo couple gauge and pirani gauge, ionization gauges – triode gauge, Bayard-Alpert gauge, Klopfer gauge, Helmer gauge, Lafferty magnetron gauge, Penning gauge, Redhead gauge. Thin films – Methods of preparation- vacuum evaporation, sputtering electrodeposition, chemical methods, liquid phase epitaxy, molecular beam epitaxy. Measurement of film thickness – optical interference technique, gravimetry, quartz crystal oscillator, other magnetic and electrical methods.

Maissel L.I and Glang R: Hand book of thin film technology, McGraw Hill Publications
*Brunner Jr.W.F and Batzer T. H : Practical vacuum techniques, Reinhold Publication*s.

PH861 Magnetism and Superconductivity **(3-0-0) 3**

Introduction to Diamagnetism, Langevin's theory of Diamagnetism, Quantum theory of Paramagnetism, Ferromagnetism and antiferromagnetism- Ferromagnetic order, Curie point and exchange integral, Magnons, Neutron Magnetic Scattering, Neutron Diffraction, Magnetic storage Devices. Nanomagnets- multi domain and single domain particles, super paramagnetism, Magnetic superlattices, Giant Magnetoresistance, Hysteresis Measurement- Vibrating sample magnetometer(VSM), Magnetic Force Microscopy(MFM), Introduction to Superconductivity, Properties of Superconductors, thermodynamics of superconducting transition, London Equation, Ginzburg Landau theory, Abrikosov vertices, Coherence Length, BCS theory, Flux Quantization, Types of Superconductors, High Temperature Superconductors, DC and AC Josephson effect, Quantum Interference, Superconducting Quantum Interference Device(SQUID)

Magnetism by D.C.Mattis
Superconductivity by Tinkham
Superconductivity by Schrieffer
C. Kittel, Introduction to solid state physics,

PH862 Laser & Fiber Optics **(3-0-0) 3**

Electromagnetic interaction of matter; spontaneous absorption and emission, Einstein's coefficients. Process, techniques and properties of stimulated emission, concept of population inversion and techniques. Properties of laser, radiation, coherence length and coherence time. Line broadening mechanisms, Doppler broadening, spectral hole burning, laser threshold and gain equations, Laser Models - Two level, three level and four level lasers, rate equations. Types of lasers: Gas lasers (He-Ne, CO2, Ar, N2, etc.) Types of lasers: Solid-state lasers (Ruby, Nd:YAG, Erbium –doped lasers, etc.). Semiconductor lasers, Q-switching , Mode-locking in lasers, Optical fiber types, Ray propagation in optical fibers, Fiber fabrication, Modes of propagation in optical fibers, Dispersion and attenuation in optical fibers, optical fiber components, fiber Bragg gratings and doped fiber amplifiers. *A. Ghatak and K. Thyagarajan, Optical Electronics, Cambridge Univ. Press (1989) W.T.Silfvast, Laser Fundamentals, Cambridge University Press, 2nd Ed. 2004*
A. Ghatak and K. Thyagarajan, Introduction to Fiber Optics, Cambridge Univ. Press (1998)

PH863 General Theory of Relativity **(3-0-0) 3**

Incompatibility of Newtonian gravity and Special Relativity; motion in non-inertial frames; gravitational anomalies – precession of perihelion of Mercury, review of Special Relativity; Minkowski spacetime; spacetime intervals; Minkowski metric; Lorentz transformation; frames of reference; accelerating observers, vectors; co-vectors, n-forms; manifolds; tangent spaces; tensors, covariant derivative; Christoffel connections; fiber bundles; geodesics; curvature; torsion; Riemann and Ricci tensors; Ricci scalar, stress-energy tensor; energy-momentum conservation; equivalence principle; Einstein's equation; cosmological term; energy conditions, perfect fluid stress tensor; symmetric metrics; Friedmann-RobertsonWalker solution; cosmological expansion and collapse; big-bang; redshift, principle of least action; Euler-Lagrange equations; Einstein-Hilbert action, inflation; cosmological horizons; structure formation; black hole entropy; quantum fields; singularities.

Gravitation and Geometry: An Introduction to General Relativity, Sean Carroll (lecture notes available online) A

First Course in General Relativity, Bernard Schutz
General Relativity, Lecture Notes by Harvey Reall (available online)
General Relativity, Robert Wald
Geometrical Methods of Mathematical Physics, Bernard Schutz

PH864 Physics of Low Dimensional Systems (3-0-0) 3
Introduction to low dimensional systems: length and energy scale, overview of fabrication techniques (M.B.E MOCVD, etc), and possibilities, applications of low– dimensional physics, examples, top-down vs bottom–up Density of states in ID,2D and 3D, growth of heterostructures and their electronic properties, strained layers, quantum wires and dots, quantum wells in heterostructures , band diagrams, two dimensional electron gas (2 DEG) system, occupation of subbands, Electrons in high magnetic fields : Hall effects, Landau levels, Landauer-Buttiker formalism, Shubnikov- de Haas oscillations, quantum Hall effect, edge states. Transport through OD quantum dots, Coulomb blockade, resonant, tunneling. Charge and spin transport in quantum point contact: quantized conductance. Optical properties; optical processes in low dimensional semiconductors, graphene as a two – dimensional system, transport properties and its device applications .
J.H.Davies , The physics of low - dimensional semiconductors : an introduction (Cambridge University Press 1998)
Kelly M J, Low – dimensional semiconductors; Materials, Physics, Technology , Devices , (Clarendon Press 1996)
S. Dutta, Electronic transport mesoscopic systems (Cambridge University Press, 1997)

PH865 Nanomaterials (3-0-0) 3
Introduction to Nanomaterials, introduction to Miniaturization: Scaling laws. A few Examples from mechanics, electricity and magnetism, optics, etc. Crystal Structures and size dependence of properties. Quantum confinement. Quantum wells, quantum wires and quantum dots. Methods of synthesis and physical properties of nanomaterials. Characterization of nanomaterials. X-ray diffraction and electron diffraction, Microscopy : Transmission electron microscopy (TEM) and field ion microscopy, etc. Applications of Nanomaterials. An overview of a few application areas: Insulation materials, machine tools, phosphors, batteries, High power magnets, Motor vehicles and aircraft, medical implants and other uses.
Introduction to Nanotechnology By Charles P. Poole Jr. & Frank J. Owens, Wiley Interscience (2003).
Nanotechnology: Understanding small systems By Rogers, Pennathur and Adams.CRC Press, Taylor and Francuis Group, NewYork. (2008)
Nanostructures and Nanotechnology, Douglas Natelson, Cambridge University Press, 2015

PH866 Characterization Techniques of Materials (3-0-0) 3
Metallographic techniques, Optical microscopy, X-ray diffraction, Crystal size, lattice parameter measurements, Phase diagram determination, Electron microscopy – TEM, SEM, STEM, Thermal analysis, Electric and Dielectric measurements.
Edington J., Practical electron microscopy, Vol – 1
B.D. Cullity, Elements of X-ray diffraction

PH867 Nonlinear Dynamics and Chaos (3-0-0) 3
Linear and nonlinear systems; Discrete time dynamical systems, the logistic map and period doubling, bifurcations, two dimensional maps, graphical iteration, Qualitative analysis of fixed points, Chaos, Feigenbaum's number, Representations of dynamical systems, vector fields of nonlinear systems, phase plane analysis, linear stability, limit cycles, the Lorenz equation, bifurcations in continuous time dynamical systems, the Rossler equation and forced pendulum, the Chua's circuit, introduction to fractals, Mandelbrot sets and julia sets, lyapunov exponent, frequency spectra of orbits, dynamics on a torus, control of chaos, introduction to floquet theory.
S Strogtaz, Nonlinear dynamics and chaos: with applications to physics, biology, chemistry, and engineering, Westview Press, 2001
F C Moon, Chaotic Vibrations, Wiley & Sons, 2004
Alligood, Sauer, Yorke, and Crawford, Chaos- An Introduction to Dynamical Systems, Springer, 1996

PH868 Solid State Electronic Devices (3-0-0) 3
Brief discussion on crystalline solids, different growth procedures, elemental and compound semiconductors and their applications in real life electronic devices, brief introduction to quantum theory of solids, energy bands and charge carrier motion in semiconductor, Carrier concentration, carrier transport phenomenon, p-n junction, Metal-semiconductor and semiconductor heterojunction – energy band diagram, concept of 2- dimesional electron gas (2DEG) system, MOSFETs: Output and transfer characteristics, Mobility models, Short Channel MOSFET I-V

characteristics, threshold voltage control, substrate bias effect, subthreshold characteristics, MOSFET scaling issues, DIBL, Short Channel Effect and gate induced Drain Leakage, Optoelectronic devices, Spin based devices.
Semiconductor physics and devices -- Basic principlesby Donald A. Neamen, 4th Ed, Mcgraw Hill Int. Ed.
Solid state electronic devicesby B. G. Streetman and S. K. Banerjee, 6th Ed, Pearson Education, Inc.

PH869 Computational Materials Science (3-0-0) 3
Mathematical preliminaries: Matrix and vector algebra, vector space, basis, operator, matrix representation of an operator, function space, bra-ket notation of vector, dual vector and dual space, functional, properties of functionals Quantum mechanical solution hydrogen atom; One and two-body operators and their expectation values; Variational principle, Hellman-Feynman principle, virial theorem. Introduction of many body problem, interacting and non-interacting wave-functions for N number of electrons, probability densities, Overview of electronic structure methods; Hartree- Fock theory and Correlation, The Uniform Electron Gas Hohenberg- Kohn Theorem, and density functional theory; Kohn-Sham Scheme. Exchange and Correlation Energy, Adiabatic Connection, Local Density Approximation, Gradient Expansion and Generalized Gradient Approximations, Hybrids Functionals, their performance and Challenges, Hands on applications of DFT using open source DFT code in metallic alloys, organic semiconductors, semiconductor nano particles etc.
Robert G. Parr and Weitao Yang, Density Functional Theory of Atoms and Molecule, (Oxford University Press, 1994).
Reiner Dreizler and E. K. U. Gross,Density Functional Theory (Springer 1990)
John P. Perdew and Stefan Kurth: Density Functionals for Non-Relativistic Coulomb Systems, in "A Primer in Density Functional Theory" Ed. C. Fiolhas, F. Nogueira, and M. Marques (Springer Lectures Notes in Physics, v.620, 2003).

PH870 Quantum Computation (3-0-0) 3
Classical models of computation: Boolean logic, binary gates, computational complexity, models of classical computers, universal classical computers – Turing machines, unsolvability of most complex problems using classical computers.
Quantum computation: Feynman's argument, relationship between physical models and computation, qubits as "quantum bits" – 2 state systems, unitary gates and operators, no-cloning theorem, entanglement as a computational resource, elementary quantum gates – Hadamard, Phase, Bit flip, CNOT, quantum algorithms – Grover's search algorithm, Shor's factorization algorithm. Universal quantum computation – quantum Turing machines. Quantum error correction. Introduction to software package for quantum computation – QuTip, Qiskit.
Advanced Topics: Fault-tolerant quantum computation. Density matrices and Kraus representation theorem. POVMs and Measurement theory. Quantum gravity and quantum computation.
Implementation of quantum algorithms
Nielsen and Chuang – Quantum Information and Quantum Computation (main text), Cambridge University Press; 10th Anniversary Edition, 702 pages
John Preskill – Lecture Notes on Quantum Computation,
http://www.theory.caltech.edu/~preskill/ph219/index.html#lecture
Julia Kempe – Approaches to quantum error correction (arXiv:quant-ph/0612185), Seminaire Poincar 2(2005)

PH871 Classical Field Theory (3-0-0) 3
Special theory of relativity : Lorentz transformation, space-time diagram, covariant and contravariant vectors, tensors and their coordinate transformations, infinitesimal generators of translations, rotations and boosts, Lorenz and Poincare group; Theory of real scalar field: principle of least action, Lagrangian for a real scalar field,.Euler-Lagrange field equation, hamiltonian density, stress-energy tensor, Lorentz invariance; Theory of complex scalar field: Lagrangian formulation, global symmetry local symmetry gauge fields; Symmetries and conformation laws: Noether's theorem, application to external and internal symmetries. the iso-vector, Lorentz-scalar field and the Yang-Mills field as a non-Abelian example; Theory of electromagnetic field : Electromagnetic field tensor, four-current field vector, action governing electromagnetic field, interaction of electromagnetic field with charges and currents, Maxwell's equations, gauge invariance - Coulomb and Lorenz gauges. equation governing free electromagnetic field - concept of electromagnetic waves and their polarization, the stress-energy tensor of the electromagnetic field, Lorentz transformation properties of 'the electric and the magnetic fields, solution to electromagnetic field equation - Green's function, radiation from a moving charge. Lienard-Wiechert potentials, case of massive electromagnetic fields - the proca lagrangian; Spontaneous symmetry breaking and formation of topological defects : The concept of spontaneous symmetry breaking - simple illustrative examples, spontaneous breaking of global symmetries - the

Goldstone theorem. spontaneous breaking of local symmetries - the Higgs mechanism in Abelian and non-Abelian models. formation of topological defects - domain walls - cosmic strings - the t'Hooft- Polyakov monopole, time-dependent solutions - solition; Basic aspects of general relativity: principle of general covariance, metric tensor and geodesics, curvature tensor, energy-momentum tensor and Einstein Hilben action, isometries - Lie derivatives, Killing equation and conserved quantities.

References :

L.Susskrnd and A. Friedman, Special Relativity and Classical Field Theory .(Basic Books,20l7).
A.O. Barut, Electrodynamics and Classical Theory of Fields and Particles (Dover, 1980).
E. Soper, Classical Field Theory (Dover, 2008).
L. D. Landau and E. M. Lifshitz, The Classical Theory of Fields (Course of Theoretical Physics, Volume 2). Fourth Revised English Edition (Pergamon Press, 1975).
B. Felsager, Geometry. Particles and Fields (Springer, 1998).
F. Scheck, Classical Field Theory (Springer, 2018).
R. D'Inverno, Introducing Einstein's Relativity (Oxford University Press, Oxford, 1992).
S. Carroll, Spacetime and Geometry (Pearson Education Limited,20l4)
T. Padmanabhan, Gravitation (Cambndge University Press, 20 10).

PH872 Cosmology **(3-0-0) 3**

Recap of General Relativity : Equivalence principle, concept oi curvature, Einstein-Hilbert action, Einstein equations; Survey of the universe : Redshift. Hubble law. homogeneity and isotropy, Friedmann-Lemaitre-Robertson-Walker metric; Kinematics of Friedmann model : Luminosity distance. comoving distance. angular diameter distance; Dynamics of Friedmann model : Friedmann equation, different epochs. age of the universe; Thermal history of the universe: Equilibrium thermodynamics. primordial abundances, bigbang nucleosynthesis, Boltzmann equation, radiation - matter decoupling; Cosmic Microwave Background : physics of' Cosmic Microwave Background (CMB), CMB polarization,CMB anisotropy; Structure formation , evolution of inhomogeneties, Jeans analysis, matter power spectrum, collapse and relaxation mechanism: Dark matter : Dark matter candidates; Dark energy : Cosmological constant. quintessence; Inflation: Horizon problem, inflationary perturbations. origin of perturbations - cosmological perturbation theory.

References :

S.Weinberg. Cosmology (Oxford University Press, 2008).
S. Dodelson. Modern Cosmology (Academic Press 2003).
T. Padmanabhan, Theoretical Astrophysics - Vol III : Galaxies and Cosmology (Cambridge University Press. 2002)
H. Mo. F. van den Bosch and S. White. Galaxy Formation and Evolution (Cambridge University Press, 2010).
R.Durrer. The Cosmic Microwave Background (Cambridge University Press, 2008)

PH898 M.Sc Project (3rd Semester) **3**

PH899 M.Sc Project (4th Semester) **5**

DEPARTMENT OF MATHEMATICAL & COMPUTATIONAL SCIENCES

MA721 Introduction to Scalable Systems (3-0-2) 4

Computer organization, Memory hierarchy, cache memory, Parallelization Principles: motivation, challenges, metrics, parallelization steps, data distribution, PRAM model; concurrent data structures, and cloud computing systems. Parallel Programming Models and Languages: OpenMP, MPI, CUDA; Distributed Computing: Commodity cluster and cloud computing; Distributed Programming: MapReduce/Hadoop model.

References:

Parallel Computing Architecture.A Hardware/Software Approach. David Culler, Jaswant Singh. Publisher: Morgan Kauffman. ISBN: 981-4033-103. 1999.

Parallel Computing.Theory and Practice. Michael J. Quinn. Publisher: Tata: McGraw-Hill. ISBN: 0-07-049546-7. 2002.

Computer Systems – A Programmer's Perspective. Bryant and O'Hallaron. Publisher: Pearson Education. ISBN: 81-297-0026-3. 2003.

Introduction to Parallel Computing.AnanthGrama, Anshul Gupta, George Karypis, Vipin Kumar. Publisher: Addison Wesley. ISBN: 0-201-64865-2. 2003.

An introduction to Parallel Programming. Peter S Pacheco. Publisher: Morgan Kauffman. ISBN: 978-93-80931-75-3. 2011.

Online references for OpenMP, MPI, CUDA

MA722 Data Structures and Algorithms (3-0-2) 4

Introduction: Fundamental data structures, The role of algorithms in computing, Asymptotic notations and analysis of the growth of the functions. Divide and Conquer methods and Solving recurrences : Sorting and searching methods Linear and non linear data structures: Arrays, Lists, Stacks, Queues, Trees and Graphs, Graph Algorithms: Single Source Shortest path, All pair shortest path, minimum cost spanning trees, Special matrices and their representations: Sparse, circulant, toeplitz etc.

References:

T.H Cormen, C.E Leiserson, R.L. Rivest, C. Stein, Introduction To Algorithms, Third edition, PHI, 2009.

Jon Kleinberg, Eva Tardos, Algorithm Design, Pearson, 2006.

Michael T. Goodrich, Robert Tamassia, Algorithm Design, John Wiley& Sons, 2006.

SartasSahni, Fundamentals of computer algorithms, Pearson

Donald E. Knutrh, Art of Computer Programming, Volume 1-3, 3rd edition.

MA723 Introduction to Data Science (3-1-0) 4

Review of basic Linear Algebra and Probability, Eigenvalues and Eigenvectors, Relationship between SVD and Eigen Decomposition, Extremal Properties of Eigenvalues, Distance between subspaces, Generating Functions for Sequences Defined by Recurrence Relationships, The Exponential Generating Function and the Moment Generating Function, The Central Limit Theorem, Probability Distributions, Bayes Rule and Estimators, Bounds on Tail Probability, Chernoff Bounds, High-Dimensional Space, Best-Fit Subspaces and Singular Value Decomposition (SVD), Random Walks and Markov Chains, Machine Learning,.

Reference:

Avrim Blum, John Hopcroft, and RavindranKannan, Foundations of Data Science, 2018 (available online)

MA724 Probability, Statistics and Stochastic Processes (3-0-0) 3

Overview of probability, random variables, probability functions, expectation, variance, correlation coefficient, some important probability distributions; correlation and regression of bivariate data, least square method, simple linear regression, multiple and partial correlations, multiple linear regression, partial regression coefficients, standard error of estimates; stochastic process, classification, Markov chains, C-K equations, ergodic chains, steady state behavior, Poisson process, birth and death process, queuing theory, basic concepts, M/M/1 and M/M/s queues.

References:

W.W.Hines and D.C.Montgomery, Probability and statistics in engineering and management science, John Wiley.

J.Medhi, Statistical methods, New age international publishers

J.Medhi, Stochastic processes, New age international publishers

MA725 Numerical Methods **(3-1-0) 4**
Root finding (zeros of a function) of polynomials and transcendental functions (nonlinear equation), bracketing, bisection, secant, and Newton-Raphson methods. Interpolation, splines, polynomial fits, Chebyshev approximation. Numerical Integration and Differentiation: Evaluation of integrals, elementary analytical methods, trapezoidal and Simpson's rules, Romberg integration, Gaussian quadrature and orthogonal polynomials, multiple integrals, improper integrals, summation of series, Euler- Maclaurin summation formula, numerical differentiation and estimation of errors. Linear system of equations, LU factorization, Special types of Matrices, Iterative Methods – Jacobi, Gauss-Siedel, SOR methods.
References:
Richard L. Burden and J. Douglas Faires, Numerical Analysis: Theory and Applications, India Edition, Cengage Brooks-Cole Publishers, 2010.
W.H. Press, S.A. Teukolsky, W.T. Vetterling, and B.P. Flannery, Numerical Recipes in C/FORTRAN, Prentice Hall of India, New Delhi, 1994.
JaanKiusalaas, Numerical Methods in Engineering with MATLAB, 2nd Edition, Cambridge University Press, 2009

MA726 Machine Learning **(3-0-2) 4**
Mathematical preliminaries: Linear algebra and matrix theory; Regression models: Linear regression with single and multiple variables, Logistic regression; Regularization: Handling over-fitting of the data; Artificial Neural networks: perceptron models, back propagation algorithm. Machine learning algorithms for large data sets; Dimensionality reduction: SVD, LDA; Classification: Supervised: Support vector machines, unsupervised: Neighborhood algorithms, k-Means Algorithm Learning theories, Bayesian Learning and Decision Trees, analytical learning, reinforcement learning.
References:
EthemAlpaydin, "Introduction to machine learning", second edition, PHI publication, 2010.
Tom Mitchell, "Machine Learning", McGraw Hill, 1997
Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.

Programme Electives:

MA841 Cloud Computing **(3-0-0) 3**
Introduction: Definition and evolution of Cloud Computing, Enabling Technologies, Service and Deployment Models Popular Cloud Stacks and Use Cases Benefits, Risks, and Challenges of Cloud Computing, Economic Models and SLAs Topics in Cloud Security; Cloud Infrastructur :Historical Perspective of Data Centers, Datacenter Components: IT Equipment and Facilities, Design Considerations: Requirements, Power, Efficiency, & Redundancy, Power Calculations, PUE and Challenges in Cloud Data Centers Cloud Management and Cloud Software Deployment Considerations; Virtualization: Virtualization (CPU, Memory, I/O) Case Study: Amazon EC2 Software Defined Networks (SDN) Software Defined Storage (SDS) ; Cloud Storage: Introduction to Storage Systems,Cloud Storage Concepts, Distributed File Systems (HDFS, Ceph FS), Cloud Databases (HBase, MongoDB, Cassandra, DynamoDB), Cloud Object Storage (Amazon S3, OpenStack Swift, Ceph) ; Programming Models: Distributed Programming for the Cloud Data-Parallel Analytics with HadoopMapReduce (YARN), Iterative Data-Parallel Analytics with Apache Spark Graph-Parallel Analytics with GraphLab 2.0 (PowerGraph)
References:
Ray J. Rafaels, Cloud Computing: From Beginning to End, Create Space Independent Publishing Platform, 2015
Michael J. Kavis, Architecting the Cloud: Design Decisions for Cloud Computing Service Models Wiley; 1st edition, 2014
Thomas Erl, ZaighamMahmood, and Ricardo Puttini. Cloud Computing: Concepts,Technology and Architecture, Prentice Hall; 1st edition, 2013
Dan Marinescu, Cloud Computing:Theory and Practice, Morgan Kaufmann; 2nd edition, 2017
Tom White, Hadoop:The Definitive Guide , O'Reilly Media, 2009.

MA842 Distributed Computing Systems **(3-0-0) 3**
Introduction: Computer Networks and Multi-processor systems, Evolution of modern operating systems, Design Goals, transparencies and fundamental issues in Distributed systems, Temporal ordering of events, Global state detection, Physical clocks, Mutual Exclusion Algorithms, Interprocess Communication, Deadlocks in distributed systems, Load balancing techniques, Distributed databases. Security in distributed systems.

References:
Shivarathi&Shingal, Advanced Operating Systems
Randy Chow, Distributed Operating Systems and Algorithms
George Couloris et al, Distributed Systems - concepts and design, Pearson Education, 2002
A.S. Tanenbaum and M.V. Steen, Distributed Systems - Principles and Paradigms, Pearson Education 2003.
Wolfgang Emmerich, Engineering Distributed Objects, Wiley, 2000.
Gerald Tel, Introduction to Distributed Algorithms, 2/e, Cambridge, 2004.

MA843 Advanced Database Systems (3-0-0) 3

Basic concepts.Architecture for data sharing, Federated DBMS.Distributed databases.Client/server architecture.Multimedia databases. Object oriented data bases. Data mining and knowledge discovery.Pattern clustering abstraction and similarity.Clustering for data mining.Data mining using neural networks and genetic algorithms.Discovery of association rules.Frequent episodes in event sequences.Applications of data mining.

References:
RamezElmasri, Shamkant B Navathe, Fundamentals of Database Systems, Addison Wesley, 2000.
Stefano Ceri&GiuesppePelagatti, Distributed Databases - Principles and Systems, McGraw Hill 1987.

MA844 Advanced Data Science (3-0-0) 3

Algorithms for Massive Data Problems: Streaming, Sketching, and Sampling, Clustering, Random Graphs, Topic Models, Nonnegative Matrix Factorization, Hidden Markov Models, and Graphical Models, An Uncertainty Principle, Linear Programming, The Ellipsoid Algorithm, Integer Optimization, Semi-Definite Programming, Wavelets, The Haar Wavelet, Wavelet Systems, Designing a Wavelet System, Applications

Reference:
Avrim Blum, John Hopcroft, and RavindranKannan, Foundations of Data Science, 2018 (available online)

MA845 Computational Linear Algebra (3-0-0) 3

Matrix multiplication problems: Basic algorithms and notations, exploiting structure, block matrices and algorithms, vectorization and re-use issues.Matrix analysis: basic ideas from linear algebra, vector norms, matrix norms, finite precision matrix computations, orthogonality and SVD, projections and the CS decomposition, the sensitivity of square linear systems. General linear systems: Triangular systems, the LU factorization, roundoff analysis of Gaussian elimination, pivoting, improving and estimating accuracy.Special linear systems: The LDM^T and LDL^T factorizations, positive definite systems, banded systems, symmetric indefinite systems, block systems, vandermonde systems and the FFT, Toeplitz and related systems.

References:
Gene H. Golubnad Charles F. Van Loan, Matrix Computations, Third Ed, Hindustan book agency, 2007.
A.R. Gourlay and G.A. Watson, Computational methods for matrix eigenproblems, John Wiley & Sons, New York, 1973.
W.W. Hager, Applied numerical algebra, Prentice-Hall, Englewood Cliffs, N.J, 1988.
D.S. Watkins, Fundamentals of matrix computations, John Wiley and sons, N.Y, 1991.
C.F. Van Loan, Introduction to scientific computing: A Matrix vector approach using Mathlab, Prentice-Hall, Upper Saddle River, N.J, 1997.

MA846 Image Processing (3-0-0) 3

Introduction to image processing, Image acquisition, sampling and quantization, Image transforms: Discrete Fourier transform, Discrete cosine transform, Discrete sine transform and wavelet transform, Image restoration: Image degradation models, blurs and noise models, restoration methods, Weiner filter and regularization filters, Image enhancement: Enhancement in Spatial and frequency domain, unsharp masking and high-boost filtering, Image segmentation: Image thresholding, region based segmentation methods, region growing, region merging & splitting and active contour models, Image Compression : lossy/lossless compression methods, Image Analysis, Introduction to image processing tool box in Matlab, Applications of image processing to various imaging systems.

References:
R.C. Gonzalez, R.E. Woods, "Digital image processing using MATLAB", Prentice Hall, Second edition, 2003.
Henri Maitre, "Image Processing",first edition, Wiley, 2008.
T.F. Chan, J.H. Shen, "Image processing and analysis", SIAM,First edition, 2005.
Rafael C. Gonzalez & Richard E. Woods, "Digital Image Processing" , Addison-Wesley, 2nd edition, 2002.
Anil K. Jain, Fundamentals of Digital Image Processing, Prentice Hall, 1992.

MA847 Soft Computing **(3-0-0) 3**
Learning and Soft Computing: basic tools of Soft Computing, Learning and Statistical Approaches to Regression and Classification.Neural Networks: Mathematical Models of Neurons, ANN Architecture, Learning Rules, Learning Paradigms – Supervised, Unsupervised, and Reinforced Learning. ANN Training Algorithms.Multi-Layer Perception Model, Hopfield Networks, Associative Memories, Application of Artificial Neural Networks. Fuzzy Logic: Classical and Fuzzy Sets, Membership Function, Fuzzy Rule generation. Operations on Fuzzy sets, Fuzzy Arithmetic, Fuzzy Logic, Uncertainty Based Information: Combination of Operations, Aggregation Operations.Fuzzy numbers, Linguistic variables, Arithmetic Operations on Intervals and Numbers, Lattice of Fuzzy Numbers, Fuzzy Equations. Classical Logic, Multi Valued Logic, Fuzzy Propositions, Non Specificity of Fuzzy & Crisp Sets, Fuzziness of Fuzzy sets.Neuro-Fuzzy Systems, Applications of Fuzzy Logic in Medicine, Economics, Genetic Algorithms in Problem Solving.
References:
Vojislav Kecman, Learning and Soft Computing, Pearson Education (Asia) PTE, 2004
Anderson J A, An Introduction to Neural Networks, PHI, 1999
S Haykin, Neural Networks: A Comprehensive Foundation ", Pearson Education, 2003
Hertz J, Krogh, R. G. Palmer, Introduction to the Theory of Neural Computation, Addition-Wesley, 1991
G.J. Klir and B Yuan, Fuzzy Sets and Fuzzy Logic", PHI 2001
Melanie Mitchell, An Introduction to Genetic Algorithms, PHI, 1998

MA848 Combinatorial Optimization **(3-0-0) 3**
Algorithms for optimization of combinatorial optimization problems. Integer Programming and Network Optimization algorithms, combinatorial problems on Graphs or Networks, Polyhedral Combinatorics, Complexity of Problems such as linear programming and the traveling salesman problem. NP-Completeness, approximation algorithms, worst case and probabilistic analysis of algorithms and local search.
References:
C.H. Papadimitriou and K. Steiglitz, Combinatorial Optimization, Algorithms and Complexity, Prentice Hall, 1982.
E. L. Lawler, Combinatorial Optimization – Networks and Matroids, Holt, Rinehart and Winston, 1976
C. Berge, Principles of Combinatorics, Academic Press, 1971
Tucker, Applied Combinatorics, 2 ndedn, John Wiley, 1984
L. R. Ford Jr. and D. R. Fulkerson, Flows in Networks, Princeton, Univ. Press, 1952.
Pardalos, Panos; Du, Ding-Zhu; Graham, Ronald L., Handbook of Combinatorial Optimization, Springer, 2013
LexSchrijver, Combinatorial Optimization: Polyhedra and Efficiency, 3-Volume book, Springer-Verlag 2003

MA849 Number Theory and Cryptography **(3-0-0) 3**
Elementary Number Theory Congruences, applications to Factoring. Finite fields, Quadratic residiues and reciprocity.Simple cryptosystems, public key cryptography, RSA, Discrete logs.Primality and Factoring, the rho method, Fermat factorization, continued fraction and Quadratic Sieve methods.
References:
N. Kobltiz., A Course in Number Theory and Cryptography, Springer, 1994.

MA850 Mathematical Modeling **(3-0-0) 3**
Introduction: Mathematical modeling through ordinary differential equations and systems of ordinary differential equations of first order, Mathematical modeling through difference equations, Modeling using partial differential equations, Mathematical modeling through graphs.
References:
J.N. Kapoor, Mathematical Modeling, Wiley Eastern, 1988.
R. Aris, Mathematical Modeling Techniques, Pitman, 1978.

MA851 Numerical Solutions of Differential Equations **(3-0-0) 3**
Ordinary differential equations: Numerical methods- error analysis, stability and convergence. Euler and Runge-Kutta methods, multistep methods, Adams-Bashforth and Adams-Moulton methods, Gear's open and closed methods, predictor-corrector methods. Stiff Differential equations, Difference methods for boundary value problems. Partial differential equations: classification, elliptic, parabolic and hyperbolic PDEs, Dirichlet, Neumann and mixed boundary conditions. Numerical solution of PDEs: Finite Difference Methods for parabolic, elliptic and hyperbolic PDEs. Finite difference time domain method.Introduction to Finite Element Method - method of weighted residuals.
References:

R. L. Burden and J. D. Faires, Numerical Analysis, 9th Edn, Brooks/Cole.
Jain M. K., Numerical Solution of Differential Equations, Wiley Eastern
Smith G.D., Numerical Solution of Partial Differential Equations, Clarendan Press
Patanker S. V., Numerical Heat Transfer and Fluid Flow, McGraw Hill
R. J. LeVeque, Finite Difference Methods for Ordinary and Partial Differential Equations: Steady-State and Time-Dependent Problems, SIAM, 2007.

MA852 Optimization Techniques (3-0-0) 3
Introduction and formulation of models, Simplex method, Duality in LP, Dual Simplex Method Sensitivity Analysis, Transportation problems and Assignment problems.Integer Programming, Classical Optimization Methods, Lagrangian Multipliers and Kuhn – Tucker conditions, Quadratic programming, Basic non-linear programming problems.
References:
H. A.Taha, Operations Research - An Introduction, 8thedition,2007,PHI.
F. S. Hillier and G.J. Lieberman, Introduction to Operations Research, Concepts and Cases, 8th edition, 2010, TMH.
S SRao Engineering Optimization: Theory and practice, Newage International publishers.

MA853 Pattern Recognition (3-0-0) 3
Introduction to pattern recognition, Classification, Non-Metric methods, Maximum-Likelihood and Bayesian Parameter Estimation, Supervised learning, Nonparametric Techniques, Linear Discriminant Functions, Feature extraction and selection, Multilayer Neural Networks, Algorithm-Independent Machine Learning, Unsupervised Learning and Clustering, Comparison of classifiers.
References:
Richard O. Duda, Peter E. Hart, David G. Stork, "Pattern Classification", 2nd Edition, Wiley, 2001.
Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.
Geoff Dougherty, Pattern recognition and classification an Introduction, Springer, 2013.

MA854 Statistical Techniques for Data Mining (3-0-0) 3
Introduction - Data Preprocessing and representation, Taxonomy for data mining tasks, Predictive modeling, Association rule mining, Cluster analysis, Classification Techniques, Regression analysis, Time series analysis, Bayesian learning, Data warehousing, Multi-Dimensional modeling and analysis, Performance issues and indexing, Development life cycle, Applications of Data Mining.
References:
Jiawei Han, MichelineKamber, Data Mining - Concepts and Techniques, Third Edition, Morgan Kaufmann Publishers, Elsevier.
Pang-Ning Tam, Michael Seinbach, AnujKarpatne and Vipin Kumar, Introduction to Data Mining, Second Edition, Pearson.
G. James, D. Witten, T. Hastie and R. Tibshirani, An Introduction to Statistical Learning - with applications in R, Springer.
T. Hastie, R. Tibshirani and J. Friedman, The Elements of Statistical Learning – Data Mining, Inference and Prediction, Second edition, Springer.

MA855 Big Data Analytics (3-0-0) 3
Introduction to Big Data Analytics, Big Data Analytics Platforms, Big Data Storage and Processing, Big Data Analytics Algorithms, Linked Big Data Analysis - Graph Computing and Network Science, Big Data Visualization, Big Data Mobile Applications, Large Scale Machine Learning, Big Data Analytics on Specific Processors, Hardware and Cluster Platforms for Big Data Analytics.
References:
Michael Minelli, Michele Chambers, AmbigaDhiraj[2013], "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley CIO.
David Loshin [2013], "Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph", Morgan Kaufmann.
Mike Barlow [2012], " Real-Time Big Data Analytics: Emerging Architecture", [Kindle Ed.], O'Reilly Media.

MA856 Computer Networks (3-0-0) 3
Introduction: Uses of Computer Network, Network hardware, Network software, Hierarchical Reference Models;

Physical Layer: The theoretical Basis for Data Communication, Transmission media. Wireless transmission, The Telephone system, Data Link Layer: Data Link Layer Design Issues, Error correction and detection, Elementary data link layer protocols; Sliding Window Protocols, Protocol Specification and verification, Medium Access Sublayer: The channel allocation problem, Multiple Access Protocols, IEEE 802 standards for LANs and MANs, Bridges. Network Layer: Network Layer Design issues, Routing algorithms, congestion control algorithms, internet working. Transport Layer: Transport services, transport protocols. Application layer Application layer protocols, Cryptography.

References:

Jim Kurose and Keith Ross Computer Networking- Top Down approach, 5 th edition, Pearson Education, 2010
Larry L. Peterson, Bruce S. Davie, Computer Networks: A Systems Approach, 5 th edition, Morgan Kaufmann, 2011
Behrouz A. Forouzan, Data Communications & Networking, 4 th edition, Tata McGraw-Hill Education, 2006
Douglas E.Comer, The Internet Book, 4 th edition, Prentice Hall, 2007

MA857 Software Engineering (3-0-0) 3

Introduction to software engineering.Generic view of Process, Process models. System Engineering: Business Process Engineering, Product Engineering, Requirements Engineering, Building Analysis model, Design Engineering, Creating an Architectural Design, Modeling component – level Design, Software Testing: Testing strategies, Testing tactics Product metrics, Managing Software Projects: Project management. Metrics for process and projects. Estimation, projects scheduling, Risk management, Quality management, change management.

References:

Roger S. Pressman, Software Engineering – A practitioner's Approach, 7 thEdn, MacGraw-Hill
Ian Sommerville, Software Engineering, 9 thEdn, Addison-Wesley
Rajib Mall, Fundamentals of Software Engineering, 3 rdEdn, Prentice-Hall India(PHI) Learning Pvt Ltd.

MA858 Algorithmic Combinatorics (3-0-0) 3

Fundamental Notions Related to Enumerative Combinatorics (Lists/Permutations, Sets/Combinations, Special Bijections, etc.), The Twelve-fold Way of Counting, Integer Partitions, Finite Group Actions, The Cauchy-Frobenius Lemma, Structures and Algorithms, Analysis of Algorithms, Complexity Classes, Integer Partitions, Set Partitions, Bell and Stirling Numbers, Labeled Trees, Catalan Families, Backtracking Algorithms, Permutation Groups.

References:

Donald L. Kreher, Douglas R. Stinson, Combinatorial Algorithms: Generation, Enumeration, and Search, Series: Discrete Mathematics and its applications, CRC Press, 1998
Tucker A., Applied Combinatorics, 2 ndedn, John Wiley, 1984
R. Graham, D. Knuth, and O. Patashnik, Concrete Mathematics,Addison-Wesley, 1994
R. Stanley, Enumerative Combinatorics, Volumes I and II, Cambridge UniversityPress, 2001

MA859 Selected Topics in Graph Theory (3-0-0) 3

Graphs – An Introduction, Classes of graphs, Distances in graphs, Domination, Labelling, Coloring – Introduction & Types of coloring – Complete Colorings, Colorings and Distance: -Coloring, (2,1)-Coloring, Radio Coloring, Hamiltonian Coloring, Critical Concepts, Independence, Matching and Covering, Chordal graphs, Perfect graphs, Interval graphs, Planar graphs, Graph Operations, Graph Partition, Probability on graphs – Random graphs, Hyper graphs, Algebraic concepts in graph theory, IP & LP formulation of selected graph problems, Graph Models.

References:

Douglas B. West, Introduction to Graph Theory, 2 nd Edition, PHI Learning Pvt. Ltd., 2012.
Haynes, T.W., Hedetniemi, S.T. and Slater, P.J., Fundamental of Domination in graphs, Marcel Dekker, Inc.,New York 1998.
Gary Chartrand and Ping Zhang, Chromatic Graph Theory, CRC Press.
Tommy R. Jensen and BjarneToft, Graph Coloring problems, John Wiley & sons.
Michael Stiebitz, Diego Scheide, BjarneToft and Lene M. Favrholdt, Graph Edge Coloring, Wiley.
Random Graphs – BélaBollobás, 2 nd Edition, Cambridge University Press.
Haynes, T.W., Hedetniemi, S.T. and Slater, P.J., Domination in graphs – Advanced Topics, Marcel Dekker, Inc.,New York 1998.

MA860 System Modeling and Simulation (3-0-0) 3

Basic simulation Modeling:The nature of simulation,definition of systems, models and simulation. Structure of simulation models; advantages and disadvantages of simulation, steps in a simulation study. Classification of simulation models; Discrete-Event simulation: Selecting Input Probability Distributions, Random-number Generators, Generating Random variables for standard distributions, Output Analysis for a single system. System Software:

GPSS;general description, facilities, storages, *Queues, transfer blocks,control statements, variable logic switches, Boolean variables, functions, concept of user chains, facility preemption, matching Introduction* to other simulation languages such as MATLAB, TUTSIM Modeling and Simulation of Continuous Systems.

References:

G.Gordon,System Simulation,PHI.
A. M.Lawand W.D.Kelton,simulation,modeling and analysis,McGrawHill.
J.A.Payne,Introduction to simulation,Programming Techniques and methods of analysis.
Thomas J.Schriber, Simulation Using GPSS,John Wiley and Sons.
Mariyansky, Digital Computer and Simulation,CBS Publishers,New Delhi.

MA861 Selected Topics in Computer Algorithms (3-0-0) 3

Computational Geometry: Convex Hull, Polygon triangulation, Voronoi diagram. String processing algorithms: KMP algorithm, Boyer-Moore algorithm. Algebraic and number theoretic algorithms: Modular arithmetic, Chinese remainder theory. Linear programming and combinatorial optimization: LPP formulation, simplex method NP-completeness and Approximation: Polynomial time reduction, NP-complete proofs

References:

De Berg, Mark and Cheong, Otfried and van Kreveld, Marc and Overmars, Mark}, Computational geometry, Springer, 2008.
Charras, Christian, and Thierry Lecroq.Handbook of exact string matching algorithms.King's College Publications, 2004.
T.H Cormen, C.E Leiserson, R.L. Rivest, C. Stein, Introduction to algorithms, Third edition, PHI, 2009.
Jon Kleinberg Eva Tardos, Algorithm Design, Pearson, 2006

MA862 Mobile Computing (3-0-0) 3

Mobility:Issues, challenges, and benefits; Review of mobile and cellular communication technology; Review of distributed/network operating systems, ubiquitous computing. Network Programming:Process communication techniques, remote login, ftp, socket programming, RPC, RMI, client-server programming. Process Migration:Steps, advantages, application taxonomy, alternatives, case study of DEMOS/MP. Mobile Computing:Physical mobility, challenges, limits andconnectivity, mobile IP and cellular IP in mobile computing, case studyof CODA. Wireless LANs: Introduction to IEEE 802.11, Bluetooth and IrDAtechnologies and standards. Mobile AdhocNetworks:Hidden and exposed terminal problems; Routing protocols: DSDV, DSR, AODV. Wireless Sensor Networks:Motes, smart dust, TinyOS, routing protocols.Hand held Devices and OS:Palm, HP; PalmOS, WindowsCE,Windows Mobile. Mobile Internet and WAP:WWW programming model, WAP programming model, gateways. Mobile agents:Aglets, Tcl, PMADE.

References:

Hansman, U. and Merck, L., Principles of Mobile Computing, 2nd Edition., Springer.
Jochen Schiller, Mobile Communications, second edition, Addison-Wesley, 2004
Milojicic, D., Douglis, F. and Wheeler R., Mobility Processes, Computers and Agent, Addison Wesley. 2000
Lange, D. B. and Oshima, M., Programming and Deploying JavaMobile Agents with Aglets, Addison Wesley. 1998

MA863 Computational Fluid Dynamics (3-0-0) 3

Philosophy of CFD, Governing Equations of Fluid Dynamics - Derivation, Physical Interpretation, Forms of Governing Equations suitable to CFD, Mathematical behavior of Partial differential Equations. Finite differences, Error & Stability Analysis of numerical schemes, Grid generation with appropriate transformations, CFD techniques - Lax – Wendroff technique, MacCormack's technique.Numerical Solutions to some one and two -dimensional flows.

References:

J. Anderson, Computational fluid dynamics: The basics with applications, McGraw Hill.
C.A.J. Fletcher, Computational techniques for fluid dynamics vol 1& 2, Springer – Verlag.
H.K. Versteeg, W Malalasekera, An Introduction to Computational Fluid Dynamics, Longman Scientific & Technical.

MA864 Design and Analysis of Experiments (3-0-0) 3

Introduction to probability, one-dimensional random variables, two and higher dimensional random variables, probability distributions, Sampling theory, moments, mgf and their properties, parameter estimation, point estimation, interval estimation of means and variances, Hypothesis testing, Goodness of fit tests, analysis of variance of one-way and two-way classified data, experimental design.

References:

Douglas Montogomery, Design andAnalysis of Experiments, John Wiley

Sheldon M. Ross,IntroductiontoProbabilityandStatisticsforEngineersandScientists,John Wiley
Hogg R.V., & Craig A.T.,Introduction to MathematicalStatistics,McMillan

MA865 Reliability Theory and Applications (3-0-0) 3
Reliability, concepts and definitions, causes of failure, concept of hazard, failure models, bathtubcurve, MTTF, MTBF, system reliability for various configurations, reliability improvement, redundancy, reliability-cost trade-off, maintainability and availability concepts, systemsafety analysis, FTA, FMEA.
References:
E.E.Lewis, Introduction to Reliability Engineering, JohnWiley.
KS.Trivedi,Probability and Statistics with Reliability, Queuing and Computer Science Applications, PHI.

MA866 Computational Number Theory (3-0-0) 3
Elementary Number Theory: Theory of Divisibility, Diophantine Equations, Arithmetic Functions, Congruences, Arithmetic of Elliptic Curves. Computational Number Theory: Introduction, Algorithms for Primality Testing, Integer Factorization, Discrete Logarithms. Quantum Number Theoretic Algorithm.Miscellaneous Algorithms in Number Theory. Cryptography and Information Security
References:
Song Y. Yan, Number Theory for Computing, 2nd Ed. Springer, 2002.
Richard Crandall and Carl Pomerance , Prime numbers: a Computational perspective, Springer, 2001.
Henri Cohen, A course in Computational Algebraic Number Theory, Springer, 2000.

