CURRICULUM

UNDERGRADUATE PROGRAMME

B.Tech.

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL
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2024

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.

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

CURRICULUM

UNDERGRADUATE PROGRAMMES

2024

CURRICULUM 2024

UNDERGRADUATE PROGRAMME

B.Tech.

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REGULATIONS (General)

Common to all Degree Programmes

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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.
- **"MoE"** means, the Ministry of Education, 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 **"Degree Awarding Department"** 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 Undergraduate 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 PhD students can register for any of PG/PhD courses and the corresponding rules of evaluation will apply. Undergraduate 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. (*continuous evaluation*)	:	25 to 40% (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 PhD 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:

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

CGPA is computed as follows:

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

* 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 $\geq$ 6.0 can be considered as equivalent to first class and 5.0 $\leq$ CGPA < 6.0 can be considered as equivalent to Second Class. Notionally, CGPA may be multiplied by a factor of 10 to obtain 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 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.

To account for approved leave of absence (over and above the approved period of seven days to participate in curricular and extracurricular activities) and/or any other such contingencies like medical emergencies etc., the attendance requirement shall be a minimum of 75% of the classes actually conducted.

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.

7.6 Minimum attendance requirement may be waived off to those students who get FF Grade in a course and re-register for the same in subsequent semesters only on prior approval. This shall not be applicable to those with FA grade and also to those who register for another elective course in lieu of an elective course in which he/she has failed in earlier semesters. The permission may be granted by HoDs of their parent Department and the Department offering the course on the basis of recommendation by the Faculty advisor.

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 be communicated 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 ≥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 ≥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.;
(iv) Scholarship holders are bound by the appropriate Rules applicable to them.
(v) 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	…	
(b)	Three faculty members (1P + 1Asso.P 1Asst.P)	…	Chairman 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

UNDERGRADUATE PROGRAMMES

B.Tech.

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL
Post Srinivasnagar, Mangalore - 575025, India. 2024

CONTENTS

REGULATIONS
specific to
B.Tech. Degree Programme

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

1. DEGREE PROGRAMMES:

1.1. Undergraduate B.Tech. Degree Programmes are offered in the following disciplines by the respective programme hosting departments listed below:

Sl. No	Hosting Department	B.Tech Degree Programmes	Dept. Code
i.	Chemical Engineering	Chemical Engineering (CH)	(CH)
ii.	Civil Engineering	Civil Engineering (CV)	(CV)
iii.	Computer Science & Engineering	Computer Science & Engineering (CS)	(CS)
iv.	Electrical and Electronics Engineering	Electrical and Electronics Engineering (EE)	(EE)
v.	Electronics and Communication Engineering	Electronics and Communication Engineering (EC)	(EC)
vi.	Information Technology	Information Technology(IT)	(IT)
		Artificial Intelligence (AI)	(IT)
vii.	Mathematical and Computational Sciences	Computational and Data Science (DS)	(MA)
viii.	Mechanical Engineering	Mechanical Engineering(ME)	(ME)
ix.	Metallurgical and Materials Engineering	Metallurgical and Materials Engineering (MT)	(MT)
x	Mining Engineering	Mining Engineering (MI)	(MI)
Other teaching departments are:			
xi.	Water Resources and Ocean Engineering		(WO)
xii.	Physics		(PH)
xiii.	Chemistry		(CY)
xiv.	School of Humanities, Social Sciences and Management		(SM)

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

2. ADMISSION:

2.1 Admission to NITK, Surathkal will be made in accordance with the instructions received from MoE from time to time. Seats are reserved for candidates belonging to Scheduled Castes and Scheduled Tribes, Other Backward Classes (OBC), Persons with Disability and other categories as per the guidelines issued by MoE.

2.2 Admission to all courses will be made in the odd semester of each session at the first year level based on the relative performance in the Joint Entrance Examination Main (JEE-Main) and qualifying examination as per the guidelines issued by the MoE, New Delhi from time to time. The candidates should have successfully passed 10+2 examination with the combination of subjects prescribed by the Competent Authority.

2.3 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 MoE.

2.4 In special cases the Institute may admit students to the THIRD semester of the B.Tech. programme, on transfer, only from other NITs, observing the Guidelines applicable and subject to approval from MoE. However, any such transfer to Third Semester at NITK from any other NIT shall be subject to the condition that no commitment shall be made on any Branch request, until after exhausting the chances for NITK students to avail the branch change facility, and provided there are clear vacancies.

2.5 Student Exchange Programmes and the Transfer of Credits, shall be as per the corresponding MOU approved by Competent Authority.

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., the Registrar shall report the matter to the Senate, recommending revoking the admission of the candidate.

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

2.10 Every Undergraduate student of the Institute shall be associated with *Parent Department* (Degree Awarding Department) offering the degree programme that the student undergoes, *throughout* his study period, right from the very first day of admission into the program.

3. COURSE STRUCTURE :

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

(a) Foundation Courses	FC	38 –50 Credits

A Foundation Course can be any of the following:
Basic Science Core Courses (BSC),
Engineering Science Core Courses (ESC), and
Humanities and Social Science Core Courses (HSC)

(b) Programme Core Courses	PC	≥ 60 Credits
(c) Elective Courses	ELE	≥ 20 Credits

An Elective Course can be any of the following:

Programme Specific Electives (PSE), Certified MOOCs (NPTEL/SWAYAM etc.), Mini Projects and Cornerstone/capstone project.

(d) Project (Mini Projects and Major Project)	MP	4 - 6 Credits
(e) Mandatory Learning Courses	MLC	16 Credits

The Minimum Credit Requirement for the B.Tech Degree is 160 to 170.

3.2 The students have the option to register for certified MOOC courses (NPTEL/SWAYAM etc.) limited to 8 credits for their elective credit requirement.

The student also have the option to register for certified MOOC courses (NPTEL/SWAYAM etc.), limited to 7 credits for MLC credit requirement towards the completion of the MLC course on "Liberal arts courses/cocurricular/extracurricular activities.

Credits earned through certified MOOC courses will not be used for SGPA/CGPA computations. However, these credits will be considered for elective/MLC credits requirement of the programme.

A student must provide all the details (original or attested authentic copies) such as course content, number of contact hours, course instructor and evaluation system for the certified course which he/she requests to be considered in order to fulfill the designated credit requirement.

These details will be evaluated by the concerned DUGC (for Elective credit requirement) before giving the approval. The DUGC 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.

The details of MOOC courses towards Category C of MLC course on Liberal arts courses/cocurricular/extracurricular activities will be evaluated by School of Management and it 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.

Project (MP)

Project work may consist of Major Project and Mini Projects (if specified by the Department) offered by parent department. The Major Project is a course with 4 - 6 credits and can comprise of Part I and Part II, spread over 1 or 2 semesters of final year, preferably during 7th and 8th semesters. DUGC may prescribe Mini Project as a requirement for the B.Tech Degree or in lieu of equivalent elective credits. The method of evaluation for major and minor projects shall be evolved by pertinent DUGC and appropriate double-letter grade is awarded which will be considered for SGPA and CGPA calculation.

Cornerstone/capstone Project:

The students have the option to register for Cornerstone/capstone Projects offered by departments as an elective.

For such a project, the student has to register in his/her department in the beginning of 3rd semester. The registration details of such students are to be maintained in the Department. The student has to work on this project under the supervision of a faculty member from 3rd semester to 7th semester. The student has to submit a report to the department at the end of every semester and work progress may be assessed by a duly constituted committee at the department level, with the guide as a member at the end of every semester. Formally the registration for this course has to be done in the seventh semester and the student has to submit a final report at the end of seventh semester. The assessment to be done at the end of seventh semester by a duly constituted committee at the department level, with the guide as a member

Mandatory Learning Courses:

These are courses that must be completed by the student at appropriate time. The 'S' grade is awarded for satisfactory completion of the course and 'N' grade is awarded for non-completion of the course. 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) ***Environmental Studies****:* This is a 1 credit course, coordinated by Department of Civil Engineering and the student is required to complete this course during 1st / 2nd semester.

(b) **Professional Ethics and Human Values**: This is a 1 credit course, coordinated by

School of Management and the student is required to complete this course during 1st/ 2nd semester.

(c) ***Seminar****: 1 credit.* The student will make presentations on topics of academic interest.

(d) ***Practical Training****: 1 credit*. The student may complete the training before the beginning of the 7th semester (or as stipulated by the DUGC) and register for it in 7th Semester. The duration and the details shall be decided by the Faculty Advisor with approval from DUGC.

(e) ***Introduction to Design Thinking (ME100)***: (2-0-0) 2 Credits. This course will be coordinated by Department of Mechanical Engineering, with course instructors from the various B.Tech Programme offering Departments. The student is required to complete this course during 1st/2nd semester.

(f) ***Liberal arts courses/co-*curricular/extracurricular activities**: This is a 10-credit course. The students are required to earn minimum 10 credits under "Liberal arts courses/co-curricular/extracurricular activities"

The Liberal arts courses/co-curricular/extracurricular activities may be categorized as follows:

CATEGORY A: Sports/club activities/organizing Institute level programmes/NSS – Maximum 3 credits may be earned under this category of activities with credit allocation as follows:

- Participation in club activities/NSS/competitions held by the club- 1 credit per participation
- Member of a Club – 2 credits per membership
- Organizing team members of Institute events like INCIDENT/Engineer/club office bearers – 3 credits per membership
- Participation in State/National/International level competitions/paper presentation/Model building competitions – 3 credits per participation

All the certificates under this category are to be submitted by the student to Department of Physical Education, Sports and Student Activities clearly specifying the category for consideration, through the faculty advisor for the respective club/Committee and further to be approved by Dean (SW).

CATEGORY B: **NCC or YOGA courses offered by the Institute or INSTITUTE DEVELOPMENT ACTIVITIES (approved by Senate) – Maximum 3 credits**.

- The certificates under NCC or YOGA courses offered by the Institute are to be submitted by the student to Department of Physical Education, Sports and Student Activities clearly specifying the category for consideration, through NCC Officer/Yoga Instructor of the Institute, as applicable and further to be approved by Dean (SW).
- The Institute Development Activities to be considered for credits under Category B has to be associated with an Institute level committee for any such purpose constituted by competent authorities and to be approved by the Senate.

  The credits may be earned under Institute Development Activities like IRIS, with credit allocation as follows:
  - Core team members or group leaders – 3 credits for two years
  - Other contributors – 1 credit per year

  The award of the credits is based credits on two satisfactory progress review through the concerned Institute level Committee.

  The certificate under Institute development Activities like IRIS must be submitted by the student, clearly specifying the category for consideration through Faculty in charge for the activity (if any) and to be recommended by the Chairman of the Committee and further to be approved by Dean (SW).

CATEGORY C: **Certified courses in Languages/Fine arts – Maximum 7 credits may be earned under this category**. The certificates issued by authorized certification bodies to be submitted by the student to School of Humanities, Social Sciences and Management clearly specifying the category for consideration.

The courses/activities under "Liberal arts courses/co-curricular/extracurricular activities" may be taken during the period from 1st semester to 7th semester B.Tech at

student's convenience.
However registration for these courses have to be done in the seventh semester. The certificates may be submitted by the student to the Department of Physical Education, Sports and Student Activities/School of Humanities, Social Sciences and Management as applicable with due forwards, recommendations and approvals from the appropriate authority as specified above.
The consolidated credits earened by all the registered students for each of the B.Tech programme, mentioning the credits earned in Category A and B to be sent by Department of Physical Education, Sports and Student Activities with approval from Dean (SW) to the respective departments. The DUGC of individual department shall send the consolidated reports of marks and grades to Office of Dean (Academics).
The consolidated credits earened by all the registered students for each of the B.Tech programme, mentioning the credits earned in Category C to be sent by School of Humanities, Social Sciences and Management to the respective departments. The DUGC of individual department shall send the consolidated reports of marks and grades to Office of Dean (Academics).

3.3 The Department Undergraduate Committee (DUGC) will discuss and recommend the exact credits offered for the programme for the above components 'a' to 'f'; the semester-wise distribution among them, as well as the syllabi of all undergraduate 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.

3.4 ***Lower and Upper Limits for Course Credits Registered in a Semester/Session, by a Full-Time Student of the B.Tech. Degree Programme:***
A full time student of the B.Tech. degree programme must register for a minimum of 12 credits, and up to a maximum of 30 credits. However the minimum/maximum credit limit can be relaxed by the Dean (Academic) on the recommendations of the DUGC, only under extremely exceptional circumstances. The maximum credits that a student can register in a summer session is 16.
The 10 credits of Liberal arts courses, exra-curricular and co-curricular activities (Registered in the 7^{th} semester) and the MOOC courses are exempted from the count towards the minimum and maximum limit of credits per semester.

3.6 ***B.Tech. Students registering for Post Graduate courses as electives:***

In exceptional situations, with prior approval of the concerned DUGC, a B.Tech. student can register for a post graduate course as elective.

3.7 **Minor programme in B Tech**

A) A student in a particular discipline can take additional specified courses totaling 15 to 20 credits for,
   a) Minor in other disciplines where all the courses are offered by a department other than his/her parent department
   or
   b) Interdisciplinary Minor where courses are offered by two or more departments

B) If the student earns the specified total number of credits required for the minor discipline, then it will find a mention in the student's grade cards and degree certificate.

C) A student can opt for Minors in Third Semester and register for Minor Courses (Mn) from Third to Eighth Semesters. Students who have cleared all the courses of first and second semester in first attempt and have obtained a CGPA ≥ 7 and GPA (of common courses in the first year) ≥ 7.0 are eligible to register for minor courses.

D) Allotment of minor will be based on merit list prepared on the basis of GPA of common courses in the first year.

E) If a student who has registered for a minor programme does not become eligible for the Minor

degree, then the credits for completed Minor courses shall be shown in the Grade card, but not included for CGPA calculation.

3.8 **Honors programme in B Tech**

a) A student in a particular discipline can take additional courses specified by respective DUGC at postgraduate level in the same discipline totaling 15 to 20 credits. If he/she gets a GPA of 6.0 and above in these courses, then it will find a mention in their grade cards and degree certificate.

b) A student can opt for Honors after the end of Fourth Semester and register for Honors Courses from Fifth to Eighth Semesters. Students who have cleared all the courses of first to fourth semester in first attempt and have obtained a CGPA of 8.0 and above at the end of fourth semester are eligible to register for Honors courses.

c) If a student who has registered for a Honors programme does not become eligible for the Honors degree, then the credits for completed Honors courses shall be shown in the Grade card, but not included for CGPA calculation.