MA867 Game Theory (3-0-0) 3
Introduction: Definition of Games. Actions, Strategies, Preferences, Payoffs.Examples. Strategic Form Games: Strategic form games and examples: Prisoner's Dilemma, Bach or Stravinsky. Dominant Strategy Equilibrium:Strongly dominant strategies, weakly dominant strategies, dominant strategy equilibrium; Examples of Prisoner’s Dilemma and Vickrey Auction. Two Player Zero Sum Games (Matrix Games): Max minimization and Min maximization. Saddle points.Nash equilibrium in matrix games.Minimax theorem.Solution via linear programming.Examples. Bayesian Games: Motivational Examples. Definition of a Bayesian Game and Bayesian Nash Equilibrium and examples.
References:
Martin Osborne. An Introduction to Game Theory.Oxford University Press, 2003.
Y. Narahari. Game Theory and Mechanism Design.IISc Press and World Scientific, 2014.
Philip D. Straffin, Jr. Game Theory and Strategy. The Mathematical Association of America, January 1993.
Ken Binmore, Fun and Games: A Text On Game Theory, D. C. Heath & Company, 1992.

MA868 Theory of Computation (3-0-0) 3
Introduction, Abstract Models for Computation and their relationship with formal languages and Theory of Recursive Functions; Computational and Representational System Models: Finite Automata; Push-down Automata; Linear Bounded Automata; Turing Machines; Formal Language Models; Regular Expressions, Context free Languages, Context Sensitive Languages, Recursively, Enumerable Languages, Generative Grammars, Recognition Procedures; Finite Representation for formal languages, Chomsky Hierarchy; Normal Forms; Derivation Graphs; Pumping Lemma; Undecidability; Recursive Functions and Computability; Computational Effectiveness, Complexity Measures, Reducibility; Complexity Classes.
References:
Hopcroft and Ullman, Introduction to Automata Theory; Languages and Computation, Narosa.Gyorgy E. Revesz, Introdution to Formal Languages, Dover. Aho, Hopcraft& Ullman, Automata, Languages and Computation, Narosa, 1986. Mishra and Chandrashekar, Theory of Computer Science, Prentice Hall of India, 1999.

MA869 Network Security (3-0-0) 3
INTRODUCTION an Overview of Computer Security-Security Services-Security Mechanisms-Security Attacks-Access Control Matrix, Policy-Security policies, Confidentiality policies, Integrity policies and Hybrid policies. CRYPTOSYSTEMS & AUTHENTICATION: Classical Cryptography-Substitution Ciphers-permutation Ciphers-Block Ciphers-DES Modes of Operation- AES-Linear Cryptanalysis, Differential Cryptanalysis- Hash Function - SHA 512- Message Authentication Codes-HMAC - Authentication Protocols, PUBLIC KEY CRYPTOSYSTEMS: Introduction to Public key Cryptography- Number theory- The RSA Cryptosystem and Factoring Integer- Attacks on RSA-The ELGamal Cryptosystem- Digital Signature Algorithm-Finite Fields-Elliptic Curves Cryptography- Key

management – Session and Interchange keys, Key exchange and generation-PKI, Digital Signatures**,** NETWORK SECURITY :Secret Sharing Schemes-Kerberos- Pretty Good Privacy (PGP)-Secure Socket Layer (SSL)- Intruders – HIDS- NIDS - Firewalls – Viruses

References:

Douglas Stinson, "Cryptography Theory and Practice", 2nd Edition, Chapman & Hall/CRC.
B. A. Forouzan, "Cryptography & Network Security", Tata McGraw Hill.
W. Stallings, "Cryptography and Network Security", Pearson Education.

MA870 Pattern Recognition (3-0-0) 3

Introduction to pattern recognition, Classification, Non-Metric methods, Maximum-Likelihood And Bayesian Parameter Estimation, Supervised learning, Nonparametric Techniques, Linear Discriminant Functions, Feature extraction and selection, Multilayer Neural Networks, Algorithm-Independent Machine Learning, Unsupervised Learning and Clustering, Comparison of classifiers.

Richard O. Duda, Peter E. Hart, David G. Stork , "Pattern Classification", 2nd Edition, Wiley, 2001.
Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.
Geoff Dougherty, Pattern recognition and classification an Introduction, Springer, 2013

MA871 Statistical Techniques in Data Mining (3-0-0) 3

Overviewofdataminingtechniques,Taxonomyofdataminingtasks,Stepsindataminingprocess,Predictive modeling,Associationrules, Statistical perspective,Clustering, Regression analysis, Time series analysis, Bayesianlearning,Datawarehousing,Dimensionalmodeling,Performanceissuesandindexing,Developmentlife cycle,Casestudies.

JiaweiHan,MichelineKamber,DataMiningConceptsandTechniques,MotganKaufmannPublishers.
UsamaMFayyad,GregoryPiatetsky-Shapiro,PadhraiSmythandRamasamyUthurusamy,Advancesinknowledge discoveranddatamining,TheM.I.T.press.

MA872 Mathematical Finance (3-0-0) 3

Introductionto Stochastic Processes, Poisson process,BrownianMotion,Martingales. PresentValue Analysis, InterestRateAnalysis,MarketModelSpecificationProblems.ArbitageTheorem, Multi-PeriodBinomialModel, Block-Scholesformula,ValuingInvestmentsbyExpectedUtility,PortfolioSelectionProblem,CapitalAssets PricingModel,RatesofReturn,SinglePeriodandGeometricBrownianMotion,Mean-VarianceAnalysisofRisk- Neutral-Priced CallOptions,AutoregressiveModelsandMeanRegression,OtherPricingOptionsandApplications

S. M. Ross, An Elementary Introduction to Mathematical Finance, CUP.
Thomas Mikosch, Elementary Stochastic Calculus with Finance in view, World Scientific.
Mark S. Joshi, The Concepts and Practice of Mathematical Finance, CUP.

MA873 Game Theory (3-0-0) 3

Introduction: Definition of Games. Actions, Strategies, Preferences, Payoffs. Examples**.** Strategic Form Games: Strategic form games and examples: Prisoner's Dilemma, Bach or Stravinsky. Dominant Strategy Equilibrium:Strongly dominant strategies, weakly dominant strategies, dominant strategy equilibrium; Examples of Prisoner's Dilemma and Vickrey Auction. Two Player Zerosum Games (Matrix Games): Maxminimization and Minmaximization. Saddle points. Nash equilibrium in matrix games. Minimax theorem. Solution via linear programming. Examples. Bayesian Games: Motivational Examples. Definition of a Bayesian Game and Bayesian Nash Equilibrium and examples.

Martin Osborne. An Introduction to Game Theory. Oxford University Press, 2003.
Y. Narahari. Game Theory and Mechanism Design. IISc Press and World Scientific, 2014.
Philip D. Straffin, Jr. Game Theory and Strategy. The Mathematical Association of America, January 1993.
Ken Binmore, Fun and Games : A Text On Game Theory, D. C. Heath & Company, 1992.

MA874 Fuzzy Sets and Fuzzy Logic (3-0-0) 3

Characteristics of Fuzzy System Models, Classification, Problems; Examples, Modeling of system uncertainties; parametric uncertainties; scope and validity of results. From Classical (Crisp) Sets to Fuzzy Sets: A grand Paradigm shift, Fuzzy Numbers, Fuzzy Arithmetic, Fuzzy Measures, Operations on Fuzzy Sets, Fuzzy Relations, Multi-valued Logic, Fuzzy Logic; Uncertainty and information, Uniqueness of Uncertainity Measure; Possibility Theory; Approximate Reasoning; Fuzzy Decision Making.

Klir and Yuan, Fuzzy Sets and Fuzzy Logic, Prentice Hall of India.

Klir and Folger, Fuzzy Sets, Uncertainty and Information, Prentice Hall of India.
T. J. Ross, Fuzzy Logic with Engineering Applications, McGraw Hill.
Zimmermann, Fuzzy Set Theory and its applications, Kluwer Academic Publishers.
C. V. Negoita, Fuzzy Systems, Abacus Press.

MA875 Computational Graph Theory (3-0-0) 3

Graph Enumerations, Distances in Graphs, Matchings, Coverings, Independence and Factorizations. Fundamental algorithmic techniques for solving graph problems – Traversal and Search Techniques, Greedy Approach, Dynamic Programming, Backtracking, Branch and Bound Techniques and their applications to various graph problems, Network Flow Algorithms, Classification of graph problems: P, NP-Hard and NP-Complete. Spanning Trees and Optimization: Basics of Minimum Cost Spanning Trees, Optimal Routing Trees, Optimal Communication Trees.

Fred Buckley and Frank Harary, Distances in Graphs, Addison Wesley, 1990.
Gary Chartrand and Ping Zhang, Introduction to Graph Theory, Tata McGraw Hill, 2006.
Geir Agnarsson and Raymond Greenlaw, Graph Theory – Modeling, Applications and Algorithms, Pearson Education, 2007.
Anany Levitin, Introduction to the Design and Analysis of Algorithms, Pearson Education, 2nd Edition, 2009.
T. H. Cormen, C.E. Leiserson, R.L. Rivest and C. Stein, Introduction to Algorithms, Prentice Hall of India, 2nd Edition, 2005.
Wu Bang Ye and Kun-Mao Chao, Spanning Trees and Optimization Problems, CRC Press, 2004.

MA601 Problem Solving and Programming (3-0-0) 3

Introduction to Algorithms, Flow charts, Procedure oriented Programming concepts, Data types, Operators and Expression, I/O functions, composite Data types (Arrays, Structs, Union) Queues (FIFO), Stacks (LIFO), Pointers, Dynamic Memory Allocation, Linked lists: - Single and doubly linked list, Introduction to Object oriented Paradigms:- Encapsulation, Data hiding, Polymorphism (Operator and Function overloading), Inheritance, Data abstraction, Introduction to Object Oriented Design.

B. Kernighan and D. Ritchie, The C Programming Language, Prentice Hall, 1990 E. Balagurusamy, Programming in ANSI C, Tata Mc.Graw Hill 2004 Hilbert Schilds, C++ complete Reference 1999.

MA602 Discrete Mathematical Structures (3-0-0) 3

Propositional & Predicate Calculus: Introduction to Propositional Logic, Well-formed formulas - Tautology, Contingency, Contradiction, Normal forms, Predicates and Quantifiers, Types of Proof techniques, Validity of logical arguments.
Graph Theory:Introduction and basic properties, Subgraphs, Isomorphism, Eulerian and Hamiltonian graphs, Trees, Planar Graphs, Graph Coloring.
Lattice Theory: Equivalence relations, Partial order relations, Linear order relations, Hasse diagrams, Lattices, Special classes of Lattices. Recurrence relations and generating functions.
Group Theory: Groups and subgroups, Cyclic groups, Cosets, Lagrange's Theorem.

MA603 Computer Organization and Architecture (3-0-0) 3

Data Representation, Number systems, Logic design, addressing modes, Assembly Language programming, Memory organization, Arithmetic: Adders, Carry Look ahead Adder, CSA, Fast multipliers, Booth multiplier, Floating point representation and operations, CPU architecture and organization, Microprogramming, Hardwired control unit, Instruction Formats I/O architecture. Multiprocessing, RISC vs., CISC Architectures, Pipelining and superscalar machine, Parallel processing.

VC Hamachar, ZG Vranesic and SG Zaky, Computer Organization, McGraw Hill 1996 Moris Mano, Computer System Architecture, Prentice Hall, 1992

MA604 Programming Lab (0-0-3) 2

C programming: - Data types, Operators, Functions, Arrays, Structures, Unions, Dynamic Allocation, linked list
C++: - Class, Inheritance, Overriding Function and Operator Overloading.

MA605 Computer Architecture Lab (0-0-3) 2

Implementation of Combinational and sequential Boolean circuits using hardware and software.

SM703 Accounting and Financial Management **(3-0-0) 3**

Principles of Accounting - Concepts - Conventions - Principles. Accounting Systems as source of Financial Information for Decision Making. Financial Accounting - Financial Statements - Ratio Analysis. Inventory Management - Depreciation Policy. Cost Accounting - Classifications. Management Accounting - Cost for Profit Planning and Decision Making. Financial Decisions. Accounting Systems for Planning Control and Decision Making. Budgeting and Budgetary Control.

I.M. Pandey, Elements of Management Accounting. Vikas Publishing House. Khan and Jain, Financial Management, Tata McGraw Hill Publication.

Prasanna Chandra, Financial Management, Tata McGraw Hill Publication. Van Horne James C., Financial Management Policy, Prentice Hall of India.

Anthony & A. Alkinson, Robert S. Kaplan & S. Mark Young, Management Accounting 4th Ed.

Ther Robert S. Kalpan Series in Management Accounting.

MA606 Data Structures & Algorithms **(3-0-0) 3**

Introduction to analysis of algorithms: asymptotic notations, big-oh, big-omega, theta, small-oh, small-omega notations, worst-case and average-case analysis, solving recurrences. Abstract data types, Linear Data Structures and their sequential storage representation: stacks, queues, priority queues, and their applications. Pointers and linked storage representation: singly linked list, circular linked list, doubly linked lists and their application, skip lists. Nonlinear data structures: trees, storage representation of binary trees, operations on binary trees: tree traversals, insertion, deletion, searching, trees, applications of trees, AVL trees. Graphs: representation of graphs, breadth first search and depth first search, shortest path problem, minimum cost spanning trees, applications of graphs. Sorting: selection sort, bubble sort, insertion sort, merge sort, heap sort, quick sort, radix sort. Searching: sequential search, binary search, search trees, hash tables.

T.H. Cormen, C.E. Leiserson, R.L. Riverst, C.Stein, Introduction to Algorithms, Prentice -Hall of India, 2003 A.V. Aho, J.E. Hopcraft and J.D. Ullman, Data Structures and Algoriths, Pearson Education, 2003

J.P. Tremblay and P.G. Sorenson, An Introduction to Data Structures with Application. Tata McGraw-Hill 1991.

MA607 Database Management Systems **(3-0-0) 3**

Files versus database systems, Three-level architecture of databases, Data Models, ER-diagram, EER-model, Relational model, ER-Relational mapping, Relational algebra and calculus. Query languages, SQL, Embedded SQL, Relational database design algorithms, Normalization, Physical database organization, Indexing and hashing, Transaction processing, Concurrency control techniques, Database recovery techniques, Database security and authorization.

Ramez Elmasri, Shamkant B Navathe, Fundamentals of database system, Addison Wesley, McGraw-Hill, 2000.

Silberschatz Korth and Sudarshan, Database System Concepts, McGraw Hill.

Ramakrishnan, R., Gehrke, Database Management Systems, Third edition McGraw Hill.

MA 608 Computational Mathematics **(3-0-0) 3**

Computer arithmetic - Floating point errors, Round-off errors, Absolute and relative errors; Polynomial interpolation: Lagrange and Newtons's interpolation methods, Hermite interpolation; Curve fitting using least-square principle; Numerical differentiation through polynomial interpolation: Deduction of first and second order formulae; Numerical integration: Newton-Cotes formula, Trapezoidal and Simpson's 1/3rd and 3/8th rules, Method of undetermined coefficients; Solution of linear system: Gauss-Elimination and LU-factorization, Basic iterative methods - a) Jacobi, b) Gauss-Siedel, c) Successive over relaxation methods; Finding root of an equation: (polynomial and transcendental) - Bisection and Regula-falsi methods (bracketing roots), Newton- Raphson (Newton) method, fixed point iterations, Muller's method; Extension of Newton's method to nonlinear system of equations; Numerical solution of ODEs (IVPs): Euler's and higher order Taylor series methods, Runge-Kutta methods, Predictor-Corrector methods: a) Modified Euler method, b) Linear multi-step methods.

References:

R L Burden and J D Faires, Numerical Analysis, 9th Edn, Brooks/Cole.

S D Conte, C De Boor, Elementary Numerical Analysis, Tata McGraw-Hill, 2006.

W H Press, S A Teukolsky, W T Vetterling, B P Flannery, Numerical Recipes in C/Fortran - The Art of Scientific Computing, Cambridge University Press, 2007.

M K Jain, S R K Iyengar, R K Jain, Numerical Methods for Scientific and Engineering Computation.

MA609 Object Oriented Programming **(3-0-0) 3**
Key concepts of Object Oriented Programming. Overview Of C++, Classes,Inheritance. Polymorphism, Overloading. Virtual functions, Templates, Exception handling, I/O stream. File I/O, Java Programming
Herbert Schild, C++ The Complete References, 1999.
HM.Deitel and PE Deitel, Java How to Program, Prentice Hall, 1998.

MA610 Data Structures and Algorithms Lab using OOP Concepts **(0-0-3) 2**
Unix commands. Simple programs using I/O. Implementation of programs using control statements, Implementation of various data structures using object oriented concepts, Functions, Arrays, Pointers, Structures, Unions, File handling, Graphics function and animation.
Brian W.Kernigham and Pike R., The Practice of Programming, Addison Wesley, 1999.
Saumyendra Sengupta, Editors: Carl P. Korobkin, Saumyendra Sengupta, C++, object-oriented data structures, 1994

MA611 Database Management Systems Lab **(0-0-3) 2**
Creation of tables, Views, Insertion, Modification and deletion of elements. Implementation of queries. Implementation of joins. Implementation of PL/SQL, triggers, cursors and sub programs. Implementation of database connectivity through front end tools. Database design and implementation. Mini project.

MA612 Operating Systems **(3-0-0) 3**
Operating System Functionalities, Types of Operating System- Multi programming, Multi-tasking, Multi processing and Realtime Operating system, Processes and threads, Process Management (learning fork system call), Inter process communication (using shared memory, Message Queues, Pipes etc.), CPU scheduling, Process synchronization Mechanism (Semaphores in Unix), Dead locks - Prevention, avoidance and recovery techniques, Memory Management (Paging, Segmentation and Swapping), Virtual Memory (Dynamic Paging Techniques and Page replacement Algorithms), File Systems Management, IO Management, Protection and Security
Silberschatz, Galvin, Gagne Operating System Concepts (Sixth Edition), John Wiley 2008 Mourice J. Bach, The Design of the Unix Operating System PHI 2002

MA613 Software Engineering **(3-0-0) 3**
Software engineering paradigms, Planning, Cost estimation, Organization structure, Software project scheduling, Risk analysis and management, Requirements and specification, Rapid prototyping, Software design, Software metrics, Software testing and maintenance, Software configuration management and case tools, OO modeling, OO software development process, OOT concepts, Unified software development process, Development Phases, UML, structural and behavioral modeling, architectural modeling.
Roger S. Pressman, Software Engineer: A Practitioner Approach, McGraw Hill, 1999 L Sommerville, Software Engineering, Addision Wesley, 1996
Grady Booch "OO Analysis and Design with Applications" Pearson Education Asia
Jacobson, Booch and Rambaugh, "The unified software Development process" Pearson Education Asia

MA614 Introduction to Web Technology **(3-0-0) 3**
The Web Design Environment; Designing for a variety of Browsers, Designing for a variety of displays, Web design principles for print designer, beginning guide for the server; HTML: HTML Overview, Structural HTML Tags, formatting text, creating links, adding image and other page elements,Tables, Frames, forms, Image mapping, cascading style sheets; Using Web design Tools like MS Front page, Flash Dreamweaver, coreldraw, Photoshop; Multimedia and Client side scripting: Audio on the web, Video on the web, DHTML, Introduction to java script, Java Applets. Server-side scripting: Active Server Pages, XML.
Hiroshi Maruyama, Kent Tamura, XML and Java Developing Web Applications., Naohiko Uramoto.
Thomas Powell, Fritz Schneider, Javascript, the complete reference, Tata McGraw Hill, 2002.
David Crowder, Rhonda crowder, Web design, IDG books of India Pvt. Ltd., 2001.
Jennifer Neiderst, Web design in a nutshell, Orielly Publications.

MA615 Operating Systems Lab **(0-0-3) 2**
Unix Operating System familiarization, UNIX shell scripting, Implementation of IPC Using Shared Memory, Pipes, Files, Message queues etc., Process synchronization using Semaphores (Reader writer and Dining Philosopher Problem), Disc scheduling Algorithms.

MA616 Software Engineering Lab **(0-0-3) 2**
A mini project to be implemented using software Engineering concepts.

MA617 Probability and Statistics **(3-0-0) 3**
Introduction of probability, total probability theorem, conditional probability, Baye's theorem, one and two dimensional random variables, functions of random variable, probability distributions, discrete and continuous cases, marginal and conditional distributions, independence of random variables, expectation and variance of a random variable, correlations, sampling theory, sampling distributions, weak law of large numbers, central limit theorem and applications, methods of estimation, parameter estimation, tests of statistical hypothesis.
Meyer P.L., Introduction to Probability and Statistical Applications, Oxford & IBH, 1979.
RV Hogg and AT Craig, Introduction to Mathematical Statistics McMilan, 1975.

MA618 Computer Graphics **(3-0-0) 3**
Graphic Hardware, Display Devices: line and point plotting algorithms, I/O Devices, Display processors, Color display Techniques (Shaddow masking & Penetration CRT), Coordinates (Screen and User), 2D and 3D transformation, Curves, Surfaces and solids, Hidden line and surface elimination, illumination and shading, Color Models (RGB, HIS etc), Animation techniques.
Hearn D and Baker MP, Computer Graphics, PHI, 2002
Roger DF, Procedural Elements of Computer Graphics, McGraw Hill, 2002, Gonzalez C and Woods RE, Digital Image Processing, Addison Wesley, 2000.

MA619 Computer Networks **(3-0-0) 3**
Introduction: Uses of Computer Network, Network hardware, Network software, Types of networks, topology, Hierarchical Reference Models OSI and TCP/IP Models. The theoretical basis for Data Communication, Transmission media. Physical Layer. Bit signal transformation, Bit rate control, Multiplexing, Circuit switching, Line coding, Data Link Layer, Data Link Layer Design issues, Addressing, Error correction and detection, Flow control, Medium Access control, Framing, Network Layer Network Layer Design issues, IP addressing, Subnetting, NAT IP v6, DHCP, ICMP, ARP, Routing algorithms, IP datagram and fragmentation, Internetworking devices Transport Layer Transport layer services, Addressing, Connection control, transport protocols such as UDP and TCP, congestion control algorithms, Quality of service. Application layer: Application layer protocols SMTP, DNS, FTP, HTTP, Introduction to Network Security, Introduction to wireless network and Mobile Ad-hoc Networks
AS Tannenbaum, Computer Networks, Prentice - Hall 2003. William Stallings, Data and Computer Communication, PHI, 1997
James F. Kurose and Keith W Rose, Computer Networking Pearson Education, 2003

MA620 Computer Graphics Lab **(0-0-3) 2**
Line and Point Drawing Algorithms, 2D 3D Transformations, Clipping and Windowing, Animation

MA621 Networking Lab **(0-0-3) 2**
Implementation of Datalink, Network, Transport, Application layer protocols techniques based on computer networks. Client/server programming. Internetworking of LANs. File transfer using TCP/IP Remote command execution UNIX socket programming.

SM612 Managerial Economics **(3-0-0) 3**
Business Objectives and Business Decisions - Nature and scope of managerial economics, Economic theories, Firms Objectives, Profit maximization, Entrepreneurship, Manager role, Managerial decisions. Demand Analysis, Forecasting and Market Structure - Demand determinants, types of demand, Demand function, Demand Elastictiy's, Demand forecasting -methods, market structure, type of competitions, price and output decisions under perfect and imperfect competition. Monopoly, Monopolistic, Oligopoly competitions, safeguarding competition and anti-trust lanes. Production, Pricing and Profit Management - Production theory, Determinants of price, Pricing structure, Price discrimination, Pricing of joint products, Pricing methods, statutory price fixation in India, Price discounts and differentials, Nature of profit, profit policy, measurement, planning and forecasting. Decision Techniques and Capital Budgeting - Optimization, Resource allocation, Evaluation alternatives, formulation of linear programming problem, marketing decision concepts, Introduction to capital budgeting, Types and evaluation of investment decisions. Data of Macroeconomics - National income, Aggregate demand and expenditure, saving and Investment,

Trade cycle and control, International trade, Balance of payments and Foreign exchange. Money System - Market for money, Interest rates, the capital market - banks, stock exchange, multiplier and accelerator. Case Studies.
Mote V.L Paul Samuel and Gupta G.S. "Managerial Economics", McGraw -Hill, 1985
Craig Petersen H. and Cris Lewis W., "Managerial Economics", Prentice Hall of India, 2000 Dwivedy D.N., "Managerial economics", Vikas Publishing House, 1995.
Mcguigam, "Managerial Economics Applications Strategy and tools", South Western, 2002. N. Gregory Mankiw. "Principles of Economics", (3rd Ed) Thomson, 2002.

MA622 Computer Applications Lab (0-0-6) 3
Implement a mini project using the concepts studied in preceding semesters.

MA641 Computer Algorithms (3-0-0) 3
Mathematical Background. Design and Analysis of algorithms. Complexity measures. Worst-case and average-case complexity. Sorting and selection. Searching and set manipulation. Hashing. Union-Find problem. Design techniques: Divide and conquer, Dynamic programming, Greedy method, Backtracking, Branch & bound. Graph and parallel algorithms. Algebraic problems. String processing. NP-completeness.
A Aho, J Hopcroft, and J Ullman, The design and analysis of computer algorithms, Pearson Education 2001.
Thomas H. Cormen, Charles E Leiserson, and Ronald L. Rivest, Introduction to Algorithms, Prentice Hall 1998.

MA642 Fuzzy System Models (3-0-0) 3
Classical (Crisp) sets versus fuzzy Sets. Fuzzy Numbers. Fuzzy arithmetic. Fuzzy measures. Operations on fuzzy sets. Fuzzy relations. Multi-valued logic. Fuzzy logic. Uncertainty and information. Uniqueness of uncertainty measure. Possibility theory. Approximate reasoning. Fuzzy decision making.
Klir and Folger, Fuzzy Sets, Uncertainty and Information, Prentice Hall 2001.
Klir and Yuan, Fuzzy Sets and Fuzzy Logic, Prentice Hall of India 2001.

MA643 Management Information Systems (3-0-0) 3
Definition of management information systems. Information systems for decision making process. Information-based support systems. Information system requirements. Planning, designing and implementing MIS. Case study.
GB Davis and MH Olson, Management Information Systems, Mc-Graw Hill, 1984. Murdick RG and Ross JE, Information systems for modern management, Prentice Hall.

MA644 Operations Research (3-0-0) 3
Linear Programming. Formulation and graphical solutions. Simplex Algorithm. Quality and sensitivity analysis.
Dual simplex method. Transportation and assignment problems. Games and their solution by linear programming. Network Analysis. Queuing Theory. Basic structure of a queuing Model. M/M/1 and M/M/S models and their variants.
Hamdy A Taha, Operations Research, Prentice Hall of India, 1997.
Hiller and Liberman: Introduction to Operations Research, Prentice Hall 1995.

MA645 Optimization Techniques & Statistical Methods (3-0-0) 3
Linear programming problem. Simplex method. Two-Phase method. Duality theory. Transportation problem. Assignment problem. Reliability. Concepts of hazard, Bath-tub curve, MTTF , MTBF. System reliability for series, parallel and mixed configurations. Data Analysis. Time series analysis, Time series models, Method of moving averages. Seasonal movements, Cyclical movements.
Kanthi Swarup, PK Gupta and Man Mohan, Operations Research, Sultan chand & Sons, 1978.
J Medhi, Statistical Methods, Wiley Eastern, 1987.

MA646 Artificial Intelligence (3-0-0) 3
Foundation and history of AI. AI Problems and techniques. Heuristic search techniques. Knowledge representation. Reasoning under uncertainty. Planning and learning. Genetic algorithms. Applications of AI. Principles of natural language processing. Expert systems. Current trends in intelligent systems. AI programming languages. Introduction to LISP and PROLOG.
Elain Rich and Kevin Knight, Artificial Intelligence, Tata McGraw Hill Publishing Company Limited, 1995.
Stuart Russel and Peter Norvig, Artificial Intelligence: A Modern Approach, Prentice Hall, 1995.

MA647 Cloud Computing **(3-0-0) 3**
Introduction: Definition and evolution of Cloud Computing, Enabling Technologies, Service and Deployment Models Popular Cloud Stacks and Use Cases Benefits, Risks, and Challenges of Cloud Computing, Economic Models and SLAs Topics in Cloud Security; Cloud Infrastructur :Historical Perspective of Data Centers, Datacenter Components: IT Equipment and Facilities, Design Considerations: Requirements, Power, Efficiency, & Redundancy, Power Calculations, PUE and Challenges in Cloud Data Centers Cloud Management and Cloud Software Deployment Considerations; Virtualization: Virtualization (CPU, Memory, I/O) Case Study: Amazon EC2 Software Defined Networks (SDN) Software Defined Storage (SDS) ; Cloud Storage: Introduction to Storage Systems,Cloud Storage Concepts, Distributed File Systems (HDFS, Ceph FS), Cloud Databases (HBase, MongoDB, Cassandra, DynamoDB), Cloud Object Storage (Amazon S3, OpenStack Swift, Ceph) ; Programming Models: Distributed Programming for the Cloud Data-Parallel Analytics with Hadoop MapReduce (YARN), Iterative Data-Parallel Analytics with Apache Spark Graph-Parallel Analytics with GraphLab 2.0 (PowerGraph)
Ray J. Rafaels, Cloud Computing: From Beginning to End, Create Space Independent Publishing Platform, 2015
Michael J. Kavis, Architecting the Cloud: Design Decisions for Cloud Computing Service Models Wiley; 1st edition, 2014
Thomas Erl, Zaigham Mahmood, and Ricardo Puttini. Cloud Computing: Concepts,Technology and Architecture, Prentice Hall; 1st edition, 2013
Dan Marinescu, Cloud Computing:Theory and Practice, Morgan Kaufmann; 2nd edition, 2017 Tom White, Hadoop:The Definitive Guide , O'Reilly Media, 2009.

MA648 Big Data Analytics **(3-0-0) 3**
Introduction to Big Data Analytics, Big Data Analytics Platforms, Big Data Storage and Processing, Big Data Analytics Algorithms, Linked Big Data Analysis - Graph Computing and Network Science, Big Data Visualization, Big Data Mobile Applications, Large Scale Machine Learning, Big Data Analytics on Specific Processors, Hardware and Cluster Platforms for Big Data Analytics.
Michael Minelli, Michele Chambers, Ambiga Dhiraj [2013], "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley CIO.
David Loshin [2013], "Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph", Morgan Kaufmann.
Mike Barlow [2012], " Real-Time Big Data Analytics: Emerging Architecture", [Kindle Ed.], O'Reilly Media.

MA649 Machine Learning **(3-0-0)3**
Mathematical preliminaries: Linear algebra and matrix theory; Regression models: Linear regression with single and multiple variables, Logistic regression; Regularization: Handling over-fitting of the data; Artificial Neural networks: perceptron models, back propagation algorithm. Machine learning algorithms for large data sets; Dimensionality reduction: SVD, LDA; Classification: Supervised: Support vector machines, unsupervised: Neighborhood algorithms, k-Means Algorithm Learning theories, Bayesian Learning and Decision Trees, analytical learning, reinforcement learning.
Ethem Alpaydin, “Introduction to machine learning”, second edition, PHI publication, 2010.
Tom Mitchell, “Machine Learning”, McGraw Hill, 1997
Christopher M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2006.

MA650 Computer Simulation & Modeling **(3-0-0) 3**
Components of a system. Models of system. Random number generation. Probabilistic distribution. Simulation languages. Applications
Jerry Banks and John Carson. S, Discrete Event System Simulation, PHInc, 1984.
Gotifried B, Elements of Stochastic process simulation, PHInc, 1984.

MA651 Genetic Algorithms **(3-0-0) 3**
Robustness of traditional optimization and search techniques, Goals of optimization, A simple genetic algorithm, Similarity templates, Mathematical Foundations, Computer Implementation of Genetic Algorithms, Advanced operators and techniques in genetic algorithm search. Industrial application of genetic algorithms.
David Goldberg, Genetic Algorithms in search, optimization and machine learning, Addision Wesley International,1999.
Charles L Karr and L Michael Freeman, Industrial applications of Genetic Algorithms, CRC Press, 1998.

MA652 Knowledge Management (3-0-0) 3
Introduction to knowledge Management. Types of knowledge within an organization. Intellectual capital. KM Architecture and Tools. ERP for KM. Knowledge sharing tools. Data ware housing. Knowledge strategy creation. KM practices. KM Process. Integrating knowledge sharing and learning. The chief knowledge Officer (CKO) and his/her job. Training programmes for organization. Wide learning. Making KM work across various segments of industry and business firms. Case studies of KM practices in successful companies, Future challenges in KM.
Ratnja Gogula (Ed), Knowledge Management: A New Down., The Institute of Hartered Financial Analysts of India, Hyderabad 2002.

MA653 Natural Language Processing (3-0-0) 3
Issues and difficulties in NLP. Language understanding systems. Types of NLP Systems. Grammars and parsing. Semantic Interpretation. Language communication. Typical Systems. Current trends in NLP.
James Allen, Natural Language Understanding, Benjamin / Cummings Publishing Co, 1995.
Ronald Hausser, Foundations of Computational Linguistics, Springer-Verleg, 1999.

MA654 Network Optimization (3-0-0) 3
Net work models. Minimal spanning trees. Shortest route problem. Matching and coloring problems. Max flow min-cut theorem. Capaciated network model. Network simplex method. PERT and CPM. Resource analysis in network scheduling. Precedence planning. Resource allocation and scheduling.
CH Papadimitriou and K Steiglitz, Combinatorial optimization: Algorithms and Complexity, Prentice Hall,1982.
Hamdy A Taha, operations research, PHI, 1997.

MA655 Object Oriented Analysis & Design (3-0-0) 3
Object oriented design fundamentals. OOSD life cycle. Object oriented analysis. UML. Object oriented design methods. Design patterns and frameworks. Object oriented development. Coding, Testing, Maintenance. Case studies in object oriented development.
Grady Booch, James Rumbaugh and Ivar Jacobson, The Unified Modeling Language User Guide, Addison Wesley Long man, 1999.
Erich Gamna, Design Patterns, Addison Wesley, 1994.

MA656 Performance Modeling (3-0-0) 3
Performance evaluation methods. Analytical versus simulation modelling. Performance measurement and benchmarking. Workload modelling. Random variables. Commonly used distributions. Stochastic processes. Markov chain models of computer systems. Queuing models. Discrete event simulation. Simulation Languages. Confidence intervals. Variance reduction techniques. Case studies of analytical and simulation studies of computer systems.
Raj Jain, The Art of Computer Systems Performance Analysis, John Wiley and Sons, New York, USA, 1991.
KS Trivedi, Probability and Statistics with Reliability, Queuing and computer science, PHI, 1982.

MA657 Stochastic and Queuing Systems (3-0-0) 3
Probability concepts. Random variables. Functions of random variable. Distributions. Moment generating function. Stationary process. Markov process. Binomial process. Poisson process. Birth and death process. Renewal process. Markov chains. Chapman-Kolmogorov equations. Transition probabilities. Series and parallel systems. Reliability and Availability of Markovian systems. Maintainability. Preventive maintenance. Markovian queuing models. Little's formula. Multi-server queues. M/G/1 Queues. Pollaczek-Khintchine formula. Decision theory and games.
Trivedi KS, Probability and Statistics with reliability, Queuing and Computer Science Applications, Prentice-Hall 1984.
J Medhi, Stochastic process, Wiley eastern 1987.

MA658 UNIX and Network Programming (3-0-0) 3
Overview of UNIX OS. File I/O. Files and directories. Standard I/O library. System data files and information. Processes. Process relationships. Terminal I/O. Advanced I/O. Threads. Interprocess communication. Message passing. Synchronization. Shared memory. Sockets. Name and address conversions. Applications: TCP echo client server, UDP echo client server.
W Richard Stevens, Advanced programming in the UNIX environment, Addison Wesley,1999.
W Richard Stevens, UNIX Network Programming Volume 1 and 2, Prentice Hall, 1998.

MA659 Advanced Client Server Computing **(3-0-0) 3**
Development of Client/Server computing. Architecture of client/server. Three tired architecture. Client characteristics and tools. Use of GUI and local processing with examples. Services like file, database, communication and security. Platforms: LAN, WAN and enterprise wide services. Network operating system. Connectivity: SWMP, NFS, SMPT, IPC. Services: pipes, semaphores, shared memory, DDE, RPC, OLE. Application development. Management and risk issues.
Robert Orfalietall, Essential Client/Server Survival guide
Larry T. Vaughn, Client /Server System Design & Implementation.

MA660 Advanced Database Management Systems **(3-0-0) 3**
Basic concepts. Architecture for data sharing, Federated DBMS. Distributed databases. Client/server architecture. Multimedia databases. Object oriented data bases. Data mining and knowledge discovery. Pattern clustering abstraction and similarity. Clustering for data mining. Data mining using neural networks and genetic algorithms. Discovery of association rules. Frequent episodes in event sequences. Applications of data mining.
Ramez Elmasri, Shamkant B Navathe, Fundamentals of Database Systems, Addison Wesley, 2000.
Stefano Ceri & Giuesppe Pelagatti, Distributed Databases - Principles and Systems, McGraw Hill 1987.

MA661 Advanced Operating Systems **(3-0-0) 3**
An overview of operating system functions. Distributed operating systems. Design issues. Distributed shared memory. Scheduling algorithms. Recovery. Protection and Security. Cryptography. Architecture of multiprocessor operating systems. Database operating systems.Transaction processing. Serializibility. Concurrency control algorithms. Object oriented operating systems. Case studies: UNIX, LINUX, Windows.
Mukesh Singhal Niranjan, G.Shivorothri, Advanced concepts in Operating Systems, Tata Mc-Graw Hill, 1994.
Andrew S Tenanbaum, Modern Operating Systems, PHI, 1995.

MA662 Cryptography and Network Security **(3-0-0) 3**
Conventional encryption. Introduction to Finite Fields. Contemporary symmetric ciphers. Confidentiality using conventional encryption. Public-Key Encryption. Hash Functions. Introduction to Number Theory. Public-Key Cryptography. Message authentication. Hash and Mac algorithms. Digital signatures and authentication protocols. Network security. System security.
William Stallings, Cryptography and Network Security, Pearson Education India 2002.
RE Smith, Internet Cryptography, Pearson Education India.

MA663 Data Mining and Warehousing **(3-0-0) 3**
Overview of data mining techniques. Taxonomy of data mining tasks. Steps in data mining process. Predictive modeling. Association rules. Statistical perspective. Clustering. Regression analysis. Time series analysis. Bayesian learning. Data warehousing. Dimensional modeling. Performance issues and indexing. Development life cycle. Case studies.
Jiawei Han, Micheline Kamber, Data Mining : Concepts and Techniques, Motgan Kaufmann Publishers, 2000.
Usama M Fayyad, Gregory Piatetsky-Shapiro, Padhrai Smyth and Ramasamy Uthurusamy, Advances in knowledge discover and data mining, The M.I.T. press, 1996.

MA664 Digital Image Processing **(3-0-0) 3**
Digital image fundamentals. Elements of visual perception. Colour models. Mathematical preliminaries of 2D systems. Image transforms. Image enhancement and restoration. Image compression. Image segmentation.
Gonzalez C and Woods RE, Digital image processing Addition Wesley, 2000.
Anil K Jain, Fundamentals of digital image processing, PHI, 1997.
William. K Pratt, Digital image processing, Wiley International, 2000.

MA665 Distributed Computing Systems **(3-0-0) 3**
Introduction to distributed Systems. Design Goals. Fundamental issues in distributed systems. Basics of networking, Temporal ordering of events. Lamport's logical Clocks. Vector clocks. Global state detection. Physical clocks. Process Synchronization. Distributed mutual exclusion. Performance matrix. Interprocess communication. RPCs. Deadlocks in distributed systems. Load balancing techniques. Distributed databases.
GF Coulouries, JD Dollimore and T Kindberg, Distributed Systems: Concepts and Design, Addison Wlesley, 1994.

Mukesh singhal and Niranjan G.Shivaratri, Advanced concepts in Operating system, Tata McGraw Hill 1994.

MA666 Information and Coding Theory (3-0-0) 3
Entropy and its characterizations. Huffman codes. Shannon-Fano coding. Information measure-noiseless coding. Fundamental theorem of information theory. Error correcting codes. Minimum distance principles. Hamming bound. General binary code. Group code. Covolution encoding. Algebraic structure. Gilbert bound. Threshold decoding. Cyclic binary codes. BCH codes. Decoding. Optimum codes. Concepts of non-cyclic codes.
R Ash, Information theory, Interscience publication, Singapore, 1965.
N Abrahamson, Information theory and coding, Mc Graw Hill, 1963.

MA667 Parallel Processing (3-0-0) 3
Theory of Parallelism. Multiprocessors and Multicomputer. Conditions for Parallelism. Data and resource dependencies. Hardware and software Parallelism. Program Flow Mechanisms. Control Flow versus data flow. Hardware technologies. Instruction set Architectures, CISC, RISC. Scalar Processors, Memory Hierarchy and Virtual Memory. Cache Memory organizations. Hardware synchronization mechanisms. Vector processing principles.
K Hwang & Briggs FA, Computer Architecture and Parallel Processing, McGraw Hill, 1985.
Kai Hwang, Advanced Computer Architecture, McGraw Hill 1993.

MA668 Pattern Recognition & Scene Analysis (3-0-0) 3
Pattern and features. Pattern recognition approaches. Discriminant functions. Statistical pattern recognition. Gaussian model. Parametric estimation. Bayesian parameter estimation. Pattern classification by distance functions Cluster analysis. Syntactics pattern recognition. Features extraction and recent advances.
Earl Gose, Richard Johnsonbaugh, Steve Jost, Pattern Recognition and Image Analysis, Prentice Hall 1999.
Duda RO and Hart PE, Pattern Classification and Scene Analysis, Wiley, 1973.

MA669 Web Design (3-0-0) 3
HTML overview. HTML tags. Formatting text. Cascading style sheets. DHTML. Web design tools. MS Front page. Dreamviewer Multimedia. Client side scripting. Introduction to java script. VB script. Server side scripting. Active server pages. Java server pages. Database connectivity. Web applications.
Thomas powell, Fritz Schneider, Java script:The complete reference, Tata Mc Graw Hill, 2002.
David crowder, Rhonda crowder, Web design, IDG books India Pvt. Ltd., 2001.

MA670 Compiler Design (3-0-0) 3
Phases of a compiler. Lexical analysis. Syntax analysis. LEX and YACC utility. Syntax directed translation. Run time Environments. Intermediate code generation. Code optimization. Code generation.
AV Aho, Ravi Sethi, and JD Ullman, Compilers: Principles, techniques and tools, Pearson education Asia, 2001.

MA671 Theory of Computation (3-0-0) 3
Finite automata. Moore and Melay machines. Regular Expressions. Pumping lemma. Minimizing the automata. Formal Languages. Regular languages. Context free languages (CFL). Chomsky and Greibach Normal forms. Pushdown automata (PDA). Equivalence of PDA and CFL. Turing machines. Theory of recursive functions. Complexity theory. NP-completeness.
Aho, Hopcraft & Ullman, Automata, Languages and Computation, Narosa,1986 Mishra and Chandrashekar, Theory of Computer Science, Prentice Hall 1998.

MA672 Object oriented programming with JAVA (3-0-0) 3
Introduction to Programming, and Java: Primitive Data Types and Operations: Selection Statements, Loops, Methods, Arrays, Strings and Text I/O; Exceptions and Assertions, Objects and Classes; Inheritance and Polymorphism; Getting Started with GUI Programming: Creating User Interfaces; Event Driven Programming; Java Database Programming; Remote Method Invocation; Java Server Pages; Multithreading; Networking; Advanced Swing Models; Menus, Toolbars, Dialogs; Containers, Layout Managers, and Borders.
References:
Y. Daniel Liang, Introduction to Java Programming Comprehensive version, Tenth Edition, Pearson publishers, 2015.
Herbert Schildt, Java: The Complete Reference, Ninth Edition, Oracle press (Mc. Graw Hill), 2014.

Bruce Eckel, Thinking in Java fourth edition, Prentice Hall, 2005.

MA673 Internet Technology & Applications (3-0-0) 3

History of Internet. Internet addressing. TCP/IP. DNS and directory services. Internet resources and applications. WWW Overview. Advanced java programming. Applet Programming. N/w programming, JDBC. Servlet programming.

Deitel & Deitel, Internet & World wide Web, How to program, Prentice Hall 2000. D Norton and H Schild, Java2: The complete reference, TMH 2000.

MA674 Artificial Neural Networks (3-0-0) 3

Introduction to artificial neural network. Learning process. Single layer and multilayer perceptrons. Back propagation algorithm. Convolution network. Radial basis function network. Kernel regression and its relation to RBF network. Learning strategies. Support vector machines. Linearly separable patterns. Non-separable patterns. SVM for nonlinear regression. Principal component analysis. Pattern classification. Hierarchical vector quantization.

Simon Haykin, Neural Networks: A comprehensive Foundation, Prentice-Hall International, New Jersey, 1999. B Yegnanarayana, Artificial Neural Networks, Prentice-Hall of India, New Delhi.

MA701 Applied Statistics & Numerical Analysis (3-0-0) 3

Introduction to probability, probability distributions, Sampling theory, Hypothesis testing, Analysis of variances of one-way and two way classified data.

Numerical solutions of ordinary differential equations - Initial and boundary value problems, Numerical solutions of partial differential equations - elliptic, parabolic and hyperbolic problems.

References:

S. M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, John Wiley.

R. V. Hogg, Craig A. T., Introduction to Mathematical Statistics McMillan.

R L Burden and J D Faires, Numerical Analysis, 9th Edn, Brooks/Cole.

G. D. Dmiyh, Numerical Solution of Partial Differential Equations, Oxford University Press.

MA702 Design & Analysis of Experiments (3-0-0) 3

Overview of probability, probability functions, random variables, probability distributions, sampling theory, random samples, statistic, sampling distributions, central limit theorem.

Parameter Estimation, point estimation, interval estimation of means and variances, Hypothesis testing, goodness of fit tests, Analysis of variances of one-way and two way classified data, experimentaldesigns: CRD, RBD, LSD, factorial experiments.