3.9 **Focus Area**

a) A student in a particular discipline can take additional specified courses totaling 15 to 20 credits of the specified Focus area courses within his/her discipline.

b) If the student earns the specified total number of credits required for the focus area, then it will find a mention in the student's grade cards but not in the degree certificate.

c) A student can opt for Focus area in Third Semester and register for Focus area Courses from Third to Eighth Semesters. Students who have cleared all the courses of first and second semester in first attempt and have obtained a CGPA ≥ 7 and GPA (of common courses in the first year) ≥ 7.0 are eligible to register for Focus area courses.

d) Allotment of Focus area will be based on merit list prepared on the basis of GPA of common courses in the first year.

e) If a student who has registered for a Focus area programme, does not satisfy clause 3.9 (b), then the credits for completed Focus area courses shall be shown in the Grade card, but not included for CGPA calculation.

4. DEGREE REQUIREMENTS:

The degree requirements of a student for the B.Tech programme are as follows:

(a) ***Institute Requirements:***

(i) Minimum Earned Credit Requirement for Degree is 160 to 170.

(ii) 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 DUGC and conforming to Clause No: 3 (Course Structure) above.

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

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	15
End of SECOND year	40

End of THIRD year	60
End of FOURTH year	80

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 at a stretch in a semester without sanctioned leave.

(c) 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 specifically for the Undergraduate (B.Tech.) degree programme:

6.1 Board of Studies (BOS-UG):

Constitution:

(a)	Dean (Academic)	…	*Chairman*
(b)	Dean (Faculty Welfare)	…	Member
(c)	Dean (Planning & Development)	…	Member
(d)	Dean (Students Welfare)	…	Member
(e)	Dean (R&C)	…	Member
(f)	Dean (AA&IR)	…	Member
(g)	Chairman of each DUGC/ his nominee	…	Member
(h)	BOG members representing the faculty	…	Members
(i)	Assistant Registrar (Academic)	…	*Convenor*
(j)	Dy. Registrar (Academic)	…	*Secretary*

Note:

- There shall be one BOS-UG 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 DUGC on matters relating to undergraduate programme and to make suitable recommendations to the Senate.

ii. To approve curriculum framed / revised by DUGC for the undergraduate courses of study.

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

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

v. To review the academic performance 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 undergraduate course and finalise the UG 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 Academic Section of the Dean (Academic).

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

6.2 Departmental Undergraduate Committee (DUGC):

Constitution:

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

Note:

- There shall be one DUGC for every department that is involved in the teaching for the B.Tech. Degree programme.
- The Secretary (DUGC) 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 undergraduate courses of the department.

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

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

iv. To develop/revise the curriculum for undergraduate courses offered by the department, and recommend the same to the BOS.

v. 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 the Dean (Academic).

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

vii. To conduct performance appraisal of Course Instructors.

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

ix. To consider any matter related to the undergraduate programme of the department.

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

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

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

* * * * *

FORMS & FORMATS

Undergraduate Programmes

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL
Post Srinivasnagar, Mangalore - 575025, India.
2024

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)
with date

Name & Signature of HOD
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													
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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

Note: Faculty advisor has to ensure that the entries in Course Instructors copy, Student copy and FA copy are matching

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					
9					
10					

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

Date:

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						
9						
10						

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 =

Nature of Leave : **Casual-Leave / Medical-Leave / special permission to attend - Sports/Cultural-meet/Conference, etc.**

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 DUGC/DPGC/DRPC can approve the leave upto 14 days.

(ii) If the leave is for more than 14 days, the leave application shall be forwarded to Dean(A) 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:
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:

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 carryout 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.

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-DUGC/DPGC/DRPC
Name & Signature
with Date

Chairman-DUGC/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 : FC/BSC / *ESC / HSC / PC / PSE / OE / PMP / MLC*

Name of the Instructor : Department :

SL.No.	Reg. No.	Name	%Marks / % Attendance*	Letter-Grade
1.				
2.				
3				
4.				
5.				
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8.				
9.				
10.				
11.				
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* For those students having less than 75% attendance and awarded 'FA' grade.

FC: Foundation Course **BSC: Basic Science Core;** **ESC: Engineering Science Core;**
PC: Programme Core; **PSE: Programme Specific Elective;** **HSC: Humanities & Social Sciences Core;**
OE: Open Elective; **MP: Project;** **MLC: Mandatory Learning Course**

==========

Course-Instructor(s)
Name & Signature with Date

Secretary-DUGC/DPGC/DRPC
Name & Signature with Date

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

RECORD OF CO-CURRICULAR & EXTRA-CURRICULAR ACTIVITIES

1. Name (in Block Letters)_____
2. Admission No.: _____
3. Roll No. _____

GROUP-1 CO-CURRICULAR ACTIVITIES (at least One)

Activity	Period		* S/N	Name & Signature of Faculty in-charge	Students signature with date
	From	To			
Professional Societies (IE(I)/IEEE/CSI/ISTE/etc)					
Department Association					
Lab. Development					
Paper Presentation					
TechFest (ENGINEER)					

GROUP-2 EXTRA-CURRICULAR ACTIVITIES (at least One)

Activity	Period		* S/N	Name & Signature of Faculty in-charge	Students signature with date
	From	To			
NCC / NSS / NSO					
Science Education & Literacy					
SPICMACAY					
Community Services					
Social Work					
Yoga / Meditation					
Health Care Service					
Language course					
Sports (Mention Event)					
Alumni Association					
INCIDENT					

* S: Satisfactory; N: Non-Satisfactory

Dean (Students Welfare)
Signature with Date & Seal

D E C L A R A T I O N

by the B.Tech. Student

I/We hereby *declare* that the Project Work Report entitled

.....

.....

which is being submitted to the **National Institute of Technology Karnataka, Surathkal** for the award of the Degree of Bachelor of Technology in .....

.....

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

Register Number, Name & Signature of the Student(s):

(1)

(2)

(3)

(4)

Department of .....

Place: NITK, SURATHKAL

Date:

[declaration to be signed by the student(s) and incorporated as part of the Project Work Report]

C E R T I F I C A T E

This is to *certify* that the B.Tech. Project Work Report entitled

.....

..... submitted by :

Sl.No. Register Number & Name of Student(s)

(1)

(2)

(3)

(4)

as the record of the work carried out by him/her/them, is *accepted as the B.Tech. Project Work Report submission* in partial fulfillment of the requirements for the award of degree of **Bachelor of Technology** in .....

Guide(s)
(Name and
Signature with Date)

Chairman - DUGC
(Signature with Date and Sea

Form for seeking Course Re-Registration during a Semester

[Applicable to FF / FA / Branch Change Cases]

(To be submitted before the Last Date of Course Registration)

[Student →FA→ HoD → Associate Dean (Academics-UG)]

[*To be filled-in by the Student*]

Date :

Name of the Student:

Roll No.:

Programme (B.Tech / M.Tech / MBA/ MSc/MCA/ Ph. D) :

Department: Semester :

I wish to register for my FF/FA/due to branch change course during this semester with following details:

Course Code :

Course Title :

Semester of this FF/FA/due to branch change course :

Section for registration of back log course in this semester (If applicable) :

Signature of the Student, with Date:

[*Forwarded with recommendation for favorable consideration of request]*

Faculty Advisor Secretary (DUGC/DPGC/DRPC) Date Chairman (DUGC/DPGC/DRPC)

[Approved]

The request by the student and the recommendation from the department has been examined. The student request is approved.

Associate Dean (Academics - UG / PG&R)

-- FOR OFFICE USE --

[*Action by MIS Office*]

This back log course has been registered.

MIS Officer

Encl :

(1) The grade card showing the student has previous semesters back log course

Form for seeking approval for Withdrawal from the Course during a Semester

(To be submitted after Drop Date of Course Registration in the semester is elapsed)

[Student →FA→ Course Instructor → DUGC/DPGC/DRPC→...→Dean-A]

[*To be filled-in by the Student*]

Date :

Name of the Student:

Roll No.:

Programme (B.Tech / M.Tech / MBA/ MSc/MCA/ Ph. D) :

Department: Semester :

I wish to withdraw my registration for the course with the details as below :

Course Code :

Course Title :

I have attached the explanation of the exceptional circumstance which is the reason for my decision of withdrawal from this course with this form. I understand that the as per regulations clause G5.12 letter grade 'W' will be recorded and remains permanently in the grade card.

Signature of the Student with Date

[Forwarded for favorable consideration of the request]

Signature(s)of the Faculty Advisor Signature of the Course Instructor

[*Recommended by DUGC/DPGC/DRPC for favorable consideration of request]*

Secretary (DUGC/DPGC/DRPC) Date Chairman (DUGC/DPGC/DRPC)

[Recommended for approval of Dean (Academic)]

The request by the student and the recommendation from the DUGC/DPGC/DRPC has been examined. The student request may be approved.

Associate Dean (UG / PG&R)

[Approved]

Dean(Academic)

--- FOR OFFICE USE --

Course Withdrawal is Recorded in IRIS MIS Officer

Course Withdrawal is noted Programmer – Academic Section

Encl :

(1) The explanation given by student for the request

(2) The DUGC/DPGC/DRPC Resolution recommending favourable consideration

Form for seeking approval for Discontinuing the Honors Programme

(To be submitted before the Drop Date of the Course Registration in the semester)

[Student →FA→DUGC/DPGC/DRPC→ Associate Dean →Dean]

[*To be filled-in by the Student*]

Date :

Name of the Student:

Roll No.:

Programme (B.Tech / M.Tech / MBA/ MSc/MCA/ Ph. D) :

Department: Semester :

I wish to discontinue the honors programme in the Department of _____ for the below reason.

Reason for the discontinuation of honors programme :

I request you to approve my request.

Signature of the Student with Date

[*Forwarded with recommendation for favorable consideration of request]*

Faculty Advisor Secretary (DUGC/DPGC/DRPC) Date (Chairman DUGC/DPGC/DRPC)

[Recommended for approval of Dean (Academic)]

The request by the student and the recommendation from the DUGC/DPGC/DRPC has been examined. The student request may be approved.

Associate Dean (UG / PG&R)

[Approved]

Dean(Academic)

-- FOR OFFICE USE --

[*Action by MIS Office*]

The Discontinuation of Honors Programme of this student has been Noted.

MIS Officer

[*Action by Programmer- Academic Section*]

The Discontinuation of Honors Programme of this student has been Noted.

Programmer- Academic Section

Form for seeking approval for Discontinuing the Minor Programme

(To be submitted before the Drop Date of the Course Registration in the semester)

[Student →FA→DUGC/DPGC/DRPC→ Associate Dean →Dean]

[*To be filled-in by the Student*]

Date :

Name of the Student:

Roll No.:

Programme (B.Tech / M.Tech / MBA/ MSc/MCA/ Ph. D) :

Department: Semester :

I wish to discontinue the minor programme in the Department of _____ for the below reason.

Reason for the discontinuation of minor programme :

I request you to approve my request.

Signature of the Student with Date

[*Forwarded with recommendation for favorable consideration of request]*

[Minor Offering Department]

Faculty Advisor Date HoD

[*Forwarded with recommendation for favorable consideration of request]*

[Parent Department]

Faculty Advisor Secretary (DUGC/DPGC/DRPC) Date Chairman (DUGC/DPGC/DRPC)

[Recommended for approval of Dean (Academic)]

The request by the student and the recommendation from the DUGC/DPGC/DRPC has been examined. The student request may be approved.

Associate Dean (UG / PG&R)

[Approved]

Dean(Academic)

-- FOR OFFICE USE --

[*Action by MIS Office*]

The student has been removed from Minor Batch in IRIS .

MIS Officer

[*Action by Programmer- Academic Section*]

The Discontinuation of Minor Programme of this student has been Noted.

Programmer- Academic Section

Approval Form for registration of MOOC courses as Elective during Odd / Even Semester

(To be submitted on or before 'Last Date of Course Registration of Odd / Even Semester as per NITK Academic Calendar)

[Student →FA of Parent Department→ DUGC/DRPC of Parent Department]

[*To be filled-in by the Student*]

Date:

Name of the Student:
Roll No.:

Programme (B.Tech / Ph. D) :

Department: Semester :

I wish to register for the MOOC course in this semester with the details as below :

Course Title :

Conducting Organisation :

Start Date : End Date : No. of Hours :

Certificate issued after conducting examination criteria (Yes / No) :

Website URL for the course details :

Type of Course (Program Specific Elective / Liberal Arts) :

I have attached the MOOC course syllabus and the qualifying examination criteria for the award of MOOC certificate. **I understand that if MOOC Certificate is submitted by me on or before the class end date of this semester, it will be included in the grade card of this semester, else it will be included in the next semester grade card**.

Signature of the Student, with Date:

[Forwarded for favorable consideration of the request after scrutinizing the credentials of the MOOC course as well as the organization conducting MOOC course]

Signature(s) of the Faculty Advisor

[DUGC / DRPC Resolution to be conveyed to students on or before 'Drop / cU options' date]

DUGC / DRPC Meeting Date :

MOOC Course Registration : Approved / Not Approved

Number of Credits Stipulated for the MOOC Course :

The transfer of credits will be recommended to Dean (Academic) after submission of MOOC course certificate by the student issued by MOOC conducting organization on the basis of qualifying examination criteria

Secretary (DUGC/DRPC) Date Chairman (DUGC / DRPC)

Encl :

(1) MOOC Course Syllabus
(2) Qualifying examination criteria for the award of MOOC certificate

Form for seeking Course Re-Registration during a Summer Session

[Applicable to FF / FA / Any Other Cases]

(To be submitted before the Last Date of Course Registration for Summer Session)

[Student →FA→ HoD → Associate Dean (Academics-UG)]

[*To be filled-in by the Student*]

Date :

Name of the Student:

Roll No.:

Programme (B.Tech / M.Tech / MBA/ MSc/MCA/ Ph. D) :

Department: Semester :

I wish to re-register for my FF/FA grade course during the Summer Session with following details:

Course Code :

Course Title :

Semester of this FF/FA grade course :

Section for registration of back log course in this Summer Session (If applicable)

*[This Section data must be filled where there are multiple sections for the course]***:**

Signature of the Student, with Date:

[*Forwarded with recommendation for favorable consideration of request]*

Faculty Advisor | Secretary (DUGC/DPGC/DRPC) | Date | Chairman (DUGC/DPGC/DRPC)

[Approved]

The request by the student and the recommendation from the department has been examined. The student request is approved.

Associate Dean (Academics - UG / PG&R)

-- FOR OFFICE USE --

[*Action by MIS Office*]

This back log course has been registered.