References:

D. Montogomery, Design and Analysis of Experiments, 3 Edition, John Wiley

S. M. Ross, Introduction to Probability & Statistics for Engineers and Scientists, John Wiley.

R.V. Hogg, Craig A. T, Introduction to Mathematical Statistics, 4th Edition, McMillan.

MA703 Linear Algebra (3-0-0) 3

Finite dimensional vector spaces, Algebra of transformations, matrix algebra, solution sets of linear system of equations, eigenvectors, Real symmetric / Complex Hermitian matrices, Algebra of polynomial matrices, Inner product spaces, singular value decomposition, polar decomposition, Applications of linear algebra in signal processing, coding theory and control theory.

References:

G. Strang, Linear Algebra and Its Applications, 3 ed., Brooks/Cole, 1998.

D. C. Lay, Linear algebra and its applications, 2nd edn, Pearson, 2000.

MA704 Numerical Analysis (3-0-0) 3

Solution of algebraic transcendental and polynomial equations, Interpolation, Numerical differentiation, Numerical Integration, Integration over infinite intervals, Error analysis, Numerical solution of ordinary differential equations, Numerical solution of partial differential equations.

References:

R. L. Burden, J. D. Faires, Numerical Analysis, 9th Edn, Brooks/Cole.

G. D. Smith, Numerical Solution of Partial Differential Equations, Oxford University Press.

M.K. Jain, S.R.K. Iyengar, R.K. Jain, Numerical Methods for Scientific and Engineering Computation, New age

international publishers.
M.K. Jain, Numerical Solutions of Differential Equation, Wiley Eastern Limited.

MA705 Operation Research (3-0-0) 3
Introduction and formulation of models: simplex method, duality in LP, Dual Simplex method, sensitivity analysis, transportation and assignment problems, Integer programming, Classical optimization methods, Lagrangian Multipliers and Khun-Tucker conditions, quadratic programming.
References:
H. A. Taha, Operations Research: An Introduction, Pearson Education, India.
F. S. Hillier, G.J. Lieberman, Introduction to Operations Research, Concepts and Cases, 8th Edition, 2010, TMH.

MA706 Probability & Statistical Applications (3-0-0) 3
Probability & Statistics: Introduction, one - dimensional random variables, two and higher dimensional random variables, marginal and conditional distributions, independence of random variables, variances and correlations, Distributions: Sampling Theory. Parameter Estimation: Hypothesis testing, goodness of fit tests, Data Analysis, Linear regression.
References:
P.L. Meyer, Introduction to Probability & Statistical Applications, Addison-wesley.
S. M. Ross, Introduction to Probability & Statistics for Engineers & Scientists, John Wiley

MA707 Random Processes and Applications (3-0-0) 3
Overview of probability, Random processes, Classification, Markov Chains, C-K equations, Ergodic chains, Poisson processes, Birth and death processes, Queuing theory, Basic concepts, M/M/1 and M/M/S queues, Reliability theory, Concept of Hazard rate function, Bath-tub curve, MTTF and MTBF, System reliability for series, parallel and mixed configurations.
References:
H. A. Taha, Operations Research: An Introduction, PHI.
F. S. Hillier and G.J. Lieberman, Introduction to Operations Research, Concepts and Cases, 8 th edition, 2010, TMH.
A. Papoulis, Probability, Random Variables and Stochastic Processes. McGraw Hill, 1984.

MA708 Statistical Methods (3-0-0) 3
Probability and Statistics, Introduction , One dimensional random variables, Two and higher dimensional, random variables, marginal and conditional distributions, independence of random variables, variances and correlations. Distributions: Sampling theory. Parameter estimation: Hypothesis testing, Goodness of fit tests. Data Analysis, Linear regression.
References:
P.L. Meyer, Introduction to Probability & Statistical Applications, Addison-wesley.
S. M. Ross, Introduction to Probability & Statistics for Engineers & Scientists, John Wiley

MA709 Database Management (3-0-0) 3
Introduction to database systems, relational data model, Relational databases- SQL, Database design- Entity relationship data model- normal Forms, Storage and file organization, access methods, Data warehouses and Data mining.
E. Ramez, S. B Navathe : Fundamentals of database systems, Pearson. J. D Ullman, Principles of database systems, W.H.Freeman & Co Ltd.
C. J. Date, An Introduction to database system Vol I,II,III Addison Wesley. P. Naveen, Introduction to Database management : Tata McGrawHill

MA710 Applied Mathematics for Surveyors (3-1-0) 4
Tracing of curves, Overview of methods of Integration. Applications of Integration to area, arc length, volume and surface of revolution. Multiple Integrals. Line Integrals, Surface Integrals, Volume Integrals. Numerical Integration : Trapezoidal and Simpson Rule's. Numerical double Integration. Projection: Projection of a point, line segment on a line, projection of planes and surfaces. Spherical Trignometry.
References:
K. A. Stroud, Advanced Engineering Mathematics, Palgrove Macmillan 4 edition Thomas, Finney, Calculus and

Analytical Geometry.
B.S. Sastry, Higher Engineering Mathematics, Khanna Publishers.
S.S.Sastry, Introductory methods of Numerical Analysis.

MA711 Statistics for Management **(3-0-0) 3**
Applications of statistics in managerial decision making – Primary and secondary data collection methods, drafting of questionnaire – Classification and tabulation of data – sampling method – Probability and Non-Probability Methods – Simple Random Sampling Method – Stratified Random Sampling – Cluster random Sampling – Measurement and Scales of Measurement – Data Analysis – Compilation and Tabulation of Data – Graphical Representation of the Data – Summary Statistics – measures of Variation –measures of Co-Variation – Estimation – Interval Estimate – Testing of Hypothesis –Null and Alternative – Types of Errors – Type I and Type II Errors – Concept of Size and Power of a test Hypothesis. Correlation analysis – Regressions analysis – Business forecasting and time series.
References:
S.P. Gupta, Statistical Methods, 33rd Edition, Sultan Chand and Sons, 2004.W. W. Daniel, J.C. Terrell, Business Statistics for Management and Economics, Houghton Mistlin Co 1992.

MA712 Optimization Techniques **(3-0-0) 3**
Introduction and formulation of models, Simplex method, duality in LP, Dual simplex method, Sensitivity analysis, Transportation and assignment problems, Integer programming, Classical optimization methods, Lagrangian Multipliers and Kuhn-Tucker conditions, Quadratic programming, basic nonlinear programming problems.
References:
H. A. Taha, Operations Research: An Introduction, PHI.
F. S. Hillier and G.J. Lieberman, Introduction to Operations Research, Concepts and Cases, 8 th edition, 2010, TMH.
S. S. Rao, Engineering Optimization: Theory and Practice, New Age International Publishers.

MA713 Mathematical Methods for Engineers **(3-1-0) 4**
Revision of Linear Algebra – Linear Transformations, Range and Kernel, Isomorphism, Matrix of transformations and change of basis.
Partial Differential Equations: Second order PDEs, Classifications, Formulation and method of solutions of Wave equation, Heat equation and Laplace equation.
Tensor Calculus: Line, area and volume integrals, Spaces of N-dimensions, coordinate transformations, covariant and mixed tensors , fundamental operation with tensors, the line element and metric tensor, conjugate tensor, Christoffel's symbols , covariant derivative.
References:
G. Hadley, Linear Algebra, Narosa, 2002.
A. N. Kolmogorov, S. V. Fomin, Elements of the Theory of Functions and Functional Analysis, 2001.
Sokolnikoff, Redheffer, Mathematics of Physics and Engineering, 2nd edition, McGraw Hill, 2006.
S. Sokolnikoff, Tensor Analysis, Wiley, New York, 2006.
R. Marsden, Abraham, Manifolds, Tensor Analysis, and Applications, Springer, 2001.
J. L. Synge, Tensor Calculus, Dover Publications (July 1, 1978).
L.A. Pipes, L.R. Harwill: Applied Mathematics for Engineers and Physicists, McGraw Hill, 2004.

MA714 Mathematical Foundations of Computer Science **(3-0-0) 3**
Combinatorics: Fundamental principles of counting, Pigeonhole principle, Countable and Uncountable sets, Principle of Inclusion and Exclusion, Derangements, Generating functions, Recurrence relations, Solution of recurrences using Generating functions.
Graph Theory: Graph Representations, Directed and Undirected graphs - Introduction and basic properties, Subgraphs, Isomorphism, Eulerian and Hamiltonian graphs, Trees, Spanning Trees, Weighted Trees, Connectivity, Planar graphs, Euler's formula, Applications of Kuratowski's theorem, Graph Colouring, Chromatic polynomials.
Group Theory: Groups and subgroups, Homomorphism theorems, Permutation groups, Normal subgroups, Cosets, Lagrange's Theorem, Rings.
References:
Kenneth H Rosen, Discrete Mathematics and its applications with Combinatorics and Graph Theory, 7th Edition, 2012.

Douglas B West, Introduction to Graph Theory, 2nd Edition, Eastern Economy Edition published by PHI Learning Pvt Ltd.
Grimaldi, R.P., Discrete and Combinatorial Mathematics: An Applied Introduction, Addison Wesley, 1994.
Kolman, B. and Busby, R.C., Discrete Mathematical Structures for Computer Science, PHI, New Delhi, 1994

MA715 Statistics for Business Management (3-0-0) 3
Role of Statistics in Decision Making, Collecting & Tabulating Data-Measure of Central Tendency and Dispersion in Frequency Distribution, Probability Theory: Classical, Objective & Subjective Approach- Addition, Multiplication & Bayes Theorem –Applications- Binomial, Poisson and Normal - Decision Making Under Certainty, Uncertainty and Risk -Sampling and Sampling Distribution: Types of Sampling - Random Sampling-Concept of Standard Error Central Limit Theorem. Testing of Hypotheses, Significance Level-Type I & Type II Error- One-Two Tail Tests - Hypothesis Testing of Means, Variance & Proportions -Chi-Square Tests- Goodness of Fit, Independence of attributes, Correlation and Regression Analysis.
References:
S. Levine, B. Krehbiel, Statistics for Managers, Using Microsoft Excel, PHI New Delhi, 2011.
T. Daniel, Business Statistics for Management and Economics, 6th Edition, Houghton Mifflin Company, 1992.
R. I. Levin and D. S. Rubin, Statistics for Management, Prentice Hall of India, 1999.
S. Shenoy and Sharma, Quantitative Techniques for Managerial Decision Making, Wiley Eastern, 1998.

MA801 Dynamical Systems (4-0-0) 4
Discrete and Continuous dynamical systems, Damped and Undamped Dynamical systems, Autonomous and non-autonomous systems, Phase- Space analysis, Local and global Stability, Limit cycles, Critical Point Analysis, Lorentz Model, Deterministic Chaos, Bifurcation Theory, Saddle Node Bifurcation, Period Doubling and Hopf Bifurcation, Hamiltonian Systems.
F. Verhulst, Non-Linear Differential Equations and Dynamical Systems, Springer, 1996. S. Wiggins, Introduction to Non-Linear Dynamical Systems, Springer, 1990.
L. Perko, Differential Equations and Dynamical Systems, 3rd Edition, Springer.
M.W. Hirsch, S. Smale, R.L.Devaney, Differential Equations , Dynamical Systems and An Introduction to Chaos, Elsevier, 2nd Edn.

MA802 Modern Algebra (4-0-0) 4
Groups, Permutation groups, Sylows theorems, Simple groups, solvable groups, Direct Products of groups and structure of finite Abelian groups. Rings: Prime and Maximal Ideals, Euclidean and Principal ideal rings, Unique factorization domains and Polynomial rings. Fields: Extension fields, Prime fields, Algebraic and Transcendental extensions. Roots of polynomials, splitting fields, finite fields, Separable and Inseparable extensions, Perfect and Imperfect fields. Simple extensions, Galois theory, Solvability of polynomials by radicals, Abel's theorem.
References:
I.N. Herstein, Topics in Algebra, Wiley.
J.B. Fraleigh, A First course in Abstract Algebra, Pearson.
J.A. Gallian, Contemporary Abstract Algebra, Cengage.

MA803 Approximation Theory & Numerical Methods (4-0-0) 4
Fundamentals : The approximation problem, general approach to the approximation problem, norms, Tchebychef norm and the Polya algorithm. Least squares and Orthogonal functions, Tchebycheff approximation. Approximation in the norm. The Weierstrass theorem and degree of convergence, Computational Methods.
References:
J.R.Rice, The Approximation of Functions, Vol. 1, Addison - Wesley.

MA804 Computational Combinatorics (4-0-0) 4
Generating functions, Recurrence relations, Generalised Permutations and Combinations, Inclusion-Exclusion, Inversion formulae, The Van-der Waerden Conjecture, Partitions, Projective and Combinatorial Geometries, The Burnside -Frobenius Theorem, Group theory in Combinatorics, Permutations Groups and their Cyclic Indices, Polya's Enumeration Theorem;(0-1) Matrices, Latin Squares, Hadamard Matrices, Reed-Muller Codes.
References:
B. Bollobas, Combinatorics, Cambridge University Press.
I. Anderson, Combinatorics of Finite Sets, Dover

MA805 Fluid Mechanics **(4-0-0) 4**
Navier-Stokes equations, boundary layer flows, similarity transformations, wave propagation and shocks, methods of characteristics; basic equations of hydromagnetic flows, Hartman flow, Reynolds equations for turbulent flows, statistical theory, empirical velocity profiles.
References:
P. K. Kundu, I. M. Cohen, D. R. Dowling, Fluid Mechanics, 5th Edition, Academic Press G. K. Batchelor, An Introduction to Fluid Dynamics, Cambridge University Press.

MA806 Formal Languages & Theory of Computation **(4-0-0) 4**
Finite automata: Moore and Melay machines, Regular Expressions, Pumping lemma, Minimizing the automata, Formal Languages: Regular languages. Context free languages (CFL), Chomsky and Greibach Normal forms. Pushdown automata (PDA), Equivalence of PDA and CFL, Turing machines, Theory of recursive functions,Complexity theory,NP-completeness.
References:
A. Hopcraft, Ullman, Automata, Languages and Computation, Narosa, 1986.
Mishra, Chandrashekar, Theory of Computer Science, Prentice Hall of India, 1998.

MA807 Mathematical Logic & Applications **(4-0-0) 4**
Propositional calculus. The notions of truth and proof, adequacy, truth functions and decidability. Predicate calculus, interpretation, proof substitution, soundness, the deduction theorem. Adequacy and compactness. First order theories, consistency, completeness, categoricity, models. The Lowenheim-Skolem theorem. Turing machines. Godel numbers. The undecidability of the predicate calculus.

MA808 Numerical Solution of Ordinary Differential Equations **(4-0-0) 4**
Initial value problem for systems of ODEs: Single step methods - Euler and Runge-Kutta methods, Linear multistep methods - predictor corrector methods, Order, Consistency, Convergence, Zero-stability, Weak stability theory, Solution of stiff ODE, Solution of system of ODEs and higher order ODEs.
Two point boundary value problems for ODEs, Shooting method, Finite difference methods, Deferred correction and extrapolation, Solution of Sturm-Liouville problems.
References:
J.D. Lambert, Computational Methods in Ordinary Differential Equations. Wiley, Chichester, 1991.
A. Iserles, A First Course in the Numerical Analysis of Differential Equations, Cambridge University Press, 1996.
K. Atkinson, W Han, D. Stewart, Numerical Solution of Ordinary Differential Equations, John Wiley & Sons, 2009.

MA809 Optimization Techniques and Statistical Methods **(4-0-0) 4**
Linear programming, simplex method, duality, transportation and assignment problems, Reliability, definitions, concept of hazard, bath-tub curve, system reliability for various configurations, data analysis: correlation and regression of data, simple linear regression, time series analysis: definitions, characteristic movements, measurement of trend, secular trend, seasonal movements, cyclical movements.
References:
H.A. Taha, Operations Research, Prentice Hall India.
J. Medhi, Statistical Methods, Wiley Eastern.

MA810 Algorithmic Graph Theory **(4-0-0) 4**
Introduction to graphs Max-flow Min-cut theorem. Algorithms for computing maximum s-t flows in graphs. Algorithms for computing the minimum cut in a graph. Edge and vertex connectivity of graphs and menger's theorem. Maximum matching, Hall's theorem, algorithms for computing maximum matching in weighted and unweighted graphs. Arborescences and algorithm for computing minimum arborescence. Edmonds theorem for disjoint arborescences. Planar graphs and algorithms for checking for planarity. Edge and vertex coloring of graphs. Independent sets and perfect graphs. Extremal graph theory.
References:
G. Chartrand and O..Oellermann, Applied and Algorithmic Graph Theory, McGraw Hill, 1993.
A Gibbons, Algorithmic Graph Theory, Cambridge University Press, 1985.

MA811 Computational Fluid Dynamics **(4-0-0) 4**
Basic concepts and equations of fluid dynamics, non-dimensional forms, boundary layer equation, grid generation,

grid refinement, adaptive grids, finite difference methods, explicit and implicit methods, fundamentals of fluid flow modeling, upwind scheme.

References:

S.W. Yuan, Fluid Mechanics, PHI.

S.V. Patankar, Numerical Heat Transfer, McGraw Hill

F. M. White, Viscous Fluid Flow, McGraw Hill.

MA812 Special Topics in Mathematics (4-0-0) 4

The contents will depend on the topic chosen and will be announced before the course is offered. Sample Course titles are: i)Mathematical Theory of Chaos and Fractals; ii) Fuzzy Sets and Applications; iii) Nonlinear Dynamics.

MA813 Number Theory & Cryptography (4-0-0) 4

Elementary Number Theory. Congruences, applications to Factoring. Finite fields, Quadratic residues and reciprocity. Simple cryptosystems, public key cryptography, RSA, Discrete logs. Primality and Factoring, the rho method, Fermat factorization, continued fraction and Quadratic Sieve methods.

References:

N. Kobltiz, A course in Number Theory and Cryptography, Springer, 1994.

MA814 Finite Element Methods (4-0-0) 4

Introduction to calculus of variations, Approximate methods, Finite Elements, nodes classifications, approximate functions, Solution of Boundary value problems of second order differential equations, Finite element equations for the heat conduction equation, vibration equation elliptic problems using Galerkine and Ritz methods.

References:

M.K. Jain, Numerical Solution of Differential Equations, PHI Ltd.

A.R. Mitchell and R. Wait, Finite Element methods in Partial Differential Equations, John Wiley, 1997.

MA815 Mathematical Modeling (4-0-0) 4

Introduction: Mathematical modeling through ordinary differential equations and systems of ordinary differential equations of first order, Mathematical modeling through difference equations, Modeling using partial differential equations, Mathematical modeling through graphs.

References:

J.N. Kapoor, Mathematical Modeling, Wiley Eastern, 1988.

R. Aris, Mathematical Modeling Techniques, Pitman, 1978.

MA816 Reliability Theory & Applications (4-0-0) 4

Reliability, concepts and definitions, causes of failure, concept of hazard, failure models, bath tub curve, MTTF, MTBF, system reliability for various configurations, reliability improvement, redundancy, reliability-cost trade - off, maintainability and availability concepts, system safety analysis, FTA, FMEA.

References:

E.E. Lewis, Introduction to Reliability Engineering, John Wiley.

K S. Trivedi, Probability and Statistics with Reliability, Queuing and Computer Science Applications, PHI

MA817 Statistical Quality Control (4-0-0) 4

Sampling theory: random samples, statistic sampling distributions, central limit theorem, concept of Quality, types of variations, process control and product control, control charts for variables and attributes, concept of acceptance sampling, by attributes, O.C., AQL, LTPD, AOQL, ATI etc, types of sampling plans, Reliability, definitions, concept of hazard, bath-tub curve, system reliability for various configurations.

References:

E.L. Grant, Statistical Quality Control, Mc Graw Hill.

D C Montgomery, Introduction to Statistical Quality Control, John Wiley.

MA818 Combinatorial Optimization (4-0-0) 4

Polynomial Boundedness; network optimization problems; Greedy algorithms; Matroid theory; Matroid Intersections; Matroid Partitions; Primal weighted Intersection algorithm; Duality Theory; Matroid polyhedra; Primal- Dual weighted Intersection Algorithm; Matroid Parity; Generalizations.

MA819 Nonlinear Programming **(4-0-0) 4**
Linear Inequalities and Theorems of the Alternative; Convex sets; Convex and concave Functions; Saddle Point Optimality criteria of Nonlinear Programming without Differentially; Differential convex and concave Functions; Optimality criteria of Nonlinear Programming with differentiability; Duality in nonlinear Programming; generalizations of convex functions; Quasi convex, strictly quasi convex; Pseudoconvex; Optimality and Duality of generalized convex and concave Functions; Optimality and Duality in the presence of equality constraints.

MA820 Modeling & Simulation **(4-0-0) 4**
Components of a system. Models of system. Random number generation. Probabilistic distribution. Simulation languages. Applications.
References:
J. Banks and J. S. Carson, Discrete Event System Simulation, PHInc., 1984.
B. Gotifried, Elements of Stochastic Process Simulation, PHInc, 1984.

MA821 Statistical Techniques for Data Mining **(4-0-0) 4**
Overview of data mining techniques. Taxonomy of data mining tasks. Steps in data mining process. Predictive modeling. Association rules. Statistical perspective. Clustering. Regression analysis. Time series analysis. Bayesian learning. Data warehousing. Dimensional modeling. Performance issues and indexing. Development lifecycle. Case studies.
References:
J. Han, M. Kamber, Data Mining: Concepts and Techniques, Morgan Kaufmann Publishers, 2000.
U. M Fayyad, G. Piatesky-Shapiro, P. Smyth and R.. Uthurusamy, Advances in Knowledge Discover and Data Mining, The MIT Press, 1996.

MA822 Mathematical Finance **(4-0-0) 4**
Introduction to Stochastic Processes, Poisson process, Brownian Motion, Martingales. Present Value Analysis, Interest Rate Analysis, Market Model Specification Problems. Arbitage Theorem, Multi-Period Binomial Model, Block- Scholes formula Valuing Investments by Expected Utility, Portfolio Selection Problem, Capital Assets Pricing Model, Rates of Return, Single Period and Geometric Brownian Motion, Mean- Variance Analysis of Risk-Neutral- Priced Call Options, Autoregressive Models and Mean Regression, Other Pricing Options and Applications.
References:
S.M.Ross, An Introduction to Mathematical Finance, Cambridge University Press,1999.
A.J.Prakash, R.M. Bare, K. Dandapani, G.L.Ghai, T.E.Pactwa and A.M.Parchigari, The Return Generating Models in Global Finance, Pergamon Press, 1998.
S.M.Ross, Applied Probability Models with Optimization Applications, Holden- Day, 1980.

SCHOOL OF MANAGEMENT

SM711 Research Methodology **(3-0-0) 3**
Introduction to Research, Research and Scientific Method, Research Ideas and Literature Review, Research Proposal, Language of Research, Ethics in Research, Research Process, Sampling Design: Probability and Non Probability, Data Collection, Analysis and Interpretation, Ethics in Business Research, Research Design and Approaches: Descriptive, Exploratory, Causal, Qualitative Research, Observation Studies, Surveys, Experiments, Measurements and Scales, Questionnaires, Data Analysis: Presentation, Exploring and Examining, Presenting Findings: Written and Oral Reports, Referencing.
Donald R. Cooper and Pamela S. Schindler, Business Research Methods, TMH, New Delhi, 9th Edition, 2006.
Earl Babbie, The Basic of Social Research, Wadsworth- Thomson Learning, 2nd Edition, 2002.

SM712 Organization Behaviour **(3-0-0) 3**
Concept of Management, Leadership, Skills of Manager, Organizations as Social Systems, Effective Human Skills, Motivation and Behaviour, Theories of Motivation, Organizational Behaviour - Nature of Organizations, Organizational Effectives, Interdisciplinary Focus, Approaches to OB. Foundations of Individual Behavior, Personality, Perception, Learning, Attitudes, Values, Job Design, Socio-technical Systems, Work Stress. Group and Interpersonal Behavior, Group Dynamics, Power, Conflict, Organizational Process, Organizational Designs.
Stephen P. Robbins, Timothy A. Judge, Seema Sanghi, Organizational Behavior, Pearson Education. Steven L Mc Shane, Mary Ann Von Gilnow and Radha R. Sharma, Organizational Behaviour, TMH Fred Luthans, Organizational Behavior, McGraw Hill International

SM713 Financial Accounting **(3-0-0) 3**
Financial Accounting — Concepts – Principles – Accounting Systems – Preparation of Financial Statements. Indian Accounting Standards – Creative. Accounting, Annual Report, Presentation and Analysis of Audit Reports and Directors Report. Human Resource Accounting –
Fixed Assets and Depreciation Accounting – Inventory Valuation (Basic). - U.S.GAAP Framework and Indian Accounting Standards Framework -. Analysis of Financial Statements –Funds Flow Analysis – Ratio Analysis – Cash Flow Analysis - Cost Accounting – Cost classification Marginal Costing – Performance Budgeting – Cycle Costing – Strategic Cost Management.
Lyrich: Accounting for Management, Tata McGraw-Hill, New Delhi, 2001.
Maheswari S. N, Cost and Management Accounting, Sultan Chand and Co., New Delhi, 6th Edition 2001. Narayan Swamy, R. Financial Accounting: A Managerial Perspective, PHI

SM714 Managerial Economics **(3-0-0) 3**
Introduction, nature and scope of managerial economics. Business objectives and decision making. Demand analysis, law of demand, elasticity of demand, demand forecasting, supply analysis, supply elasticity. Production analysis and production function, cost concept and analysis. Market equilibrium, average revenue concept and market structure. Perfect and imperfect competition, pricing strategy. National income dynamics, theories of profit. Decision techniques and capital budgeting. Macroeconomic facts, money system and case studies.
Craig Petersen and Chris Lewis W, Managerial Economics, Prentice-Hall of India, 2000 Mcguigam, Managerial Economics Applications Strategy and tools, South Western, 2002. Mankiw N. Gregory, Principles of Economics, Thomson, 2002.

SM716 Corporate Communication **(3-0-0) 3**
Importance of Communication, Nature of Communication, Communication Process and Flow; Communication Channels and their Use; Communication Climate; Communication, Culture and Work; Verbal and Non-Verbal Communication, Interpersonal Communication, Interview Skills – Principles, Planning and Conducting Interviews; Group Dynamics; Presentations, Persuasive Presentations; Keys to Functional Writing, Business Correspondence, E-Communication.
Ronald B. Adler and Jeanne Marquardt Elmhorst, Communicating at Work: Principles and Practices for Business and the Professions, McGraw-Hill, 2008

SM718 Spreadsheet Modelling for Business **(2-0-2) 2**
Introduction to Spreadsheet- Functions of Spreadsheet- Spreadsheet Uses and Limitations- Entering Formulas into Excel- Control-Flow Statements-Charts in Excel- Dash Board- Sensitivity Analysis- Creating Tornado Diagrams-

Pivot Tables and Charts- Modeling with IFPS and VBA- Matrix Operations - Regression Analysis- Macros - Recording and Editing- Lookup and Reference Functions- DCF-NPV and IRR Functions- Data Tables- Database Manipulation- Workbook Sharing & Merging- Customizing Toolbars And Menus- User-Defined Functions- Matrix Operations In Excel- Auditing Tools

SM721 Managerial Accounting **(3-0-0) 3**

Organizations and accounting - Differences between Financial Accounting and Management Accounting - Understanding Financial Statements - Interpreting Financial Statements Financial Statement Analyses – Horizontal and Vertical Analyses – Value Chain Analysis - Significant Accounting Policies, Accounting Standards - Features of Corporate Accounting - Creative Accounting - Cash Flow and Fund Flow Techniques - Costs - Cost Estimation - Estimating Product Costs and Activity-Based Costing - Product Planning Decisions - Cost-Volume-Profit Analysis - Budgets and Budgeting - Cost Allocations - Traditional Absorption Costing Systems - Management Accounting in a Changing Environment.

Horngreen and Sundlem -Introduction to Management Accounting, PHI

Manmohan & Goyal - Principles of Management Accounting, Sahitya Bhawan Publications, 1998 Maheshwari S. N., Management Accounting and Financial Control, Sultan Chand & Sons

SM722 Marketing Management **(3-0-0) 3**

Introduction to Marketing - Marketing Process - Marketing Environment - Marketing Research - Demand Forecasting - Competition - Marketing Strategy - Consumer Behaviour- Industrial Marketing -Customer Satisfaction - Segmentation - Targeting, Positioning Developing New Market Offerings - Product Life Cycle - Designing Global Market Offerings - Product and Branding Strategy - Designing and Managing Services - Developing Pricing Strategy - Advertising Strategy - Media Planning - Marketing Channels - Retailing - Marketing Communication – Advertising.

Philip Kotler *and* Kevin Lane Kelle,r*Marketing Management, Pearson, 12th Edition, 2006.* Philip Kotler andGary Armstrong, *Principles of Marketing, Prentice Hall, 13th Edition, 2009.*

Philip Kotler, Kevin Lane Keller , Abraham Koshy *and* Mithileshwar Jha , *Marketing Management: A South Asian Perspective, Pearson Education; 12th Edition, 2007.*

Tapan K Panda Marketing Management: Indian Context *, Excel Books, 2008*

SM723 Entrepreneurship **(3-0-0) 3**

Nature and importance of entrepreneurship, entrepreneurial decision making process, role of entrepreneurship in economic development , National knowledge commission report, entrepreneurship- characteristics, motivation, role models and support systems, entrepreneurial entry into international business, MSME’s in India , intrepreneurship, entrepreneurial process - identifying and evaluating opportunities, developing business plan, assessment of resources, project appraisal and feasibility plan , creating and starting venture- legal requirements, marketing strategies, financial plans and human resources management, managing growth, concept of family business, conceptual models of family business, challenges facing entrepreneurs -individuals ,family ,groups, society , provisions for nursing sick units.

Robert D. Hisrich and Michael P. Peters, Entrepreneurship, Mc Graw – Hill, 2006

Donald Roratko & Richard Hodgetts ,Entrepreneurship – A contemporary approach , PHI, 2007 David holt , New venture Creation - , Prentice hall India, 5TH ED, 2008

SM724 Operations Management **(3-0-0) 3**

Operations Functions, Types of Operations, Time Series Analysis- Function of Production Planning and Control. Aggregate Planning - Guidelines. Operation Scheduling - Assignment Model – ‘n’ jobs to be Produced in ‘m’ machines - Run Out Time Method - Network Scheduling. Quality Control: Purpose of Inspection and Quality Control - Process Control - Control Charts for Variables- Control Charts for Fraction Defectives - Control Charts for Defects - Sampling Plan - Single Sampling Plan, OC Curve, AQL, AOQL, LTPD. Inventory Control - Deterministic Models - Probabilistic Models. Maintenance and Replacement- Breakdown Vs. Preventive Maintenance - Group vs. Individual Replacement. Just in Time Production. Simulation, Monte Carlo Simulation.

Buffa E.S. and Sarin R.K., Modern Production / Operations Management, John Wiley & Sons, 8th Ed., New York, 1990

Chary S.N., Production & Operations Management, TMH, New Delhi, 1992

SM725 Financial Management **(3-0-0) 3**

General Financial Environment – Introduction – Capital, Secondary and Money Markets, Basics, Instruments, Financing and Rating Institutions, and legal environment. - Corporate Financial Objectives and Functions - Financial Analysis, Ratio analysis, Common size statement analysis, Trend analysis, Sickness prediction - Funds Flow analysis - Risk and Return Portfolio Theory - Sources of Funds , Types, Issuing and Pricing, Valuation of Stocks and bonds - Dividend Policy - Capital Structure Decision, Capital Structure Theories - Valuation Of The Firm - Evaluation Techniques, Evaluation Of Lease Contracts - Corporate Restructuring, Mergers And Acquisitions - Financial Restructuring, - Working Capital Management

Van Horne James C., Financial Management Policy, Prentice of India, (9th Edition) Pandey I.M., Financial Management, Vikas Publications House, (7th Edition) Chandra, P., Fundamentals of Financial Management, TMH

SM726 Human Resource Management **(3-0-0) 3**

Overview Of HRM, Strategic HRM, HR Planning, Job Analysis, Recruitment And Selection, Human Resource Development, Performance Assessment And Management, Compensation System, Incentives And Benefits, Safety And Health, Labour Relations, Multinational HRM, Role Of Culture, Legislations Pertaining To Labour Acquisition, Compensation And Maintenance, Emerging Issues In HRM.

Michel Armstrong, Human Resource Management, 5th Edition, 2006

V S P Rao, Human Resource Management, PHI, 7th Edition, 2004

Cynthia D. Fisher, Human Resource Management, Biztantra, 5th Edition, 2004.

Flippo Edwin B., Principles of Personnel Management- McGraw Hill – Kogak.

SM727 Business Analytics and Decision Making **(3-0-0) 3**

Analytical decision making: emerging business environment- analytical competition-embedding analytic in business process- reporting / descriptive analytics, modeling or predictive analytics, data-driven strategies- analytics and business performance- building analytical culture- industry trends in analytics-review techniques and tools. Business contexts-stages of enhanced analytics capabilities-defining metrics- categories and levels of metrics- defining KPIs- linking strategic outcomes and KPIs- KPI directories for different industry segments- aligning technologies in analytics domain. Blue printing a solution framework: identifying core KPIs- sourcing data- using high. Analysis & interpretation: gathering and reporting-use of dashboards and other visualizations tools- interpretations of analysis- suggesting strategic and tactical programs. Project development: industry inputs- validation of models- frameworks- data analytics .

Davenport Tom, Harris Jeanne G., Morison Robert, Analytics at Work: Smarter Decisions, Better Results, (February 2010)

Davenport Thomas H., Harris Jeanne G., Competing on Analytics: The New Science of Winning, (March 2007)

SM731 Strategic Management **(3-0-0) 3**

Strategy in context - strategic thinking-case study in achieving profitable growth- core differentiation strategies- vision mission and values- strategic map model. Competitive edge- defining investment priorities- competitive position - environmental changes. Presenting the change plans pulling everything together into a plan- leading people through change. Strategic management process, firm and environment: environmental analysis – macro- micro and relevant environment – models for environmental analysis – SWOT analysis- BCG matrix- GE's stoplight matrix. Strategy and resources. Pyramid of business policy. Types of strategies: dependency – generic strategies. Generation of strategic alternatives – strategic information systems. Organizational level strategies: franchising- licensing- sub contracting- diversification- concentric diversification- conglomerate expansion. Strategy implementation – evaluation and control. Matching structure and control, global issues of 21st century—strategic audit-issues in non-profit organizations.

Arthur A Thomson and A J Stickland, Strategic Management, Tata McGraw Hill

John A. Pearce and Richard B. Robinson, Strategic Management - Strategy Formulation and Implementation, AITBS Publishers and Distributors.

Charles W. L. Hill and Gareth R. Jones, Strategic Management Theory, Integrated Approach, All India Publishers & Distributors. Jauch Lawrance R. & Glueck William F., Business Policy and Strategic Management- McGraw Hill (5t h Edition).

Johnson Gerry & Scholes Kevan, Exploring Corporate Strategy- Prentice Hall of India (4t h Edition).

SM732 Corporate Information System **(3-0-0) 3**

Managerial overview of information systems, information needs and management process- information system - data

information system to problem solving- data information and its attributes - level of people and information needs - types of decisions and information information system - stages in system analysis - classification of information system, technical foundations of information systems: hardware, software, telecommunications and networks, database, client server computing; business applications of information systems: DSS, EIS, artificial intelligence, expert systems, neural network, office automation, business information systems, systems analysis and design, tools for information system development, managing information resources, securities concerns - network securities.
James A O'Brien ,George M Marakas, Ramesh Behl, Management Information Systems , TMH Education Pvt. Ltd , 2010.
Uma G. Gupta, Management Information Systems, A Managerial Perspective, Galgotia Publications, 1998 Kenneth J Laudon, Jane P. Laudon, Management Information Systems, Pearson/PHI, 10/e
W. S. Jawadekar, Management Information Systems, Tata McGraw Hill Edition, 3/e

SM733 Legal Environment (2-0-0) 2
Nature of contract requirements & classifications – discharge of contract – remedies for the breach- quasi contract – contingent contract. Sale of goods act - sale, agency, negotiable instruments act, nature and requisites instruments, transfer of negotiable instruments, holder in due course special rules for cheques banks, discharge of negotiable instruments. Partnership act - nature of the companies, kinds of companies – formation and incorporation of a company, memorandum of association, Articles of Association and prospectus ,company management, company meetings (board and general), majority rule and minority protection , compromises, arrangements. Reconstruction and amalgamation – winding up. Competition, / FEMA, consumer protection, right to information act. Special economic zones, environment & business, business and the ip regime, wto.
Kapoor, N.D. ,Mercantile Law, Sultan Chand & Sons, 28th Ed.
Majumdar, A.K. and Kapoor, G.K., Company Law and Practice, Taxmans Publications, New Delhi, Revised 2000.

SM741 Ethics and Sustainability (3-0-0) 3
Evolution- management structure for corporate governance- board structure-building responsive boards - issue and challenges- effectiveness of board- board committees and audit committee- legal compliance committee and stakeholders' relationship committee-appraisal of board performance- transparency and disclosure- internal control system and risk management-corporate governance in various countries – investor protection and institutional investors-corporate social responsibility -various corporate governance forums - CACG ,OECD , ICGN , NFCG organization perspectives- ethical principles in business – codes and innovations-concept of stakeholders' organization- activity analysis- process-business ethics as a strategic management tool - stakeholders' protection-sustainability reporting -stakeholder engagement-corporate sustainability management systems-legal framework-conventions and treaties on environmental- health and safety and social security issues-principle of absolute liability .
Taxmann ,Corporate Governance , ICSI& Taxmann Publication
Adrian Cadbury, Corporate Governance and Chairmanship – A personal View - Publication: Oxford University Press.
Sanjiv Agarwal, Corporate Governance: Concept & Dimensions, Published by Snow White Publication.

SM811 Organization Development and Management of Change (3-0-0) 3
Introduction to OD- organisations as systems, dimensions of organisational design, the evolution of organisational theory and design, role of organization theory and design, change management -nature of planned change, designing interventions, recruitment and selection, leading & managing change, evaluating and institutionalizing OD. Change and HR strategies- implementation and impact of change, role of HR strategies in implementing change. Structure and strategic change, HR implications of structural choice and change interpersonal group processes , organization process approaches , restructuring organizations , employee involvement , organization transformation , organizational development in global settings OD in healthcare, schools, and public sector organizational culture.
Richard H. Hall, Organizations-structures, Processes and Outcomes, 8th edition, PHI, 2002
Richard L.Daft, Organization Theory and Design, 7th edition Thomson south western. 2002
Harold Koontz and Heinz Weihrich, Essentials of Management, Tata McGraw Hill, 9th Edition, 2012.
Pradip N. Khandwalla, Corporate Creativity, Tata McGraw Hill.2005

SM812 Industrial Relations (3-0-0) 3
An overview of historical background of industrial relations (IR). Labour movement theories. Legislations related to labour laws, attitudes and approaches. Industrial conflict. Collective bargaining. Workers' participation in management. Governments' labour policy. India and ILO.

Agnihotre V., Industrial Relations in India.
Agarwal R. D., Dynamics of Industrial Relations in India.
Srivastava S.C., Industrial Relations and Labour Law, New Delhi, Vikas 1994

SM813 Compensation Management (3-0-0) 3
Conceptual and theoretical understanding of economic theory related to compensation management (wage concepts and wage theories). Employees satisfaction and motivation issues in compensation design. Establishing internal, external and individual equally. Strategic importance of variable day-determination of inter and intra industry compensation differentials. Individual and group incentives. Dearness allowance concept-emergence & growth in India. Role of fringe benefits in reward systems retirement plans including VRS/golden handshake schemes. Executive compensation. Compensation systems in multinational companies and it companies including ESOP. Collective bargaining strategies-long term settlements- cases of productivity settlements-exercises on drawing up 12 (3) and 18(1) settlements. Emerging trends in IR due to LPG.
Relevant Bare Acts

SM814 Training & Development (3-0-0) 3
Introduction to training design & implementation -needs analysis and needs assessment, performance analysis, job analysis, task analysis, learner analysis, context analysis and skill gap analysis. Training objectives-training deliverables and instructional strategies, training design budgets and schedules, training project management, design blue prints and proto types. Drafting training materials- developing tests/assessments, quality control issues . Train the trainer programmes- classroom delivering of training, non class room delivering techniques. Evaluation- role of evaluation, evaluation techniques- Kirkpatrick model, CIRO model, cost benefit analysis- evaluating reactions and learning, evaluating transfer of training- learning – principles and theories, social learning.
Donald J. Ford ,Bottom-Line Training, PHI, 1999 .
Craig R.L. Training and Development Hand book: A guide to Human Resource Development, New York, NY:McGraw Hill 1996.
McGrath, Training for Life and Leadership in Industry, Prentice Hall of India, New Delhi.
Blanchard, P Nick, and James W. Thacker, Effective Training-Systems, Strategic and Practices,Pearson Education, New Delhi

SM815 Performance Management (3-0-0) 3
Introduction- performance appraisal vs. performance management- PFM theatre- planning for manager's performance and development-monitoring and mentoring- annual stocktaking- appraisal for recognition and reward-organizational effectiveness-high performing teams.
Michael Armstrong & Angela Baron, Performance Management: The New Realities, Jaico Publishing House, New Delhi, 2002.
T.V.Rao, Appraising amd Developing Managerial Performance, TV Rao Learning Systems Pvt Limited, Excel Books, 2003.
David Wade and Ronad Recardo, Corporate Performance Management, Butter Heinemann, New Delhi, 2002.

SM816 Multicultural Workforce Management (3-0-0) 3
Concept of culture, Gert Hoofstede model. comparative human resource (HR) practices: power distance, individualism, masculinity, implications for Indian manager. HR issue for the international manager: international staffing; MNC training; MNC performance appraisal; compensation and benefits; international unions. Cross cultural management approach: organizational structure and intercultural management- conventional organizational structures of global organizations; intercultural communication. . core values as for bonding between employees and corporate across the globe. Global strategy and local adaptation. Conflict resolution strategies to handle: environmental turbulence; different attitudes to corporate culture and ethics. Cultural conflict and management style. Expatriate management.
Nina Jacob., Intercultural Management (MBA Master Class series). Kogan Page, New Delhi 2004 Peter J. Dowling, International Human Resource Management, South Western – Thomas Learning.
Heinz Weihrich, Mark V. Cannice and Harold Koontz ,Management, Tata McGraw Hill, 13th Edition, 2012.
Evans, Pucik, Barsoux, The Global Challenge, Tata McGraw Hill, 2010.

SM819 Marketing Metrics (3-0-0) 3
Introduction to marketing metrics, linking marketing to financial consequences, Share of heart, Share of mind and

Share of market, Role and importance of marketing metrics in strategic marketing decisions. Margins & Profits and Customer Profitability Selling Price, variable cost, average variable cost, market spending, Break even point and Target volume, customer, recency, retention, customer life time value, prospect life time value, acquisition versus retention spending Product and Portfolio Management Trail, repeat, penetration, volume, CAGR, fair share draw, cannibalization rate, brand equity metrics, conjoint utilities: segmentation, customer preference and volume projection. Sales Force and Pricing Sales force coverage, goals, results, compensation, pipeline analysis, facings, shares of shelf, out of stock, inventory turns, markdowns etc., Price premium, reservation, percent good value, price elasticity, optimal, own cross and residual elasticity, Advertising, Promotion and Web Metrics baseline sales, incremental, lifts, redemption, rebates, deal. Pass through, waterfall, Impressions, GRP, OTS, CPM, reach, frequency, share of voice, click through rates, cost per impression, clicks, acquisitions, visitors and abandonment.
Marketing Metrics: 50+ Metrics Every Executive Should Master, Wharton School Publishing, 2006, ISBN 0-13-187370-9
Marketing Metrics: 103 Key Metrics Every Marketer Needs Philip Kotler, Ned Roberto John Wiley & Sons Inc December 2006, ISBN-10: 0470821329.
Managing Customers for Profit: Strategies to Increase Profits and Build Loyalty, l/e, V. Kumar Pearson Education 2008, ISBN No. 9788131719800
Other Reading materials of relevant articles from the international marketing journals.

SM820 Digital Marketing (3-0-0) 3
Digital Marketing, Scope and Challenges, Difference between traditional marketing and digital marketing, Dynamic environment -Integrated approachDigital Estate – Website /Facebook Page/ Twitter handle, Responsive Websites-Information Structuring; Creating a hub and spoke model for digital assets, Connecting to social networks - Social Hub in a page Search Engine Optimization- Content Marketing - Keyword Structuring, On-page & Off-page optimization Techniques, On Page factors and Off Page factors to rank in search engines Online Advertising: Search Engine Marketing- Google AdWords and Keyword research, Bing Ads; Display Advertising; Facebook Advertising; Twitter Advertising; AdSense Social Media: Facebook Marketing- LinkedIn Marketing –Twitter Marketing – video Marketing; Blogging-Online PR, Reputation Management- Email Marketing, Auto responders-, e newsletters-Frequency Conversion Optimization, analytics providers, Landing Pages -Marketing Automation - B2B Lead Generation & Nurturing the leads, Mobile Marketing, Short Code, Mobile Website, Apps and QR Code - Ecommerce - Payment Gateway, Drop Shipping & Fulfillment, Affiliate Marketing- Gamification project execution challenges.
Matt Bailey, Internet Marketing: An Hour a Day, Wiley Publishing
Damian Ryan, Calvin Jones, Understanding Digital Marketing: Marketing Strategies for Engaging the Digital Generation, Kogan Page
WSI, Digital Minds: 12 Things Every Business Needs to Know About Digital Marketing, Friesen Press
Hanlon Annmarie), Akins Joanna, Quickwin Digital Marketing: Answers to Your Top 100 Digital Marketing Questions, PHI
David Meerman Scott, The New Rules of Marketing & PR: How to Use Social Media, Online Video, Mobile Applications, Blogs, News Releases, and Viral Marketing to Reach Buyers Directly, John Wiley & Sons.

SM821 Marketing Communication (3-0-0) 3
Introduction to Integrated Marketing Communications-Evaluating the Economic-Social and Regulatory Aspects of Advertising and Promotion-The Role of Ad Agencies and other Marketing Communication Organizations-Consumer Behavior-The Communication Process- Communications Mix. Creative Strategy- Pre Testing and Post Testing-Media Mix - Media Planning- Challenges in Media Planning. Developing the Media Objectives- The Message. Developing the Media Strategy- Media Scheduling, Calculating the Cost Efficiency. Steps in Campaign Planning-Role of Research in Advertising. Appropriation of Advertisement Budget.
Belch E. George & Belch A. Michael, Advertising and Promotion, Tata McGraw Hill, New Delhi, 2001. Parameswaran, Brand Building Advertising: Concepts and Cases, Tata McGraw Hill, New Delhi, 2002. William F Arens ,Contemporary Advertising, Tata McGraw Hill, NewDelhi, 2008

SM822 Business-To-Business Marketing (3-0-0)3
Fundamental of Business Markets. - Organisational Buying Process. - Org. Buyer Behavior - Differences Between Consumer Marketing and Industrial Marketing - Classification of Industrial Products - Nature of Demand - Industrial Marketing System- Models - Buying Situation -Buying Centre Concept. Demand Estimation -Industrial Marketing Segmentation. Managing Industrial Products -Strategies Involved PLC Concepts and Industrial Products. Pricing

Strategies - Competitive Bidding - Negotiation. Distribution Channels - Influencing Factor. Industrial Marketing Communications - Industrial Marketing Research - Differences between Consumer Marketing Research and Industrial Marketing Research. Marketing Strategy Formation - Key Account Selling.
Michael D. Hutt, Thomas W. Speh, Business Marketing Management, Thomson, 9th Edition, 2007. Hill- M Richard- Alexander S. Ralph- Cross James S, Industrial Marketing, AITBS, New Delhi, 4th Edition, 1991. Dwyer, F. Robert & Tanner, John F. Jr., Business Marketing,McGraw-Hill, 4th Edition, 2009

SM823 Brand Management (3-0-0) 3
Introduction To Brand Management and Crafting of Brand Elements - Consumer Brand Knowledge , Product Management – Role of a Product Manager, Organizing The Brand Management System, Brand Positioning and Values – Customer Based Brand Equity Model, Brand Identity, Brand Image, -Managing Brand Architecture and Brand Portfolios - Corporate Branding and Tools for Building Brand Equity - Measurement of Brand Equity, Brand Marketing Programs –Designing Marketing Programs to Build Brand Equity, Integrating Marketing Communication to Build Brand Equity. Measuring and Interpreting Brand Performance – Capturing Customer Mindset, Capturing Market Performance, Co-Branding
Kevin Lane Keller, Strategic Brand Management- Building, Measuring And Managing Brand Equity, Pearson, 2nd Edition, 2006.
Jean-Noel Kapferer, *Strategic Brand Management, Free Press, 1st Edition, 1994.*
Subrato Sengupta, Brand Positioning, McGraw Hill, 2nd Edition, 2005.

SM824 Consumer Behaviour (3-0-0) 3
Nature of Consumer Behaviour- Model of Consumer Decision Making — Its Implications on Consumer Behaviour- Major Models in Consumer Behavior. Individual Psychological Factors-Perception Attitudes Learning Personality and Motivation - Implications of Not Achieving the Goal. Group Factors in Consumer Behaviour - References Group Concepts - Opinion Leadership Aspects - Usage of these Concepts in Marketing Communications. Decision Process, Diffusion of Innovation in Consumer Behaviour - Its Implication on Consumer Behavior. Concepts of Customer Satisfaction - Concept of Cognitive Dissonance-Cultural Aspects in Consumer Behavior- Consumer Research *Della & Bitta, Consumer Behaviour: Concepts & Applications, Tata McGraw Hill, NewYork, 1993.*
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Roger D Blackwell, Paul W Miniard and James F Engel, Consumer Behavior South-Western College Pub, 10th Edition, 2005.

SM825 Marketing Research (3-0-0) 3
Nature and Scope of Marketing Research- Conceptual Aspects Involved in Marketing Research- Marketing Information System, Marketing Research Process- Basic Research Designs, Applicability of Research Designs, Data Collection Procedures and Methods. Scaling Concepts, Scaling Techniques, Questionnaire Design and Development. Concept of Sampling, Sampling Types, Multivariate Analysis Applications in Cluster Analysis, Conjoint Analysis, Multidimensional Scaling, Factor Analysis, Discriminant Analysis , Exposure to Statistical Packages. Product Research, Advertising Research, Market and Sales Analysis Research.
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Donald R. Lehmann, Sunil Gupta, and Joel H. Steckel, Marketing Research, Addison-Wesley Educational Publishers Inc., 1998.

SM826 Retail Marketing (3-0-0)3
Introduction to Retailing – Retailing in India - Retail Formats and Theories-Understanding the Retail Consumers, Overview of Retailing Environment and Management, Strategic Planning, Structural Change, Market Structure, Retail Planning, Development and Control. Learning, Attitude. Motivation and Perception. Situational Analysis, Retail Institutions By Store- Based Strategy- Mix, Web, Nonstore-Based and other Forms of Non Traditional Retailing. CRM, Promotional Strategies Used in Retailing .Choosing a Store Location- Managing Retail Business- Service Characteristics, Branding, Perceptions of Service Quality, Retail Information Systems, Merchandise Management Retail Pricing, Development and Implementing Plans, Internationalization and Globalization.
Michael Levi M and Barton Weitz ,Retailing Management, Tata McGraw Hill, 5th Edition,2008.

Dunne Patrick M., Lusch Robert F. and Griffith David A – Retailing, Cengage Learning, 4th Edition,2010. Barry Berman, Joel R Evans, Retail Management- A Strategic Approach, Pearson, 10th Edition, 2009. Newman A.J. and Cullen P, Retailing: Environment and Operations, Vikas, 1st Edition

SM827 Rural Marketing (3-0-0) 3

Issues In Rural Marketing And Characteristics Of Rural Markets -Understanding Consumers -Researching Rural Markets - Creating And Delivering Value -Communicating And Positioning In Rural Markets -Communication And Diffusion Process : An Approach To Accelerate Consumer Acceptance -Distribution In Rural Markets -Non Conventional Methods Of Reaching Rural Markets -Developing Marketing Strategy For Rural Markets.

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Sanal Kumar, Rural Marketing, Sage Publications, 2002.

SM828 Sales and Distribution Management (3-0-0) 3

Conceptual Understanding of Sales Management, Importance of Sales Force Management in the Indian Context. Personal Selling Process- Prospecting, Pre Approach, Approach Presentation, Planning Sales Calls, Motivating a Sales Force and Sales Force Compensation, Sales Force Expenses and Transportation, Sales Meeting and Sales Contest, Sales Records and Reporting Systems Forecasting Sales and Developing Sales Budgets, Designing and Organizing Sales Territories. Sales Organisations, Relations with other Departments. Profiling and Recruiting Sales People- Distribution Management- The Vertical and Horizontal Marketing Systems. Wholesaler, Retailing and Retailer Marketing Decisions. Physical Distribution-Logistics & Participants in Physical Distribution Process,

Richard R. Still , Edward W. Cundiff *and* Norman A. P. Govoni,Sales *Management – Decision, Strategies & Cases; PHI./Pearson Education, 1988.*

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Spiro, Stanton, Rich, Management of Sales Force, Tata – McGraw Hill, New Delhi,7th Edition, 2003.

SM829 Services Marketing (3-0-0) 3

Services Marketing – Nature, Need, Classification of Services, Barriers and Issues in Services Marketing in the Indian Context. Gaps Model of Service Quality, Expectations and Perceptions, Measuring Service Quality-SERVQUAL, Building Customer Relationships and Service Recovery. Relationship Marketing, Positioning, Service Development and Designing Services, Service Blue Printing, Quality Function Deployment, Adding Value, Physical Evidence and Services Cape. Pricing Strategies for Services, Creating and Managing Service Delivery, Balancing Demand and Capacity, Waiting Lines and Reservation. Integrated Services Marketing Communication, Services Advertising Strategies, Integrated Model of Services Quality.

Christopher Lovelock, Services Marketing – People, Technology, Strategy, Addison Wesley Longman (Singapore), Pearson Education Asia, 4th Edition, 2001.

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SM830 International Marketing (3-0-0) 3

Introduction to International Marketing – International Marketing Environment—Social and cultural environment – political, legal and regulatory environments-international marketing strategies International Marketing mix-International research and segmentation-developing global products and pricing-international promotion and advertising-International distribution systems Indian Export scenario-The export import scene in India- Export import policy-Export documentation-export procedure-International technology transfer and counter trade.

International Marketing Planning- Managing systems for international marketing-strategic elements of competitive advantage-leading, organizing and controlling the global marketing effort.

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SM831 International Financial Management (3-0-0) 3
Introduction – Introduction to Foreign Exchange Markets – Supply And Demand Conditions and Demand Factors of Currency – Exchange Rate Theories. International Financial Systems: Exchange Systems –IMF And World Bank — Capital Account Convertibility. International Financial Markets – Euro Banking and Euro Currency Market — Term structure in International Capital Markets. - International Financing — Depository Receipts – International Financing Decision - Funding And Risk Management Aspects - International Credit Instruments — International Credit Syndication Mechanism — Risk Factors Of International Financing. International Capital Budgeting– Foreign Direct Investments –Valuation of International Cash Flows – Cash Management – International Portfolio Investing.
Levi Maurice D., International Finance, McGraw Hill (3rd Edition).
Apte P. G., International Financial Management, Tata McGraw Hill.
Shapiro, A., Multinational Financial Management, Wiley India Edition

SM832 Banking, Financial Services and Insurance (3-0-0) 3
Indian Banking System - Banking Structure and Performance Measurement - Financial Statement Analysis and Bank Performance Measurement - Banking Regulations Organisation - Bancassurance and Universal Banking - Financial Innovations - Factoring, Securitisation and Take Out Finance - International Banking Services of Custodians-Central Depository, Systems, Mutual Funds, Commercial Paper, Financial Journalism, Portfolio Management, Investment Management. Nature Of Insurances –Values And Costs Of Insurance – Basis Of Recovery. Property And Liability Loss Exposure – Life, Health And Income Exposures – Types Of Life Insurance – Channels of Distribution
Pond Keith, Lipscombe Geoffrey, The Business of Banking: An Introduction to the Modern Financial Services Industry, Financial World Publishing
Vaughan Emmet J. & Vaughan Therese M., Fundamentals of Risk and Insurance, Wiley Finance, 10th Edition

SM833 Financial Derivatives (3-0-0) 3
Introduction - Forward Contracts, Future Contracts, Options, Swaps And Other Derivatives; Operation Of Margins; Sources Of Financial Risk: Foreign Exchange Risk, – Options Warrants And Convertibles. – Futures - Future Contracts; Future Markets - Clearing House, Margins, Trading, Future Positions And Taxation; Future Prices And Spot Prices; - Currency Derivatives- Interest Rate Derivatives- Term-Structure and Pricing Principles, Trading Strategies. - Managing Market Risk - Hedging Schemes - Portfolio Insurance. - Derivatives Market In India
Chance, Don M: An Introduction to Derivatives, Dryden Press, International Edition.
Chew, Lilian: Managing Derivative Risk, John Wiley, New Jersey.
Hull, J.: Options: Futures and other Derivatives, Prentice Hall, New Delhi.

SM834 Corporate Finance (3-0-0) 3
Introduction to corporate finance: Introduction and objective of corporate finance, understanding financial statements, value, price and basis of risk. Financial Analysis: Fundamental concepts in financial analysis- Financial analysis and forecasting. Investment Analysis: Investment decision rules- the risk of securities and cost of capital- financial securities. Corporate financial policies: Value, capital structure policies, Equity Capital and Dividend. Financial Management: Corporate governance and financial engineering, managing cash flows and financial risk.
Brealey R.A., Myers S.C. Principles of Corporate Finance. McGraw Hill. Ross S., R.Westerfield, J.Jaffe. Corporate Finance. IRWIN-McGraw-Hill. Damodaran A. Applied Corporate Finance. Wiley&Sons. Vernimmen, P. and Quiry, P. Corporate Finance: Theory and Practice. Damodaran A. Corporate Finance Theory and Practice. Wiley & Sons.

SM835 Financial Risk Management (3-0-0) 3
Introduction to risk management-Understanding risk, nature and sources of risk, need for and benefits of risk management, risk policy and risk management approaches. Risk classification and measurement of risk- Credit risk, market risk, interest rate risk and operational risk. Risk management- Managing credit risk, market risk, operational risk and insurance. Tools of risk management- Modeling risk, VaR and stress testing, Volatility modelling. Issues in risk management- Regulatory issues in risk management, Basel committee, legal issues, accounting issues and tax issues.
John Hull, Risk Management and Financial Institutions, 3rd ed., Wiley Finance. Joël Bessis, Risk management in Banking, 3rd ed., Wiley. Peter F. Christoffersen, Elements of Financial Risk Management, Tata McGraw Hill. Philippe Jorion, Financial Risk Manager Handbook, 6 ed., Wiley Finance.

SM836 Security Analysis & Portfolio Management (3-0-0) 3
Investment Environment – Stock Exchanges – Bond Analysis – Derivative Instruments – Technical Structures And Valuation. Theoretical Framework For Investment Decisions –Analysis Of Risk & Return, Asset Pricing Models. Fundamental Analysis –Technical Analysis – Random Walk Hypothesis – Efficient Market Hypothesis. Portfolio Management – Portfolio Theory – Capital Market Theory – Utility Analysis – Portfolio Revision – Performance Analysis Of Managed Portfolios.
Fischer Donald E. & Jordan Ronald J., Security Analysis and Portfolio Management, Prentice Hall of India.
Elton Edwin J. & Gruber Martin J., Modern Portfolio Theory and Investment Analysis, John Wiley & Sons.

SM837 Merger and Acquisitions (3-0-0)3
Mergers, Acquisitions, Amalgamations – Strategic Perspective, SWOT Analysis, BCG Matrix, Porter's Five Forces Model – Corporate Restructuring, Methods – Valuation Approaches, Methods Of Financing Mergers, Accounting For Amalgamation, Methods Of Payment, Share Repurchase And Exchanges – Takeovers, Types, Defenses – Legal And Regulatory Framework, Company's Act, Income Tax Act, SEBI Guidelines, Provisions Of Competition Act – International Mergers And Acquisitions.
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SM841 Service Operations (3-0-0)3
Introduction, the service concept, customer and relationships, customer expectations and satisfactions, managing supply relations, service processes, service people, resource utilization, network technology and information, performance measurement, linking operations decisions to business performance, driving operational improvement, service strategy, service culture, operational complexity
Robert Johnston and graham clark, Service Operations Management,2nd Edition, Pearson.
Bill Hollins & Sadie Shinkings, Managing service operations design and implementation.

SM842 Operations Strategy (3-0-0) 3
Strategic context: strategic management, business environment, strategic design, operations strategy: role of operations management, the concept of an operations strategy, designing an operations strategy, analysis for strategy design, implementing the strategy. Strategic decisions in operation: products and innovation, quality management, process planning and improvement, capacity management, structure of supply chain, movement of materials *Donald Walters, Operations strategy, Thompson Publications.*

SM843 Project Management (3-0-0) 3
Entrepreneurship – generation of project ideas – portfolio models of planning – screening of project ideas. Market opportunity analysis – systematic market appraisal – demand forecasting methods. Technical feasibility – technology development / acquisition – decision on appropriate technology – determination of plant capacity – material inputs and sourcing, structure and civil works. environment appraisal for projects. financial feasibility – estimation of the cost of project – working capital requirement – projected cash flow statement and balance sheet – project appraisal techniques – social cost benefit analysis – Projecting scheduling – tools used in projects scheduling, PERT and CPM, resource allocation in projects – projects control – budgetary control, standard costing and other control measure in project implementation – project abandonment analysis. – organization structure for project implementation – preparation for project reports, methods and techniques – Project financing in India
Chandra Prasanna, Projects: Planning, Analysis, Selection, Implementation and Review, Tata McGraw Hill (4th Edition).

SM844 Six Sigma (3-0-0) 3
History of six sigma , why six sigma , six sigma and applications in different industries and functions roles and infrastructures , the non-delegable , role of executives , lean and six sigma, work out and six sigma , organization culture and six sigma , the customer connection, process improvement – DMAIC , design for six sigma , process management , managing with dashboards, preparing for six sigma , launching six sigma , cross cultural aspects of deploying six sigma, stabilizing , extending and integrating six sigma, measuring the effectiveness of six sigma, deployment , change management , and communication , black belt selection and development, project selection, project review , replicating results and managing knowledge . Measuring and auditing results, developing change leadership capacity

Rath and Strong, Six Sigma A Leadership Handbook, AON Management Consultant

SM845 Materials Management (3-0-0)3

Introduction to materials management-role of materials management in business - purchasing & quality sources of supply. International buying - importance - global sourcing - global trading - green purchasing - supply chain management (SCM) - exim policy - exchange rate management - forward contracts .contracts& pricing practices - negotiation - purchase timing - make or buy - capital equipment purchase - sourcing of projects. Strategic material planning - materials budgeting - inventory management -approach to system design. Stores and transportation. stores management - insurance - sales tax - transportation - marine insurance. Policies - standards and practices - procedures.

Gopalakrishnan P. & Sundaresan M., Materials Management: An Integrated approach, Tata-McGraw Hill, New Delhi,1996.

SM846 Supply Chain Management (3-0-0) 3

Supply chain – objectives – importance – decision phases – process view – competitive and supply chain strategies – achieving strategic fit – supply chain drivers – factors influencing distribution – distribution networks in practice – network design in the supply chain –supplier scoring and assessment– procurement process-sourcing planning and analysis– CRM – internal supply chain management – supplier relationship management – Bullwhip effect – obstacle to coordination – building partnerships and trust – collaborative planning, forecasting and replenishment - logistics interfaces with other areas – approaches to analyzing logistics systems. – channels of distribution, cases in supply chain management.

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Donald J. Bowersox, D J Closs, M B Coluper, Supply Chain Logistics Management, TMH, Second Edition, 2008.
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SM851 Customer Relationship Management (3-0-0) 3

Marketing: Evolution and New Paradigms - CRM – Definition and The Basic Concepts. CRM and Services Marketing - Tools For CRM. Key Account Management - CRM and Knowledge Management – Life Time Value of the Customer. Data Mining and Data Warehousing - Real-World Applications. Strategies for Profitable Dialog with Customers- Sales Force Automation - Marketing Automation- Call Centers- BPO And KPO. CRM Implementation and Effectiveness – Banking- Health Care- Insurance- Travel Industries.

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William G. Zikmund and McLeod, Raymond Jr,Customer Relationship Management, Wiley, 2003.

SM852 System Thinking and Strategic Modeling (3-0-0) 3

Introduction to system thinking-system philosophy- system theory- system methodology, holistic, operational and design thinking – business architecture- system practice, membership, learning and business systems - analytic approach to system thinking- business process- decision system- introduction to strategic modeling and system feedback thinking- modeling dynamic systems- managing business growth- public sector application of strategic modeling- model validity, mental model and learning.

Jamshid Gharajedhagi, System Thinking, Morgan Kaufhann, 2011
John Morecroft, Strategic Modeling and Business Dynamics, John Wiley and Sons, 2007

SM853 Enterprise Resource Planning (3-0-0) 3

Overview of enterprise wide software solution – evolution, concept, difference between ERP and traditional information system, overview of the ERP package – ERP market – players and characteristics. technical architecture of ERP systems – distributed computing – client server systems – concept of business objects – distributed object – computing architecture – support for data mining and warehousing. Functional architecture – salient features functional modules of ERP – marketing, finance, human resources, production and operations – comparisons of ERP packages. Implementing ERP systems – business process re-engineering using ERP- business process modeling – framework for ERP implementation – extending the scope of ERP through supply chain management and CRM.

Garg V K & Venkitaraman N K, Enterprise Resource Planning: Concepts and ERP Practice, Prentice Hall of India, New Delhi, 1998.
Alexis Leon, Enterprise Resource Planning.
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SM854 Product Pricing (3-0-0) 3
Key Principles: Overview of Break Even Analysis- Contribution- Discounting- Price-Contribution- Volume Relationship. Demand and Supply- Elasticity - Perfect and Imperfect Competition - Commoditization. Pricing Points - Odd and Even Endings - Sticker Shock and Other Horrors. Understanding Value: Defining Value- The Value Triad and Value Triangle- Differentiation and Value. Pricing Strategies: Cost Based Pricing- Competition Based Pricing- Market Based Pricing- Overview of Value Based Pricing- Price Building. Assessing Pricing Choices: Impact of Pricing Policy on Business Strategy- Impact of Pricing on Profitability.
Michael V. Marn, Eric V. Roegner *and* Craig C. Zawada*, The Price Advantage, Wiley, 2004. Baker Ronald J., Pricing on Purpose: Creating and Capturing Value, Wiley, 2006.*

SM855 Forecasting Models (3-0-0) 3
Elements/properties of a good forecast; Steps in the forecasting process; Approaches to forecasting - qualitative and quantitative; Judgemental forecasting- Executive opinions, sales force opinions, consumer surveys, Delphi method; Time series forecasting- identifying trends, seasonality and cycles; Moving averages and exponential smoothing; Specific techniques for long trends; Techniques for seasonality- seasonal relatives; Associative forecasting techniques- bivariate and multivariate regression models; Forecast accuracy- MAD, MSE, MAPE.
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Chatfield, C. Time Series Forecasting, CRC, 2000.

SM856 Introduction to Management Science and Big Data (3-0-0) 3
Introduction to management science; types of data; steps in data science process; linear programming; What-if analysis for linear programming; Integer programming; Non- linear programming; the evolution of Big Data; characteristics of Big Data; Big Data trends; Big Data in various industries; Big Data Analytics; Introduction to Big Data technologies like Hadoop; security and privacy issues in Big Data.
Hillier, Frederick S. and Mark S. Hillier, Introduction to Management Science, Third Edition, Tata McGraw-Hill Edition, Special Indian Edition, New Delhi, 2009.
Van Rijmenam, Mark, Think Bigger: Developing a Successful Big Data Strategy for your business, American Management Association, 2014.
Acharya S. and Chellappan, S., Big Data and Analytics, Wiley, New Delhi, 2015.
Garcia Marquez, F. P. and Lev, B. (Eds.), Big Data Management, Springer, 2017.

SM857 HR Analytics (3-0-0) 3
Why Workforce Analytics, Establishing Analytics Culture, Analytical Foundations of HR Measurement, The Hidden Cost of Absenteeism, Employee Attitudes and Engagement, Financial Effects of Work-Life Programs, The Economic Value of Job Performance, The Payoff from Enhanced Selection, and Cost and Benefits of HR Development Programs.
Investing in People: Financial Impact of Human Resource Initiatives (2nd Edition) by Wayne Cascio (Author), John Boudreau (Author) ISBN-13: 978-0137070923 ISBN-10: 0137070926, Pearson Education Inc.,
The Power of People: Learn how Successful Organizations use Workforce Anaytics to Improve Business Performance by Nigel Guenole, Jonathan Ferrar and Sheri Feinzing, Pearson Publication.

SM858 Marketing Analytics (3-0-0) 3
Introduction to marketing analytics, data collection, market research and analysis; Marketing Metrics; Customer Understanding through Analytics, market segmentation; Traditional media analytics; Classical Econometrics; Discrete Choice Modeling; Introduction to digital analytics for marketing- web, social media and mobile analytics; Case studies and Applications.

Jeffery, M., Data-Driven Marketing: The 15 Metrics Everyone in Marketing Should Know, John Wiley & Sons, 2010.
Grigsby, M., Marketing Analytics: A Practical Guide to Real Marketing Science, Kogan Page Publishers, 2015.
Sponder, M. and Khan, G. F., Digital Analytics for Marketing, Routledge, 2018
Mizik, N. and Hanssens, D.M. (Eds.), Handbook of Marketing Analytics: Methods and Applications in Marketing, Edward Elgar Publishing, 2018.

SM859 Machine Learning for Business Management (3-0-0) 3
Scope & Objectives Data mining process – Data mining functionalities – Data preprocessing, Supervised Learning: Introduction, Decision Tree Induction, Bayesian Classification: Naïve Bayes. Rule Based Classification, Artificial Neural Network: Classification by Back propagation. Support Vector Machines, Associative Classification, K-NN classifier, Case-Based Learning, Rough set, Fuzzy set approaches, Hidden Markov models. Ensemble model: Bagging, Boosting. Accuracy and Error Measures, Evaluating the Accuracy of a Classifier, Model Selection, Feature selection. Unsupervised Learning-I: Types of Data in Cluster Analysis, Clustering Methods- Partitioning Methods: K-Means, Fuzzy Clustering Methods: FCM, PCM, FPCM, PFCM. Hierarchical Methods: Agglomerative and Divisive, Balanced Iterative Reducing Clustering using Hierarchies, Unsupervised Learning-II: Grid-Based Methods: Statistical Information Grid, Model-Based Clustering Methods: EM algorithm, Self Organizing Map. Clustering High-Dimensional Data: Clustering In Quest, Projective clustering, Outlier Analysis. Soft Computing Components: Neighborhood based algorithms-Simulated annealing, Tabu search. Population based algorithms Evolutionary computation: Evolutionary programming and strategies, Genetic algorithms, Differential evolution. Swarm Intelligence: Ant colony optimization, Particle swarm optimization.
Jiawei Han and Micheline Kamber. Data Mining Concepts and Techniques. Morgan Kaufmann publication, 2006.
Xin-she Yang. Nature-Inspired Metaheuristic Algorithms. Luniver press, 2010.

SM860 Data Analytics: Business Decision Making (3-0-0) 3
Econometrics as a tool for Economic and Managerial Analysis – Modeling, Data and Methodology
The Classical Multiple Linear Regression Model –Least Squares Regression, Goodness of Fit and Analysis of Variance, Hypothesis Testing, Multicollinearity, Heteroscadasticity and Autocorrelation
Qualitative Response Regression Models – Logit, Probit and Tobit Models Panel Data Regression Models – Estimation of Fixed and Random Effects Models Endogeneity and Instrumental Variable (IV) Model
Gujarati, Damodar N. (2003). Basic Econometrics. Fourth Edition, McGraw – Hill Higher Education Wooldridge, J. (2002). Econometric Analysis of Cross section and Panel data, MIT Press
Wooldridge, J. (2013). Introductory Econometrics: A Modern Approach. 5th Edition. South-Western Cengage Learning.

SM861 Business Process Design and Reengineering (3-0-0)3
Introduction to BPR - re-engineering and its relationship with functional areas of business, history of re-engineering, deterministic machines, complex dynamic system, interacting feedback loops and social constructs perspectives of BPR. - managing process flows business process and flows – through put rate, work-in-process, cycle time, little's law - cycle time and capacity analysis – cycle time reduction, theory of constraints. - implementation process - redesign of business processes – systematic or clean sheet, main and supporting processes, key enablers of BPR, technology for BPR, critical success factors, cross functional teams, tools and techniques of BPR, virtual ingredient – 'black hole', using process simulation to minimize the risk – business process map and simulation model, parameter analysis, simulation and key performance indicators. - ERP and BPR, ERP in modeling business processes, workflow management systems in BPR, steps of BPR, five- stage model of as-is/to-be analysis, process centric organizations, business process maturity model, business process performance measurement.
Laguna, Business Process Modeling, Simulation and Design, 2005, Pearson.
Chan Meng Khoong, Re-engineering in action, 1st Edition, 2009, Cambridge.
Charles Poirier, Business Process Management Applied, 2005, Cengage.
Varun Grover, M. Lynne Markus, Business Process Transformation, 2010, PHI.
Daniel Minoli, Business Process Re-engineering, 2010, Routledge

SM862 Contemporary Issues in Management (3-0-0) 3
Understanding emerging environment - emergence of vertical environment, understanding hyper-turbulence, networks and business eco- systems, role of information technology , understanding networked, knowledge-based economy - organisations as networks, self-organizing systems, organisational designs for change and innovation –

team working, high performance work systems, managing empowerment and accountability, roles and systems in flat, networked organisations, developing competencies for new organizational forms - changing models of people technology and ethical behavior, business success through social responsibilities, cost effective business models – changing business cycles – emerging trends - triple bottom-line concept, ethical leadership , empowerment, teamwork & communication, lean business, customer driven marketing, sustainable competitive advantages , balanced scorecards .

Claude George Jr, The History of Management Thought, Prentice Hall.
Subhash Sharma, Management in New Age: Western Windows Eastern Doors, New Age International Publishers, New Delhi.
Siddharth Shastri (ed.), Indian Management for Nation Building, WISDOM, Banasthali Vidyapith, Banasthali.

SM863 Economic Environment & Policy (3-0-0) 3

Economic and non-economic environment. Interaction between economic and non-economic environment. Analysis of contemporary macro-economic and micro-economic problems and issues, related governmental policies and their impact on the business firm including unemployment, inflation, fiscal and monetary policy. Government regulation of business. Business concentration and anti-trust policy; income distribution and international economic relations.

Welch, Patrick J. and Welch, Gerry F., Economics: Theory and Practice, John Wiley & Sons, 2000.
Mankiw N. Gregory, Macroeconomics, Worth Publishers, 2008.
Bimal Jalan, India's Economic Policy, Viking, 1996.

SM864 International Business Management (3-0-0) 3

Introduction. Globalization of world economy, world trade & foreign investment trends. Technological changes. Types of international business. The cultural dimensions of international business. The global trade and investment environment. Trading practices. World financial environment. Tariff and non-tariff barriers. WTO and regional blocks. Global financial environment. Determinants of exchange rates. International banks. Non-banking financial institutions. Global competitiveness: export and import financing. Licensing and joint ventures. Research and development in global market. Globalization with social responsibility. World economic growth and environment. Negotiations in international business and multilateral settlements.

Hill Charles W. L., International Business: Competing in the Global Marketplace, 5/E, McGraw Hill/Irwin, 2005.
Hill Charles W. L., Global Business Today,4/E, McGraw Hill/Irwin, 2006.
Bhalla V. K. and Shivaramu S., International Business: Environment and Management, Anmol, 2003.

SM865 Enterprise Risk Management (ERM) (3-0-0) 3

Introduction – benefits of risk management , environment of business, know business, establishment checks and balances, set limits and boundaries ,concepts : risk concepts, risk process, risk awareness, risk measurement, risk control, enterprise risk management frame work, enterprise risk management : benefits of enterprise risk management, chief risk officer, components of ERM. Corporate governance, line management, portfolio management, risk transfer, risk analysis, data and technology, stake holder management , risk management application : credit risk management , market risk management , operations risk management ,business applications , financial institutions , energy firms, non financial corporation's look up to future : predictions

James Lam, Enterprise risk management (ERM): from incentives to control, Publisher : Wiley finance

SM867 Sustainable Management of Environmental Resources (3-0-0) 3

Overview of Environmental Issues, Environmental and Resource Economics, Economic Perspectives on the Environment, Environmental issues, Measurement and Intervention for Sustainability, Environmental Regulation, Environment and Development, Environment and Development: Sustainability, Technology and Business

Chris Barrow. Environmental Management and Development, 2d edition (2006) Jennifer A. Elliott. An Introduction to Sustainable Development, 3rd edition (2006) Karl-Göran Mäler, Jeffrey R. Vincent. Handbook of Environmental Economics, Volume1-3 Sankar, U. Environmental economics. Oxford University Press, first edition, (2001)

SM868 Management Control System (3-0-0) 3

Introduction to MCS - purpose- types- approaches to MCS- cybernetic and contingency approach- business strategy and management control system- hierarchy of control process- industrial dynamics and management control - design of MCS- steps- factors influencing design of MCS- it and design of MCS- key success variables as control indicators- environment and MCS- goals strategy and organization for adaptive control- divisional autonomy and responsibilities- management control tools and - processes – strategic planning and programming process- budgeting and budgetary control- standard costing system and variance analysis for control- transfer pricing- reward system- management control of operations- strategic cost management- auditing as a tool- MCS in organizations-MCS in non-profit organizations- current issues in MCS- corporate governance and management control.

Subhash Chandra Das- Management Control System- Prentice-Hall India- 2011 Kenneth Merchant and Wim Van Der Stede - Pearson Publication- 2011

SM869 Merger and Acquisitions (3-0-0)3

Mergers, Acquisitions, Amalgamations – Strategic Perspective, SWOT Analysis, BCG Matrix, Porter's Five Forces Model – Corporate Restructuring, Methods – Valuation Approaches, Methods Of Financing Mergers, Accounting For Amalgamation, Methods Of Payment, Share Repurchase And Exchanges – Takeovers, Types, Defenses – Legal And Regulatory Framework, Company's Act, Income Tax Act, SEBI Guidelines, Provisions Of Competition Act – International Mergers And Acquisitions.

Weston, F., Chung, K.S., Hoag, S.E. Mergers, Restructuring and Corporate Control, Pearson Education. Vadapalli., R.,Mergers acquisitions and Business valuation, Excel books, 1/e 2007 Damodaran,A., Corporate Finance-Theory And Practice, John Wiley & Sons

SM870 Services Management (3-0-0) 3

Introduction to service operations - nature of services, strategy and positioning - designing service operations - technology and its impact on services - design and development of services and service delivery systems - work measurement, locating facilities, designing their layout - managing service operations - capacity planning and waiting line management (queuing) - managing capacity and demand - improving service processes – use of tools for process improvement - project presentations

James A. Fitzsimmons, Mona J.Fitzsimmon ,Service Management , Tata McGraw Hill

COURSE CONTENTS - 900 Level Courses

DEPARTMENT OF WATER RESOURCES & OCEAN ENGINEERING

WO901 Fuzzy Logic, ANN & GA **3**

Fuzzy logic - Classical sets and fuzzy sets. Fuzzy set operations. Fuzzy relations. Extension principle. Membership functions. Lambda-cuts for fuzzy sets and relations. De-fuzzification methods. Fuzzy rule-based systems. Fuzzy nonlinear simulation. Fuzzy regression. Artificial Neural Networks (ANN) - McCulloch-Pitts model of a neuron. Learning rules. Activation functions. Single layer perceptron networks. Multilayer feedforward networks. Back propagation algorithm. Hopfield networks. Genetic Algorithms (GA), fitness function. Genetic Algorithm operators - reproduction, crossover, mutation. Schemata and schema theorem. Application of GA to optimization problems.

Ross T.J., Fuzzy logic with Engineering Applications, McGraw Hill.
Haykin S., Neural Networks - A comprehensive foundation, Prentice Hall.
Goldberg D., Genetic Algorithms, Addison-Wesley.

WO902 Wetland & Management **3**

Introduction, Scope, Importance, Wetland Classification system, Wetland Indicators for Identification and Delineation, Wetlands Processes (Functions) and Values, Types of wetlands and their roles in the watershed. Human Impacts: wetland loss and Degradation, Major Causes, The Main Activities that cause wetland impairment, Wetland Protection and Successful Mitigation - Issues, Measures of Success, Common Mitigation-pitfalls, Wetland Management- Natural wetland protection, The Challenge of Protection, Management Issues Buffers and Other Protective Measures for Wetlands Natural wetlands and Riparian areas as Buffers, Wetland restoration and creation, Constructed wetlands, Comparison of created and natural wetlands.

Environmental Laboratory. Crops of Engineers Wetlands Delineation Manual, U.S. Army Engr. Waterways Expt Station, Vicksburg, MS,.1987, (Rev. Version 1997)
Lawrence R. Liebesman, The Water Supplier's Guide to Wetlands Regulation and Management, American Water Works Association, Denver CO 80235, USA, 1995

WO903 Groundwater Systems Analysis **3**

Digital simulation models for groundwater development, application of finite difference and finite element methods for solving problems in groundwater development and management; Analog methods: direct electric analog, viscous flow analog and other analogs; Optimization methods, models for conjunctive development of surface and groundwater; Special problems in ground-water development and management; Artificial recharge, ground subsidence, salt water intrusion and others.

Rushton, K.R. Groundwater hydrology: Conceptual and computational models. Wiley,2003.
Anderson, M.P. and W.W. Woessner, Applied groundwater modeling, Academic Press, 2002.

WO904 Finite Element Application to Flow Problems **3**

Introduction to partial differential equations, numerical methods, initial and boundary value problems, weighted residual techniques. Galerkin finite element method, element families, formulation of element equations, global matrix, higher order elements, solution techniques application of Galerkin. FEM to various surface and subsurface flow problems.

Huyakern P.S. and Pinder G. F, Computational Methods in sub-surface flow, Academic Press, 1983
J.Donea, Finite Element methods for flow problems, Applied Publishers, 2003

WO905 Computational Methods in Subsurface Flow **3**

Partial differential equations in subsurface flow, initial and boundary value problems, solution methodology. Finite difference method -various schemes and their solution, simulation of single phase subsurface fluid flow. Finite element method - Galerkin method, element families, solution of steady and transient groundwater flow problems. Boundary element method - Basic concepts, application to one and two dimensional sub-surface flow problems. Method of characteristics and its applications, Analytical elements, infinite elements and applications.

Huyakern P.S. and Pinder G. F, Computational methods in sub-surface flow, Academic Press, 1983 Bear J. and Verruijit A., Modelling groundwater flow and pollution, 1988

WO906 Innovative Type Breakwaters **3**

Different types of breakwaters, function, location, design wave, advantage and disadvantage, rubble mound breakwaters: design factors, hydraulics of cover layer, stability of breakwaters and factors effecting them, artificial armor

units, construction method. Berm breakwaters: stability and reshaping of berm breakwaters, factors influencing them, material specification, construction method, Tandem breakwaters: design factors, stability coefficient and factors effecting them, performance of other type of breakwaters: reef breakwaters submerged breakwaters, pile breakwaters, floating breakwaters, design factors, modelling technique: rubble mound and other types of breakwaters.

US Army Corps of Engineers - Shore Protection Manual Per Brunn - Port Engineering Vol. 1.
Herbich J.B. - Hand Book of Coastal and Ocean Engineering Vol. 1

WO907 RS & GIS Applications in Coastal Engineering **3**

Fundamentals of RS & GIS, Data products and data formats, fundamentals of visual and digital image processing, ground truth and accuracy estimation, Overview of instruments image processing and GIS software. Case Studies: Shoreline change detection, Coastal land use / land cover, suspended sediment concentration, marine ecology, coastal cadastral mapping, Bathymetry, marine resources monitoring and management, ICZMP, Harbour area information system (HIS), CZIS, Coastal wetland monitoring and management, Disaster warning system, Coastal vulnerability analysis, Ocean parameter estimation wing, Satellite data.

Thomas N Lillesand and R W Kiefer - Remote Sensing and Image interpretation.
Cracknen A.P. - Remote Sensing in Meteorology, Oceanography and Hydrology.
Sabins F.L. - Remote Sensing Principles and Interpretation. Jenson – Digital Image Processing.

WO908 Watershed Management **3**

Principles of watershed management: Basic concepts, surface water, groundwater, water availability, conjunctive use, Watershed management in arid, semi-arid and per-humid regions. Watershed management through wells, water supply, case studies. Long term and short strategic planning for conservation of water, recycle and reuse. Watershed management community participation, private sector participation. Sustainable watershed management, water harvesting. Application of GIS and remote sensing in watershed management.

Murthy, J.V.S., Watershed management, New Age International, New Delhi, 2 edition,1998. Singh,
V.R., Watershed planning and management, Yash Publishing House,
Bikaner,1996. Murthy, J.V.S., Watershed management in India. Wiley Eastern, New
Delhi,1994. ASCE, Watershed management. ASCE, New York.
Allam, G.I.Y., Decision support system for integrated watershed management. Colorado State Univ.,
USA, 2003.

DEPARTMENT OF CIVIL ENGINEERING

CV900 Soil Chemistry **4**
Introduction, Soil formation, Soil structure, Clay mineralogy, Chemical composition of soils, Soil-lime reactions, Flyash reactions, Soil-cement reactions, Reactions of various other chemicals with soil, Soil grouting, Colloid chemistry, Change in soil properties due to chemical reactions, Impact of environment on soil properties.
Engineering Principles of Ground Modifications, McGraw-Hill.
Renben H. Carol, Chemical Grouting and Soil Stabilization, M. Drekker Publishers, NY.

CV901 Advanced Soil Reinforcing Techniques **4**
Historical background, Reinforced soil structures and RCC, Vidalean concept of reinforced earth, Triaxial studies on reinforced soil, Enhanced confining pressure concept and apparent anisotropic cohesion concept, Reinforcing man made slopes, and natural slopes, Reinforcement in body embankment stability of reinforced steep soil slopes, reinforced walls, type of reinforcements, properties of backfill soils, Soil-reinforcement interaction studies, pullout tests and direct shear tests, Reinforcement beneath foundations and embankments, Geosynthetics properties, tests and applications in civil engineering. Recent advances in Soil Reinforcing Techniques.
CJFP Jones, Earth Reinforcement and Soil Structures, Butterworths, London.
R. M. Koerner, Designing with Geosynthetics, Prentice-Hall.

CV902 Vibration of Plates **4**
Strain energy of vibrating systems, free and forced vibration, continuum and discrete systems, differential equations of lateral motions, flexural vibration of plates, Hamilton's principle, Energy methods for determining natural frequencies, eigenvalue and eigenvector, solution methods.
AW Leissa, Vibration of Plates, NASA SP-160.

CV903 Hydrogeology **4**
Hydrologicalcycle, Aquifers, classification and characteristics, Groundwater distribution, occurence, movements, Groundwater exploration, Geological, hydrological, geophysical and remote sensing methods, Groundwater budgeting, Groundwater recharge, Rainwater harvesting, Quality of groundwater, Groundwater management, Case histories of typical groundwater studies.
David Keith Todd, Ground Water Hydrology, John Wiley and Sons.
Karanth K. R., Groundwater assessment, development, management, Tata McGraw-Hill.

CV904 Advanced Environmental Geotechnology **4**
Perspective of environmental geotechnology, Soil, environment, water interaction, mass transport, Energy gradient and conductivity, Sources of water contamination, Under ground, groundwater flow conditions, Contaminate migration, Disposal and containment of solid, water remediation. Recent advances in Environmental Geotechnology. *Donald P. Coduto, Geotechnical Engineering, Principles and Practices, Prentice-Hall.*
Daniel, D. E. Geotechnical Practice for Waste Disposal, Chapman and Hall, London.
Reddi L. N., and Inyang. H. F. Geoenvironmental Engineering- Principles and Applications, Marcel Dekker, Inc.

CV905 Special Concretes **4**
High performance concrete, definition, materials used, mix design methods, properties of fresh and hardened states, Recent advances in mix design procedure, Lightweight aggregate concrete, definition materials used, mix proportioning and properties, Self compacting concrete, definition, mix proportioning, testing at fresh state, No fines concrete, definition, mix design and properties.
PC Aitcin, High Performance Concrete, E&FN SPON, London.
AM Neville, Properties of Concrete, Longman Scientific and Technical Publishers.

DEPARTMENT OF MINING ENGINEERING

MI901 Applied Rock Mechanics **4**

Rock mechanics applications in mining and civil constructions, Design and stability analysis of underground openings. Caverns for underground storage, Rock mechanics for improved mining methods in coal and non-coal mines. Design of pillars, Rock support and reinforcement -rock support interaction analysis. Evaluation and testing of rock support systems. Selection of supports and roof capability.

Obert, L and Duvall, W.I. "Rock mechanics and the design of structures in rock". New York, Wiley, 1967.
John Conrad Jaeger, Neville G. W. Cook and Robert Zimmerman. "Fundamentals of rock mechanics". Wiley-Blackwell; 2007.
Brady, B.H.G and Brown, E.T. "Rock Mechanics for underground mining". Kluwer Academic Publishers, New York, Boston, Dordrecht, London, Moscow, 1993.
Peng.S.S. "Coal mine ground control"". Woodhead Publishing, 2007.

MI902 Rock Mechanics & Ground Control **4**

Introduction to Rock Mechanics. Analysis of stresses and strains. Representation of stress- strain, Determination of various rock indices, Determination of physical and mechanical properties of Rocks. Elastic Constants, Engineering classification of rock mass. Instrumentation used for determination of in-situ stresses and laboratory investigations, Design of underground openings. Design of pillars in underground coal mines, Rock reinforcement / Ground improvement techniques in rock masses, Subsidence: Prediction and measurement of subsidence. Subsidence damage and control.

Obert, L and Duvall. W.I."Rock mechanics and the design of structures in rock". New York, Wiley, 1967.
John Conrad Jaeger, Neville G. W. and Robert Zimmerman. "Fundamentals of rock mechanics". Wiley-Blackwell; 2007.
Brady, B.H.G and Brown, E.T. "Rock mechanics for underground mining". Kluwer Academic Publishers, New York, Boston, Dordrecht, London, Moscow, 1993.

MI903 Geomechanics **4**

Geological structures in rockmass, Objective and methods of rockmass characterisation. Methods of determination of strength and deformability of rock and rockmass, Failure criteria for rock and rockmass, Influence of anisotropy and discontinuity on rock behaviour, Pre-mining state of stress: sources, methods of determination and presentation, Propagation of elastic waves in rock medium and dynamic behaviour of rocks, Stress distributions around single and multiple openings in rocks: methods of estimation; factors influencing stress concentration; zone of influence of an excavation; effect of planes of weaknesses and shape of excavation; delineation of zone of failure. Introduction of mechanics of rock cutting, drilling and blasting.

Obert, L and Duvall. W.I. "Rock mechanics and the design of structures in rock". New York, Wiley,1967.
John Conrad Jaeger, Neville G. W. and Robert Zimmerman. "Fundamentals of rock mechanics". Wiley-Blackwell; 2007.

MI904 Drilling Engineering **4**

Classification of rock drilling. Applicability and limitations, Factors influencing drilling. Drillability of rocks, Construction, operation and limitations of various drills, Drill bits. Coring and core barrels. Alignment and deviation in drilling. Fishing tools. Directional drilling, Surveying and logging of drill holes, Drilling practices. Drilling patterns for drivages.