MIS Officer

Encl :

(1) The grade card showing the student has previous semesters back log course

Form for seeking approval for Registration of Different Elective Course in lieu of the Elective Course in which "FF" Grade has been awarded

(To be submitted before the last date of Course Registration)

[Student →FA→DUGC/DPGC/DRPC→ Associate Dean]

[*To be filled-in by the Student*]

Date :

Name of the Student:

Roll No.:

Programme (B.Tech / M.Tech / MBA/ MSc/MCA/ Ph. D) :

Department: Semester :

	FF Grade Course Details of earlier semester	In-Lieu Course Details for Registration this Semester
Course Code		
Course Title		
Credits		

Signature of the Student with Date

[*Forwarded with recommendation for favorable consideration of request]*

Faculty Advisor Secretary (DUGC/DPGC/DRPC) Date Chairman (DUGC/DPGC/DRPC)

[Approved]

The request by the student and the recommendation from the department has been examined. The student request is approved.

Associate Dean (Academics - UG / PG&R)

-- FOR OFFICE USE --

[*Action by MIS Office*]

This In-Lieu Course Registration of Elective has been verified in IRIS .

MIS Officer

[*Action by Programmer- Academic Section*]

This In-Lieu Course Registration of Elective has been Noted.

Programmer – Academic Section

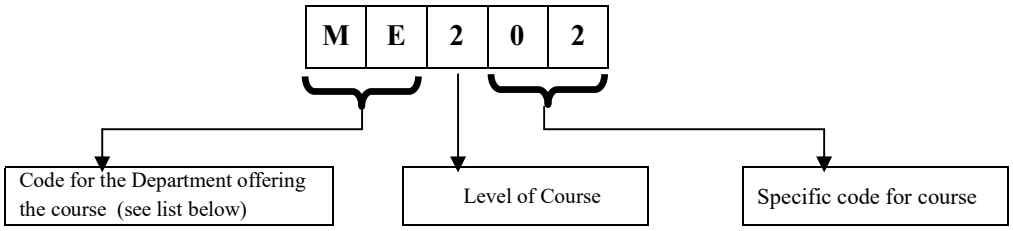
STRUCTURE - UG

CONTENTS

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Course Numbering Scheme

Course Numbers are denoted by character strings



Typically, courses whose three numerals are between 100 and 499 are taken by Undergraduate students and 600 to 999 by Post Graduate & Research students. Brief descriptions of courses for Undergraduate students are given in this booklet.

List of Codes for Departments

Department Code	Name of the Department
CH	Chemical Engineering
CY	Chemistry
CV	Civil Engineering
CS	Computer Science & Engineering
EE	Electrical & Electronics Engineering
EC	Electronics & Communication Engineering
IT	Information Technology
MA	Mathematical & Computational Sciences
ME	Mechanical Engineering
MT	Metallurgical & Materials Engineering
MI	Mining Engineering
PH	Physics
SM	School of Humanities, Social Sciences and Management
WO	Water Resources & Ocean Engineering

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 course title.

Example: ME202 FLUID MECHANICS AND MACHINERY (3-1-0) 4

It is a 4 credit course consisting of : 3hr Lectures, 1hr Tutorial and 0hr Practical, per week.

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

First Year Bachelor of Technology

List of Courses Common to All Undergraduate Programmes

Foundation Courses (FC)

Basic Science Core (BSC)

MA110	Engineering Mathematics – I	(3-0-0) 3
MA111	Engineering Mathematics – II	(3-0-0) 3
PH110	Physics	(3-1-0) 4
PH111	Physics Laboratory	(0-0-2) 1
CY110	Chemistry	(3-0-0) 3
CY111	Chemistry Laboratory	(0-0-3) 2

Engineering Science Core (ESC)

WO110	Engineering Mechanics	(3-0-0) 3
ME111	Engineering Graphics	(1-0-3) 3

Humanities and Social Science Core (HSC)

SM110	Professional Communication	(3-0-0) 3

Mandatory Learning Courses (MLC)

CV110	Environmental Studies	(1-0-0) 1
SM111	Professional Ethics and Human Values	(1-0-0) 1
ME100	Introduction to Design Thinking	(2-0-0) 2

Other courses under Engineering Science Core (ESC)

Computer Programming courses under ESC (Set 1 or Set 2 as specified by the Department offering the B.Tech. Programme)

Set 1

(For Computer Science, AI, IT, E &C branches only)

CS110	C Programming	(3-0-0) 3
CS111	C Programming Lab	(0-0-3) 2

Set 2

(For E & E, Computational and Data Science, Mechanical, Civil, Mining, Metallurgy, Chemical Engineering branches only)

CS100	Python Programming	(3-0-0) 3
CS101	Python Programming Lab	(0-0-3) 2

EC100 Elements of Electronics and Communication Engineering (2-0-0)2

(For Artificial Intelligence, Computational and Data Science, Mechanical, Civil, Mining, Metallurgy, Chemical Engineering branches only)

EE110 Elements of Electrical Engineering (2-0-0)2

(For Mechanical, Civil, Mining, Metallurgy, Chemical Engineering branches only)

ME110 Elements of Mechanical Engineering (2-0-0)2

(For Computer Science, IT, E &C, E & E, Civil, Mining, Metallurgy, Chemical Engineering branches only)

Programme Specific Core Courses

Chemical Engineering

CH150	Process Calculations	(2-2-0)4

Civil Engineering

CV100	Civil Engineering Materials and Construction	(3-1-0)4

Computer Science And Engineering

CS112	Discrete Mathematical Structures	(3-1-0) 4

Electrical & Electronics Engineering

EE101	Analysis Of Electric Circuits	(3-1-0)4
EE143	Mathematics For Electrical Engineers	(3-1-0)4

Electronics And Communication Engineering

EC101	Joy of Electronics and Communication	(2-0-3)4
EC102	Circuits and Systems	(3-1-0)4

Information Technology

IT110	Digital System Design	(3-0-2)4
IT150	Object Oriented Programming	(3-0-2)4

Artificial Intelligence

IT111	Fundamental of Computer Systems	(4-0-0) 4
IT112	Computer Systems Lab	(0-0-2) 1
IT150	Python Programming	(3-0-0) 3
IT151	Python Programming Lab	(0-0-2) 1

Mechanical Engineering

ME112	Materials Science and Engineering	(3-0-0)3
ME113	Mechanics of Deformable Bodies	(3-0-0)3

Metallurgical And Materials Engineering

MT160	Introduction to Material Science & Technology	(3-1-0)4

Mining Engineering

MI101	Introduction to Mining Engineering	(3-0-0)3

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Suggested Plan of Study:

First Semester

GROUP – I (S1-S6)

Mechanical (S1,S2,S3)	MA110 (3-0-0)3	PH110 (3-1-0)4	PH111 (0-0-2)1	EC100 (2-0-0)2	EE110 (2-0-0)2	ME111 (1-0-3)3	SM110 (3-0-0)3	SM111 (1-0-0)1	-	(PSC) ME112 (3-0-0)3
Mining (S3)	MA110 (3-0-0)3	PH110 (3-1-0)4	PH111 (0-0-2)1	EC100 (2-0-0)2	EE110 (2-0-0)2	ME111 (1-0-3)3	SM110 (3-0-0)3	SM111 (1-0-0)1	ME110 (2-0-0)2	-
Civil (S4,S5)	MA110 (3-0-0)3	PH110 (3-1-0)4	PH111 (0-0-2)1	EC100 (2-0-0)2	EE110 (2-0-0)2	ME111 (1-0-3)3	SM110 (3-0-0)3	SM111 (1-0-0)1	ME110 (2-0-0)2	-
Metallurgy (S5,S6)	MA110 (3-0-0)3	PH110 (3-1-0)4	PH111 (0-0-2)1	EC100 (2-0-0)2	EE110 (2-0-0)2	ME111 (1-0-3)3	SM110 (3-0-0)3	SM111 (1-0-0)1	ME110 (2-0-0)2	-
Chemical (S6)	MA110 (3-0-0)3	PH110 (3-1-0)4	PH111 (0-0-2)1	EC100 (2-0-0)2	EE110 (2-0-0)2	ME111 (1-0-3)3	SM110 (3-0-0)3	SM111 (1-0-0)1	ME110 (2-0-0)2	-