Chugh.C.P. "Diamond Drilling". Oxford and IBH Publications CO.,, New Delhi ,1979.
Eugene P. Pfleider. "Surface mining". AIMMPE; 1968.
Rabia, H. "Oilwell Drilling Engineering: Principles and Practice". Graham & Trotman; 1985.

MI905 Rock Fragmentation Engineering **4**

Developments in explosives and accessories. Substitutes for explosives, Mechanisms of rock fragmentation due to blasting. Factors controlling fragmentation. Fragmentation prediction models. Fragmentation Assessment methods, Blast design. Choice of explosives, Theory of shaped charges. Recent advances in blasting techniques, Special techniques of blasting. Environmental effects and their control. Economic evaluation of blasting operations.

Mishra G.B. , Surface mining, Lobely prakshan pupb, 1988.
Misra G.B. "Mine environment and ventilation". Oxford University Press 1998.

Gregor.C.E "Explosives for north american engineers". Trans Tech Pubn; 1979.
Sastry V.R., Advances in drilling and blasting, Oxford&IBH, 1993.
Lopez Jimeno, C., Lopez Jimeno, E., and Francisco Javier Ayala Carcedo. "Drilling and blasting of rocks". CRC Press, Tylor and Francis, 1995.

MI906 Rock Slope Engineering **4**

Role of slope stability in economics, design and operation of surface mines, waste dumps and embankments, Factors affecting slope stability, Geological data collection and graphical presentation, Mechanics of slope failure, Factor of safety of slopes, Slope stability analysis-techniques, Monitoring of slope deformations, field instrumentation, stabilistaion of slopes.
Hoek, E and Bray, J.D. "Rock slope engineering". CRC Press, Tylor and Francis, 1981. Brawner. C,O. "Stability in surface mining". Society for Mining Metallurgy & Exploration.1984 Gian Paolo Giani. "Rock slope stability analysis". CRC Press, Tylor and Francis, 1992.

MI907 Physical & Numerical Modelling **4**

Concept, methodology and principles of physical modeling. Dimensional analysis. Different materials used for physical modeling. Modeling as a technique for rock load determination and analysis. Physical modeling of rock mass. Elastic linear, elasto-plastic and time dependent rheological models, Various numerical techniques of mine simulation, FEM, FDM and BEM, Application in strata mechanics.
Bieniawski.Z.T "Strata control in mines". A.A.Balkema / Rotterdam,1987.
Jeremic, M.L "Strata mechanics in coal mining". Rotterdam, Netherlands, Boston : A.A. Balkema, 1985.

MI908 Tunneling Technology **4**

Design principles of underground openings, Rock conditions and initial state of stresses. Computer aided tunnel design, Tunnel driving techniques for hard and soft rocks. Blasting in tunnels, Tunnel supports, Remote control and automation of supports, Shield tunneling system with road headers, Support assessment, Tunneling in soft strata. Tunnel lining, Tunnel stability analysis, Monitoring. Back analysis, Case histories.
Duvall, W.A., Obert.L "Rock mechanics and the design of structures in rock". John Wiley & Sons Inc, 1967.
Lama, R.D. and Vutukuri, V.S. Handbook on mechanical properties of rocks, Trans Tech Publications, Switzerland, 1978.
Colin A. Lawrence, Anthony Del Vescovo. "Rapid excavation and tunneling conference 2017 proceedings". Society for Mining, Metallurgy, and Exploration,, 2017.

MI909 Design of Mine Supports **4**

Insitu and induced stresses: Methods for determination insitu stresses and instrumentation:. Analysis of induced stresses, Rockmass classification systems, Design of support systems for bord and pillar method and longwall method of working, Rock reinforcement.
Cemal Biron, Ergin Arioglu, J. Richard Lucas. "Design of supports in mines". Wiley; 1983.
Kaiser, P.K., McCreath, D "Rock support in mining and underground construction". CRC Press, Tylor and Francis, 199).
Chugh. C.P. "Ground control in room & pillar mining". Random House Trade,1983.

MI910 Planning of Underground Coal Mines **4**

Status of Underground Coal Mining in India, Stages of planning of underground coal mines: Feasibility and Detail Project Report, Bord and pillar mining systems. Design of Blasting gallary layout method, Design of Longwall Mining. Design considerations for exploitation of thick seams, Exploitation of contiguous seams and seams liable to bumps;hydraulic mining and underground gasification of coal.
Singh R.D., Principles and practices of modern coal mining, New Age Int.(P) Ltd Publishers, 1997.
Singh T.N. "Underground mining of coal" .Oxford and PBA Publishing Co. Pvt. Ltd. 1984
Peng.*S.S "Longwall mining". Wiley-Blackwell, 1984.*

MI911 Planning of Underground Metal Mines **4**

General engineering design; design methods in mining, Classification of exploitation methods; choice of mining systems, Design of stoping layouts, Mining in rockburst prone areas, Novel and innovative mining methods, Mine closure, sealing and abandonment.

Hartman H.L., Introductory mining engineering, John Wiley and Sons, Toronto, 1987.
Hustrulid W.A.. SME handbook on metalliferous mining, USA, 1984.
Agoshkov M. Mining of ores and non-metallic minerals, Mir Publishers, Moscow, 1983.

MI912 Planning of Surface Mines **4**

Mine planning & its components; planning phases & planning costs; economic concepts, Steps in mine planning; reserve estimation; determination of mine size, Geometrical considerations; mine layouts; pit slope geometry; stripping ratios, Choice of mining system; determination of ultimate pit, Production planning & calendar plans for mining programme, Selection of equipment system, Design of high wall slopes and waste dumps, Design of haul roads.
Hartman H.L., Introductory mining engineering, John Wiley and Sons, Toronto, 1987.
William Hustrulid, Mark Kuchta. *"Openpit planning and design". Balkema, 1995.*
Misra G.B. "Surface mining" Lovely Prakashan Pubn, 1989.

MI913 Excavation Technology & Materials Handling **4**

Classification of surface excavating equipment systems vis-à-vis unit operations. Equipment selection criteria. Continuous and conventional systems. Shaft boring machines. Tunnel boring machines. Loading and transportation equipment. Maintenance of excavation equipment. Automation in excavation projects.
Ira Cyril Frank Statham. *"Coal mining practice". London, 1958.*
Stack. *B. "Handbook of Mining and Tunnelling Machinery". John Wiley & Sons Ltd 1982.*
Mishra G.B. , "Surface mining mining", lobely prakshan pupb, 1988.
Eugene P. Pfleider. *"Surface mining". AIMMPE; 1968.*
Das S.K, "Surface mining technology", Central Techno Publishers, Dhanbad, 1988.

MI914 Environmental Impact Assessment & Management in Mines **4**

Nature and Causes of environmental problems due to mining. Monitoring and control. Acid mine drainage and its control, Pollution due to noise and vibrations: Causes, monitoring and control techniques, Environmental Impact Assessment. Impact Assessment methods and preparation of EMP for mineral industries. Ranking of Impacts, Environmental Management plan. Environmental audits. Changes of Social Environment due to mining, Socio-economic factors. Legislation and Pollution Control Acts.
Dhar, B.B. "Environmental management of mining operations". Ashish Publishing House, 1990.
Chad-Wicketal. "Environmental impacts of coal mining and utilization". Pergamon Press, 1987.

MI915 Planning of Underground Ventilation Systems **4**

Introduction to fluid mechanics: Fluid pressure, fluid in motion, Fundamentals of steady flow thermodynamics: Thermodynamic diagrams, Subsurface ventilation engineering, Incompressible flow relationships, Ventilation surveys, Ventilation network analysis, Simulation studies for heat flow in underground mines.
Vutukuri V.S. and Lama, R.D. "Environmental engineering in mines". Cambridge University Press;, 2010.
McPherson, M.J. "Subsurface ventilation and environmental engineering". Chapman & Hall, 2009

MI916 Risk & Safety Management in Mines **4**

Accidents at work, accident prevention. Safety concepts management and direction of safety. Statutory provisions for safety in mining operations, Conceptional health problems in rock excavation; prevention and suppression of dust, Risk analysis, safety management, Hazard identification methodologies, risk assessment methods, Mine Safety, Safety audits and control, Accident investigation; reporting, analysis.
Singh, C.P. "Occupational safety and health in industries and mines". International Labour Organization, 2014.
Rakesh & Prasad."Legislation in Indian mines a critical appraisal". Tara Book Agency, 1999.
Singh, V.N. "Industrial and mine management". John Wiley and Sons, Toronto, 1981.

MI917 Optimization of Mining Operations **4**

Mathematical programming problem. Mathematical Models, Methods for special linear programs, Lagrange's method; sensitivity analysis, Non-Linear programming methods, Geometric programming; Goal Programming; stochastic linear programming, Dynamic programming; Game Theory.
Kalyanmoy Deb, "Optimization for engineering design: Algorithons and Examples", Prentice Hall of India, 2000.
Kambo N.S. "Mathematical programming techniques", East-West Press 1991.
Mital K.V. and Mohan C., "Optimization methods in operations research and systems analysis", New Age Intl. Publi. 1996

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

CS901 WIRELESS NETWORKS & SYSTEMS **4**

Introduction to network resilience problems & solutions, Wireless beyond 3G, Performance modeling of(Wireless)networks & Formal Methods, Network design algorithms and Network design using Network Processors, Wireless Ad-hoc Networks, Security Issues in control, Management, routing and other areas of networks, Distributed control in(Wireless) network and Middleware, Distributed Mobile Computing, Embedded Systems in Mobile/ Wireless/Network Systems – Hardware & Software Design/ Development issues, Standardization in Wireless / Mobile Network Systems.

Theodore. S Rappaport, Wireless Communications – Principles & Practices, Pearson Education, 2nd Edition, 2002.
Boucher. N, Cellular Radio Handbook, Quantum Publishing, 1991.
Feng & Leonidas, Wireless Sensor Networks, Elsevier India, 2005.

CS902 NETWORK MANAGEMENT **4**

Network management Overview, Network Management, SNMP and Network Management, TMN, Network Management Applications, Management of Heterogeneous Network with Intelligent Agents, Network Security Management, Internet Management(IEEE Communication May, Oct /03), QoS in IP Network, Basic Methods & Theory for Survivable Network Design & Operation, Network Planning, Network Management Standards.

Subramanian M., Network Management: Principles and Practice, Addson – Wesly, 2000
James F. Kurose and Keith W. Rose, Computer Networking, Pearson Education, LPE, 2003
Burke J., Network Management Concepts and Practice, A Hands- On Approach, Pearson Education John Strassner, Policy based Network Management, Elsevier India, 2004.

CS903 EVOLUTIONARY COMPUTING **4**

Introduction to Evolutionary Computation, Search Operators, Selection Schemes, Search Operators and Representations, Evolutionary Combinatorial Optimization, Co-evolution, Niching and Speciation, Constraint Handling, Genetic Programming, Multi objective Evolutionary Optimization, Learning Classifier Systems, Theoretical Analysis of Evolutionary Algorithms.

Baeck T., D. B. Fogel, and Z. Michalewicz (eds.), Handbook on Evolutionary Computation, IOP Press.
Z Michalewicz, Genetic Algorithms + Data Structures = Evolution Programs (3rd edition) Springer-Verlag,1996.
Goldberg D E, Genetic Algorithms in Search, Optimisation & Machine Learning, Addison-Wesley, 1989.

CS904 SOFTWARE & IT SYSTEMS – ARCHITECTURE, 4 MEASUREMENT AND TESTING **4**

Architecture, Measurement, Testing, Tools.

Len Bass, Software Architecture in practice, Paul elements & Rick Addison – Wesley Edward Kit, Software Testing in the Real world, Pearson Education
Craig R. D. &. Jaskiel S. P, Systematic Software Testing, Artech House, Bosten.

CS905 BIOINFORMATICS **4**

Introduction to Bioinformatics, Biological Databanks, Sequence Analysis, Structure Prediction, Protein Folding,Proteomics, Emerging Areas in Bioinformatics.

Krane D.E. & Raymer M.L, Fundamental Concepts of Bioinformatics, Pearson, 2003 Attwood & Parrysmith: Introduction to Bioinformatics, Pearson Ed, 2003
Zoe. L & Terenee. C, Bioinformatics, Elsevier, 2004.

CS906 VLSI SYSTEMS-DESIGN & TESTING: PERSPECTIVES FROM 4 COMPUTER ENGINEERING **4**

State machine model design of VLSI system, Computational aspects of VLSI and algorithm, Genetic algorithms forVLSI Design partitioning cell routing.

S. Sjoholm & L. Lindth, VHDL for Designers, Prentice Hall.
J. D. Ullman, Computational aspects of VLSI, Computer Science Press
Genetic Algorithm for VLSI Design, Layout & Test Automation, Pinaki Mazumder, Elizabeth M. Rudrick PH PTR

CS907 PROTOCOL ENGINEERING **4**

Protocol Design & Implementation, Protocol Verification and Validation, Protocol Testing, Formal Methods (FDTs)

Web sites, IEEE, ISO and ITU-T sites

P. Venkatram & S. S., Manavi, Communication Protocol Engineering, PHI, 2004

CS908 SOFTWARE RELIABILITY & FAULT TOLERANCE **4**

Introduction to fault tolerant computing, Software Safety, Software Fault Injection and fault analysis.

Les Hatton, Software Faults & Failures, Addison Wesley, 2000.

Neil Storey, Safety critical computer systems, Addison Wesley, 1996.

CS909 SIMULATION & MODELING **4**

System models, System Simulation, Exponential growth models, exponential decay models, Discrete system simulation, Web based simulation and Distributed Simulation. *Geoffrey Gordon, System simulation, Prentice Hall, 1987 Maryanski. F., Digital Computer Simulation, CBS Distributors. Banks and Carson, Discrete Event System simulation. Prentice Hall 2004.*

Bernard, Herbert & Tag, Theory of modeling and simulation, 2/e, Elsevier India, 2004

CS910 WEB ENGINEERING **4**

Requirements specification and analysis, Web-based systems development methodologies and techniques, Migration of legacy systems to Web environments ,Web-based real-time applications development, Testing, verification and validation ,Quality assessment, control and assurance, Configuration and project management, "Web metrics" – generating metrics for estimation of development efforts, Performance specification and evaluation ,Update and maintenance, Development models, teams, staffing, Integration with legacy systems, Human and cultural aspects, User-centric development, user modeling and user involvement and feedback, End-user application development.

Journal of Web Engineering, Rinton Press & IEEE and ACM publications on these areas.

Cato & John, User centered Web design, Pearson Education, 2001.

Zimmermann Olaj, Tomlinson Mark R, Peuser, Stefan, Perspectives on Web Services, Allied Publishers, 2004

CS911 ADVANCED PARALLEL COMPUTATION **4**

Survey of leading high-end computing systems and their programming environments. Advanced models of parallel computation. Mapping of parallel algorithms to architectures. Performance programming and tools for performance optimization on parallel systems. Execution environments and system software for large-scale parallel computing. Multiprocessor Programming, Case studies of parallel applications, Expression of parallelism: CUDA, SSE and OpenMP.

Ananth Grama, George Karypis, Vipin Kumar, and Anshul Gupta, Introduction to Parallel Computing, Addison-Wesley, 2003.

Michael J. Quinn: Parallel Programming in C with MPI and OpenMP, McGraw Hill Higher Education, 2004. Ian Foster, Designing and Building Parallel Programs.

CS912 ADVANCED OPTIMIZING COMPILERS **4**

Introduction and Motivation, Effectiveness of parallelizing compilers, Basic Transformations, Program Analysis, Advanced Loop Optimizations, Program Analysis, Performance of Compiler Techniques, optimizations for Accelerators, Class Presentations.

Michale Wolfe, High Performance Compilers for Parallel Computing, Addison-Wesley

Utpal Banerjee, Ken Kennedy and John R. Allen, Optimizing Compilers for Modern Architectures: A Dependence based Approach, Morgan Kaufmann Publishers.

Cooper and Torczon, Engineering a Compiler, Morgan Kaufmann, 2004

CS913 INTELLIGENT INFORMATION RETRIEVAL **4**

Overview of IR Systems, Historical Perspectives, Basic Evaluation, Document Representation: Statistical Characteristics of Text, Basic Query Processing, Data Structure and File Organization for IR, Automatic Indexing and Indexing Models, Retrieval Models: Similarity Measures and Ranking, Boolean Matching, Vector Space Models, Probabilistic Models, Search and Filtering Techniques: Relevance Feedback, User Profiles, Collaborative Filtering, Document and Term Clustering, Document Categorization, IR Systems and the WWW, Heterogeneous Information Sources, Intelligent Web Agents, Web Mining and Its Applications.

D. Grossman and O. Frieder. Information Retrieval: Algorithms and Heuristics, Kluwer Academic Press, Richard K. Belew, Finding Out About: A Cognitive Perspective on Search Engine Technology and the WWW, Cambridge University Press, 2001.
C. J. van Rijsbergen , Information Retrieval(online book).

CS914 AUTONOMIC COMPUTING 4
Key concepts and techniques underlying the design and engineering of autonomic computing and networking (AC) systems, characteristics of AC, foundational AC principles based on control theory, artificial intelligence and systems concepts. Architectures and technologies for AC, Machine learning in AC systems, Agent-based systems, Algorithms and optimization methods for AC, Autonomic networking and communications , Advanced topics, Case studies and technologies used to implement AC systems.
Joseph L. Hellerstein, Yixin Diao, Sujay Parekh, Feedback Control of Computing Systems, John Wiley & Sons, Inc, 2004

CS915 NETWORK ALGORITHMS 4
Algorithms for data aggregation in networks and distributed systems, algorithms for distributed search, algorithms for distributed configuration management, and algorithms for distributed trust and reputation schemes, overlay networks.
Ravindra K. Ahuja, Thomas L. Magnanti, James B. Orlin. Network flows. Theory, Algorithms, and Applications. Prentice-Haal, Englewood Cliffs, New Jersey, 1993
Alexander Schrijver, Combinatorial Optimization. Polyhedra and Efficiency. Springer-Verlag, 2003. Christos H. Papadimitriou, Kenneth Steiglitz , Combinatorial optimization : Algorithms and complexity .

CS916 NETWORK-ON-CHIPS 4
Network-on-Chip specifications. Traffic patterns. Butterfly Networks, Torus, Mesh vs. Torus. Express cubes. Non-Blocking Networks - Non-blocking vs. Non-interfering, Crossbars, Clos, Benes, Sorting networks. Concentrators and distributors. Slicing multistage networks. Routing Taxonomy, Deterministic routing. Oblivious routing. Randomized routing, Adaptive routing. Flow control - Resources and allocation units, bufferless flow control. Buffered flow control Packet-buffer flow control, Flit-buffer flow control, buffer management and backpressure, flit -reservation flow control. Router architecture, router datapath. Arbitration. Network interfaces. Error control Buses. Performance analysis. Simulation of interconnection networks. Case studies and current NoC proposals.
William Dally and Brian Towles, Principles and Practices of Interconnection Networks. Morgan Kaufmann, 2004.
Recent publications from NOCS, ISCA, MICRO and other leading conferences. Li-ShiuanPeh and Natalie Enright Erger. On Chip Networks. Synthesis Lectures on Computer Architecture. Morgan and Claypool Publishers.
Christopher J. Nitta, Matthew K. Farrens ,Venkatesh Akella . On-Chip Photonic Interconnects: A ComputerArchitect's Perspective. Synthesis Lectures on Computer Architecture. Morgan and Claypool Publishers.

CS917 ARCHITECTURE SIMULATION 4
Performance evaluation. Performance Metrics, Workloads. System throughput. Average performance: Harmonic vs. arithmetic average, Geometric average. Workload Design. Analytical Performance Modeling. Mechanistic modeling. Hybrid mechanistic-empirical modeling. Simulation Fundamentals. Functional simulation, Operating system effects, Full-system simulation, Trace-driven simulation, Execution-driven simulation. Modular simulation infrastructure. Sampled Simulation: Statistical sampling, Targeted Sampling. Initializing architecture state, Initializing microarchitecture state. Sampled multiprocessor and multi-threaded processor simulation, Statistical Simulation.Parallel Simulation and Hardware Acceleration: Parallel sampled simulation, Parallel simulation, FPGA-accelerated simulation.
Lieven Eeckhout. Computer Architecture Performance Evaluation Methods. Synthesis Lectures on Computer Architecture. Morgan and Claypool Publishers. 2010.
Recent publications from NOCS, ISCA, MICRO and other leading conferences.

CS918 POWER EFFICIENT COMPUTER ARCHITECTURE 4
Power problem. CMOS Power Consumption: Dynamic Power, Leakage, Other Forms of CMOS Power Dissipation. Modeling, Simulation, and Measurement: Dynamic-power Models, Leakage Models, Thermal models, Power Simulation. Dynamic Voltage and Frequency Scaling: System-Level DVFS, Program-Level DVFS, Offline and online. Compiler Analysis, Program-Level DVFS for Multiple-Clock Domains, Hardware-Level DVFS. Optimizing Capacitance and Switching Activity to Reduce Dynamic Power, Idle-Capacity Switching Activity: Instruction Queue, Caches. Parallel Switching-Activity in Set-Associative Caches. Cacheable Switching Activity, Value-dependent Switching Activity: Bus encodings, Dynamic Work Steering. Managing Static (Leakage) Power: Sub-threshold Leakage, Gate

Leakage, Architectural Techniques Using the Stacking Effect. Architectural Techniques Using the Drowsy Effect, Architectural Techniques Based on VT.
Stefanos Kaxiras and Margaret Martonosi. Computer Architecture Techniques For Power-Efficiency. Synthesis Lectures on Computer Architecture. Morgan and Claypool Publishers. 2008.
Recent publications from ISCA, MICRO, HPCA, ASPLOS, and other leading conferences.

CS919 LARGE SCALE DATA ANALYSIS 4
Big Data Analysis Systems and Frameworks: Map-Reduce, Mahout, Spark , Big data Storage and Processing: Parallel DB, Data Store, Big Data Analysis Models and Algorithms : Structured Data Mining, Text Analysis, Graph mining, Image Retrieval, Dimensionality Reduction, New Research Trends, and Applications: Crowd-sourcing, Human intelligence, Probabilistic Databases, Knowledge Bases, Data Visualization.
Mining of Massive Datasets by Anand Rajaraman and Jeff Ullman.
Software for Data Analysis: Programming with R (Statistics and Computing) by John M. Chambers (Springer). Data Analysis Using Regression and Multilevel/Hierarchical Models, 1st Edition by Andrew Gelman, Jennifer Hill. Categorical Data Analysis by Alan Agresti, Wiley publications

CS921 DESIGN OF SECURE PROTOCOLS 4
One-Way Functions, Pseudorandom Generators, Hash functions, Block ciphers, Stream Ciphers, Access Control Methods, Message Authentication and Digital Signatures, Vulnerabilities and Security Challenges of Wireless networks, Trust Assumptions, Adversary models and Protocols, Attacks against naming and addressing in the Internet, Security protocols for address resolution and address auto configuration, Security for global IP mobility, IP Security (IP Sec) protocol, Key Establishment and Revocation Protocols in Sensor Networks, Secure Neighbor Discovery, Secure routing protocols in multi-hop wireless networks, Provable Security for Ad-hoc Network routing protocols, Privacy preserving routing in Ad-hoc Networks, Location privacy in vehicular Ad-hoc networks, Secure protocols for behavior enforcement Game theoretic model of packet forwarding.
L. Buttyan, J. P. Hubaux, "Security and Cooperation in Wireless Networks", Cambridge University Press, 2008.
O. Goldrich, "Foundation of Cryptography-Vol. 1 and Vol. 2", Cambridge University Press, 2001.
James Kempf, "Wireless Internet Security: Architecture and Protocols", Cambridge University Press, 2008

CS922 ELLIPTIC CURVE CRYPTOSYSTEMS 4
Introduction: Wierstrauss Equation, The Group Law, Projective Space and the Point at Infinity, Proof of Associativity, Equations for Elliptic Curves, Coordinate Systems, The j-invariant, Endomorphisms, Singular Curves, Elliptic Curves mod n. Tortion Points: The Tate-Lichtenbaum Pairing Elliptic Curve over Finite Fields- Zeta Functions: A Family of Curves, Schoof's Algorithm, Super singular Curves. Discrete Logarithm Problem: Elliptic Curve Cryptography: Introduction, The Basic Setup, Diffie-Hellman Key Exchange, Massey-Omura Encryption, El-Gamal Public Key Encryption. Primality and Factorization of Integers: Primality, Complexity of factoring, RSA. Elliptic Curve OVER Q. The Torsion Subgroup. The Lutz-Nagell Theorem, Descent and the Weak Mordell-Weil, Theorem Heights, the Height Pairing, Fermat's Infinite Descent, 2-Selmer Groups; Shafarevich-Tate Groups, A Nontrivial Shafarevich-Tate Group, Galois Cohomology, Mordel-Weil Theorem. Elliptic Curve OVER C: The Torsion Subgroup: Doud's Method, Division Polynomials. Complex Multiplication: Elliptic Curves over C, Elliptic Curves over Finite Fields, Integrality of invariants, Kronecker'sJugendtraum. Isogeny: The Complex Theory, The Algebraic Theory, Velu's Formulas, Point Counting, Complements.
L.C. Washington, Ellipptic curves: Number Theory and Cryptography.
H. Cohen and G.Frey, Handbook of Elliptic curve and Hyperelliptic Curve Cryptography, CRC Press, 2006. Darrel Hankerson, Alfred Menezes, Scott Vanstone, Guide to Elliptic Curve Cryptography Springer 2004.

CS923 ALGORITHMIC GAME THEORY 4
Non-cooperative Game Theory: Games in Normal Form - Preferences and utility, examples of normal-form,
Analyzinggames: Pareto optimality, Nash equilibrium, Maxmin and minmax strategies, dominated strategies, Rationalizability, Correlated equilibrium Computing Solution Concepts of Normal-Form Games: Computing Nash equilibria of two player, zero-sum games, Computing Nash equilibria of two-player, general-sum games, Complexity of computing Nash equilibrium, Lemke–Howson algorithm, Searching the space of supports, Computing Nash equilibria of n-player, general-sum games, Computing max min and min max strategies for two-player, general-sum games, Computing correlated equilibria Games with the Extensive Form.
Repeated games: Finitely repeated games, Infinitely repeated games, automata, Stochastic games Bayesian games: Transferable Utility, Analyzing Coalitional Games, The Shapley Value, The Core Mechanism Design: strategic voting,

unrestricted preferences, Implementation, quasilinear setting, Efficient mechanisms, Computational applications of mechanism design, Task scheduling, Bandwidth allocation in computer networks Auctions: Single-good auctions, Canonical auction families, Bayesian mechanisms, Multiunit auctions, Combinatorial auctions

Noam Nisan, Tim Roughgarden, Eva Tardos, Vijay V. Vazirani, Algorithmic Game Theory, Cambridge University Press, 2007.

Ronald Cohn Jesse Russell, Algorithmic Game Theory, VSD Publishers, 2012.

CS924 FORMAL METHODS IN COMPUTING 4

Introduction to Formal Methods, Propositional and Predicate logic, Equality and Definite Description, Sets and Definitions Relations and Functions, Sequences and Free Types, Schema and Schema Operators, Promotion and Preconditions Examples; Cyber-physical Systems and Mathematical Models of Systems: Introduction to Cyber-Physical Systems, Synchronous Models: Dataflow languages, Safety and Liveness Specifications: ω-automata and temporal logics, Asynchronous Models: Communicating machines and synchronization, Continuous Dynamical Systems Timed and Hybrid Systems, Techniques for reasoning about dynamical systems; Verification Techniques: Model Checking, Deductive Verification: Lyapunov and Barrier Certificates

Alur, Rajeev. Principles of Cyber-Physical Systems. MIT Press, 2015.

Tabuada, Paulo. Verification and control of hybrid systems: a symbolic approach. Springer Science & Business Media, 2009.

Edward A. Lee and Sanjit A. Seshia, Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, ISBN 978-1-312-42740-2, 2015.

Lee, Edward A., and Sanjit A. Seshia. "An introductory textbook on cyber-physical systems." Proceedings of the 2010 Workshop on Embedded Systems Education. ACM, 2010.

CS925 GREEN AND SUSTAINABLE ICT 4

Green ICT and environmental sustainability: Basic Green ICT concepts, importance of Green ICT, impact of ICT components on environmental sustainability, aims of Green ICT, Green ICT standards and initiatives; Greening by ICT: Planning and executing a Green ICT policy, adopting Green ICT strategies - web conferencing, telecommuting, going paperless, etc.; Greening of ICT: green devices, green cloud computing, green data centres, green storage, green networking, green algorithms, green software; Measurement and management: metrics, measuring the resource utilization, energy consumption, GHG emission, carbon footprint of ICT components, automated power management, tools and techniques; Research challenges: recent trends in Green ICT research, explored and unexplored topics, open research challenges.

San Murugesan, & G. R. Gangadharan (Eds.). (2012). Harnessing Green IT: Principles and Practices. A John Wiley& Sons, Ltd., Publication.

Ishfaq Ahmad & Sanjay Ranka (Eds.). (2012). Handbook of Energy-Aware and Green Computing - Two Volume Set (1st ed.). Chapman &Hall/CRC.

Mohammad S. Obaidat, Alagan. Anpalagan& Isaac Woungang (Eds.). (2013). Handbook of Green Information and Communication Systems. (1st ed.). Academic Press.

Coral Calero Munoz, & Mario Piattini (Eds.). (2015). Green in Software Engineering. (1st ed.). Springer International Publishing.

CS926 RESEARCH PRACTICUM 2

This course is specifically designed for research students and is a practice oriented course. A student is expected to learn different tools that will be used in his/her areas of area of research. The tools that are used can be of any type aslong as they are relevant to the current context in which the research work is planned to be carried out. The number of tools and assisting technologies is not limited by any numbers but the researchers are expected to choose most appropriate set of tools or tool that is latest and which perfectly fits into the working research area.

Whiteman, Wayne E., William J. Wepfer, and Jeffrey A. Donnell. "Study of a Teaching Practicum in an engineering Ph. D. Curriculum." American Society for Engineering Education, 2011.

CS927 MEDICAL IMAGE PROCESSING 4

Imaging Systems, Introduction to different medical imaging modalities, X-rays, Ultrasound imaging, Computed Tomography, Magnetic Resonance Imaging, Optical Coherence Tomography, nuclear imaging techniques, PACS, Image enhancement in spatial and frequency domain, Image Segmentation, Image registration, Mathematical morphology, texture analysis, pattern recognition, medical applications of imaging.

Geoff Dougherty, Digital Image Processing for Medical Applications, Cambridge University Pres, 2009.

Paul Suetens, Fundamentals of Medical Imaging, Cambridge University Pres, 2009
J. *L. Prince and J. M. Links, Medical imaging signals and systems, Prentice Hall, 2005.*
Rafael C. González, Richard E. Woods, "Digital Image Processing", 3rd Ed., PHI, 2007
Anil K. Jain, "Fundamentals of Digital image Processing", Prentice Hall, US Ed., 1989.

CS928 CONVOLUTIONAL NEURAL NETWORKS 4

Review of basic concepts in image processing and machine learning, Loss functions and optimization, Introduction to neural networks, Feed forward Deep Networks, Back propagation algorithm, Regularization Methods, Convolutional Neural Networks, Training CNNs, CNN Architectures, Deep Learning Hardware and Software, Recurrent Neural Networks, Deep Reinforcement Learning.

Goodfellow, I., Bengio, Y., Courville, A., &Bengio, Y. (2016). Deep learning (Vol. 1). Cambridge: MIT press.
Martin Thaganetc, Neural network design (2nd edition), 2014
Taqiq Rashid, Make your own Neural Network, 2016
Tom Mitchell, Machine Learning, McGraw-Hill, 1997

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGGINEERING

EC900 Selected Topics in Advanced VLSI Design **(4-0-0) 4**

Topics from state-of-the-art design methodologies. Architecture, circuit and layout level issues, Timing and Design closure. Deep sub-micron circuit design-logic and layout issues.

Neil Weste and David Harris, "CMOS VLSI Design: A circuits and Systems perspective", 3rd Ed., Addison Wesley, 2004

RF microelectronics, Behzad Razavi, Prentice Hall, 1998.

William J. Dally, John W. Poulton, "Digital Systems Engineering, "Cambridge University Press 1999

Yaun Taur and Tak H.Ning, "Fundamentals of modern VLSI devices", Cambridge University Press 1999

Recent publications from IEEE, IEICE and ACM Journals

EC901 Modeling and Design of High-Speed VLSI Interconnects **(4-0-0) 4**

Course Description: Detailed study of various problems in modeling and design of high-speed VLSI interconnect at both IC and packaging levels, including device and interconnect modeling, interconnect topology optimization for delay minimization, wire sizing and device sizing for both delay and performance optimization, and clock network design for high performance systems. Noise issues and reliability

William J. Dally, John W. Poulton, "Digital Systems Engineering, "Cambridge University Press 1999

Howard Johnson, Martin Graham, "High-Speed Digital Design" A handbook of black magic, "Prentice Hall 1993.

Recent publications from IEEE, IEICE and ACM Journals

EC902 Integrated Circuits for Communications **(4-0-0) 4**

Course Description: Analysis and design of electronic circuits for communication systems, with an emphasis on integrated circuits for wireless communication systems. Analysis of distortion in amplifiers with application to radio receiver design. Power amplifier design with application to wireless radio transmitters. Class A, Class B, and Class C power amplifiers. Radio-frequency mixers, oscillators, phase- locked loops, modulators, and demodulators. System integration in single chip/multichip module, system partitioning, high throughput and low latency design requirement for real-time communication, critical path analysis for high speed VLSI design, design of analog front ends, impedance matching with bonding pads, Si-Ge devices for RF circuits, interface for optical fibres.

The design of CMOS radio-frequency integrated circuits, Thomas H.Lee. Cambridge University Press, 1998. RF microelectronics, Behzaad Razavi, Prentice Hall, 1998.

Analysis and Design of Integrated Circuits, Paul R Gray, Paul J Hurst, Stephen H. Lewis, Robert G Meyer, Wiley, 2001.

Recent publications from IEEE, IEICE and ACM Journals

EC903 RF and High-Speed Integrated Circuits **(4-0-0) 4**

Course Description: Design of RF and high-speed electronic circuits with special attentions to integrated circuits at Both transistor and system levels. Topics include basic RF design concepts, wireless/wireline transceivers, active/passive devices, the physics of noise, amplifiers, low noise amplifiers, mixers, oscillators and phase noise, phase locked loops, frequency synthesizers, clock and data recoveries, and power amplifiers *Thomas H Lee, The Design of CMOS RF IC, Cambridge University Press, 1998. Razav, RF microelectronics, Prentice Hall, 1998.*

Hagen, RF Electronics: Circuits and Applications, Cambridge University Press, 1996.

Gray, Hurst, Lewis, and Meyer, Analysis and Design of Integrated Circuits, Wiley and Sons, 2001. Van Der Ziel, Noise in Solid-Stage Devices and Circuits, John Wiley and Sons, 1986.

Ott, Noise Reduction Techniques in Electronic Systems, John Wiley and Sons, 1988.

Recent publications from IEEE, IEICE and ACM Journals

EC904 Advanced Topics in Digital Communications **(4-0-0) 4**

Fading channels, Characterization of Mobile Radio propagation, Signal-time spreading, channel variance, mitigating the degradation effects of fading, fundamentals of statistical detection theory, Baye's theorem, Decision theory, Neyman-Pearson theorem, Multiple hypothesis testing, minimum Baye's risk detection for binary and multiple hypothesis, Orthogonal Frequency Division multiplexing (OFDM), OFDM transmission techniques, synchronization, modulation, demodulation, amplitude limitation of OFDM signals, Space-Time Wireless communications,

Introduction, Space-Time propagation, Space-Time channel and signal models, spatial diversity, Space-Time OFDM.
J G Proakis, Digital Communications, 4th edition.
H L Van Trees, Detection, Estimation and Modulation Theory, Part I.
T S Rappaport, Wireless Communications " Principles and Practice, 2nd Edition.

EC905 Advanced RF Techniques (4-0-0) 4
Planar Transmission Lines-Stripline, microstrip line, suspended stripline and coplanar line; Parallel coupled lines in stripline and microstrip - Analysis, design and characteristics. Microwave Network Analysis - Microwave network representation, Impedance and admittance matrices, Scattering and ABCD parameters, Typical two-port, three port, four port networks. Impedance Matching Techniques - Smith chart, Matching networks using lumped elements, Single and double-stub matching, Quarter wave transformer. Basic Passive Components -Lumped elements in MIC, Discontinuities and resonators in microstrip, Balun, Analysis and design of stripline/microstrip components-Directional couplers, Power divider, Hybrid ring. Basics of MIC, MMIC and MEMS technologies - Substrates used. Fabrication process, and Design techniques. Transistor Amplifiers - Types of amplifiers. S-parameter characterization of transistors; FETs- Equivalent circuit models. Single stage amplifier design- unilateral and bilateral case, Amplifier stability, Constant gain and noise circles, DC bias circuits for amplifiers. Detectors and Mixers - Point contact and Schottky barrier diodes-Characteristics and equivalent circuit, Theory of microwave detection, Detector circuit design. Types of mixers. Mixer theory and characteristics. SSB versus DSB mixers. Single-ended mixer and single-balanced mixer-Design and realization in microstrip. Double balanced and image rejection mixers. Oscillators-Oscillator versus amplifier design, Oscillation conditions. Gunn diode- Modes of operation, Equivalent circuit. Design of Gunn diode oscillator in microstip. FET oscillators. Frequency tuning techniques.

EC906 Selected topics in Signal Processing (4-0-0) 4
Statistical Signal Processing - Autocorrelation and power spectrum, Filtering, Linear estimation, Spectrum estimation, Adaptive filters. Multirate Systems – Multirate operations, Filter banks, PR systems, Tree structured and cosine modulated filter banks. Wavelet analysis – Localization and uncertainty, Orthogonal wavelets, biorthogonal wavelets, Block transforms, frames, approximation and denoising in frames. Sparse signal processing – Sparsity and redundant dictionaries, Matching pursuits.
Sophocles J. Orfanidis, Optimum Signal Processing An Introduction, McGraw-Hill, 2007.
P.P. Vaidyanathan, Multirate Systems and Filter Banks, Pearson Education India, 2006.
Stephane Mallat, A Wavelet Tour of Signal Processing - The Sparse Way, AP, 2009.
Jelena K., Vivek K Goyal, and Martin Vetterli, Fourier and Wavelet Signal Processing, EPFL Press, 2013.

EC907 Multi-dimensional Signal Processing (4-0-0) 4
Speech Fundamentals, Perception and Production, Analysis, Lossless and Perceptually lossless compression, Recognition, Speaker recognition and identification, Image Fundamentals, Transforms, Segmentation, Restoration, Enhancement, Compression standards, Medical Imaging Video analysis, MPEG standard of coding, Segmentation and tracking. Biometrics.
Anil K .Jain, Fundamentals of Digital Image Processing, PHI, 2010
R.C.Gonzalez and R.E.Woods, Digital Image Processing, Pearson, 2008
Douglas O'Shaughnessy, Speech Communication, Human and Machine, IEEE Press, 1999
L.R. Rabiner and R.W. Schafer, Digital Processing of speech signals, Prentice Hall, 2013
Fundamentals of Medical Imaging , Paul Suetens, Cambridge Press, 2009

EC908 Selected Topics in Computer Communication Networks (4- 0-0) 4
Introduction to network resilience problems & solutions, Wireless beyond 3G, Performance modeling of (Wireless) networks & Formal Methods, Network design algorithms and Network design using Network Processors, Wireless Ad-hoc Networks, Security Issues in control, Management, routing and other areas of networks, Distributed control in Wireless network and Middleware, Distributed Mobile Computing, Embedded Systems in Mobile/ Wireless/ Network Systems – Hardware & Software Design/ Development issues, Standardization in Wireless / Mobile Network Systems. Wireless Sensor Networks & Protocol, Queuing Theory in Networking, Network Management
Feng & Leonidas, Wireless Sensor Networks, Elsevier India, 2005
Kumar D. Manjunath and J. Kuri Communication Networking, An analytical approach, Elsevier, 2004
Subramanian M., Network Management: Principles and Practice, Addson – Wesley, 2000
Burke J., Network Management Concepts and Practice, A Hands- On Approach, Pearson Education, 2000.

EC909 Selected Topics in Radar Signal Processing (4-0-0) 4

Elements of a Radar, statistical models of radar cross section (RCS), probability density functions (PDFs) for RCS, RCS Correlation, Swerling models, range and Doppler ambiguities, Radar waveforms, Matched filter for continuous waveforms, Matched filtering for moving targets, ambiguity functions of single pulse and pulse burst of waveforms, The Linear FM (LFM) Waveform, Vector matched filter, Tracking principles, Detection principles, Space time adaptive processing (STAP).

Mark A Richards, Fundamentals of Radar Signal Processing, Tata McGraw Hill,
2005 Nadav Levanon, Radar Signals, Wiley-IEEE Press, 2004
M.I Skolnik (ed), Radar Hand Book, McGraw Hill Publication, 1990

EC910 Selected topics in Analog and Mixed Signal Integrated Circuits (4-0-0) 4

Trade-offs in mixed signal design, Data converters and Switched Capacitor circuits, Calibration and Digital error correction.

R. Jakob Beker, CMOS: Mixed Signal Circuit Design, 2nd Ed., Wiley-IEEE, 2009
Behzad Razavi, Principles of Data Conversion System Design, Chand & Company Ltd (IEEE Press),
2000. Gabriele Manganaro, Advanced Data Converters, Cambridge Univ. Press, 2012 Mingliang
(Michael) Liu, Demystifying Switched capacitor Circuits, Elsevier, 2006
Analog Devices Inc. (edited by Walt Kester), The Data Conversion Handbook, Newnes, 2005

EC911 Mathematical Methods for Signal Processing and Communication Engg (4-0-0) 4

Selected Topics in Vector spaces: Vectors, Vector norms, vector algebra, subspaces, basis vectors, Gramm-Schmidt orthonormalization. Matrices, matrix rank, matrix norms, determinant, inverse, condition number. Hermitian and symmetric matrices, positive definite matrices unitary matrices, projection matrices and other special matrices. LDU decomposition, QR decomposition, Eigenvalue decomposition, singular value decomposition. Solving linear system of equations using matrices. Least-Squares approach, total least squares approach. Numerical issues. Perturbation theory of matrices. Differentiation of scalar functions of vectors and matrices. Matrix functions of scalar variables, Kronecker product of matrices.

Analysis: Review of real and complex number systems, topology of metric spaces. Continuity and differentiability. Construction of the Lebesgue measure, measurable functions, limit theorems. Lebesgue integration. Different notions of convergence and convergence theorems. Product measures and Fubini’s theorem. Signed measure and the Radon-Nikodym theorem, change of variables.

Optimization Techniques: Need for unconstrained methods in solving constrained problems. Necessary conditions of unconstrained optimization, structure of methods, quadratic models. Methods of line search, Armijo-Goldstein and Wolfe conditions for partial line search. Global convergence theorem, steepest descent method. Linear and Quadratic Programming. Duality in optimization.

Stochastic Models: Review of Random variables, Stochastic processes, Markov chains, stationary distribution of Markov chains, Poisson and birth and death processes.

Todd K Moon, Striling, “Mathematical Methods and Algorithms for Signal Processing, Prentice Hall, 2000.
Stephen Boyd, Lieven Vandenberghe, Convex Optimization, Cambridge University Press Ross S.M,
Introduction to Probability Models, Academic Press and Hardcourt Asia, 2000.
Rudin, W., Principles of Mathematical Analysis, McGraw-Hill, 1986.

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

EE900 Selected Topics in Power Electronics **4**
Multilevel inverters, Topologies, High-power applications of multilevel inverters, Active filters, FACTS Controllers, High-voltage power supplies, Topologies and design, Current topics in Power Electronics.

EE901 Selected Topics in Electric Drives **4**
Switched reluctance motors, Permanent magnet synchronous machines, applications, Special drives for electric vehicles, topics of current interest.

EE902 Selected Topics in Power System Protection **4**
Topics of current interest in power system protection.

EE903 Selected Topics in Power System Dynamics and Stability **4**
Topics of current interest in power system control, stability, dynamics, Applications of FACTS controllers, Voltage-Stability analysis, Interrelation between voltage and angle -stability.

EE904 Current Topics in Electric Machines **4**
Design of special machines, disc motors, switched reluctance motors, high-power stepper motors.

EE905 Finite-Element Methods and Applications **4**
Field analysis of electric machines, Finite-element methods and their applications to the analysis of electric machines and related topics of interest.

EE906 Real-Time Operating Systems **4**
Basic Real-time concepts, The Software life cycle, Real-time specifications and design techniques, Operating system concepts, Introduction to RTOS, Tasks, Semaphores, Message queues, Exceptions and interrupts, Timer and timer services, I/O subsystem, Memory management, modularization, Synchronization and communication, Common design problems.
P. A. Laplante, Real-Time Systems Design and Analysis: Engineer's Handbook, 2nd Edition, IEEE Press.
Qing Li, Caroline Yao, Real-Time Concepts for Embedded Systems, CMP Books.

EE907 Selected Topics in Power System Communications **4**
Remote metering of electrical energy, Fundamentals of computer-networking protocols, DLMS/COSEM specification of electricity meters, Study of Device Language Messaging Specification (DLMS), Companion Specification for Energy Metering (COSEM) Standards, IEC 62056-21, 42, 46, 47, 53, 61, 62 : 2002, IEC 61334-6:2002, xDLMS - Extended Device Language Messaging Specification.
Centre for Software Engineering and Training, Tutorial on International Electricity Metering Protocol, CPRI, Bangalore.
IEEE/IEE Papers on Electricity metering.
http://www.dims.com

EE908 Design of Intelligent Electronic Devices **4**
Role of Intelligent Electronic Devices (IED), Architecture of IEDs, Design methodology, Communication protocols for IEDs, Case studies of IED application, Recent developments in instrumentation for power station and control applications, Digital simulation of IEDs for specific power apparatus monitoring and control.
J. NorthCotem, G. David Hart, R. Wilson, Control and Automation of Electric Power Distribution Systems, CRC Press.
C. Rehtanz, Autonomous Systems and Intelligent Agents in Power System Control and Operation, Kluwer, 2003.