GROUP – II (S7-S14)

Computer (S7,S8)	CY110 (3-0-0)3	CY111 (0-0-3)2	MA110 (3-0-0)3	CS110 (3-0-0)3	-	CS111 (0-0-3)2	-	WO110 (3-0-0)3	CV110 (1-0-0)1	UC100 (2-0-0)2	-	-
E & C (S9, S10)	CY110 (3-0-0)3	CY111 (0-0-3)2	MA110 (3-0-0)3	CS110 (3-0-0)3	-	CS111 (0-0-3)2	-	WO110 (3-0-0)3	CV110 (1-0-0)1	UC100 (2-0-0)2	(PSC) EC101 (2-0-3)4	-
E & E (S11,S12)	CY110 (3-0-0)3	CY111 (0-0-3)2	MA110 (3-0-0)3	-	CS100 (3-0-0)3	-	CS101 (0-0-3)2	WO110 (3-0-0)3	CV110 (1-0-0)1	UC100 (2-0-0)2	(PSC) EE101 (3-1-0)4	-
IT (S13)	CY110 (3-0-0)3	CY111 (0-0-3)2	MA110 (3-0-0)3	CS110 (3-0-0)3	-	CS111 (0-0-3)2	-	WO110 (3-0-0)3	CV110 (1-0-0)1	UC100 (2-0-0)2	(PSC) IT110 (3-0-2)4	-
AI (S14)	CY110 (3-0-0)3	CY111 (0-0-3)2	MA110 (3-0-0)3	CS110 (3-0-0)3	-	CS111 (0-0-3)2	-	WO110 (3-0-0)3	CV110 (1-0-0)1	UC100 (2-0-0)2	(PSC) IT111 (4-0-0)4	(PSC) IT112 (0-0-2)1
CDS (S14)	CY110 (3-0-0)3	CY111 (0-0-3)2	MA110 (3-0-0)3	CS100 (3-0-0)3	-	CS101 (0-0-3)2	-	WO110 (3-0-0)3	CV110 (1-0-0)1	UC100 (2-0-0)2	(PSC) MA112 (4-0-0)4	-

Note: UC401 LIBERAL ARTS COURSES/CO-CURRICULAR/EXTRACURRICULAR ACTIVITIES
CATEGORY A : Maximum 3 credits, CATEGORY B : Maximum 3 credits, CATEGORY C : Minimum 4 Credits and Maximum 7 credits.
10 Credits have to be earned from 1st Semester to 7th Semester by choosing Category (A + B + C) OR Category (A + C) or Category (B + C) courses combination. Registration for 10 Credits has to be done in 7th Semester.
For details of CATEGORY A, CATEGORY B and CATEGORY C refer to clause 3.2 (f) under Regulations specific to Undergraduate Programmes.

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Second Semester

GROUP – I (S1-S6)

Mechanical (S1,S2,S3)	CY110 (3-0-0)3	CY111 (0-0-3)2	MA111 (3-0-0)3	CS100 (3-0-0)3	CS101 (0-0-3)2	WO110 (3-0-0)3	CV110 (1-0-0)1	UC100 (2-0-0)2	(PSC) ME113 (3-0-0)3
Mining (S3)	CY110 (3-0-0)3	CY111 (0-0-3)2	MA111 (3-0-0)3	CS100 (3-0-0)3	CS101 (0-0-3)2	WO110 (3-0-0)3	CV110 (1-0-0)1	UC100 (2-0-0)2	(PSC) MI101 (3-0-0)3
Civil (S4,S5)	CY110 (3-0-0)3	CY111 (0-0-3)2	MA111 (3-0-0)3	CS100 (3-0-0)3	CS101 (0-0-3)2	WO110 (3-0-0)3	CV110 (1-0-0)1	UC100 (2-0-0)2	(PSC) CV100 (3-1-0)4
Metallurgy (S5,S6)	CY110 (3-0-0)3	CY111 (0-0-3)2	MA111 (3-0-0)3	CS100 (3-0-0)3	CS101 (0-0-3)2	WO110 (3-0-0)3	CV110 (1-0-0)1	UC100 (2-0-0)2	(PSC) MT160 (3-1-0)4
Chemical (S6)	CY110 (3-0-0)3	CY111 (0-0-3)2	MA111 (3-0-0)3	CS100 (3-0-0)3	CS101 (0-0-3)2	WO110 (3-0-0)3	CV110 (1-0-0)1	UC100 (2-0-0)2	(PSC) CH150 (2-2-0)4

GROUP – II (S7-S14)

Computer (S7,S8)	MA111 (3-0-0)3	PH110 (3-1-0)4	PH111 (0-0-2)1	ME110 (2-0-0)2	-	ME111 (1-0-3)3	SM110 (3-0-0)3	SM111 (1-0-0)1	(PSC) CS112 (3-1-0)4	-
E & C (S9, S10)	MA111 (3-0-0)3	PH110 (3-1-0)4	PH111 (0-0-2)1	ME110 (2-0-0)2	-	ME111 (1-0-3)3	SM110 (3-0-0)3	SM111 (1-0-0)1	(PSC) EC102 (3-1-0)4	-
E & E (S11,S12)	MA111 (3-0-0)3	PH110 (3-1-0)4	PH111 (0-0-2)1	ME110 (2-0-0)2	-	ME111 (1-0-3)3	SM110 (3-0-0)3	SM111 (1-0-0)1	(PSC) EE143 (3-1-0)4	-
IT (S13)	MA111 (3-0-0)3	PH110 (3-1-0)4	PH111 (0-0-2)1	ME110 (2-0-0)2	-	ME111 (1-0-3)3	SM110 (3-0-0)3	SM111 (1-0-0)1	(PSC) IT150 (3-0-2)4	-
AI (S14)	MA111 (3-0-0)3	PH110 (3-1-0)4	PH111 (0-0-2)1	-	EC100 (2-0-0)2	ME111 (1-0-3)3	SM110 (3-0-0)3	SM111 (1-0-0)1	(PSC) IT151 (3-0-0)3	(PSC) IT152 (0-0-2)1
CDS (S14)	MA111 (3-0-0)3	PH110 (3-1-0)4	PH111 (0-0-2)1	EC100 (2-0-0)2	-	ME111 (1-0-3)3	SM110 (3-0-0)3	SM111 (1-0-0)1	(PSC) MA113 (4-0-0)4	-

Note: UC401 LIBERAL ARTS COURSES/CO-CURRICULAR/EXTRACURRICULAR ACTIVITIES

CATEGORY A : Maximum 3 credits, CATEGORY B : Maximum 3 credits, CATEGORY C : Minimum 4 Credits and Maximum 7 credits. 10 Credits have to be earned from 1st Semester to 7th Semester by choosing Category (A + B + C) OR Category (A + C) or Category (B + C) courses combination. Registration for 10 Credits has to be done in 7th Semester.

For details of CATEGORY A, CATEGORY B and CATEGORY C refer to clause 3.2 (f) under Regulations specific to Undergraduate Programmes.