EE909 Overvoltages in Power Systems **4**
Transient phenomena on transmission lines, Method of computation, Use of PSPICE, Lightning discharges, Origin and characteristics of lightning and switching overvoltages, behaviour of apparatus and line insulation under overvoltages,

VFTO in GIS, Protection of apparatus against overvoltages, Surge arresters and insulation coordination.
A. Greenwood, Electrical Transients in Power Systems, Wiley Interscience.
EPRI, Transmission Line Reference Book: 345 kV and Above, EPRI, 1984.

EE910 Computational Methods in Electromagnetics **4**
Laplace's and Poisson's equations in insulation design, Transient fields due to finite conductivity, Method of images, Images in two-layer soil, Numerical methods, Finite differences, Finite-element and charge simulation methods.
J. A. Stratton, Electromagnetic Theory, McGraw-Hill.
P. P. Silvester, R. L. Ferrari, Finite Elements for Electrical Engineers, Cambridge University Press, 1996. Andrew F. Peterson, Scott L. Ray, Raj Mitra, Computational Methods for Electromagnetics.

EE911 Dynamic Security Analysis of Power Systems **4**
Security Analysis: Static and dynamic security analysis, Transient stability analysis: Time domain and energy function based analysis, Trajectory sensitivity analysis.
K.R. Padiyar, Power Systems Stability and Control, Interline, 1996.

EE912 Selected topics in Power System Deregulation **4**
Horizontal and vertical structures, Deregulated market, ATC calculations.

EE913 System Analysis with FACTS devices **4**
Modeling of FACTS devices, Load flow, Transient stability, Small-signal stability, Voltage-stability and SSR analysis with FACTS devices.

EE914 Embedded Generation **4**
Concept of embedded generation, Optimum placement, Stability and control studies.

EE915 Advanced Energy Auditing **4**
Introduction to energy auditing, Analysis of domestic electrical systems in urban/rural areas., Micro and macro perspectives of rational use of energy, Energy utilization and requirements, Methodology and case study of generating station/distribution systems.
J. H. Shirley, W. James, J. H. Brown, Investment Grade Energy Audit.
R. W. Donald, Energy Efficiency Manual, Energy Institute Press.

EE916 Direct Energy Conversion **4**
Energy conversion and thermodynamic principles, Electrochemical effects and fuel cells, thermoelectric systems, MHD generation.
S. L. Soo, Direct Energy Conversion.
S .W. Angrist, Direct Energy Conversion.

EE917 Electric Vehicles **4**
EV working systems, poer sources for EV systems, Types of drive systems used for EVs, Embedded systems for EV drive/controllers.

EE918 Selected Topics in Alternative Energy Sources **4**
Photovoltaic systems, Grid-connected PV Systems, Power generating systems with wind energy, Micro and pico hydro power generating systems, Hybrid power generating systems.

EE919 Selected Topics in Condition Monitoring Techniques for Electrical Equipments **4**
Introduction to diagnostic techniques. Insulation resistance, Polarization index, Recovery voltage measurement, Sweep frequency response analysis, Capacitance and dissipation factor, Dielectric spectroscopy, Partial discharge measurements (Electrical and acoustic), Thermal imaging, Surge measurements and issues related to their measurement, diagnostics.
Baldev, R., Jayakumar, T. and Thavsimuyhu, 2008. Practical non-destructive testing. Narosa Pub. House.

IEEE Standard 43.
IEEE Standard, 2004. C-62-2
IEEE Standard, 2000. C-57-127.

EE920 Selected Topics in Control Systems **4**

Review of classical control theory, state-variable methods, optimal control, robust control, introduction to non-linear control.

K. Ogata, Modern Control Engineering, Prentice Hall International, NJ.2004
Gopal, Madan. Control systems: principles and design. Tata McGraw-Hill Education, 2002.
Gopal, Madan. Modern control system theory. New Age International, 1993.
M. Athans and P. L. Falb, Optimal Control: An Introduction to the Theory and Its Applications, Dover Books on Engineering, 2006.
D. S. Naidu, Optimal Control Systems, CRC Press, 2002.
Gu, Da-Wei, Petko Petkov, and Mihail M. Konstantinov. Robust control design with MATLAB. Springer Science & Business Media, 2005.

EE921 Selected Topics in large Electric Power Systems **4**

Solution of linear system of equations, Sparse matrix solution techniques, Solution of nonlinear system of equations, numerical solution of ordinary differential equations, application to power system problems, Eigen value and modal analysis, state estimation.

S A Soman, S A Khaparde, Shubha Pandit, Computational Methods for Large Sparse Power System Analysis, Kluwer, 2002
Steven C. Chapra, R. P. Canale, Numerical Techniques for Engineers, TMH, 2000.
Mariessa Crow, Computer Techniques for Large Electric Power Systems, CRC Press, 2003

DEPARTMENT OF INFORMATION TECHNOLOGY

IT900 ADVANCED DATABASE MANAGEMENT SYSTEMS 4

Basic concepts and terminology, software architecture for data sharing, federated database management system,designing distributed databases, distributed transactions, client server architecture, multimedia databases, object oriented DBMS, query Processing & optimization.

Tamer Ozsu, Patrick Valduring: Principles of Distributed Database systems,
PHI Ceri S, Pelagatti S: Distributed Databases: Principles and Systems, McGraw Hill.
Thomas Connolly & Carolyn Begg, Database systems: A Practical Approach to Design, Implementation and Management, 3/e, Pearson Education, 2003. (Chapters 19 & 20)
Patrick O'Weil & Elizebeth O'Weil, Database Principles, Programming & Performance, Harcourt India Pvt. Ltd., 2/e,2002(Chapters 8, 9 & 10)

IT901 DISTRIBUTED COMPUTING SYSTEMS 4

Introduction Computer Networks and Multi-processor systems, Evolution of modern operating systems, Design Goals, transparencies and fundamental issues in Distributed systems, Temporal ordering of events, Global state detection, Physical clocks, Mutual Exclusion Algorithms, Interprocess Communication, Deadlocks in distributed systems, Load balancing techniques, Distributed databases

Shivarathi & Shingal, Advanced Operating Systems
Randy Chow, Distributed Operating Systems and Algorithms
George Couloris et al, Distributed Systems - concepts and design, Pearson Education, 2002
A.S. Tanenbaum and M.V. Steen, Distributed Systems - Principles and Paradigms, Pearson Education 2003.
Wolfgang Emmerich, Engineering Distributed Objects, Wiley, 2000.
Gerald Tel, Introduction to Distributed Algorithms, 2/e, Cambridge, 2004.

IT902 ADVANCED SOFTWARE ENGINEERING 4

Managing software projects : Project management concepts, Project metrics, Project planning, Project scheduling and tracking; Quality, Configuration management, Technical metrics and formal methods; Object oriented software engineering; Reuse, Reengineering, Client/Server software engineering, CASE.

Roger S Pressman, Software Engineering - A Practitioner's Approach,
McGraw-Hill Ian Sommerville, Software Engineering, Addison Wesley.
Joel Henry, Software Project Management, Pearson Education, 2003.
Kenneth R. Bainey, Integrated IT Project Management: A Model-Centric Approach, Allied Publishers, 2004.
Mario E. Moreira, Software Configuration Management Hand Book, Allied Publishers, 2004.
Len Bass, Paul Clements, and Rick Kazman, Software Architecture in Practice, Addison-Wesley, 1998.
William J. Brown, Raphael C. Malveau, Hays W. "Skip" McCormick III and Thomas J.Mowbray Wiley. AntiPatterns: Refactoring Software, Architectures, and Projects in Crisis, 1998.

IT903 DESIGN AND ANALYSIS OF ALGORITHMS 4

Fundamentals of Algorithmic Problem Solving, Fundamental data Structures, Fundamentals of the Analysis of Algorithm Efficiency, Brute Force, Divide -and-Conquer, Decrease and Conquer, Transform and Conquer, Space and Time Tradeoffs, Dynamic Programming, Greedy Technique, Limitations of Algorithm Power. Coping with the Limitations of Algorithm Power.

Anany Levitin, Introduction to The Design And Analysis Of Algorithms, Pearson Education, 2003.
T.H. Cormen, C.E. Leiserson, R.L. Rivest, Introduction to Algorithms, McGraw Hill, 1994.
Dan Gusfield, Algorithms on Strings, trees and Sequences, Cambridge, 2005.
Sara Baase, Computer Algorithms: Introduction to Design and Analysis, Addison Wesley, 1998.
Michael T Goodrich & Roberto Tamassia, Algorithm Design: Foundations, Analysis & Internet Examples, John Wiley, 2002.

IT904 ADVANCED OPERATING SYSTEMS 4

An overview of operating system functions, Distributed operating systems, Protection and security, Multiprocessor operating systems, Database operating systems, Concurrency control, Object oriented operating systems and its
characteristics, Case studies of OS such as UNIX OS, Netware OS, Windows

etc, *Mukesh Singhal Niranjan, Shivorothri G: Advanced concepts in Operating Systems*
Andrew S Tenanbaum: Distributed Operating systems
Doreen L Galli, Distributed Operating System- Concepts and Practice, Prentice-Hall, 2000.
A. Silberschatz, Applied Operating System Concepts, Wiley, 2000.
Lubemir F. Bic & Alan C. Shaw, Operating Systems Principles, Pearson Education, 2003

IT905 DATA WAREHOUSING AND DATA MINING 4
Data Warehousing, Data Mining, Association Rules, Classification, Clustering, Decision Trees, Other Techniques for Data Mining, Web Mining, Searching Techniques
Jiawei Han, Micheline Kamber: Data Mining: Concepts and Techniques, Harcourt India Pvt. 2001.
Arun Poojary K., Data Mining Concepts, Hyderabad Press, 2001.
George M. Marakas, Modern Data Warehousing, Mining & Visualization, Pearson Education, 2003.
Margaret H. Dunham, Datamining: Introductory & Advanced Concepts, Pearson Education, 2003.

IT906 GENETIC ALGORITHMS 4
Population based search techniques, Introduction to Genetic algorithms, Mathematical foundations, Computer implementation of genetic algorithms, Advanced operators and techniques in genetic algorithm search, Industrial application of genetic algorithms.
David Goldberg, Genetic Algorithms in Search, Optimization and Machine learning, Addison Wesley International
Charles L Karr and L Michael Freeman, Industrial Applications of Genetic Algorithms, CRC Press

IT907 ADVANCED COMPILERS 4
Review of Compiler structure, overview of advanced architectures, compiler challenges, Data Flow and Control Flow Analyses, Dependences and Transformations, Loop Transformations and its applications, Scheduling concepts: instruction/vector unit, register allocation, compiling for HPF, a few recent advances.
Steven Muchnik, "Advanced Compiler Design Implementation" Elsevier Publications, 2003
Randy Allen and Ken Kennedy, "Optimizing for Compilers for Modern Architectures", Elsevier Press, 2002

IT908 INTELLIGENT INFORMATION SYSTEMS 4
Emerging Technologies and applications with latest knowledge applied to customized logic systems, agent based approaches to modeling, and human-based models, multi-mobile agent systems, the product development process, fuzzy logic systems, neural networks, and ambient intelligent environment such as development of information and communication technologies for spatial audio and video information, multimedia data hiding and watermarking algorithms for real world audio and video applications.
Xuan F. Zha, "Artificial Intelligence and Integrated Intelligent Information Systems: Emerging Technologies and Applications", IGI Global, 2006
Jialie Shen, "Intelligent Music Information Systems: Tools and Methodologies", Idea Group Reference Publishers, 2007
Pan, J.-S; Huang, H.-C; Jain, L.C.; Fang, W.-C; "Intelligent Multimedia Data Hiding", Springer, 2007

IT909 ADAPTIVE BLIND SIGNAL AND IMAGE PROCESSING 4
Introduction to Blind Signal and Image Processing: Principal Component analysis (PCA), Blind Source Separation (BSS) and Independent Component Analysis (ICA), BSS of Instantaneous and Convolutive Mixtures, Sequential Blind Signal Extraction, Robust BSS/ICA with noisy data; Learning Algorithms for Estimation of Sources; Applications: Audio, Speech, Image and Biomedical Signal Processing.
A.*Cichocki and S. Amari, "Adaptive Blind Signal and Image Processing: Learning Algorithms & Applications", John Wiley, 2002*
Hyvarinen, J. Karhunen, and E. Oja, "Independent Component Analysis", John Wiley, 2001
C S. Roberts and R. Everson, "Independent Components Analysis: Principles and Practice", Cambridge University Press, 2001
A. S. Bregman, "Auditory Scene Analysis", MIT Press, 2nd Edition, 1999 Handbook on Speech Processing and Speech Communication, Springer, 2007

IT910 PERCEPTUAL AUDIO AND SPEECH PROCESSING 4
Audio Coding and Human Auditory Perception; Speech Analysis - Short Time Discrete Fourier Transforms, Gamma-tone Filter banks, Sub-band coding and Wavelet Transforms, Audio Processing, Standards for audio compression in

multimedia applications - MPEG.
Ben G. and Nelson M., "Speech and Audio Signal Processing: Processing and Perception of Speech & Music", Wiley, 1999
K. Rao et al,, "Introduction to Multimedia Communications: Applications, Middleware, Networking", Wiley 2006 Douglas O'Shaugnessy, "Speech Communication - Human and Machine", IEEE Press, 2000
L R Rabiner, "Digital Processing of Speech Signals", Pearson, 1978
Zi Nian Li, "Fundamentals of Multimedia", Pearson Education, 2003

IT911 PERCEPTUAL IMAGE AND VIDEO PROCESSING 4

Picture Coding and Human Visual Perception; Perceptual Video Quality Metrics, Perceptual Coding and Processing of Digital Pictures; Image Transforms - DCT, Hadamard, Haar, KL and Wavelet; Standards for Image Compression - JPEG; Standards for Video Compression - MPEG, H.264.
H. R. Wu and K. R. Rao, "Digital Video Image Quality and Perceptual Coding", CRC Press, 2005 R. C. Gonzalez and R E Woods, "Digital Image Processing", Pearson Education, 2002
W Pratt, "Digital Image Processing", Wiley, 2001
Al Bovik, "Handbook of Image and Video", Academic Press, 2000 Keith Jack, "Video Demystified", LLH, 2001

IT912 MODERN CRYPTOGRAPHY 4

Classical Encryption Techniques and their Cryptanalysis : Symmetric cipher models Symmetric-Key Encryption Schemes: Data Encryption Standard and Advanced Encryption Standards, RC4, Attacks on DES, AES. Number Theory: Prime numbers and factoring, modular arithmetic, computations in finite fields, Discrete logarithms. Public-Key (Asymmetric) Cryptography. Hash Functions: Design of Collision-Resistant Hash Functions, Popular Uses of Collision-Resistant Hash Functions, Random Oracle Model. Hash algorithms: MD5, SHA-256.
Message Authentication: Message Authentication Codes Definitions, Constructions of Secure Message Authenticate Codes, Practical Constructions of Message Authentication Codes. Digital Signatures and Applications:.
William Stallings, Cryptography & Network Security, Pearson Education Asia.
2006 Schiner Bruce, Applied Cryptology, John Wiley & Sons, 2001.
Wade Trappe & Lawrence C Washington, Introduction to Cryptography with Coding Theory, Pearson Education, 2006.
Kahate A, Cryptography & Network Security, Tata Mc Graw Hill, 2004.
Charlie Kaufman, Radia Perlman and Mike Speciner, Network Security: Private Communication in a Public World, Prentice Hall of India Private Limited.
Behrouz A. Forouzan, Cryptography and Network Security, Mc Graw Hill.
Jonathan Katz and Lindell, Introduction to Modern Cryptography: Principles and Protocols, Chapman and Hall/CRC.
Jonathan Katz and Yehuda Lindell, Introduction to Modern Cryptography, CRC Press.
A. Menezes, P. Van Oorschot and S. Vanstone, Handbook of Applied Cryptography, CRC Press, 1996.

IT913 COMPUTER NETWORK SECURITY 4

Security at the Application Layer: Email architecture, PGP (Pretty Good Privacy), S/MIME. Security at the Transport Layer (SSL and TLS): SSL architecture, Four protocols, SSL message formats, Transport Layer Security, Secure Electronic Transaction. Security at the Network Layer (IPSec) : Two modes, Two Security protocols, Security Association, Security Policy, Internet Key Exchange, ISAKMP. Intruder: Intruder, Intrusion Detection, Password Management. Malicious Software : Viruses and Related Threats, Virus Countermeasures, Distributed Denail of Service Attack. Firewall : Firewall Design Principles, Trusted systems, Common Criteria for Information Technology Security Evaluation. Authentication : Kerberos V4 and V5, X.509 Authentication Service, Public Key Infrastructure. Physical Layer Security:Shannon’s perfect secrecy, Secure Communication over Noisy Channel, Channel Coding for Secrecy, Secret Key Agreement from noisy observation, Active attacks, Physical Layer Security and Classical Cryptography.
William Stallings, Cryptography and Network Security, Third Edition.
William Stallings, Network Security Essentials, Third Edition.
Behrouz A. Forouzan, Cryptography and Network Security, McGraw Hill.
Jie Wang, Computer Network Security Theory and Practice, Springer Berlin Heidelberg New York.
William Stallings, Cryptography and Network security Principles and Practice , Fifth Edition.

Kwok T. Fung, Network Security Technologies, Second Edition, Auerbach Publications, A CRC Press Company.
Joseph Migga Kizza, A guide to Computer Network Security, Springer Publications.

IT914 DIGITAL FORENSIC 4

Introduction to legal issues, context, and digital forensics; Stages of Forensic: acquisition or imaging of exhibits, analysis and reporting standards. Computer forensics. Network forensics: monitoring and analysis of Computer Networks, Social Network analysis for Online Forensics. Database forensics: forensic study of databases and their metadata. Investigative use of database contents, log files and in-RAM data in order to build a time-line or recover relevant information. Mobile device forensics: recovery of digital evidence or data from a mobile device.

Media Analysis: disk structure, file systems (NTFS, EXT 2/3, HFS), and physical layer issues; Tools for digital forensics.

Analysis Techniques: keyword searches, timelines, hidden data; Application Analysis; Network Analysis; Analysis of Cell phones, PDAs, etc.; Binary Code Analysis; Evidence: collection, preservation, testimony.

Kanellis, Panagiotis, Digital Crime and Forensic Science in Cyberspace, IGI Publishing.
Jones, Andrew, Building a Digital Forensic Laboratory. Butterworth Heinemann, 2008.
Marshell, Angus M., Digital Forensics: Digital Evidence in Criminal Investigation, Wiley Blackwell, 2008.
Philip Craiger, Sujeet Shenoi, Advances in Digital Forensics, Springer, 2007. -
Paul Crowley Dave Kleiman, CD and DVD Forensics, Syngress Publishing Inc, 2007.
Chris Prosise, Kevin Mandia, Incident Response & Computer Forensics, McGraw-Hill, 2nd Edition, 2003.

IT915 SPECIAL TOPICS IN COMPUTER NETWORKS 4

Voice Packetization: Quality of Service, Distributed Network Architecture. Packet Transport Technologies: Voice over the Internet Protocol, Voice over ATM, Voice Over Frame Relay, Comparison among other technologies. Broadband Access and Evaluation Networks: Voice over cable, Voice over DSL. Fast access technologies. (For example, ADSL, Cable Modem, etc.) IPv6: Why IPv6, basic protocol, extensions and options, support for QoS, security, etc., neighbour discovery, auto-configuration, routing. Changes to other protocols. Application Programming Interface for IPv6. Mobility in networks. Mobile IP. IP Multicasting. Multicast routing protocols, address assignments, session discovery, etc. TCP extensions for high-speed networks, transaction-oriented applications. Other new options in TCP.

David J. Wright, Voice over Packet Network, Wiley Publisher.
W. R. Stevens, TCP/IP Illustrated, Volume 1: The Protocols, Addison Wesley, 1994.
G. R. Wright, TCP/IP Illustrated, Volume 2: The Implementation, Addison Wesley, 1995.
W. R. Stevens, TCP/IP Illustrated, Volume 3: TCP for Transactions, HTTP, NNTP, and the Unix Domain Protocols, Addison Wesley, 1996.
R. Handel, M. N. Huber, and S. Schroeder, ATM Networks: Concepts, Protocols, Applications, Addison Wesley, 1998.
C. E. Perkins, B. Woolf, and S. R. Alpert. Mobile IP: Design Principles and Practices, Addison Wesley, 1997.

IT916 VEHICULAR ADHOC NETWORKS 4

Introduction to Vehicular Networks. Vehicular Network Applications and Services. Medium Access Control Protocols for Vehicular Networks. Heterogeneous Wireless Communications for Vehicular Networks. Routing in Vehicular Networks. Routing in Vehicular Networks: A User’s Perspective. Data Dissemination in Vehicular Networks .

Hassnaa Moustafa, Yan Zhang (Ed), Vehicular Networks Techniques, Standards, and Applications, CRC Press.
Hannes Hartenstein, VANET: Vehicular Applications and Inter-Networking Technologies, A John Wiley and Sons, Ltd., Publication.
Radu Popescu-Zeletin, Ilja Radusch, Mihai Adrian Rigani, Vehicular-2-X Communication, Springer publisher.

IT917 SPECIAL TOPICS IN WIRELESS SENSOR NETWORKS 4

Motivation for a Network of Wireless Sensor Nodes. Sensor Network Architecture and Sensor Devices, Physical Layer in Sensor Networks, MAC Layer in Sensor Networks, Higher Layer Issues in Sensor Networks, Time Synchronization in Wireless Sensor Networks. Software Issues in Wireless Sensor Networks. Sensor Networks’ Integration. Mobility Aspects in WSN. Medical Applications of Wireless Sensor Networks. Vehicular Sensor Networks: General Aspects

Waltenegus Dargie, Fundamentals of Wireless Sensor Networks Theory and practice, John Wiley =.
Application and Multidisciplinary Aspects of Wireless Sensor Networks Concepts, Integration, and Case Studies, Springer Publisher.
Kaveh Pahlavan and Prashant Krishnamurthy, Networking Fundamentals Wide, Local and Personal Area Communications, John Wiley.

IT918 PERFORMANCE ANALYSIS OF LOCAL AREA NETWORKS AND WIDE AREANETWORKS 4
Transmission systems : Introduction, Subscriber Loop Design, Unigauge Design for Telephone Customer Loop Plants Signal Multiplexing, Digital Transmission Systems, Optical Fiber Transmission Systems. Switching systems: Centralized Switching, Switching Techniques, Congestion in Space-Division Switching Networks, AND Time-Division Switching Networks, Nonblocking Networks. Modeling of traffic flows, service times and single-server queues: Distribution for Number of Arrivals in a Fixed Time Interval, The Interarrival Time Distribution, The Service Time Distribution, The Residual Service Time Distribution, The Birth and Death Process, Erlang Loss System and Erlang Delay System. Engset loss and delay systems. Local area networks. Polling networks. Token ring networks. Random access networks
Wah Chun Chan, Kluwer, Performance Analysis of Telecommunications and Local Area Networks, Academic Publishers.

IT919 MODELLING AND ANALYSIS OF NETWORKS PROTOCOLS 4
Introduction and Overview. Introduction to Queuing Theory. Layered Architectures in Data Networks. Data Link Layer: Examples and Performance Analysis. Network Layer: Flow Control and Congestion Control. Network Layer: Routing Function Transport Layer. Polling and Random Access in Data Networks. Local Area Networks. Introduction to Circuits Switching. Call Processing in Digital Circuit-switching Systems. The Evolution toward Integrated Networks
Mischa Schwartz, Telecommunication Networks: Protocols, Modeling and Analysis, Addison-Wesley

IT920 PACKET FORWARDING TECHNOLOGIES 4
Basic Functionalities of Routers, Evolution of Router Architecture, Key Components of a Router, Network Processor, IP-Address Lookup and Routing Table, Construction of Optimal Routing Tables, Matching Techniques, Difficulty of the Longest-Prefix Matching Problem, , Multibit Tries. Pipelined Multibit Tries. Efficient Data Structures for Bursty Access Patterns. Caching Technologies: Suez Lookup Algorithm, Host Address Range Cache, Prefix Caching Schemes, Multi-Zone Caches, Hashing Schemes: Binary Search on Hash Tables, Parallel Hashing in Prefix Length, Multiple Hashing Schemes, Using Bloom Filter. TCAM-Based Routing-Table Partitioning, Technologies Forwarding Engine
Weidong Wu, Packet Forwarding Technologies , Auerbach Publications Taylor & Francis Group.

IT921 COMPUTER NETWORK SYSTEMS DESIGN 4
Traditional Protocol Processing Systems, Conventional Computer Hardware Architecture, Basic Packet Processing: Algorithms And Data Structures, Packet Processing Functions, Protocol Software On A Conventional Processor, Hardware Architectures For Protocol Processing, Classification And Forwarding, Switching Fabrics, Network Processor Technology The Complexity Of Network Processor Design, Network Processor Architectures, Issues In Scaling A Network Processor, Examples Of Commercial Network Processors, Design Tradeoffs And Consequences ability, Overview Of The Intel Network Processor, Embedded RISC Processor (XScale Core), Packet Processor Hardware (Microengines).
Version Douglas E. Comer. Network Systems Design Using Network Processors (Intel2XXX).

IT922 TOPICS IN AFFECTIVE COMPUTING 4
Introduction to affective computing; Emotion research from Cyber Psychology & Behaviour: concepts related to ‘affective computing' (e.g., emotion, mood, personality, attitude) in ways that facilitate their use in computing; Computational models of human emotion processes (e.g., decision-making models that account for the influence of emotion; predictive models of user emotional state); Studies on cross- cultural, group and cross-language differences in emotional expression; Behavior Generation & User Interaction: Computational models of visual, acoustic and textual emotional expression for synthetic and robotic agents; Models of verbal and nonverbal expression of various forms of affect that facilitate machine implementation; Methods to adapt interaction with technology to the affective state of users; Computational methods for influencing the emotional state of people; New methods for defining and

evaluating the usability of affective systems and the role of affect in usability; Methods of emotional profiling and adaptation in mid- to long-term interaction; Application of affective computing including education, health care, entertainment, customer service, design, vehicle operation, social agents/robotics, affective ambient intelligence, customer experience measurement, multimedia retrieval, surveillance systems, biometrics, music retrieval and generation; Sensing & Analysis: Algorithms and features for the recognition of affective state from face and body gestures; Analysis of text and spoken language for emotion recognition; Analysis of prosody and voice quality of affective speech; Recognition of auditory and visual affect bursts; Recognition of affective state from central (e.g. fMRI, EEG) and peripheral (e.g. GSR) physiological measures; Methods for multi-modal recognition of affective state; Recognition of group emotion.

Picard, R. (2000), "Affective Computing", Cambridge, MA: MIT Press.
Fellous, J-M, and Arbib, M. (2005), "Who Needs Emotions? The Brain Meets the Robot", Oxford University Press.
Minsky, M. (2007), "The Emotion Machine: Commonsense Thinking, Artificial Intelligence & Future of Human Mind", NY, NY: Simon & Schuster.
Lewis, M., Haviland-Jones, J.M., Feldman Barrett, L. (2010), "Handbook of Emotions", Third Edition. NY, NY: The Guilford Press.
Journal Articles from IEEE Transactions on Affective Computing [2010 to Till Date].

IT923 TOPICS IN BIG DATA ANALYTICS 4

Introduction to Big Data Analytics, Big Data Analytics Platforms, Big Data Storage and Processing, Big DataAnalytics Algorithms, Linked Big Data Analysis - Graph Computing and Network Science, Big Data Visualization, Big Data Mobile Applications, Large Scale Machine Learning, Big Data Analytics on Specific Processors, Hardware and Cluster Platforms for Big Data Analytics.

Michael Minelli , Michele Chambers, Ambiga Dhiraj [2013], "*Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley CIO.*
David Loshin [2013], "Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph", Morgan Kaufmann.
Mike Barlow [2012], " Real-Time Big Data Analytics: Emerging Architecture", [Kindle Ed.], O'Reilly Media.

IT924 TOPICS IN BIO-INSPIRED COMPUTING 4

Life: Life and Information, Logical Mechanisms of Life; Computation: Universal Computation and Computability, Simulations and Realizations; Limitations of Life: Computational Beauty of Nature, Bio-inspired computing, Natural computing, Biology through the lens of computer science; Complex Systems and Artificial Life: Complex Networks, Self-Organization and Emergent Complex Behavior, Cellular Automata, Boolean Networks, Development and Morphogenesis, Open- ended evolution; Evolutionary Algorithms: Evolution and Adaptation, Genetic Algorithms, Genetic Programming, Differential Evolution; Collective Behavior and Swarm Intelligence: Social Insects, Stigmergy and Swarm Intelligence, Competition and Cooperation, Communication and Multi-Agent simulation, Meta-Heuristics: Ant Colony Optimization, Artificial Bee Colony algorithm, Bat-Termite Algorithm Particle Swarm Optimization, Cat Swarm Optimization, Glowworm swarm optimization, Grey-Wolf Optimization, Wolf-pack Optimization, Multi-Swarm Optimization; Immuno-Computing: Artificial immune systems, Distributed Design for Computational Intelligence, Engineering Application.

Nunes de Castro, Leandro [2006], "Fundamentals of Natural Computing: Basic Concepts, Algorithms and Applications", Chapman & Hall.
Floreano, D. and C. Mattiussi [2008], "Bio-Inspired Artificial Intelligence: Theories, Methods and Technologies", MIT Press.
Nunes de Castro, Leandro and Fernando J. Von Zuben [2005], "Recent Developments in Biologically Inspired Computing", MIT Press.
Forbes, N. [2004], "Imitation of Life: How Biology is Inspiring Computing", MIT Press.
Flake, G. W. [1998], "The Computational Beauty of Nature: Computer Explorations of Fractals, Complex Systems and Adaptation", MIT Press.

IT925 TOPICS IN CLOUD COMPUTING 4

Overview of Cloud Computing: Cloud Computing Characteristics (elasticity, multi-tenant, on-demand, ubiquitous access, usage metering, self-service, SLA-monitoring, etc.), Cloud Computing and SOA, Enterprise Cloud drivers and adoption trends, Typical Cloud Enterprise workloads, Cloud service models & types (public, private, hybrid, and community clouds), Cloud deployment models (IaaS, PaaS, SaaS, BPaaS), Cloud ROI models, Cloud reference architectures, Cloud standards (OSDIAPIs, etc.), Technology providers vs. Cloud providers vs. Cloud vendors, Planning Cloud transformations (suitability assessment, future state definition, financial assessment and platform selection, roadmap definition); Infrastructure as a Service (IaaS): Virtualization-VMware/Xen/KVM virtualization, adaptive virtualization, Cloud Computing & on-demand resource provisioning, Infrastructure services (storage, compute, services management, cloud brokers, etc.), IaaS vendor solutions: Amazon EC2, HP, Microsoft, Savvis, Terremark, Right Scale, Rackspace cloud, IBM, Oracle, Verizon; Platform as a Service (PaaS): Cloud platform services (monitoring/management, application servers, messaging, data management, development and testing, integration, business intelligence, etc.), PaaS vendor solutions: EMC, Google App Engine, HP, IBM, Microsoft Azure, Rackspace, Savvis, Verizon, force.com, VMware vFabric, OpenStack, Eucalyptus, Storage-as-a-Service platforms (Google Storage, ObjectStore S3, Amazon Dynamo, etc.); Software as a Service (SaaS): Cloud application development lifecycle; SaaS platform services (application development, application migration, SaaS implementation, business intelligence - Cloud-based/big data/real time analytics); Quality of Service (QoS) Aware Load Balancing in Large Scale Heterogeneous Cloud Environment and other Recent Trends in Cloud Computing.

Kai Hwang, Jack Dongarra, Geoffrey C. Fox [2011], " Distributed and Cloud Computing: From Parallel Processing to Internet of Things", Morgan Kauffmann.
Rajkumar Buyya, Christian Vecchiola, S Thamarai Selvi [2013], "Mastering Cloud Computing", Tata McGraw-Hill. Toby Velte, Anthony Velte, Robert C. Elsenpeter [2010], " Cloud Computing: Practical Approach", *McGraw-Hill. Journal Articles from IEEE Transactions on Cloud Computing [2013 to Till Date]*

IT926 TOPICS IN GREEN COMPUTING 4

Introduction to Green Cloud Computing, Migrating into Cloud, Green IT: An Overview, Green Devices and Hardware, Green Software; Green Data Centers: Data Centers and Associated Energy Challenges, Data Centre IT Infrastructure, Data Centre Facility Infrastructure: Implications for Energy Efficiency, IT Infrastructure Management, Green Data Centre Metrics, Data Centre Management Strategies, Green Data Storage: Introduction, Storage Media Power Characteristics, Energy Management for Hard Disks, System-Level Energy Management; Green Networks and Communications: Introduction, Objectives of Green Network Protocols, Green Network Protocols and Standards, Sustainable Information Systems and Green Metrics; Green Cloud Computing and Environmental Sustainability: Energy Usage Model, Features of Clouds Enabling Green Computing, Towards Energy Efficiency of Cloud Computing, Green Cloud Architecture; Energy Adaptive Computing for Ecosystem: Implementing the Data Center Energy Productivity Metric in a High-Performance Computing Data Center, Sustainable Dynamic Application Hosting Across Geographically Distributed Data Centers, Energy Efficient task scheduling and Resources allocation at Data Center using Bio inspired Techniques, Energy Efficient Virtual Machine Provisioning and Migration w.r.t S.L.A agreements; Cloud Computing Tools : Simulators such as CloudSim, iCanCloud, Open Stack, Green Cloud, Open Nebula, Aneka; Recent Trends in Green Computing and IT.

"The Green Computing Book: Tackling Energy Efficiency at Large Scale", Edited by Wu-chun Feng, Chapman & Hall/CRC Computational Science, CRC Press, June 2014.
"Design Technologies for Green and Sustainable Computing Systems", Edited by Partha Pratim Pande, Amlan Ganguly, Krishnendu Chakrabarty, Springer, 2013.
"Harnessing Green IT: Principles and Practices", Edited by San Murugesan, G.R. Gangadharan, Wiley, 2012.
"Cloud Computing: Principles and Paradigms", Edited by Rajkumar Buyya, Jams Broberg, Andrzej Goscinski, Wiley, February 2011.

IT927 TOPICS IN INTERNET OF THINGS 4

IoT definitions: overview, applications, potential & challenges, and architecture; IoT examples: Case studies, e.g. sensor body-area-network and control of a smart home; Internet of Things: layers, protocols, packets, services, performance parameters of a packet network as well as applications such as web, Peer-to-peer, sensor networks, and multimedia; Mobile Networking: roaming and handoffs, mobile IP, and ad hoc and infrastructure less networks; Real- time networking: soft and real time, quality of service/information, resource reservation and scheduling, and performance measurements; IoT Security; IoT Ethics/Privacy; IoT in Energy/Environment; IoT in Infrastructure: Smart Homes/Cities; IoT in Healthcare.

Vijay Madisetti and Arshdeep Bahga, "Internet of Things: A Hands-On Approach", Published by VPT, 1st Ed., Aug. 2014.
Adrian McEwen, Hakim Cassimally, "Designing the Internet of Things", John Wiley & Sons, 2014.
Honbo Zhou, "The Internet of Things in the Cloud: A Middleware Perspective", CRC Press (Taylor &

Francis), 2013. Articles from IEEE Internet of Things Journal [2014 to Till Date].
Articles from IEEE Transactions on Emerging Topics in Computing [2013 to Till date].

IT928 TOPICS IN SOCIAL MEDIA ANALYSIS 4

Introduction and Phenomenology of Social Media: Social Information Processing in Social News Aggregation, Influence and correlation in social networks; Social Network Analysis: Networks, Crowds, and Markets: Reasoning about a Highly Connected World, Four Degrees of Separation; Topic Analysis: Probabilistic topic models, Matrix Factorization Techniques For Recommender Systems; Sentiment Analysis and Opinion Mining; Influence and Centrality in Social Networks; Wikipedia Knowledge Extraction; Search Query Logs; Social Ties and Information Diffusion; Social Ties and Link Prediction; Social Spam & Malicious Behavior; Geospatial Social Data Mining; Privacy in a Networked World; Health and Social Media; Politics and Social Media; Predicting Future with Social Media; Emotional Contagion, Friendship Paradox and Detection of Contagions; Crowd Sourcing; Modelling individuals and collective behaviour; Social Multimedia Analysis: Photos, Videos.

Stanley Wasserman, Katherine Faus, "Social Network Analysis: Methods & Applications", Cambridge University Press, 1994.
David Easley and Jon Kleinberg, "Networks, Crowds and Markets", Cambridge University Press,
2010 Christina Prell, "Social Network Analysis: History, Theory and Methodology", SAGE
Publications, 2011. John Scott, "Social Network Analysis", SAGE Publications, 3rd Edition, 2013.
Journal Articles from IEEE Transactions on Computational Social Systems, Elsevier Journal of Social Networks and Springer International Journal of Social Network Analysis and Mining.

IT929 NATURAL LANGUAGE PROCESSING AND APPLICATIONS 4

Introduction to NLP, History and Applications; Language Modelling: Grammar based Language Models, Statistical Language Models; Mathematical Foundations of NLP and Information Theory; Word Level Analysis and Collocation, n-grams; Syntactic Analysis: CFGs, Parsing, Treebanks, Semantics: Representing Meaning, Lexical Similarity, Lexemes, WordNets; Semantic Analysis: Word Sense Disambiguation; Sentiment Analysis and opinion mining, Generating and developing sentiment lexicons, learning lexicons, machine learning based techniques, case studies, Text Mining and Document Categorization Techniques; Machine Translation, NL Applications.

Christopher D. Manning and Hinrich Schütze, "Foundations of Statistical Natural Language Processing" MIT Press, 1999
Daniel Jurafsky and James H. Martin. "Speech and Language Processing: An Introduction to Natural Language Processing", Prentice Hall 2000.
Tanveer Siddiqui and U.S Tiwary, "Natural Language Processing and Information Retrieval", Oxford Press,
2008 James Allen, "Natural Language Understanding". Benjamin/Cummings, 2ed, 1995
Steven Bird. "Natural Language Processing with Python". O'Reilly, 2009

IT930 DEEP LEARNING FOR NATURAL LANGUAGE PROCESSING 4

Introduction to NLP and Deep Learning, Language Modeling, History and Applications, Basic Text Processing, Simple Word Vector representations: word2vec, GloVe, Advanced word vector representations: language models, softmax, single layer networks, Neural Networks and back-propagation -- for named entity recognition; Gradient checks, overfitting, regularization, activation functions; Recurrent neural networks -- for language modeling and other tasks; GRUs and LSTMs, Recursive neural networks -- for parsing and other applications; Convolutional neural networks -- for sentence classification; Reinforcement Learning and applications, The future of Deep Learning for NLP: Dynamic Memory Networks.

Li Deng and Dong Yu, "Deep Learning Methods and Applications", Microsoft Research, Foundations and Trends Book, 2014
Josh Patterson and Adam Gibson, "Deep Learning: A Practitioner's Approach" 1st Edition, 2016
Christopher D. Manning and Hinrich Schütze, "Foundations of Statistical Natural Language Processing" MIT Press, 1999
Collobert, Ronan, et al. "Natural language processing (almost) from scratch." Journal of Machine Learning Research 12.Aug (2011): 2493-2537.

IT931 INTELLIGENT INFORMATION RETRIEVAL 4

Introduction, Basics Concepts, IR System Architecture; IR Models and Operations - Preprocessing, Bag of Words, Indexing, Boolean, Term Weighting, Vector-Space Retrieval, Probabilistic Models, Best Match Models, Latent

Semantic Indexing, ; Experimental Evaluation of IR Systems; Document Representations; Query Operations and Languages; Relevance feedback and query expansion; Web Search and Link Analysis: Algorithms and evaluation; Structured Information Retrieval, Multimedia Information Retrieval; Recommender Systems; Information Extraction and Integration; Selected research papers on upcoming trends and open problems.

C. D. Manning, P. Raghavan and H. Schütze, Introduction to Information Retrieval, Cambridge University Press. 2008. Baeza-Yates & Ribeiro-Neto, Modern Information Retrieval, Pearson Education, 2010
Information Retrieval: Algorithms and Heuristics, by D. Grossman and O. Frieder, 2004
Information Retrieval: Implementing and Evaluating Search Engines, by S. Büttcher, C. Clarke, and G. Cormack., 2010 Korfhage Robert R, Information Storage and Retrieval, John Wiley & Sons, Inc, 1997.

IT932 TOPICS IN MULTIMEDIA INFORMATION RETRIEVAL 4

Introduction to multimedia information retrieval, Characteristics of MM data; similarity-based retrieval model-retrieval framework; feature engineering for multimedia, feature selection and extraction techniques, Color-based Retrieval: color models; histogram model; indexing and retrieval; relevance feedback; histogram refinement; color cluster technique; Texture-based Retrieval: texture models; statistical models; combined color-texture representation; Shape-based Retrieval: shape matching; contour -based method (Fourier descriptors); region-based method (moment invariants); Audio Retrieval: characteristics of audio data; spectrum analysis; pitch tracking; techniques for audio feature extraction, similarity matching and retrieval; Video Retrieval: Video segmentation in raw and compressed domain; key-frame extraction; video summarization and retrieval techniques; Multimedia Retrieval Framework: multi-attribute query processing; knowledge-based methods, Evaluation metrics for multimedia information systems; benchmarking, Multimedia Retrieval Trends, Applications; Research Problems.

R. Jain, R. Kasturi, B.G. Schunck (1995), Machine Vision, McGraw-Hill.
B. Furht, S.W. Smoliar, H.J. Zhang (1995), Video and Image Processing in Multimedia Systems, Kluwer, Boston. Roberto Raieli, "Multimedia Information Retrieval- Theory and Techniques", Elsevier, 1st Edition, 2013 Mark T Maybury, "Intelligent Multimedia Information Retrieval", AAAI Press, *MIT Press*
C. D. Manning et al., Introduction to Information Retrieval, Cambridge University Press. 2008.
Baeza-Yates & Ribeiro-Neto, Modern Information Retrieval, Pearson Education,2010

DEPARTMENT OF CHEMICAL ENGINEERING

CH901 Membrane Separation Processes **4**

Introduction, Classification of Membrane Processes, Membrane Materials and their Selection, Membrane modules. Transport in Membranes. Non-porous membranes. Flow patterns in membrane modules. Concentration Polarisation. Modelling and Design considerations of various membrane processes - Reverse Osmosis, Dialysis, Electrodialysis, Ultra filtration, Pervaporation, Gas permeation Membranes. Membrane Applications in Waste Water Treatment.

Seader J.D., Emest J. Henley, Separation Process Principles, John Wiley & Sons, 1998,
Judd S., B. Jafferman, Membranes for Industrial Waste Water Recovery and Re-use, Elsiever Publications, 2003.

CH902 Industrial Effluent Treatment **4**

Introduction - Waste water sources and characteristics. Classification, Application and Selection of treatment methods - Principles and design. Chemical preparation, chlorination processes, activated sludge process, aerated lagoons, trickling filters, sludge digestion facilities, waste water reclamation and reuse. Treatment of effluents in specific industries.

Metcalf and Eddy, Waste water Engineering - Treatment, Disposal and Re-use, Tata-McGraw-Hill, 1991.
Mahajan S.P, Pollution Control in Process Industries, Tata-McGraw-Hill, 1985.
Arundel J, Sewage and Industrial Effluent Treatment, Blackwell Sewer Ltd., 1995.

CH903 Instrumental Techniques for Effluent Analysis **4**

Fundamentals. Spectro Analytical Methods. Chromatographic Methods. Electro and Radio Analytical Methods. Thermal Analysis.

Willard H., Merritt, L. Dean D.A. and Settle F.A., Instrumental Methods of Analysis, CSS Publisher, 1986.
Ewing C.W., Instrumental Methods of Chemical Analyser, 5th Edition, McGraw Hill 1995.

CH904 Computational Methods for Process Simulations **4**

Introduction to Computational Methods. Modelling and Simulation of chemical Engineering systems. MATLAB - Simulation exercises using MATLAB.

Ramirez W.F., Computational Methods in Process Simulation, Butterworth, 1989.
Franks R.E, Modelling and Simulation in Chemical Engineering, John Wiley, 1972.
Rudra Pratap, MATLAB - A Quick Introduction for Scientists and Engineers, Oxford University Press, 2002.

CH905 Fundamentals of Biochemical Engineering **4**

Microbiology. Environmental and Industrial microbiology, ecology, microbiology of soil and air. Laboratory techniques in microbial operation. Control of Microorganisms by physical and chemical methods Biochemistry/Chemistry of life Microbial metabolism, biosynthesis, molecular genetics and control systems Mechanism and kinetics of enzyme catalysed reactions. Mixed microbial populations in applications.

Bailey J.E. and Ollis D.F., Biochemical Engineering Fundamentals, McGraw Hill, 1977.
Aiba S., Biochemical Engineering, Academic Press, 1965.
N.J.Pelczar Jr. Microbiology, McGraw Hill, 1988.

CH906 Design & Analysis of Bioreactors **4**

Transport Phenomena in bioprocess systems. Design of bioreactors. Sterilization reactors, Immobilized biocatalysts, Multi-phase bioreactors, Design and operation of typical fermentation process. Operating considerations for bioreactors. Selection, scale up, operation, Instrumentation and control of bioreactors. Product recovery operations.

B.Atkinson, Biochemical Reactors, Pion Ltd. 1974.
Michael L. Shules, Fikret Kargi, Bioprocess Engineering - Basic Concepts, Prentice Hall, 1992.
Baily J.E and D.F.Ollis, Biochemical Engineering Fundamentals, McGraw-Hill, 1977.