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Department of Chemical Engineering
Bachelor of Technology in Chemical Engineering

Basic Science Core Courses (BSC)

CY110	Chemistry	(3-0-0)3
CY111	Chemistry Laboratory	(0-0-3)2
MA110	Engineering Mathematics - I	(3-0-0)3
MA111	Engineering Mathematics - II	(3-0-0)3
PH110	Physics	(3-1-0)4
PH111	Physics Laboratory	(0-0-2)1
CY205	Organic Chemistry	(3-0-0)3
CY255	Technical Analysis Lab	(0-0-4)2
CY300	Instrumental Methods of Analysis	(3-0-0)3

Engineering Science Core Courses (ESC)

CS100	Python Programming	(3-0-0)3
CS101	Python Programming Lab	(0-0-3)2
EC100	Elements of Electronics & Communication Engineering	(2-0-0)2
EE110	Elements of Electrical Engineering	(2-0-0)2
ME110	Elements of Mechanical Engineering	(2-0-0)2
ME111	Engineering Graphics	(1-0-3)3
WO110	Engineering Mechanics	(3-0-0)3

Humanities and Social Sciences Core Courses (HSC)

SM110	Professional Communication	(3-0-0)3
SM300	Engineering Economics	(3-0-0)3
SM302	Principles of Management	(3-0-0)3

Programme Core Courses (PC)

CH150	Process Calculations	(2-2-0)4
CH200	Momentum Transfer	(3-1-0)4
CH201	Particulate Technology	(2-1-0)3
CH202	Chemical Engg. Thermodynamics	(3-1-0)4
CH203	Transport Phenomena	(2-2-0)4
CH204	Computer Simulation Lab	(0-0-3)2
CH250	Heat Transfer	(3-1-0)4
CH251	Mass Transfer-I	(3-1-0)4
CH252	Chemical Reaction Engg.–I	(2-1-0)3
CH253	Momentum Transfer Lab	(0-0-3)2
CH254	Particulate Technology Lab	(0-0-3)2
CH300	Chemical Reaction Engineering – II	(2-1-0)3
CH301	Mass Transfer – II	(3-1-0)4
CH302	Process Dynamics & Control	(3-1-0)4
CH303	Heat Transfer Operations Lab	(0-0-3)2
CH350	Chemical Process Industries	(3-0-0)3
CH351	Process Design of Chemical Equipment	(3-1-0)4
CH352	Mass Transfer Operations Lab	(0-0-3)2
CH353	Design and Simulation Lab	(0-0-2)1
CH400	Pollution Control and Safety in Process Industries	(3-0-0)3
CH401	Chemical Reaction Engg. & Process Control Lab	(0-0-3)2
MA207	Numerical Methods	(3-0-0)3
MA211	Laplace and Z Transforms	(1-0-0)1

Programme Specific Elective Courses (PSE)

CH450	Process Instrumentation	(3-0-0)3
CH451	Energy Technology	(3-0-0)3
CH452	Petroleum Refining Processes	(3-0-0)3
CH453	Biochemical Engineering	(3-0-0)3
CH454	Introduction to Molecular Simulations	(2-0-2)3
CH455	Energy Conservation & Management in Process Industries	(3-0-0)3
CH456	Fuel Cell Engineering	(3-0-0)3
CH457	Chemical Project Engineering	(3-0-0)3
CH458	Biology for Chemical Engineers	(3-0-0)3
CH460	Cornerstone/capstone Project	4

Project (MP)

CH449	Major Project I	(0-0-3) 2
CH499	Major Project II	(0-0-6) 4

Mandatory Learning Courses (MLC)

SM 111	Professional Ethics and Human values	(1-0-0)1
CV110	Environmental Sciences	(1-0-0)1
CH440	Practical Training	01
CH448	Seminar	01
UC100	Introduction to Design Thinking	(2-0-0)2
UC401	Liberal arts courses/cocurricular/extracurricular activities	10

Honor Courses (Hn)

CH701	Molecular and Turbulent Transport	(3-1-0) 4
CH702	Process System Analysis and Control	(3-1-0) 4
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
CH764	Bioreactor Engineering	(3-1-0) 4

Minor Courses (Mn)

CH150M	Process Calculations	(2-2-0)4
CH202M	Chemical Engineering Thermodynamics	(3-1-0)4
CH203M	Transport Phenomena	(2-2-0)4
CH252M	Chemical Reaction Engineering I	(2-1-0)3
CH302M	Process Dynamics and Control	(3-1-0)4

Department specific course for Interdisciplinary Machine Learning Mnor

CH459M	Machine Learning Applications in Chemical Engineering	(0-0-6) 4

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Suggested Plan of Study for B.Tech. in Chemical Engineering:

Slot/Semester	I	II	III	IV	V	VI	VII	VIII
1	MA110	CY110	CH200	CH250	CY255	CY300	CH400	*Elective*
2	PH110	CY111	CH201	CH251	SM300	SM302	CH401	*Elective*
3	PH111	MA111	CH202	CH252	CH300	CH350	*Elective*	*Elective*
4	EC100	CS100	CH203	CY205	CH301	CH351	*Elective*	*Elective*
5	EE110	CS101	CH204	CH253	CH302	CH352	*Elective*	CH499
6	ME110	WO110	MA207	CH254	CH303	CH353	CH449	
7	ME111	CH150	MA211			*Elective*	CH440	
8	SM110	UC100					CH448	
9	SM111	CV110					UC401	

Requirements for B.Tech. in Chemical Engineering:

Category of Courses	Minimum Credits to be Earned
Foundation Courses Basic Science Core (BSC): 24 Engineering Science Core (ESC): 17 Humanities and Social Science Core (HSC): 9	50
Programme Core Courses (PC)	68
Electives Courses (Ele) Programme Specific Electives, MOOC Courses (0 – 8 credits)	21
Project (MP)	06
Mandatory Learning Courses (MLC)	16
Total	**161**

Requirement for Honors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
5	20

Requirement for Minors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
5	19

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Department of Civil Engineering (CV)
Bachelor of Technology in Civil Engineering

Basic Science Core Courses (BSC)

CY110	Chemistry	(3-0-0)3
CY111	Chemistry Laboratory	(0-0-3)2
MA110	Engineering Mathematics - I	(3-0-0)3
MA111	Engineering Mathematics - II	(3-0-0)3
PH110	Physics	(3-1-0)4
PH111	Physics Laboratory	(0-0-2)1

Engineering Science Core Courses (ESC)

CS100	Python Programming	(3-0-0)3
CS101	Python Programming Lab	(0-0-3)2
EC100	Elements of Electronics and Communication Engineering	(2-0-0)2
EE110	Elements of Electrical Engineering	(2-0-0)2
ME110	Elements of Mechanical Engineering	(2-0-0)2
ME111	Engineering Graphics	(1-0-3)3
WO110	Engineering Mechanics	(3-0-0)3

Humanities and Social Science Core Courses (HSC)

SM110	Professional Communication	(3-0-0)3
SM300	Engineering Economics	(3-0-0)3
SM302	Principles of Management	(3-0-0)3

Programme Core Courses (PC)