CH907 Modeling & Simulation of Environmental Bioprocesses **4**

Modeling Principles. Formulation of Dynamic balance equations. Chemical and Biological reaction systems. Modes of reactor operation. Modeling of bioreactor systems. Mass transfer theory. Optimization, parameter estimation and sensitivity analysis. Description, modeling and simulation of waste water treatment processes. Primary treatment processes. Secondary treatment processes.

Snape J.B, Dunn I.J, Ingham J., Prenosil J.E., Dynamics of Environmental Bioprocesses, V& H Publishers, 1995
Jasun K. Ghosh, Process Computations in Biotechnology, McGraw Hill 1994.

CH908 Applied Mathematics for Chemical Engineering 4

Introduction to computational methods - Matrix algebra by computers, elementary matrix operations, solutions of simultaneous linear equation, eigen values and eigen vector problems, matrix representation of extremum problems. Finite difference method. Solution of ordinary differential equations, partial differential equation. *Hanna O.T. and Sandall O.C., Computational Methods in Chemical Engineering, Prentice Hall, 1995*

Brebba C. A., and Ferranta A. J., Computational Methods for Solution of Engineering Problems, Pented Press, 1978.

CH909 Genetic Engineering 4

Isolation of genes using probes, Modifying the genes using DNA modifying enzymes, Cloning and expression vectors, Plasmid, Lambda, Cosmid, BACs, YACs, MACs, Construction and screening of genomic and cDNA library. Chromosome walking. Techniques of transformation / Introduction of DNA into animal cells and plant cells. DNA sequencing by Maxim and Gilbert method, Sanger method, automatic sequencing. Gene analysis techniques: Nucleic acid hybridization, Southern and Northern Blotting. Polymerase chain reaction - Types, application, RAPD, AFLP, Microsatellite, EST, SNP. DNA chip technology : microarrays, types, technique and applications. Applications of genetic engineering in Agriculture, Industry, Pharmaceuticals and therapeutics.

Principle of gene manipulation, R. N. Old and S.B. Primrose, 1994, Blackwell scientific Publication

Molecular Biology of the gene. J.D. Watson, W.H. Hopkins, J.W. Roberts, J.A.Steitz and A.M. Weiners, The Benjamin Cummings

Publication Company, Inc. California

Genes, B. Lewin, Oxford University Press, New York.

Gene cloning. T.A.Brown, Chapman and Hall 1998

From Genes to Clones. Winnacker EL. VCH, 2003

CH910 Molecular Biology 4

Central Dogma of molecular biology; DNA helix topology and types of DNA. Genetic code, Wobble hypothesis. Concept of prokaryotic gene structure and eukaryotic gene structure, C-value paradox, gene families and multigene concepts. DNA replication: In prokaryotes and Eukaryotes, Role of regulatory proteins and enzymes in replication. Transcription: Mechanism in prokaryotes, .Eukaryotic transcription, RNA polymerase, transcription factors, initiation, elongation and termination. Post transcriptional modification- capping, polyadenylation, splicing. Translation: Amino acid activation, amino acylation of tRNA, Prokaryotic and eukaryotic translation mechanism of initiation, elongation, termination and inhibitors of translation, post translational modifications. Regulation of gene expression in prokaryotes: control elements, negative and positive regulation with operon concept of *lac* and *trp*. Regulation of gene expression in Eukaryotes: cis control elements, promoters, enhancers, Trans acting factors, Activators, hormonal regulation of gene expression, post transcriptional control.

Molecular biology of cell, Alberts, B, D. Bray, J.Lewis, M. Raff, K.Roberts and J.D.Watson. Garland Publising company inc. NewYork.

Molecular Cell Biology, Lodish H., D. Baltimore, A.Berk, S.L.Zipurksy, P.Matsudaira and J.Darnell, 1995, Scientific American books, Inc,.NewYork.

Cell and Molecular Biology, G.Karp. John Wiley and Sons Inc. Molecular Biology. D.Freifelder. Narosa Publishing House.2000

CH911 Fluid - Particle Systems 4

Hydrodynamics of fluidized beds; bubbles in dense beds; flow patterns in fluidized beds; entertainment and elutriation in fluidized beds; spouted beds - hydrodynamics; applications.

D. Kunii and O. Levenspiel, Fluidization Engineering, John Wiley & Sons, 1969. J. F. Davidxon and D-Harrison, Fluidization, Academic Press, 1971.

CH912 Adsorption & Catalysis 4

Equilibria, Kinetics, measurement techniques multicomponent, Adsorption equilibria. Porous media, bulk separation, purification purposes, characterization of catalysts, experimental methods in catalysis.

Mantell C. L., Adsorption, McGraw Hill, New York, 1951.

Adsorption Analysis - Equilibria and kinetics, D.O.D.D., ICP, London, 1998

Chakrabarty, D. K., Adsorption and catalysis by solids, Wiley, New Delhi, 1990.

DEPARTMENT OF MECHANICAL ENGINEERING

ME900 Satellite Thermal Control **3**

Introduction: Satellite Temperature and Thermal Energy Management. Relation Between Heating and Temperature: Method of Control. Thermal Interface Requirements. Heat Transfer: Conduction, Convection, Radiation. Radiation in Thermal Control, Heating Fluxes, Orbit Environment Heating Fluxes, Satellite Thermal Analysis, Thermal Energy Equation, Thermal Model, Approximate Analytical Solution, Thermal Control Hardware, Heat Pipes, Thermal Verification Tests. Design and analysis of electronic devices.

References: Robert D. Karam, Satellite Thermal Control for System Engineers.

ME901 Estimation of Thermodynamic & Thermo physical Properties of Working Fluids **3**

Development of thermodynamic and thermophysical properties of various working fluids used in power plants, refrigeration plants (pure and mixtures)

ME902 Computer Simulation of IC Engines **3**

Introduction S.I. Engines and C.I. engines, reactive processes, adiabatic flame temperature, isentropic changes of state, simulation: with air as working medium, with adiabatic combustion, with progressive combustion, with gas exchange processes.

References: V. Ganesan, computer simulation of S.I. Engines processes, Universities press V. Ganesan, computer simulation of C.I. Engines processes, Universities press Ramos J.I, internal combustion engine modelling, Hemisphere publishing Corp

ME903 Tribology **3**

Introduction to Tribology, Basic Principles of Tribology, Elements of Contact Mechanics, Friction, Lubrication and Wear in Kinematics pairs, Sliding element and Rolling contact Bearings, Lubrication and efficiency of Involute Gears. Tribological properties of solid materials, metals, bearing, alloys, solid lubricants, polymers and composites, ceramics and cermets, super alloys. Materials for Nuclear Reactors. Friction Materials for Clutches and Brakes. Surface treatments to reduce wear.

References: T.A. Stolarshi, Tribology in Machine Design, Industrial Press Inc. 1990.
Arnell R.D., Davies P.B., Halling J., Whomes T.L., Tribology, Principles and Design Applications, Springer Verlag.
Karl-Heinz Zum Gahr, Microstructure and Wear of Materials, Elsevier, 1987.
William A. Glaeser, Materials for Tribology, Elsevier, 1992.

ME904 Failure of Materials **3**

Modes of Mechanical Failures, High cycle & low cycle fatigue, Use of statistics in fatigue analysis and testing. Concepts of cumulative damage, Life Prediction and Fracture Control, Tribological Failures - Frelting, Frelting Fatigue and Frelting Wear, Buckling and Instability, creep, stress rupture, corrosion.

References: J.A. Collins, Failure of Materials in Mechanical Design - Analysis, Prediction, Prevention, John Wiley, 1981.
Metal Failures: Mechanisms, Analysis, Prevention, A. J. McEvily, 2001, Wiley.
ASM Handbook: Volume 11: Failure Analysis and Prevention (ASM Handbook) (ASM Handbook)10th Edition by W. T. Becker (Author), R. J. Shipley (Author), 2002.

ME905 Advanced welding processes **3**

Welding- Analysis of HAZ- optimization of process parameters in welding process- Modeling of metal flow and Heat transfer in welding process- Recent developments in the metal joining process.

References: Saddat Ali Rivzi, Advanced Welding Technology, S. K. Kataria & Sons, 2010,
Joseph William Giachino, William R. Weeks, George Stewart Johnson ,Welding technology 2nd edition, American Technical Society, 2007
Little Mn ,Welding & Welding Technology, Tata McGraw-Hill Education, 2001
Radhakrishnan, Welding Technology And Design, 2nd edition, New Age International, 2005,
A. L. Phillips, Welding Handbook: Fundamentals of welding, American Welding Society, 2009
Boniface E. Ross , Welding Engineering, McGraw-Hill Interamericana, 2007

ME906 Advanced Metal Casting Process **3**

Analysis of fluid flow and heat transfer in solidification process.- Science of solidification phenomena- Microstructure

modeling - Simulation studies in metal casting- Modern trends in metal casting.
References: Roy A. Lindberg, Process and materials of manufacturing , Allyn and Bacon publication, 4th edition, 1990. Richard W. Heine, Carl R. Loper, Philip C. Rosenthal , Principles of Metal Castings , Tata McGraw-Hill Education, 2nd edition, 2001.
P.N. Rao, Manufacturing Technology, Tata McGraw-Hill Education, 3rd edition, 2009

ME907 Composite materials **3**

Analysis of PMC, CMC and MMC - Recent advances in processing of composite materials- Natural composites- Nano-composites- Modeling and analysis of composite structures for engineering applications- FEM of composite structure.
References: Mein Schwartz , Composite Materials Handbook - Mc Graw Hill, 2nd edition , 1992
Autar K Kaw Mechanics of Composite Materials - CRC Press New York. – 2nd edition, 1997.
Rober M. Joness , Mechanics of Composite Materials - Taylor & Francis Group, 2nd edition, 1999.
M. W. Hyer, Scott R. White, Stress Analysis of Fiber Reinforced Composite Materials , Destech Publications, Inc, 2009.
Krishan K , Chawla , Composite Material Science and Engineering , Springer, 2nd edition - 1999.
P.C. Mallik , Fiber Reinforced Composites , Marcel Decker- 2nd edition, 1993.

ME908 Nonlinear and Random Vibration **3**

Nonlinear Vibration, Introduction, Examples of nonlinear vibration problems, exact methods, Approximate analytical methods, Sub harmonic and super harmonic oscillations, Graphical Methods, Stability of equilibrium states, Chaos. Random Vibration, Introduction, Random variables and random processes, Probability Distribution, Mean Value and standard deviation, Probability distribution and Correlation functions, Stationary and Gaussian Random Process, Fourier Analysis, Power spectral density, Wide-band and Narrow Band process, Response of a single degree of freedom system. Response due to stationary random excitations,
References: Mechanical Vibrations, by Singiresu S Rao, Pearson Education, 2011.
Mechanical Vibrations Theory and Applications, by S Graham Kelly, Cengage Learning, 2012.
Theory of Vibration with Applications, by Willimam T Thomson, Marie Dillon Dahleh and Chandramouli Padmanabhan, Pearson Education, 2008.
Elements of Vibration Analysis by Leonard Meirovitch McGraw Hill (India) Education, 2014

ME909 Mechanics of Metal Removal Processes **3**

Single and multi point cutting, Force analysis in various machining processes, friction, Abrasive processes, AJM, USM, ECM, EDM, LBM, EBM, Hot machining, high speed machining, cryo machining, Special purpose machining
References: Modern machining process by PANDEY AND SHAH, TATA McGraw Hill
Metal Cutting Principles: M.C Shaw, Oxford Publication.
Metal Cutting by Edward.W. Trent.Butterwork.
Fundamentals of Metal Machining & machine tools by Boothroyd. McGraw-Hill.
Manufacturing Technology: Metal cutting and machine tools, P N Rao, Mc Graw Hill.

ME910 Modelling of Mechatronic Systems **3**

Building blocks of mechatronics system, working principals of dynamic systems, modelling and control strategies, order of system equations, lumped mass and continuous systems, CAD tools for modelling, Bond graph approach to modelling
References:
Dean C. Karnopp, Donald L. Margolis, Ronald C. Rosenberg System Dynamics : Modeling and Simulation of Mechatronic *Systems 5 edition Wiley-Interscience;*
Ernest O. DoebelinSystem Dynamics: Modeling, Analysis, Simulation, Design Marcel Dekker 1998
CRC plus, 2009 *Shuvradas : Mechatronic modeling and simulation using bond graph,*

DEPARTMENT OF METALLURGICAL & MATERIALS ENGINEERING

MT900 METALLURGICAL PROCESS DESIGN 3

Design and its significance. Modern trends, fluid flow and heat transfer principles applicable to design. Furnaces, classifications, Glinkove theory. Burners. Principles of chimney design. Fuel economy. Design features of electric arc furnac

A. *Glinkove, A general Theory of Furnaces, MIR Publishers Moscow,*
1980. G. E. Dieter, Engineering Design, 2nd Edition, McGraw Hill, 1990.

MT 901 MASS TRANSPORT 3

Diffusion in solids, liquids, gases. Diffusion in ceramic materials and elemental semiconductors, Diffusion through porous media Steady state diffusion and transient diffusion, Finite system solutions, microelectronic diffusion processing, homogenization of alloys and formation of surface layers. Diffusion through a stagnant gas film, diffusion into a falling liquid film. Concentration boundary layer

Mass transfer, General equation of diffusion with convection, concept of mass transfer coefficient, mass transfer correlations, models of mass transfer coefficient, mass transfer in chemical vapour deposition, interphase mass transfer, overall mass transfer, interfacial turbulence, enhanced vaporization.

Batch and continuous chemical reactors, F and C diagrams, eddy diffusion model, design of chemical reactors, staged operations.

Motion of bubbles in fluids, impinging jets and submerged jets, Droplet generation in the BOF steelmaking process, Wakelin model.

D. R. Poirier and G. H. Geiger, Transport Phenomena in Materials Processing, TMS Warrendale, 2016, ISBN 978-3-319-48565-2 ISBN 978-3-319-48090-9 (eBook) DOI 10.1007/978-3-319-48090-9

N.J. Themelis, Transport and Chemical Rate Phenomena, Gordon Breach, 1995, ISBN-10: 2884491279 | ISBN-13: 9782884491273

R.I.L. Guthrie, Engineering in Process Metallurgy, Clarendon Press, 1992, ISBN-10: 0198563671 | ISBN-13: 978-0198563679

S Seetharaman, Fundamentals of Metallurgy (Woodhead Publishing Series in Metals and Surface Engineering) 1st Edition, ISBN-13: 978-1855739277ISBN-10: 1855739275

MT902 THERMODYNAMICS OF MATERIALS 3

First law of thermodynamics, second law of thermodynamics, some relations between thermodynamics quantities, thermodynamics of phase transformation and chemical reactions. Partial molar and excess quantities. Thermodynamic properties of alloy system - equilibrium between phases of variable composition. Free energy of binary system. Thermodynamics of surfaces and interfaces. Classification of defects in the crystal, defects in the metals, defects in elemental semiconductors, defects in nearly stoichiometric compound, defects in non - stoichiometric compound.

R. A. Swalin, Thermodynamics of solids, John Wiley, 1962

MT903 SOLIDIFICATION PROCESSING 3

Science of Solidification, Thermodynamics of solidification, Concept of Undercooling, Homogeneous and Heterogeneous nucleation, Theory of Nucleation Rates, Growth in Pure Metals & Alloys, Constitutional supercooling, Nucleation ahead of an advancing interface, Eutectic growth structures, Modification and Grain refinement of Al-Si Alloys.

Concept of liquid metal engineering, Solidification heat transfer, Casting & Moulding Processes, Sand Quality Control, Special Casting Techniques, Aluminium, Cast iron and Steel Foundry Practice, Melt treatment and product quality.

Flow of liquid metals in moulds, Elements of Good Gating Design, Concept of bifilms, Campbell' s Ten Rules, Feeding of Castings, The Seven Feeding Rules, Feeding Mechanisms, Engineering Design of Castings, Defects in Castings, Rapid Solidification, semi solid processing.

Processing and properties, homogenization, mechanical properties of equiaxed cast structure, properties of columnar structure, effect of working.

J. Campbell, Complete Casting Handbook, 2nd Edition, Metal Casting Processes, Techniques and Design, Butterworth-Heinemann, 2015. ISBN ISBN: 9780444635099

Peter Beeley,Foundry Technology, 2nd Edition, Butterworth-Heinemann, 2001, ISBN: 9780750645676

D.M.Stefanescue, Science & Engineering of Casting Solidification, Second Edition, Springer Science, 2009 ISBN 978-0-387-74612-8

W.C.Winegard, Solidification of Metals, Institute of Metals, 1964
D. R. Poirier and G. H. Geiger, Transport Phenomena in Materials Processing, TMS Warrendale, 2016, ISBN 978-3-319-48565-2
M.C. Flemings, Solidification Processing, McGraw Hill, 1974, ISBN-13: 978-0070212831

MT904 MATERIALS SCIENCE & ENGINEERING 3
Introduction, atomic structure and bonding, crystal structure and crystal geometry, solidification, crystal imperfections and diffusion in solids, electrical properties of materials, mechanical properties of metals, polymeric materials, phase diagrams, engineering alloys, ceramic materials, silicate structure, processing of ceramics, electrical, mechanical, thermal properties of ceramics. Magnetic materials, corrosion, composite materials, optical properties, superconducting materials.
E. Reed Hill, Introduction to Physical Metallurgy, Van Nostrand, East west Press, New Delhi, 1973.

MT905 PLASTIC DEFORMATION 3
Interatomic forces, metallic crystals and their elastic properties, elementary theory of structural imperfections in crystals, plastic deformation of single crystals, plastic deformation of polycrystals. Deformation textures, characteristics and driving forces of softening process in deformed crystals. Fracture, resistance of metal to plastic deformation, ductility and deformability of metals and alloys, thermo-mechanical treatment, superplasticity and its applications.
G. E. Dieter, Mechanical Metallurgy, McGraw Hill, 1988.

MT906 STRUCTURE & PROPERTIES OF ALLOYS 3
Structure of pure metal, properties of pure metal, solidification solid solution, working and annealing, two phase alloy, Aluminum alloys and age hardening, magnesium and berylium, theory of heat treatment of steels, steels for structural applications, carbon and alloy tool steels, stainless steels, cast iron, reactive and refractory metals for high temperature applications, failure of materials, non-destructive testing.

MT907 HEAT TRANSFER 3
Modes of heat transfer, one dimensional, steady state conduction, transient conduction, external flow (convection), internal flow (convection), free (natural, buoyant) convection, boiling and condensation, radiation, radiation exchange between surfaces.
J. P. Holman, Heat Transfer, 9th Edition, McGraw Hill, 2002.

MT908 MATERIALS DEGRADATION AND PROTECTION 3
Definition of corrosion, corrosion damage, standard expressions for corrosion rate, classification of corrosion, electrochemical aspects, electrochemical reactions, Pourbaix diagrams, mixed potential theory, polarization, Evan's diagrams, passivity, effects of environment - oxygen and oxidizers, temperature, corrosive concentration, cathode/anode area ratio, galvanic coupling using mixed potential theory. Forms of corrosion - uniform, galvanic, crevice, intergranular, pitting, selective leaching, erosion, stress corrosion, corrosion fatigue, fretting. Corrosion rate measurements - Tafel and linear polarization, AC impedance, small - amplitude cyclic voltammetry. Corrosion testing. Interpretation of results, Corrosion protection: materials selection, alternative environment, design, cathodic and anodic protection, coatings, High - temperature corrosion: mechanisms and kinetics, high - temperature materials.
Mars G. Fontana, Corrosion, McGraw - Hill Book Company 1986.
David Talbot and James Talbot, Corrosion Science and Technology, CRC Press, NewYork, 1998
Denny A. Jones, Principles and Prevention of Corrosion, Maxwell Macmillan 1992
Metals Handbook, Vol.13, Corrosion, ASM Metals Book, Ohio,1987.

MT909 SURFACE MODIFICATION TECHNOLOGY 3
Surface Cleaning: Classification and Selection of Cleaning Processes Finishing Methods: Classification and Selection of Finishing Processes; Topography of Surfaces; Microstructural Analysis of Finished Surfaces Plating and Electroplating: Electrodeposition Processes: Copper Plating; Nickel Plating; Zinc Plating; Zinc Alloy Plating; Selective (Brush) Plating; Electroforming. Nonelectrolytic Deposition Processes: Eletroless Nickel Plating; Electroless Alloy Deposition Dip, Barrier and Chemical Conversion Coatings: Batch Hot Dip Galvanized Coatings; Phosphate Coatings; Chromate Conversion Coatings; Rust Preventive Compounds; Painting; Ceramic Coatings and Linings;

Anodizing. Vacuum and Controlled - Atmosphere Coating and Surface Modification Processes: Thermal Spray Coatings; Chemical Vapor Deposition of Nonsemiconductor Materials; Chemical Vapor Deposition of Semiconductor Materials; Plasma - Enhanced Chemical Vapor Deposition; Growth and Growth - related Properties of Films Formed by Physical Vapor Deposition; Vacuum Deposition, Reactive Evaporation, and Gas Evaporation; Sputter Deposition; Ion Plating; Ion-Beam-Assisted Deposition; Arc Deposition; Ion Implantation; Diffusion Coatings; Pulsed - Laser Deposition. Testing and Characterization of Coatings and Thin Films: Film Thickness Measurements Using Optical Techniques; Corrosion Testing; Evaluation of Mechanical Properties of Thin Films.

P. K. Dutta & I. S. Gray, Surface Engineering, Vol. I - III, Royal Society of Chemistry, 1993.
ASM Hand Book, Vol.5, ASM International, Metals Park, Ohio, 1999.
Kenneth G. Budinsk, Surface Engineering for wear resistance, Prentice Hall, NJ 1988.

MT910 ADVANCED CHARACTERIZATION TECHNIQUES 3

Spectroanalytical Methods: Introduction and fundamentals, Beer-Lambert's law, Selection rules; Fundamental principles, instrumentation and applications of IT spectroscopy, UV-visible spectroscopy, Raman spectroscopy, Atomic absorption spectroscopy; Thermal Analysis: Fundamental principles, instrumentation and application of Thermogravimetry, Differential thermal analysis, Differential scanning calorimetry, Dynamic mechanical thermal analysis, Hyphenated techniques; Surface characterization by spectroscopy, Fundamental principles, instrumentation and applications of X-ray photoelectron spectroscopy, TOF-SIMS; Surface analysis by microscopy, Fundamental principles, instrumentation and application of Scanning probe microscopy, Scanning tunneling microscopy, sample preparation techniques for electron microscopy.

J. W. Robinson, E. M. S. Frame and G. M. Frame II, Undergraduate Instrumental Analysis, 6th Ed., Marcel Dekker, 2005.
D. A. Skoog, F. J. Holler and T. A. Nieman, Principles of Instrumental Analysis, 4th Ed., Harcourt, 2001.
C. R. Brundle, C. A. Evants, Jr., and S. Wilson, Encyclopaedia of Materials Charaterization, Butterworth-Heinemann, 1992
J. D. Menczel, R. B. Prime, Thermal Analysis of Polymers, Wiley, 2009.
http://www.cem.msu.edu/~reusch/VirtualText/Spectrphy/spectro.htm#intro

DEPARTMENT OF CHEMISTRY

CY900 Polymer Chemistry **4**

Introduction. Classification. Elastomers, Fibres and Plastics. Copolymers. Types of polymerization, mechanisms and kinetics. Metathesis. Group-Transfer polymerization. Solution Properties, Thermodynamics, and Molecular-weight determination. Thermal properties and Degradation, Stability, & environmental issues. Polymer recycling. Biodegradation. Polymer additives, blends, interpenetrating networks & composites. Applications for polymers in separations, biotechnology, and electronics - Membrane separations, Biomedical applications. Applications in electronics. Photonic polymers.

Joel R. Fried, Polymer Science and Technology, Prentice Hall 1999.
Fred W. Billmeyer, Jr, Text Book of Polymer Science, Wiley-Interscience 1985.

CY901 Advanced Organic Chemist **4**

Stereochemistry: Asymmetric carbon atoms. Configuration. Racemic modification. Properties. Resolution. Conformations. O R D. and Circular Dichroism. Named Organic reactions, Rearrangements and Reagents. Photochemistry: Photochemical reactions. Woodward-Hoffmann rules. Proteins and Enzymes. Structure. Vitamins and Nucleic acids. Biosynthesis of pyrimidines, purines and proteins, Haemoglobin. *Ernest L. Eliel, Stereochemistry of carbon compounds, Tata McGraw-Hill, 1976. I. L. Finar,Organic Chemistry, Vol. 1 and 2, ELBS and Longman, 1975.*

CY902 Spectroscopy of Organic Compounds **4**

UV-Visible Spectroscopy: Principle, Instrumentation, and its applications in structural elucidation of organic compounds. Quantitative analysis. IR-Spectroscopy and Raman spectroscopy: Theory and FT Raman Spectrometer. Applications. NMR Spectroscopy: Quantum description of NMR. NMR spectrometer. Sample handling. Applications to structure determination. Carbon-13 NMR. Nuclear Overhauser enchancement. Applications of NMR to P-31 and F-19 nuclei, 2-D NMR. Mass spectrometry: Principle. Double focusing spectrometer. Identification of organic compounds. Structural information and fragmentation patterns. Rearrangements. GCMS and its applications. J. R. Dyer, Applications of absorption spectroscopy of organic compounds, Prentice Hall, 1974.
D. A. Skoog, F. J. Holler, T. A. Nieman, Principles of Instrumental Analysis, Harcourt Asia PTE Ltd., V Ed., 1992.

CY903 Chromatography **4**

Classification and Principles of Chromatography: Theory and general description of various types and applications. Gas Chromatography: Instrumentation and applications. Gas-solid chromatography. Liquid Chromatography: Types-Liquid-solid. Liquid-liquid. Instrumentation. HPLC: Instrumentation, Components, and applications. Partition chromatography, Ion chromatography and Gel Permeation chromatography: Theoretical plate theory and applications. Ion Chromatography: Ion-exchange resins, ion selectivity, Applications, Gel permeation chromatography: Theory & applications in polymer analysis. Paper chromatography, Thin layer chromatography. Adsorption chromatography: Solvents, development of chromatogram.

Lloyd R Snyder, Principles of Adsorption Chromatography, Marcel Dekker Inc, 1968. R. Stock and C. Rice, Chromatographic Methods, II Ed, Chapman and Hall, 1967.

CY904 Advanced Physical Chemistry **4**

Quantum Mechanics: Schrodinger wave equation: Solutions for simple systems. Particle in a 3-d.box. Radial probability distribution. Wave mechanical treatment of probability distribution. Chemical Kinetics and Catalysis: Kinetics and mechanism of complex reactions, Molecular reaction dynamics. Acid-base and Enzyme catalysis. Quantitative correlations of reaction rates and equilibria. The Hannut and Taft equations. Ionic equilibria and Electrolytic Conductance: The theory of electrolytic conductance. Debye- Huckel limiting equations. Instrumental Methods of Electrochemistry: Polarization. Overvoltage. Electroanalysis and coulometry-principles & applications. Voltametry and Polarography: Principles. Kinetics of electrochemical reactions.

Samuel Glestone, An introduction to Electrochemistry, East-West edition, New Delhi.
Paul Delahay, New Instrumental methods is electrochemistry, Interscience .

CY905 Advanced Inorganic Chemistry **4**

Acids and Bases: Acid-base concepts. Strengths. Solvents: Theory and factors affecting solubility. Energy change. Born equation. Coordination Chemistry-I: Valence Bond Theory for Complexes, Inner and outer orbital complexes. Magnetic properties, Crystal Field Theory. Molecular Orbital Theory- for sigma bonding complexes and pi-bonding complexes. Coordination Chemistry II: Spectral properties. Magnetic permeability and susceptibility. Factors affecting stability, Kinetics and mechanism of reactions of complexes. Organometallic Chemistry: Metal carbonyls, Nitrosyls, Metallocenes, Dinitrogen compounds.

J.E. Huhuy, E.A. Keiter, R.L. Keiter, Inorganic Chemistry: Principle of Reactivity and Structure, Addison Wesley Pub.1993. H.J. Emeleces and A.G. Sharpe, Modern Aspects of Inorganic Chemistry, Universal Book Stall, New Delhi, 1989.

CY906 Environmental Chemistry **4**

Concept and scope of Environmental Chemistry. The hydrological, oxygen, nitrogen, phosphate and sulphur cycle. Atmosphere: Composition, structure and evolution. Chemical and photochemical reactions. Water resources, Physical Chemistry of sea and fresh water. Composition of Lithosphere, water, air, organic and inorganic components in soil. Air pollutants: CO, NO_X , Hydrocarbons, Photochemical smog, SO_2, acid rain, particulates, radioactivity. Tropospheric chemistry. Water pollution. Water quality parameters, sampling, preservation, monitoring techniques and methodology. Chemical toxicology: Toxic chemicals and their impact on the environment.

A.K.De, Environmental Chemistry, New Age Intl.(Pvt) Ltd.,1998.
Peter O'neil, Environmental Chemistry, Chapman and Hall, 1985.

CY907 Electroanalytical & Thermal Methods **4**

Conductometry: Conductivity. Measurement. Conductometric titrations - principle of different types. High frequency titrations. Potentiometry: Theory. Various types of Potentiometric titrations. Voltammetry: Polarography. Principle and applications. Sinusoidal a.c. polarography. Stripping voltammetry. Amperometric titrations. Biamperometric titrations. Chronopotentiometry. Electrogravimetry. Coulometry. Thermogravimetry. Theory and Instrumentation. Differential thermal analysis. Instrument, applications. DSC. Instrument and applications. Thermometric titrations.

G.H.Jeffery & others, Vogels Textbook of quantitative Chemical analysis, V Ed. Longman.
Willard, Merritt, Dean and Settle, Instrumental methods of analysis, VI Ed., CBS Publishers and Distributors, Delhi, 1986.

CY908 Advanced Membrane Technology **(4-0-0) 4**

Introduction, Importance of membranes in water management, Types of membranes; Micro filtration, Ultra filtration, Nano filtration, Reverse osmosis membranes. Advantages of NF membranes over RO membranes, common materials used for preparation of membranes, requirements of good membranes, various applications of synthetic membranes, different types of membrane preparation Nafion membranes, polysulphone based membranes, cellulose acetate membranes. Membranes for fuel cell applications. Support for membranes. Characterization of membranes by SEM, performances studies of different membranes.

Naylor T Dev, Polymer membranes Elsevier science, Vol8, No5, 1996.
Schafer A, Anthony Fane T David Waite, Nanofiltration: Principles & applications. ElsevierSscience, 2002. Rijin C.J.M Van, Nano and micro engineered membrane technology. Elsevier Science 2004.

CY 909 Advanced Electrochemical Methods of Analysis **(4-0-0) 4**

Introduction, principles of potentiometry and polarogrpahy, cyclic volametry, stripping voltametry, Concept of parallel plate capacitors and its applications, super capacitors, Energy storage devises, Semiconductor electrodes, Potentyiodynamic and galvanodynamic polarization method for corrosion study, AC impedance spectroscopy and its advantages over DC method, Interpretation of Nyquist and Bode's plot, p-n type capacitors, Mott-Schottky plot. Capacitance vs. E plot. Electrochemical Noise study and its applications. Scanning electrochemical microscope (SECM): Instrumentation and its applications. Inhibitors, Frumkin and Langmuir adsorption. Electrochemical methods in development and characterization of nano materials.

Banerjee S N, An Introduction to Corrosion and Corrosion Inhibition, Oxonian Press Ltd., New Delhi, 2000. Fontana M G and Greene N D , Corrosion Engineering McGraw Hill New York, 3rd Edn., 2004. Roos Macdonald J, Impedance Spectroscopy, John Wiley and sons, new York. 1987. Stephen Bialkowski, Photothermal Spectroscopy Methods for Chemical Analysis, Wiley-Interscience, 1996. Robert Cottis and Stephen Turgoose, Electrochemical impedance and noise, NACE International, 1999.

CY 910 Specialty Polymers **(4-0-0) 4**

Conjugated or conducting polymers (CPs), types of conjugated polymers: polyacetylene, PPP, PPV, polythiophenes, polypyrroles, polyfluorenes and their synthetic methods, determination of molecular weights (number average and weight average) of polymers: gel permeation chromatography-theory, conductivity in CPs:doping dopants and doping level, mechanism of conductivity in CPs, charge carriers in conjugated polymers: polarons, bipolarons, solitons. Optcal properties of conjugated polymers: energy levels in CPs, HOMO-LUMO, fluorescence emission in CPs. Electroluminescence (EL), electroluminescence efficiency, factors affecting EL efficiency. Applications of conjugated polymers: polymer light -emitting diodes (PLEDs), electrochemical cells, sensors, FETs, photovoltaic cells etc. Conjugated polymers for photonic applications: Nonlinear optical properties of conjugated polymers, Liquid crystal polymers, Polymers for TFT applications.

T.A. Skotheim, R.N. Elsenbaumer, J.R. Reynolds Handbook of conducting polymers, 2 Ed., Marcel Dekker Inc. New York, 1998.

P.N. Prasad, D.J. Williams, Intrduction to Nonlinear Optical Effects in Molecules and Polymers, John Wiley, New York, 1990. R.L. Sutherland, Handbook of Nonlinear Optics, Series of Optical Engineering, Marcel Dekker Inc. New York, 1996.

CY911 Supramolecular Chemistry **(4-0-0) 4**

Introduction to Supramolecular Chemistry: Inspiration, History and definitions. Molecular Forces. Molecular Structure: Shape and Size, van der Waals radii, bond lengths and bond angles, conformation. Common Motifs in Supramolecular Chemistry. Overview of Experimental Techniques in Supramolecular Chemistry. Host / Guest Chemistry: Cation binding, Anion binding, Neutral molecule binding. Crystal engineering: Introduction & Tectons - synthons, Special role of hydrogen bonding, Cambridge Structural data bases, Polymorphism, Co-crystals, Hydrogen bond synthons common & exotic, Halogen bonding. Supramolecular polymers, gels and fibres.

Steed J. W., and Atwood J. L., Supramolecular Chemistry*, Wiley & Sons: Chichester, 2000, 2nd Edn., 2009. Katsuhigo Ariga & Toyoki Kunitake, Supramolecular chemistry- fundamentals & applications, Springer publications, 2007.*

Jonathan W. Steed, David R. Turner, Karl Wallace, Core Concepts in Supramolecular Chemistry and Nanochemistry, *,2007.*

Lehn J. M., Supramolecular Chemistry: Concepts and Perspectives, Weinheim: VCH 1995. Paul D. Beer, Philip A. Gale and David K. Smith, Supramolecular Chemistry, Oxford university press, 2005.

DEPARTMENT OF MATHEMATICAL & COMPUTATIONAL SCIENCES

MA900 ADVANCED GRAPH THEORY (3-0-0) 3
Trees, Eulerian Graphs and Digraphs, Matchings, Connectivity, Coloring, Perfect graphs, Domination.
References:
D. B. West, Introduction to Graph Theory, Prentice Hall of India, 2001.
F. Harary, New Directions in the Theory of graphs, Academic Press, New York.

MA901 ADVANCED MATHEMATICAL METHODS (3-0-0) 3
Ordinary Differential Equations, Local Analysis, Difference equations, Perturbation Method, Global Analysis.
References:
E. A Coddington, An Introduction to Ordinary Differential Equations, PHI.
C.l Bender M. Orszag . Advanced Mathematical Methods for Scientists & Engineers, McGraw Hill

MA902 COMPUTATIONAL FLUID DYNAMICS (3-0-0) 3
Basic concepts and equations of fluid dynamics, non-dimensional forms, boundary layer equation, grid generation, grid refinement, adaptive grids, finite difference methods, explicit and implicit methods, fundamentals of fluid flow modelling, upwind scheme.
References:
S.W. Yuan, Fluid Mechanics, PHI.
S.V. Patankar, Numerical Heat Transfer, McGraw Hill White F.M., Viscous Fluid Flow, McGraw Hill

MA903 LIFE TESTING & RELIABILITY ESTIMATION (3-0-0) 3
Exponential failure models, Gamma and Weibull distributions, Normal and related distribution, Mixtures and Compound distributions.
References:
S. K. Sinha , B.K. Kale , Life Testing and Reliability Estimation, Wiley Eastern Ltd.
E.E Lewis, Introduction to Reliability Engineering, John Wiley & Sons Inc.

MA904 LINEAR ALGEBRA & MATRIX THEORY (3-0-0) 3
Matrices and linear Equations, Types of Matrices, Vector Spaces and linear transformations, Inner Products, Orthonormal basis, Gram-Schmidt Orthogonalization Process, Vector Norms, Matrix Norms, Eigen values and Eigen Vectors, Triangular, Jordon and Rational Canonical forms and applications, Perturbation theory.
References:
W. D. Lewis W., Matrix Theory, Allied Publications Ltd.
G. Strang, Linear Algebra and Its Applications III Edition, Thomson Learning (Int.Student Edition)

MA905 NUMBER THEORY (3-0-0) 3
Divisibility and Congruences, Some functions of Number Theory, Some Diophantine Equations, Primes and Multiplicative Number Theory, Algebraic Numbers.
References:
I Niven, H. Zuckermann, H.L. Montgomery, An Introduction to the Theory of Numbers, Vth Edition, John Wiley, 2000.
G.H. Hardy, E.L. Wright: Introduction to the Theory of Numbers, Vth Edition, Oxford University Press, 1980.
J.S. Kraft, L.C Washington, Introduction to Number Theory and Cryptography, II Edition, Springer- Verlag, 1994.

MA906 NUMERICAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS (4-0-0) 4
Finite difference methods: Schemes for parabolic, hyperbolic and elliptic equations; Consistency, stability and convergence of the schemes.
Finite element methods: Types of integral formulations, one and two dimensional elements, Galerkin formulation, Application to Dirichlet and Neumann problems.
References:
G.D. Smith, Numerical Solution of Partial Differential Equations, Clarendan Press
O. Axelsson and V. A. Barker, Finite Element Solution of Boundary Value Problems: Theory and Computation, SIAM. G. Evans, J. Blackledge, P. Yardley, Numerical Methods for Partial Differential Equations, 2nd edition, Springer, 2001.

MA907 NUMERICAL ANALYSIS OF DIFFERENTIAL EQUATIONS (4-0-0) 4

Ordinary differential equations: Initial value problem for systems of ODEs:- Single step methods - Euler and Runge-Kutta methods, Linear multistep methods - predictor corrector methods, Order, Consistency, Convergence, Zero-stability, Weak stability theory, Solution of stiff ODE, Solution of system of ODEs and higher order ODEs. Two point boundary value problems for ODEs, Shooting method, Finite difference schemes, Deferred correction and extrapolation, Solution of Sturm-Liouville problems.

Partial differential equations: Finite difference schemes for parabolic, hyperbolic and elliptic equations; Consistency, stability and convergence of the schemes.

References:

J.D. Lambert, Computational Methods in Ordinary Differential Equations. Wiley, Chichester, 1991.

A. Iserles, A First Course in the Numerical Analysis of Differential Equations, Cambridge University Press, 1996.

K. Atkinson, W Han, D. Stewart, Numerical Solution of Ordinary Differential Equations, John Wiley & Sons, 2009.

G. D. Smith, Numerical Solution of Partial Differential Equations, Clarendan Press.

R. *J. LeVeque, Finite Difference Methods for Ordinary and Partial Differential Equations: Steady-State and Time-Dependent Problems, SIAM, 2007.*

MA908 OPERATIONS RESEARCH (3-0-0) 3

Linear Programming, Network Analysis, Queuing Theory.

References:

H. A. Taha, Operations Research: An Introduction, PHI.

F. S. Hillier and G.J. Lieberman, Introduction to Operations Research, Concepts and Cases, 8 th edition, 2010, TMH.

MA909 STOCHASTIC PROCESSES, QUEUEING THEORY & RELIABILITY (3-0-0) 3

Preliminaries of Probability, random variables, probability distributions, Stochastic processes Queueing Models, Reliability Theory.

References:

J. Medhi, Stochastic Processes, New Age International Publishers.

E.E. Lewis, Introduction to Reliability Engineering, John Wiley & Sons Inc.

MA910 DATA STRUCTURES & NETWORK ALGORITHMS (3-0-0) 3

Trees and Graphs, Disjoint sets and compressed Trees, Heaps, Search Trees, Self-Adjusting Binary trees, Linking and cutting Trees, Minimum spanning trees, shortest path trees, flows, cuts, minimum cost flows, bipartite matching, network flows. Algorithms for Non-Bipartite Matching.

References:

R. E. Tarjan, Data Structures and Network Algorithms, SIAM, CMBS-44.

T. Kind, Dynamic Data Structures, Academic Press.

MA911 NETWORK FLOW OPTIMIZATION (3-0-0) 3

Networks, Paths and cuts, flows and capacities, Analysis of flows, Matching Theory and assignment problems, potentials and spans, networks with linear costs, optimal flows and potentials algorithms for convex costs, Linear systems of variables.

References:

Ford and Fulkerson, Flows in Networks, Princeton Univ. Press.

R. T. Rockafellar, Network Flows and Monotropic Optimization, Wiley Interscience.

MA912 MONOTROPIC OPTIMIZATION (3-0-0) 3

Optimization and equilibrium, examples of Monotropic programming, duality and existence of solutions, boundedness property, decomposition, applications to network flow optimization, Basic Descent algorithms, Fortified and Discretised Descent, Simplex methods, Generalised out-of-kilter algorithm, Parametric monotropic programming.

References:

R. T. Rockafellar, Network Flows and Monotropic Optimization, Wiley Interscience.

E. L. Lawler, Combinatorial Optimization- Networks and Matroids, Hort-Rinehart-winston.

MA913 COMBINATORICS (3-0-0) 3
Study of known configurations; Investigation of unknown configurations; Counting of configurations; Enumeration of configurations; optimization of configurations.
References:
C. Berge, Principles of Combinatorics, Academic Press.
H. Rosen, Handbook of Discrete Mathematics.

MA914 COMBINATORIAL PROBLEMS (3-0-0) 3
Basic enumeration; the sieve; permutations; Labelled and Unlabelled Trees; spanning Trees; 1-factors; the Ising problem; restricted permutations; Parity and Duality; connectivity Factors of graphs; Independent sets of Points; chromatic number; external problems for graphs; spectra of graphs; Automorphisms of graphs; Hypergraphs; Ramsey theory; the Reconstruction Problem.
References:
L. Lovasz, Combinatorial Problems and Exercises,
N. Holland, Combinatorial optimization, An Algorithmic approach.

MA915 COMBINATORIAL OPTIMIZATION (3-0-0) 3
Polynomial Boundedness; network optimization problems; Greedy algorithms; Matroid theory ; Matroid Intersections; Matroid Partitions; Primal weighted Intersection algorithm; Duality Theory; Matroid polyhedra ; Primal-Dual weighted Intersection Algorithm; Matroid Parity; Generalisations.
References:
E. L. Lawler, Combinatorial Optimization- Networks and Matroids.
Holt-Rinehart-winston, Combinatorial Optimization, An Algorithmic Approach.

MA916 CONJUGATE DUALITY & OPTIMIZATION (3-0-0) 3
Convexity and Duality, Examples of convex optimization Problems, conjugate convex Functions in paired spaces, Dual Problems and lagrangians Examples of Duality schemes, continuity and derivatives of convex functions, solutions to optimization Problems, computation of conjugates and subgradients, Integral Functionals, Applications.
References:
R.T. Rockafellar, Conjugate Duality and optimization, SIAM, CBMS16.
O. M. Mangasarian, Non-linear Programming, McGraw Hill.

MA917 NONLINEAR PROGRAMMING (3-0-0) 3
Linear Inequalities and Theorems of the Alternative; Convex sets; Convex and concave Functions; Saddle Point Optimality criteria of Nonlinear Programming without Differentiability; Differential convex and concave Functions; optimality criteria in nonlinear Programming with differentiability; Duality in nonlinear Programming; generalizations of convex functions; Quasi - convex, strictly quasi - convex; Pseudoconvex; Optimality and Duality for generalized convex and concave Functions; Optimality and Duality in the presence of nonlinear equality constraints.
O. *M. Mangasarian, Non-linear Programming, McGraw*
Hill. R.T. Rockafellar, Convex Analysis, Princeton Univ.
Press

MA918 SELECTED TOPICS IN COMPUTATIONAL SYSTEMS SCIENCE & ENGINEERING (3-0-0) 3

MA919 THE THEORY OF SUBGRADIENTS (3-0-0) 3
Non-differentiable Functions; Tangent Cones; Normal vectors; subderivatives; subgradients; lipschitzian cases; subgradients as limits; Stationary Points; Sub differential Calculus; Duality and Marginal Functions; Monotonicity of subgradient Multifunctions.
References:
R. T. Rockafellar, The Theory of Subgradients, Heldermann Verlag.
F. H. Clarke, Optimization and Non-smooth Analysis, John Wiley & Sons.

MA920 THE THEORY OF MAX-MIN OR MINIMAX (3-0-0) 3
Best approximation by algebraic polynomials-discrete as well as continuous cases; The discrete minimax problem

unconstrained as well as constrained cases; the generalized Problem of Nonlinear Programming. The continuous minimax problem; special cases.

References:

V.F. Demyanov and V. N. Malozemov, Introduction to Minimax, Keter Publishing House.

J. M. Danskin, The Theory of Max-Min Springer-Verlag.

MA921 NON-DIFFERENTIABLE OPTIMIZATION (3-0-0) 3

Aggregate subgradient Methods for unconstrained convex minimization; Methods with subgradient locality Measures for Minimizing non-convex functions; methods with subgradient deletion rules for unconstrained non-convex minimization; Feasible point methods for convex constrained minimization problems; Methods of feasible directions for non-convex constrained problems; Bundle Methods; Numerical examples; subgradient methods with space dilation; computational algorithms.

References:

N. Z. Shor, Minimization Methods for non-differentiable Functions.

K. C. Kiwiel, Methods of Descent for Non-differentiable Optimization, Springer Verlag.

MA922 ADVANCED DATABASE MANAGEMENT SYSTEMS (3-0-0) 3

Basic concepts and terminology, software architecture for data sharing, federated database management system, designing distributed databases, distributed transactions, client server architecture, multimedia databases, Object oriented DBMS.

References:

T. Ozsu, P. Valduring: Principles of Distributed Database systems, PHI.

S. Ceri S. Pelagatti, Distributed Databases: Principles and Systems, McGraw Hill, New York

MA923 ADVANCED OPERATING SYSTEMS (3-0-0) 3

An overview of operating system functions, Distributed operating systems, Protection and security, Multiprocessor operating systems, Database operating systems, Concurrency control, Object oriented operating systems and its characteristics, Case studies of OS such as UNIX OS, Netware OS, Windows etc.

References:

M. S. Niranjan, G. Shivorothri, Advanced concepts in Operating Systems, McGraw Hill Education.

A. S. Tenanbaum, Distributed Operating systems, Pearson.

MA924 ANALYSIS & DESIGN OF ALGORITHMS (3-0-0) 3

Fundamentals of Algorithmic Problem Solving, Fundamental data Structures, Fundamentals of the Analysis of Algorithm Efficiency, Brute Force, Divide-and-Conquer, Decrease and Conquer, Transform and Conquer, Space and Time Tradeoffs, Dynamic Programming, Greedy Technique, Limitations of Algorithm Power , Coping with the Limitations of Algorithm Power.

References:

A. Levitin, Introduction To The Design And Analysis Of Algorithms, Pearson Education, 2003

MA925 DATA WAREHOUSING & DATA MINING (3-0-0) 3

Data Warehousing, Data Mining, Association Rules, Classification, Clustering, Decision Trees, Other Techniques for Data Mining, Web Mining, Searching Techniques.

References:

J. Han, M. Kamber: Data Mining: Concepts and Techniques, Harcourt India Pvt., 2001.

A. K. Poojary, Data Mining Concepts, Hyderabad Press, 2001.

MA926 DISTRIBUTED SYSTEMS (3-0-0) 3

Evolution of modern operating systems, Design Goals, transparencies and fundamental issues in Distributed systems, Temporal ordering of events, Global state detection, Physical clocks, Mutual Exclusion Algorithms, Interprocess Communication, Deadlocks in distributed systems, Load balancing techniques, Distributed databases.

References:

Shivarathi, Shingal, Advanced Operating Systems.

R. Chow, Distributed Operating Systems and Algorithms.

(3-0-0) 3

MA927 NUMBER THEORY AND CRYPTOGRAPHY

Elementary Number Theory Congruences, applications to Factoring. Finite fields, Quadratic residues and reciprocity. Simple cryptosystems, public key cryptography, RSA, Discrete logs. Primality and Factoring, the rho method, Fermat factorization, continued fraction and Quadratic Sieve methods.

References:

N.Kobltiz., A Course in Number Theory and Cryptography, Springer, 1994.

MA928 ELLIPTIC CURVES AND CRYPTOGRAPHY **(3-0-0) 3**

Introduction to Elliptic curves, Discriminant and j-invariant, curves over K, char (K) ¹ 2, 3 and char (K) = 2, Group structure, Divisor Theory, Elliptic curves over Z Isomorphism classes of Elliptic curves over Finite Fields, The

n,

Discrete Logarithm problem, Pohlig - Hellman Method, Index Calculus Method, Singular Elliptic curves. The Elliptic curve Logarithm problem, The Weil pairing, Reduction to Logarithms in a Finite Field, Supersingular curves, Cryptographic Implications.

Implementation of Elliptic curve Cryptosystems, Counting points on Elliptic curves over F2m.

References:

A Menezes: Elliptic Curve Public Key Cryptosystems, Kluwer Academic, Dordsecht. 1993.

A Menezes, S. Vanstone & P. Van Oorschot: Handbook of Applied Cryptography, CRC, Boca Raton, 1996.

MA929 FINITE FIELDS AND APPLICATIONS **(3-0-0) 3**

Lattices, Applications of Lattices, Finite Fields and Polynomials, Coding Theory, Cryptology, Applications of Groups, Fast Fourier Transforms, Grobner bases for Algebraic and Differential Equations.

References:

R. Lidl, G. Pitz: Applied Abstract Algebra, Springer, 1998.

MA930 ALGEBRAIC NUMBER THEORY **(3-0-0) 3**

Algebraic Numbers and Number fields, Discriminants, Norms and Traces, Algebraic Integers and Integral Bases, Factorization and Divisibility, Applications of Unique Factorization, Quadratic Fields, Units in Number Rings, Geometry of Numbers, Dirichlet's unit Theorem, The Number Field Sieve, Ideal Classes, the Class group, Class Numbers of Quadratic Fields, Cyclotomic fields and Kummer's Theorem, Cryptography in Quadratic Fields, Ideal decomposition and Reciprocity Laws.

References:

R. A. Mollin: Algebraic Number Theory, CRC, Boca Raton, 1999.

J. Esmonde, M.Ram Murthy: Problems in Algebraic Number Theory, Springer, 1999.

MA931 COMPUTATIONAL NUMBER THEORY (3-0-0) 3

Fundamentals, Euclidean Algorithm, Modular Arithmetic, Fast Powers, Congruences - Linear and Quadratic congruences, Chinese Remainder Theorem, Euler's Phi-function, Primitive Roots for Primes, Universal Exponent, The Form of Carmichael Numbers, Prime testing and certification, Strong Liars are scarce, Coding secrets and Factoring Algorithms, Pepin's Test, Quadratic Reciprocity, Continued Fractions, Prime testing with Lucas Sequences, Gaussian integers and primes.

References:

D. Bressoud, S. Wagon: A Course in Computational number Theory, Springer, 2000.

MA932 ANALYTIC NUMBER THEORY **(3-0-0) 3**

Arithmetical Functions and Dirichlet Multiplication, Mobius Functions, Euler totient function, Mangoldt function, Liouville's function, Averages of Arithmetical functions, some Elementary Theorems on the Distribution of Prime Numbers, Congruences, Finite Abelian Groups and Their Characters, Dirichlet's Theorem on Primes in Arithmetic Progressions, Periodic Arithmetical functions and Gauss Sums, Quadratic Residues and the Quadratic Reciprocity Law, Primitive Roots, Dirichlet Series and Euler Products. The functions and , Analytic Proof of the Prime Number Theorem.

References:

T. M.Apostol, Introduction to Analytic Number Theory, Springer, 1989.

M. Ram Murthy, Problems in Analytic Number Theory Springer, 2001.

MA933 ALGEBRA **(3-0-0) 3**

Groups - Permutation groups, Sylow theorems solvable groups, Direct products of groups and finite abelian groups. Rings: - Ideals, Euclidean and Principal ideal rings, Unique factorization domains and Polynomial rings. Fields: - Extension fields, Prime fields, Algebraic and Transcendental extensions. Roots of polynomials, splitting fields, finite fields, Separable and inseparable extensions Galois Theory, solvability of polynomials by radicals and Abel's theorem.

References:

I.N. Herstein, Topics in Algebra, Wiley casten Ltd.
J.B.Fraleigh; A first course in Abstract algebra, Narera publishers.
N.S. Gopalakrishnan, University, Algebra, Vikas publishing House Pvt. Ltd.

MA934 FIXED POINT THEORY & ITS APPLICATIONS **(3-0-0) 3**

Banach's contraction principle on complete metric spaces, its variants and applications. Fixed point theorem for non-expansive and set valued maps. Brouwer's and schauder's theorems and its applications. Fixed point theorems on topological spaces and partially ordered spaces and partially ordered spaces.

References:

M. A. Khamsi and William A. Krik, An Introduction to Metric spaces and fixed point theory, Wiley Inter-science, New York.
E. Zeidler, Nonlinear Functional Analysis and its Applications, Part I: Fixed Point Theorems Springer - Verlag, Heidelberg.
D. Smart, Fixed Point Theorems, London (1973) .

MA935 MEASURE THEORY & INTEGRATION **(3-0-0) 3**

Lebesgue measure on R^n: Introduction, outer measure, measurable sets, Lebesgue measure, regularity properties, a nonmeasurable set, measurable functions, Egoroff's theorem, Lusin's theorem. Lebesgue integration: Simple functions. Lebesgue integral of a bounded function over a set of finite measure, bounded convergence theorem, integral of nonnegative functions Fatou's Lemma, monotone convergence theorem, the general Lebesgue integral, Lebesgue convergence theorem, change of variable formula. Differentiation and integration: Functions of bounded variations, differentiation of an integral, absolutely continuity. L^p - Spaces : The Minkowski's inequality and Holder's inequality, conver gence and completeness approximation in L^p, denseness results in L^p, bounded linear functionals on L^p spaces. Fouri er series: Definition of Fourier series, formulation of convergence problems, L^2 theory of Fourier series , convergence of Fourier series.

References:

H.L. Royden, Real Analysis, Macmillan, New York
G. de Barra, Measure theory and integration, New Age, New Delhi.

MA936 TOPOLOGY **(3-0-0) 3**

Topological spaces, bases, continuous functions, subspaces, quotient spaces, nets and filters, compactness, connectedness, separation properties, Tychonoff Theorem, compactification, Urysohn Lemma and Tietze Extension Theorem, function spaces.

References:

J. Munkres, Topology, Prentice - Hall, New Delhi.
J. Dugundji, Topology, Practice Hall, New Delhi.

MA937 FUNCTIONAL ANALYSIS **(3-0-0) 3**

Topological Vector spaces: Linear mappings, boundedness and continuity, Baire category, the Banach - Steinhaus theorem, the open mapping theorem, the closed graph theorem, bilinear mappings. Geometry of Hilbert spaces: Inner product spaces, the Riesz representation theorem, the adjoint of a linear and bounded operator, the existence of orthonormal bases, the dimension of Hilbert spaces. Banach Algebras: Banach algebras, the space of multiplicative linear functions, invertible elements, the Gelfand transform, basic properties of spectra, the Gelfand-Mazur theorem, the Gelfand theorem for commutative Banach algebras, the spectral radius formula, the Stone- Weierstrass theorem. C*
- Algebras: The multiplier algebra, the unitization of a C* - algebras, *- homomorphisms, Gelfand's structure theorem for commutative C* - algebras, functional calculus with normal operators, the spectral mapping theorem.

References:

W. Rudin, Functional Analysis, Second Edition, Tata McGraw- Hill, New Delhi
R.G. Douglas, Banach Algebras Techniques in Operator Theory, Second Edition, Springer- Verlag, New York
G.J. Murphy, C - Algebras and Operator Theory, Academic Press, San Diego.*

MA938 OPERATOR THEORY (3-0-0) 3
Operator on normed linear spaces: Normed linear spaces, characterization of Banach spaces, schauder basis and reparability, Riesz lemma, projection theorem, bounded operators, Riesz representation theorem, convergence of sequence of operators, closed operators. Compact Operators: Some characterizations, space of compact operators, the dual space of compact operators and trace class. Operators on Hilbert theory: Adjoint of an operator, self-adjoint, normal and unitary operator, numerical range and numerical radius, Hilbert-Schmidt operators. Spectral results: Eigenspectrum and approximate eigenspectrum, spectral radius, spectral mapping theorem, integration of operator-valued functions, spectral projections, Riesz- Schauder theory, spectral results for Hilbert Space operators, spectral theorems for bounded normal operators, compact normal operators.
References:
R.G. Douglas, Banach Algebra Techniques in Operator Theory, Second Edition, Springer - Verlag, New York.
J. B. Conway, A Course in Operator Theory, Springer, New York.
M. T. Nair, Functional Analysis, Prentice - Hall, India.

MA939 TOPICS IN FUNCTIONAL EQUATIONS (3-0-0) 3
Introduction to functional equations.Cauchy's equations and applications.Functional equations on several variables including d'Alembert's equation, Jensen's equation. Selected topics on iterative functional equation.
References:
J. Aczel, Lectures on functional equations and their applications, Academic Press, New York, 1966.
M. Kuczma, B. Choczewski, R. Ger, Iterative Functional Equations, Cambridge University Press, Cambridge, 1990.

MA940 MATHEMATICAL METHODS FOR IMAGE PROCESSING (4-0-0) 4
Mathematical preliminaries: space of functions of bounded variation; deterministic image models; elements of differential geometry. Image restoration: Energy based methods; regularization of the problem; Euler equations; numerical approximation, PDE based models; smoothing and enhancing methods, Segmentation problem: energy minimization approaches and contour based approaches, Image inpainting: variational and curvature based models, Scopes for future research.
T.F. Chan, J.H. Shen, “Image processing and analysis”, SIAM,First edition, 2005.
R.C. Gonzalez, R.E. Woods, “Digital image processing using MATLAB”, Prentice Hal*l, Second edition, 2003.*
H. Maitre, “Image Processing”,Wiley, first edition, 2008.
R. C. Gonzalez & Richard E. Woods, “Digital Image Processing” , Addison-*Wesley, 2nd edition,*
2002. A. K. Jain, Fundamentals of Digital Image Processing, Prentice Hall, 1992.
G. Aubert and P. Kornprobst, “ Mathematical problems in image processing”, Springer, Second edition,
2006. *Recent journal papers published in the relevant areas.*

MA941 TOPICS IN COMPUTER VISION AND APPLICATIONS (4-0-0) 4
A review of Linear algebra, Singular Value Decomposition, Principal component analysis, Linear Discriminant analysis, Independent component analysis and applications, Kalman filter, Multi resolution representation: Active contours, Texture, colour and motion descriptors, shape representation, Pattern analysis, recognition and classification, Vision as an inverse problem, Applications: Face recognition, detection and interpretation, Scopes for future research.
References:
S. Gong, Dynamic Vision: From Images to Face Recognition, Imperial College Press, 2001.
A. Hyvärinen, J. Karhunen, E. Oja Independent Component Analysis, John Wiley & Sons, 2001.
L. Shapiro, G. Stockman, “Computer Vision”, Prentice Hall, 2001.
S. Umbaugh, Computer Vision and Image Processing: A Practical Approach Using CVIP tools, Prentice Hall, 1999.

MA942 TOPICS IN DIFFERENTIAL EQUATIONS (4-0-0)4
Nonlinear first-order PDE: Complete Integrals, Envelopes, Characteristics, Boundary Conditions and local solution, Conservation laws, Shocks, entropy condition, Lax- Oleinik formula, Weak solution, Uniqueness, Riemann's problem, Long time behaviour, Hamilton - Jacobi equations, Calculus of variations , Legendre transform, Hopf-Lax formula. Sobolev Spaces: Holder Spaces, Sobolev spaces, Weak derivatives, Elementary properties, Approximations by smooth

functions, Extensions, Traces, Sobolov inequalities, Gagliardo-Nirenberg-Sobolev inequality, Morrey's inequality and Compactness.

References:

L.C. Evans, Partial Differential Equations, AMS Publishers, 2009.
I. P. Stavroulakis and S. A. Tersian, Partial Differential Equations, World Scientific Publishers, 2004.

MA943 THEORY OF PARTIAL DIFFERENTIAL EQUATIONS (4-0-0)4

Linear PDE: Transport Equation, Laplace's Equation, Mean-value formulas, Green's function, Energy methods, Heat equation, Fundamental solutions, Properties of solutions, Wave equation, Solutions by spherical means, Nonhomogeneous problem.

Distributions: Test functions, Operations with Distributions, Support of Distributions, Convolution of Distributions, Fundamental solutions, Fourier Transform, Schwartz space, Fourier Inversion Formula, Tempered Distributions.

References:

I. P. Stavroulakis and S. A. Tersian, Partial Differential Equations, World Scientific Publishers, 2004.
L. C. Evans, Partial Differential Equations, AMS Publishers, 2009.
S. Kesavan, Topics in Functional Analysis and Applications, New Age International Publishers, 2008.

MA944 - FOURIER AND WAVELET ANALYSIS WITH APPLICATIONS (4-0-0) 4

Fourier series: Uniform convergence of Fourier series, The Riemann-Lebesgue lemma, The Dirichlet and Fourier kernel, Pointwise convergence and uniform convergence of Fourier Series, The Gibbs Phenomenon, Fourier transform: The finite Fourier transform, Convolution on T, The Fourier map, Convolution on R, Inverse Fourier transform, Parseval's identity, The Plancherel theorem, The discrete and fast Fourier transform, Windowed Fourier transform.

Wavelets: Continuous wavelet transform, The uncertainty principle and time frequency tilting, Multiresolution analysis (MRA), Scaling function and approximation, Wavelets and detail spaces, Orthogonal system. The Discrete wavelet system: Haar wavelet function, Daubechies wavelets, Signal decomposition and reconstruction, Wavelets and filter banks, Mallat' s algorithm. Regularity and vanishing moments of wavelets, Bi-orthogonal wavelet bases, Wavelet packets, Image compression, Denoising.

References:

G. Bachmann, L. Narici, E. Beckenstein, Fourier and wavelet analysis, Springer.
G Mallat, Wavelet tour of signal processing, Academic press.
K P Soman, K I Ramachandran, N G Resmi, Insight into Wavelets: From theory to Practice, Estern economic press.
C K Chui, An introduction to wavelets (Wavelet analysis and its applications series), Vol - 1, Academic press 1992.

MA945 - PORTFOLIO THEORY AND INVESTMENT ANALYSIS (3-0-0) 3

Risk and risk aversion, Measuring risk and return of a single asset and portfolio, Mean-Variance portfolio theory: Diversification, Forming portfolios with on assets, efficient frontier. The Markowitz model, the two-fund theorem, Inclusion of a risk free asset, the one-fund theorem.

The capital asset pricing model: Market equilibrium, Capital market line, Pricing model, Security market line, Investment implications use of CAPM for performance evaluation, CAPM as a Pricing formula.

Single and multifactor models, CAPM as a factor model, Arbitrage pricing theory (APT), APT and CAPM, Estimation of parameters of mean-variance portfolio theory, CAPM and APT. Tilting away from equilibrium.

Market Efficiency and behavioral Finance, Empirical Evidence on Security returns, Evaluation of portfolio performance, Equity evaluation models, International diversification. The process of portfolio management, the theory of active portfolio management.

References:

D.G. Luenberger, Investment Science, Oxford University Press.
Z. Bodie, A Kare, A.J Marcus, P.Mohanty, Investments, 6th Edition, TMH.
E.J.Elton, M.J Gruber, Modern Portfolio Theory and Investment Analysis, John Wiley, Student Edition.
T.E. Copeland, J. Fred Weston, K. Shastri, Financial Theory and Corporate Policy, Addison Wesley.

DEPARTMENT OF PHYSICS

PH900 Advanced Solid State Physics **4**

Crystal Structure, Symmetry operations; Symmetry elements, Point groups, and space group. Lattice Vibration and Phonons; optical properties in the infrared phonons; inelastic scattering Thermal Properties of Solid-Various theories of lattice specific heat; Free Electron Theory of Solid Heat capacity of the electron gas; spin paramagnetism of free electron; Band Theory of Solid-Nearly free electron model; origin of energy gap; Bloch theorem; Kronig and - Penney model; concepts of hole; effective mass of electron in crystals; tight band electron approximation; application to a simple cubic lattice; Brillouin zone; density of state; overlapping energy levels. Semiconductors, Superconductivity, theoretical and experimental aspects.
Asheroft and Mermin, Solid State Physics.
C. Kittel, Introduction to Solid State Physics.

PH901 Advanced Crystallography **4**

Symmetry of crystals, crystal projection, reciprocal lattice, diffraction of x-rays, Factors affecting intensity of diffraction beams, experimental techniques of structure analysis.
L.V. Azaroff, Elements of x-ray crystallography, McGraw Hill

PH902 Materials Preparation Techniques **4**

Crystal growth equilibrium, growth methods - solid-solid, liquid-solid and vapour-solid transformation, Growth from aqueous solutions, hydrothermal, high temperature solution and zone melting techniques.
R.A. Laudise, Growth of single crystals.

PH903 High & Ultra High Vacuum Technology **4**

Production and measurement of vacuum, behaviour of gases at low pressure, vacuum materials, vacuum assembly techniques, design of vacuum systems and ultra high vacuum systems. *L.I.*
Maissel & R. Glang, Hand book of thin film technology, McGraw Hill.
G.W. Green, Design & construction of small vacuum system, Chapman & Hall.

PH904 Crystal Growth & Characterization **4**

Basic concepts, Nucleation phenomena, Mechanisms of Crystal Growth, Dislocations, Crystal dissolution, Materials preparation and phase diagrams. Experimental methods of crystal growth, Growth from liquid-solid equilibria, Growth from vapor-solid equilibria. Mono-component and multi-component techniques. Thin film growth methods including LPE, MOCVD, MBE, PLD, etc. Crystal characterization.
Ivan V. Markov, Crystal Growth for Beginners, Fundamentals of Nucleation, Crystal Growth & Epitaxy, World Scientific,
Singapore, 1996.
R. A. Laudise, Growth of Single Crystals, Prentice-Hall, 1970

PH905 Properties of Materials **4**

Structure of metals - elements and simple alloys. Semiconductors - properties and structure - junctions, metal-metal, metal-semiconductor and p-n junctions. Properties of insulators - electrical, optical and magnetic.
LV Azaroff, Introduction to solids, Tata McGraw Hill, New Delhi.

PH906 Electronic Thin Film Science **4**

Thin film deposition and Layered structures, Surface energies, diffusion in solids, stress in thin films, Surface Kinetic Processes, Homoepitaxy: Si and GaAs, Heteroepitaxy and Superlattices, Electrical and Optical Properties of heterostructures, Quantum wells, Barriers, Schottky barriers and Interface Potentials, Interdiffusion, Thin film reactions, Morphological changes in thin films.
King-Ning Tu, James W. Mayer and Leonard C. Feldmann, Electronic Thin Film Science for Electrical Engineers and Materials
Scientists , Macmillan Pub. Co, New York, 1987
O. S. Heavens, Thin Film Physics, Methuen & Co. Ltd, London, 1970

PH907 Experimental Techniques for Characterisation of Materials **4**

Metallographic Techniques - Optical Microscopy, Image Analysis. Diffraction Method - Characterisation of X-ray

diffraction. Crystallographic Texture Measurement and Analysis, X-ray diffraction residual stress techniques, Neutron Diffraction. Resonance Methods - Electron Spin Resonance, Ferromagnetic Resonance, Nuclear Magnetic Resonance, Mossbauer Spectroscopy.
Electron Optical Methods - Analytical Transmission Electron Microscopy, Scanning Electron Microscopy, Scanning Tunneling Electron Microscopy (STEM), Electron Probe X-ray Micro-analysis. Classical, Electrochemical and Radiochemical Analysis- Classical Wet Analytical Chemistry, Volummetry, Electrogravimetry, Electrometric Titration, Radio Analysis.
Spectroscopy and Other Methods-Atomic Absorption Spectrometry, X-ray Spectrometry, Infrared Spectrometry, Raman Spectroscopy, Augar Electron Spectroscopy, Field Ion Microscopy, Atom Probe Micro-analysis, Electric, Dielectric and Magnetic Properties characterisation.
Edington J.W., Practical Electron Microscopy, Vol-01.
B.D. Cullity, Elements of X-ray diffraction.

PH908 Thin Film Technology & Devices **4**
Methods of preparation, theories of growth, measurement of film thickness, properties - mechanical, electrical, structural characterization, Pattern generation, thin film devices.
L.I. Maissel & R. Glang, Hand book of thin film technology, McGrawHill.
K L Chopra, Thin film phenomena, McGraw Hill.

PH909 Modern Optics **4**
Propagation of light; Ray optics. Plane harmonic waves. Polarization, Fresnel's Equations. Coherence and Interference-Multiple beam Interference. Diffraction. Optics of solids. Thermal radiation and light quanta, optical spectra-Amplification of Light and lasers. Fibre Optics- Modes in step-index fibers and their Intensity patterns, LP modes, Dispersion and mode cut-off.
Grant R. Fowles, Introduction to Modern Optics , (2 Ed.), Dover Pub. 1989.
Eugene Hecht, Optics (4th Ed.) Pearson Ed. Indian Ed. 2002

PH910 Laser Physics **4**
The Einstein coefficients, Optical amplification and population inversion; Line shape functions:
Laser Rate Equations: Theshold condition for laser oscillation, Optimum output coupling; Q-switching and mode locking in lasers, Single longitudinal and single transverse mode oscillation; Laser systems: Ruby, Nd:YAG, Nd: Glass lasers; Tunable lasers: Ti-Sapphire laser; Semiconductor lasers: quantum well lasers, *Thyagarajan K and Chatak A.K., Lasers, Theory and Applications, Plenum Press New York.*
Koichi Shimoda, Introduction to Laser Physics, Spriger - Verlag, 1984.

PH911 Numerical Methods & Programming **4**
Interpolation - Neuton's Langrange's Aitken - Neville's, Hermite's, spline techniques. Incurse interpolation-solution of transcendental and polynomial equations - Neuton - Rapson method-Iterative methods-Successive bisection. Numerical differentiation and integration methods- Simpsons's rule- Gaussion quadrature formula-Monte-Carlo method.
Linear systems and Matrices-Cramer's rule-Jacobi method-Eigen value problems. Solution of differential equations-Euler, Picard, Runge-Kutta methods. Polynomial and trigonometric approximations. *H.M. Antia , Numerical Methods for Scientists and Engineers, Tata McGraw Hill.*
Yohn H. Mathews, Numerical Methods for Methetics, Science and Engineering, Prentice Hall.

PH912 Advanced Magnetic Resonance **4**
Resonance theory, relaxation times. Nuclear Magnetic Resonance (NMR): Bloch equations,
Wide-line and high resolution NMR. Electron Spin Resonance (ESR): Zeeman interaction (g- tensor), Nuclear hyperfine interaction, Nuclear quadrupole interaction, Application to transition metal ions and free radicals. Principles of Nuclear Quadruplole Resonance (NQR): Zeeman effect, Phase transition. Double resonance: Electron Nuclear Double Resonance (ENDOR), Electron Electron Double Resonance (ELDOR), Nuclear Magnetic Double Resonance

(NMDR), Optical Detection of Magnetic Resonance (ODMR). Zero Field Nuclear Magnetic Resonance, Ferromagnetic Resonance, Spin Wave Resonance. Practical aspects of resonance spectrometers: NMR, ESR and ENDR. Pulsed spectrometers: Measurement of relaxation times.
A. Carrinton and A.D. McLechlan, Introduction to Magnetic Resonance and Application to Chemistry and Chemical Physics. Chapman & Hall, 1979.
.E. Wertzd and J.R.Bolton, Electron Spin Resonance, Chapman and Hall, 1972.

PH913 Semiconductor Materials & Devices **4**

Review of atomic structure and statistical mechanics : Schrodinger wave equation- Particle in a periodic potential well. Crystalline and amorphous; inorganic and organic; elemental and compound semiconductors. Band models. Impurities and Defects. Bulk and thin film preparation methods. Equilibrium and non-equilibrium characteristics. Carrier transport phenomena. Optical and dielectric properties. Oxidation methods, Diffusion, Ion implantation, Metallization and Etching processes. The PN Junction Diode: Basic device technology; Heterojunction. Bipolar transistor, Microwave and power transistor and related devices. Metal-semiconductor contacts. JFET, MESFET, MOSFETs : Device structures and characteristics. Transferred-electron devices - Gunn effect. Principles of Photonic devices - LEDs, Diode, LASERs, Photodiodes. APDs and Solar Cells.
M. S. Thyagi, Semiconductor Materials and Devices, John Wiley & Sons, 1991
S Mahajan and K S Sree Harsha, Principles of Growth and Processing of Semiconductors, McGraw-Hill, 1998.

PH914 Applied Quantum Mechanics **4**

Schrodinger wave equation and applications: free electrons in 3-dimensions, harmonic oscillator, Hamilton's equations, Hydrogen atom, Many electron atoms, Molecules, Crystals, Bonds in solids. Transitions, Tunneling, Statistical Physics, Bosons and Fermions, Electrons and Phonons, Electron Dynamics, Lattice vibrations, Operators, Quantum Optics: Coherent states, Many body effects, Magnetism. *Walter A. Harrison, Applied Quantum Mechanics, World Scientific, 2000*
Ajoy Ghatak and S Lokanathan, Quantum Mechanics, Theory and Applications (fourth edition), Macmillan, 1975

PH915 Electronic Materials & Devices **4**

The Crystalline nature of materials, bonding, Space lattices and X-ray diffraction. Wave mechanics of electrons, quantum wells and tunneling, particle in a box, Periodic Potentials, Electrical transport, Quantum statistics, Semiconductor Devices, PN Junction, BJT, MOSFET. Dielectric effects - Piezoelectric, Pyroelectric and Ferroelectric materials. Optoelectronic devices : Photodiodes and Lasers. Magnetic materials: dia, para, ferro and ferrimagnetism. Superconductivity. London's equations and BCS Theory.
David K Ferry and J.P. Bird, Electronic Materials and Devices, Academic Press, 2001
Rolf E Hummel , Electronic Properties of Materials, Narosa Pub. House, 1994.

SCHOOL OF MANAGEMENT

SM 900 Research Methodology **(1 -1- 0) 2**

Nature of science,Human Inquiry and Science , Learning and creativity , Innovation and creativity , Nature of Research, Research Ideas and problems , Critically Reviewing the Literature and Literature Map, Identifying research gaps , Framing research questions, Research objectives, Ethics in Research , Research approaches, process, strategies,

Research Design: Conceptualization, Operationalization and Measurement, Sampling: Probability and Non - Probability, Using Primary and Secondary Data, Quantitative and Qualitative data , Data collection , Exploring and Examining, Analysis and interpretation ; Communicating research findings: Written , oral , visual ; Referencing .

William M.K. Trochim, Research Methods, Biztantra publications, 2nd Edition.
John W. Creswell, Research Design, Qualitative, Quantitative and Mixed Approaches, 2ndEdition, Sage Publication, 2003.
Earl Babbie, The Basic of Social Research, Wadsworth- Thomson Learning, 2nd Edition, 2002.
E. M. Phillips And D. S. Pugh, How To Get A PhD -A Handbook for PhD Students and their supervisors, Viva Books, 2006
Antony Wilson, Jane Gregory, Steve Miller, Shirley Earl, Handbook of Science Communication, Overseas Press India Pvt ltd, 2005
Donald R. Cooper, Pamela S. Schindler, Business Research Methods, TMH, New Delhi, 2006.
JuriNeimark, Mathematical Models in Natural Sciences and Engineering, Springer, 2003.
Rutherford Aris, Mathematical Modeling Techniques, Dover Publications, New York, 1994.
J N Kapur, Mathematical Modeling New Age Publishers, New Delhi, 1988.
T. Roscoe, Writing Reviews for Systems Conferences, http://people.inf.ethz.ch/troscoe/pubs/review- writing.pdf.
H. Schulzrinne, Writing Technical Articles, http://www.cs.columbia.edu/ hgs/etc/writing-style.html.
G.M. Whitesides, Writing a Paper, http://www.che.iitm.ac.in/misc/dd/writepaper.pdf.

SM 901 Marketing Research **4**

Introduction to Market/ Marketing Research, Research Components, Identification of Research Variables, Qualitative, Quantitative Research; Issues in Market Research, Research Problem definition, Research Methodology, Research Design, Data collection approaches, Sampling, Measurement and scaling, Data Processing, Hypothesis Testing, Statistical analysis of data; Analysis of Variance, Application of Computers in Market Research, Software Packages, Market Research Report Writing, Case studies, Mini Project.

G.A. Churchill, Marketing Research, Chicago Drydin Press, 1983.
P.E. Green and D.S. Tull, Research for Marketing Decision, PHI, 1982.
D.J. Luck, R.S. Rubin: Marketing Research (Seventh Edition), Prentice Hall, 1987.

SM 902 Marketing Management **4**

Marketing concept. Marketing management process. Marketing environment. Organizational market and buyer behaviour. Marketing Information System and research. Market segmentation, targeting and positioning. Planning marketing tactics. Product, price distribution and promotion decisions, E-Commerce, Ethnic Marketing, E-Marketing, Issues related to IPR, Case studies.

P. Kotler: Marketing Management, Prentice, Hall of India, 1984.
D.J. Dalrymple and L.J. Parsons, Marketing Management, John Wiley,
1982. R.W. Haas: Industrial Marketing Management, Petrocelli / Charter,1974.

SM 903 Managerial Accounting **4**

An overview of the accounting process, Nature and scope of corporate accounting, Elements of cost; Classification and distribution of overheads, Cost accounting flows, Financial accounting concepts, Impact of exchange rates, Balance sheet preparation, Financial statement analysis, Cost and management decisions: Product costing. Break-even analysis and cost profit relationships. Capital and cash budgeting for return on capital, periodic and continuous budgeting, budgetary control. Reporting systems for control: Scope for computerization.

R.N. Anthony, Management Accounting Principles, Irwing-
Taraporewala.
Taylor & Shearing, Financial and Cost Accounting for Management,
ELBS. Horngren, Accounting for Management Control, Prentice Hall.

SM 904 Management of Human Resources in Organizations 4

An introduction of the personal and interpersonal dynamics of the organization - Managing high performance: A challenge - Work motivation: Theoretical and behavioural framework. Improving work motivation in organizations. Human Resources Development (HRD): Behaviour scientist's view. Human capacity: Organizational change and development. T group and sensitivity training, management by objectives (MBO), transactional analysis (TA), quality circles (QC), performance appraisal (PA), AND training programmes. Managing human resources and organizational development: The present status.

C.R. Anderson, Management: Skills, Functions, and Organizational Performance, Wm. C. Brown, 1984.

W.L. French, C.H. Bell, and R.A. Zawacki, Organizational development: Theory, Practice and Research, Irwin, 1989.

P. Hersey and K.H. Blanchard, Management of Organizational Behaviour: Utilizing Human Resources. Prentice Hall, 1988.

SM 905 Organizational Behaviour& Implications for Management 4

An Introduction of Organizational Behaviour, Historical development and basic concepts, Understanding a social system, Mainsprings of motivation, Human needs and motivating employees. Interpreting motivational models of Maslow, Herzberg, Vroom, and McClelland. Job satisfaction and work performance. Appraising and rewarding performance. Leadership and organizational development. Supervision and participation. Interpersonal and communication problems within the organizations. Organizational Development Techniques: Their applications in Indian Organizations. Japanese Management: Basic philosophy and features. Comparative analysis of American and Japanese management. Organizational behaviour in perspective.

Davis, K. Human behaviour at work:Organizationalbehaviour. NY: The Groller Business Library, 1987. Luthans, F. Organizational behaviour. NY: McGraw, 1995.

Hersey, P. & Blanchard, K.H. Management of organizational behaviour: Utilising human resources. Prentice-Hall, 1988.

SM 906 Research Methodology - Methods & Techniques 4

Research Methodology: An introduction. Defining the Research Problem. Research Design. Sampling Design. Measurement and Scaling Techniques. Methods of Data Collection. Processing and Analysis of Data. Sampling Fundamentals. Testing of Hypotheses - I (Parametric or Standard tests of Hypotheses). CHI- Square Test. Analysis of Variance and Covariance. Testing of Hypotheses- II (Non-parametric or Distribution-Free Tests). Multivariate Analysis Techniques. Interpretation and Report Writing. The Computer: Its Role in Research.

Kothari C.R. - Research Methodology- Methods and Techniques, Wiley Eastern, 1990.

SM 907 Management Information System 4

Various issues revolving around the strategic role of managing information - Purposes of various hardware components comprising the computer system - Internet, Intranet and Extranet - Strategic role of major business applications software - Current operating systems and network support utilities commonly found in a variety of IS environments - Methodologies used to redesign the information infrastructure of the organizational enterprise - Managing systems security and implementing systems wide information controls - Factors to consider when managing international information systems.

Kenneth C. Laudon and Jane Price Laudon, Management Information Systems, Prentice Hall

O'Brien, Irwin, Management Information Systems: Managing Information Technology in the E-Business Enterprise, 2002.

SM 908 Strategic Management 4

Introduction to Business Strategy; Industry and Firm Analysis - Industry, Organization, Stakeholders, Market Environment Analysis; Formulation of Business Policy and Strategy; Evaluation and Choice of Business Policy; Strategy Alternatives and Selection; Competitive Dynamics - Game Theory; Corporate and Global Strategy; Strategy

Implementation. Case Analysis -The cases are about real world business situations, which provide an opportunity to apply the concepts, discussed in class as well as further develop ability to think about business strategy.

Hitt, Michael A., R. Duane Ireland, and Robert E. Hoskisson, Strategic Management: Competitiveness and Globalization, Cincinnati, Ohio, South- Western College Publishing, 2002.
George A. Steiner, John R. Miner and Edmund R. Gray Management Policy and Strategy, Maxwell MacMillan Intl. 1989.

SM 909 Mathematical Economics **4**

The nature of mathematical economics - Mathematical vs. non-mathematical economics - mathematical economics vs. econometrics.Elementary mathematics: Revision concepts- Matrix algebra - functions, differentiation and integration, maximisation and minimisation, set theory. Marginal analysis, Equilibrium analysis: Static, dynamic and comparative static analysis. Optimisation and linear programming. Input-output analysis - Static and dynamic versions. Game theory. Micro, macro applications of the models.
Allen, R. G. D., Mathematical Analysis for Economists, ELBS, London, 1973.
Chiang, A. C., Fundamental Methods of Mathematical Economics, Mcgraw-Hill, New York, 1967. Mckenna, C. J. and Rees, R., Economics: A Mathematical Introduction, OUP, London, 1992.
Basu, A. K., Ghosh, J. K., Sen, P.K. and Sinha, B.K., Perspectives in Statistical Sciences, OUP, New Delhi, 2001.

SM 910 Research Methods in Economics **4**

The Methodological Foundations of Economic Analysis - Historicism, Positivism, Abstraction and Generalisation in Economic Science. The purpose of and approach to Research. Formulation of Research problem and Research Design. Meaning of Hypothesis and Testing of hypotheses. Methodology of model building. Types of Economic models - Methods of data collection. Surveys and Sampling techniques. Structure of Dissertation.
C.T. Kurien, (Ed.), A Guide to Research in Economics, Sangam Publishers, Madras, 1973.
C.R. Kothari, Research Methodology: Methods and Techniques, Wiley Eastern, New Delhi, 1985.
M. Blaug, The Methodology of Economics, Cambridge University Press, Cambridge, 1980.

SM 911 Financial Institutions and Markets **4**

Financial System - Type of Financial Institutions - Commercial and Co-operative Banks - Non-Banking Financial Institutions - Equity Market - Debt Market - Government Securities Market - Major Financial Services - Foreign Exchange Market - Interest Rates in Financial Markets.
Bhole, L. M., Financial Institutions and Markets [New Delhi: Tata McGraw Hill], Third Edition, 1999.
Edminister, R. O. Financial Institutions and Markets, and Management [New York: Tata McGraw Hill], 1986. Johnson, H. J. Financial Institutions and Markets [New York: McGraw Hill], 1993.

SM 912 Technology, Industry and Trade **4**

Technology, Industry, Trade and Cycles: Technological and Non-technological theories linking industrialization with trade. The Process of Technological Innovation: Patterns and influence. Evaluating Policies for Technological Innovation and Elements of Technology Policy. The Technological Structure and Performance of Developing Country Exports. Skills and Competitiveness in developing countries. Multinational Corporations, Technology Development and Export Competitiveness. Global Business Environment, Technology and Trade. Globalisation and Technology Intermediation. Trade Prospects with Reindustrialization and Technology Policy.
Dunning, John H., TheGlobalisation of Business [London: Routledge], 1993.
Lall, Sanjaya. Competitiveness, Technology and Skills [Cheltenham: Edward Elgar], 2001.
Nayyar, Deepak (Ed.). Trade and Industrialization [New Delhi: Oxford University Press], 1999.
Siddharthan, N. S. and Y.S. Rajan. Global Business, Technology and Knowledge Sharing: Lessons for Developing Country Enterprises [New Delhi: Macmillan], 2002.
Srinivasan, T. N., Developing Countries and the Multilateral Trading System: From the GATT to the Uruguay Round and the Future [New Delhi: Oxford University Press], 2000.

SM 913 Economic Environment & policy **4**

Economic and Non-Economic Environment, Interaction between Economic and Non-Economic Environment. Analysis of contemporary Macro - Economic and Micro - Economic Problems and Issues, Related Governmental Policies and Their Impact on the Business Firm. Including Unemployment, Inflation, Fiscal and Monetary Policy,

Government Regulation of Business, Business Concentration and Anti - Trust Policy; Income Distribution and International Economic Relations.
Dunning, John H., TheGlobalisation of Business [London: Routledge], 1993.
Welch, Patrick J. and Welch, Gerry F., Economics: Theory and Practice, John Wiley & Sons, 2004, (7th Edition)

SM 914 Quantitative Methods for Managerial Decisions 4
Basic concepts of probability, probability distributions, decision trees and different decision criterion. Linear Programming: Sensitivity analysis. Transportation problem. Integer programming, goal programming and dynamic programming. Introduction to Queueing theory, Simulation and Game theory. Nonlinear programming.
H.M. Wagner, Principle of Operations Research, Prentice Hall.
F.S. Hiller and G.J. Liebermann, Introduction to Operations Research, Holden Day, 1967. H.A. Taha, Operations Research, 2nd edition, Macmillian, 1982.

SM 915 Aesthetics and Criticism 4
The nature of Aesthetics: Aesthetics as "metacriticism"; the relationship between art-criticism and aesthetic theorizing; the relationship between creative practices and aesthetics. Some major theories of art: Western- (a) Formalism-
Structuralism; (b) Post-structuralism; (c) Art and the human mind: Psychoanalysis; (d) Art and human society and culture: Marxism, Cultural Studies; (e) Feminism; (f) Post-modernism and Post-colonialism; Some major theories of art: Indian- (a) the Dhvani theory; (b) the Rasa theory
Ahmad, Aijaz. In Theory: Classes, Nations, Literatures. Delhi: OUP, 1992.
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SM 916 Comparative Literature (3-1-0) 4
Definition and Scope of Comparative Literature, Development of the Discipline, Methodology; History and Literary History, Elements of Literary History, Problems of Periodisation; Theory of Genres: Oral, Written, Ancient, Medieval and Modern; Comparative Indian Literature: Traditions, Movements, Themes and Genres; Literary Theory: Sanskrit, Tamil/Kannada Poetics, Western Literary Theories; Cross-Cultural Literary Relations: Influence, Analogy and Reception; Translation Studies: History of Translation - Indian and Non-Indian Theories of Translation, Linguistic and Cultural Problems of Translation; Literature and Other Arts; Literature and Cultural Studies
Sisir Kumar Das and Amiya Dev. Comparative Literature: Theory and Practice, Allied Publishers, 1989
Sheldon Pollock. Literary Cultures in History: Reconstructions from South Asia, University of California Press, 2003 Aijaz Ahmad. In Theory: Classes, Nations, Literatures. OUP, 1992.
Krishna, Daya, India's Intellectual Traditions: Attempts at Conceptual Reconstructions. ICPR &MotilalBanarsidass, 1987.
TejaswiniNiranjana, P. Sudhir and V. Dhareshwar, Interrogating Modernity: Culture and Colonialism in India Seagull, 1993.
M. Rader, (ed.) A Modern Book of Esthetics, Harcourt, 1979 Alan Singer, et al. (eds.) Literary Aesthetics. Blackwell, 1999
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SM 917 Research Methodology in Literature **(3-1-0)4**

Types of Literary Research: Theoretical Research, Textual Research, Historical Research, Interpretative Research, Interdisciplinary Research. Methods of Literary Research: Presentation, References, Footnotes, Indexing, Bibliography.

R. Altick, The Art of Literary Research, Norton & Co., N.Y.
C. Saunders, An Introduction to Research in English Literary History, Macmillan, N.Y.
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F.W. Bateson, The Scholar-Critic: An Introduction to Literary Research, Routledge and Kegan Paul, London
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SM 918 Literary Theory **(3-1-0)4**

The nature of literary evaluation and critical discussion. The place of universal criteria in literary criticism. Is iterary experience autonomous? The relation between literary value and (a) social reality: the problem of Commitment, Black literature, Dalit literature, etc., (b) psychological reality, the problem of the unconscious (Freudian and Jungian).The theory of the forms/genres of literature. Structuralism and stylistics.

R. Wellek, and A. Warren, Theory of Literature, Penguin, Harmondsworth
W. Wimsatt and C. Brooks, Literary Criticism: A Short History, OUP & IBH, New Delhi
T. Engleton, Literary Theory: An Introduction, Oxford, Blackwell K. Elam, Semiotics of Theatre & Drama, Methuen, N.Y.
T.S. Eliot, The Use of Poetry and the Use of Criticism, Faber, London
D. Lodge, (Ed.), Twentieth-Century Literary Criticism, Longman, London D. Lodge (ed.), Modern Criticism & Theory. Longman, London
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(1) I will not give or receive aid in examinations; that I will not give or receive un-permitted aid in class work, in preparation of reports, or in any other work that is to be used by the instructor as the basis of evaluation/grading; and

(2) I will do my share and take an active part in seeing to it that others as well as myself uphold the spirit and letter of the *NITK Honour Code*.

I realize that some examples of misconduct which are regarded as being in violation of the *Honour Code* include (but is not limited to) what is listed here below:

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- Allowing another to copy from one's own examination paper;
- Un-permitted collaboration in any form whatsoever;
- Plagiarism of any form or extent;
- Revising and resubmitting a marked quiz or examination paper for re-grading without the instructor's knowledge and consent;
- Giving or receiving un-permitted aid on take-home examinations, etc.;
- Representing as one's own work the work of another, including information available on the Internet, etc.;
- Giving or receiving aid on an academic assignment under circumstances in which a reasonable person should have known that such aid was not permitted;
- Committing a cyber offence, such as, breaking passwords and accounts, sharing passwords, electronic copying, planting viruses, etc.;
- Engaging in any act of indiscipline whatsoever, directly or indirectly, whether in the Institute premises or in the Hostels/Campus/etc, or even outside the Institute, that would reflect or project an undesirable image on the Institute;

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Student's Full Signature : ____

FULL NAME IN BLOCK LETTERS : ____

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Student Register Number :

Admission Number (if assigned)	Roll Number (if assigned)

Date : ____________________

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to be duly filled-in by the student, and *signed in presence of the Faculty-Advisor or the HOD*.

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- copy to be retained by the student, as a *Reference* -

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