CV100	Civil Engineering Materials and Construction	(3-1-0)4
CV201	Elements of Surveying	(3-0-0)3
CV202	Engineering Geology	(3-0-0)3
CV216	Civil Engineering Materials Lab.	(0-0-3)2
CV251	Design of RCC Structures	(3-0-0)3
CV252	Soil Mechanics	(3-0-0)3
CV253	Structural Analysis	(3-0-0)3
CV254	Highway and Traffic Engineering	(3-0-0)3
CV265	Surveying Practice	(0-0-3)2
CV266	Geology Lab	(0-0-3)2
CV267	Soil Mechanics Lab	(0-0-3)2
CV301	Environmental Engineering	(3-0-0)3
CV316	Building Design and Drawing	(1-0-3)3
CV351	Design of Steel Structures	(3-0-0)3
CV366	Highway Materials and Concrete Testing Lab	(0-0-3)2
CV367	Environmental Engineering Lab	(0-0-3)2
CV401	Estimation Costing and Specifications	(3-0-0)3
CV417	Structural Design and Drawing	(1-0-3)3
MA207	Numerical Methods	(3-0-0)3
WO200	Mechanics of Materials	(3-0-0)3
WO216	Strength of Materials Lab	(0-0-3)2
WO218	Mechanics of Fluids	(3-0-0)3
WO219	Hydraulics Lab	(0-0-3)2
WO260	Water Resources Engineering	(3-0-0)3

Programme Specific Elective Courses (PSE)

CV268	Advanced Mining Geology	(3-0-0)3
CV321	Applied Soil Engineering	(3-0-0)3
CV322	Concrete Technology	(3-0-0)3
CV323	Architecture and Town Planning	(3-0-0)3
CV324	Analysis of Indeterminate Structures	(3-0-0)3
CV325	Structural Masonry and Alternative Building Technologies	(3-0-0)3
CV326	Disaster Management and Mitigation	(3-0-0)3
CV371	Railways, Tunnels, Harbours and	(3-0-0)3
CV372	Design of P.S.C Structures	(3-0-0)3
CV373	Probability Methods in Civil	(3-0-0)3
CV374	Transportation Systems Planning	(3-0-0)3
CV375	Rock Mechanics	(3-0-0)3
CV376	Disaster Management with Spatial Methods	(3-0-0)3
CV385	Geoinformatics	(3-0-0)3
CV386	Applied Rock Enginneing	(3-0-0)3
CV387	Applied Geology	(3-0-0)3
CV388	Advanced Surveying	(3-0-2)4
CV389	Advanced Structural Analysis	(3-0-0)3
CV400	Cornerstone/capstone Project	((0-0-2)1 x4)
CV421	Bridge Engineering	(3-0-0)3
CV422	Advanced Design of Structures - I	(3-0-0)3
CV423	Design of Foundations, Earth and Earth Retaining Structures	(3-0-0)3
CV424	Advanced Environmental Engineering	(3-0-0)3
CV425	Computer Aided Design and Applications in Civil Engineering	(2-0-3)4
CV426	Solid Waste Management	(3-0-0)3
CV427	Structural Dynamics and Wind Engineering	(3-0-0)3
CV471	Advanced Design of Structures - II	(3-0-0)3
CV472	Ground Improvement Techniques	(3-0-0)3
CV473	FEM Applications in Civil Engineering	(3-0-0)3
CV474	Elements of Earthquake Engineering	(3-0-0)3
CV475	Oil and Natural Gas Exploration	(3-0-0)3
CV477	Seismoresistant Concrete Structures	(3-0-0)3
CV485	Air Pollution and Noise Pollution	(3-0-0)3
CV486	Environmental Impact Assessment	(3-0-0)3
CV487	Construction and Project Management	(3-0-0)3
CV488	Ground Water Development and Management	(3-0-0)3
CV489	Retrofitting and Rehabilitation of Structures	(3-0-0)3
CV490	Non-destructive testing & evaluation for concrete structures	(3-0-0)3
CV491	Bituminous Materials, Mixtures and Pavements	(3-0-0)3
CV492	Reinforced Earth Structures	(3-0-0)3
WO371	Open Channel Flow and Sediment transport	(3-0-0)3
WO372	Civil Engineering Systems	(3-0-0)3
WO400	Geographic Information System	(3-0-0)3
WO401	Satellite Digital Image Analysis	(3-0-0)3
WO402	Introduction to Geospatial Technology and Applications	(3-0-0)3
WO403	Global Positioning Systems	(3-0-0)3
WO421	Design and Drawing of Hydraulic Systems	(1-0-3)3
WO422	Fundamentals of Coastal Engineering	(3-0-0)3
WO423	Basics of Offshore Engineering	(3-0-0)3
WO424	Coastal Erosion and its Mitigation	(3-0-0)3
WO445	Fundamentals of Finite Element Method	(3-0-0)3
WO455	Engineering Optimization	(3-0-0)3
WO473	Water Resources Excess Management	(3-0-0)3
WO474	Computational Methods in Hydrology	(3-0-0)3
WO475	Ground Water Engineering	(3-0-0)3

WO477	Open Source Virtual Instrumentation	(2-0-2)3
WO478	Theory of Isotropic Elasticity	(3-0-0)3
CV380	Mini Project I	(0-0-3)2
CV381	Mini Project II	(0-0-3)2
WO380	Mini Project I	(0-0-3)2
WO381	Mini Project II	(0-0-3)2

Project (MP)

CV449	Major Project - I	(0-0-3)2
CV499	Major Project - II	(0-0-6)4

Mandatory Learning Courses (MLC)

CV110	Environmental Studies	(1-0-0)1
SM111	Professional Ethics and Human Values	(1-0-0)1
UC100	Introduction to Design Thinking	(2-0-0)2
UC401	Liberal arts courses/cocurricular/extracurricular activities	10
CV390	Seminar	1
CV440	Practical Training	1

Honor Courses (Hn)

Students seeking Honors degree shall credit minimum **FIFTEEN (15)** additional credits from minimum **FIVE** Postgraduate courses offered by the Department of Civil Engg. and Water Resources and Ocean Engg., as decided by DUGC.

Minor Courses (Mn)

WO200M/ CV201M	Mechanics of Materials/ Elements of Surveying	(3-0-0)3
CV252M	Soil Mechanics	(3-0-0)3
CV301M	Environmental Engineering	(3-0-0)3
CV254M	Highway and Traffic Engineering	(3-0-0)3
CV401M	Estimation, Costing and Specification	(3-0-0)3

Department specific course for Interdisciplinary Machine Learning Mnor

CV448M	Machine Learning Applications in Civil Engineering	(0-0-6) 4

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Suggested Plan of Study for B.Tech. in Civil Engineering

Number of Courses	Semester							
	I	II	III	IV	V	VI	VII	VIII
1	MA110	CY110	CV201	CV251	SM302	SM300	CV401	Elective
2	PH110	CY111	CV202	CV252	CV301	CV351	CV417	Elective
3	PH111	MA111	CV216	CV253	CV316	CV366	Elective	CV499
4	EC100	CS100	MA207	CV254	Elective	CV367	Elective	
5	EE110	CS101	WO200	CV265	Elective	Elective	Elective	
6	ME110	WO110	WO216	CV266	Elective	Elective	Elective	
7	ME111	CV100	WO218	CV267	Elective	Elective	CV449	
8	SM110	CV110	WO219	WO260	Elective	Elective	CV440	
9	SM111	UC100				CV390	UC401	

Requirements for B.Tech. in Civil Engineering:

Category of Courses	**Minimum Credits to be Earned**
Foundation Courses Basic Science Core (BSC): 16 Engineering Science Core (ESC): 17 Humanities and Social Science Core (HSC): 9	42
Programme Core Courses (PC)	65
Electives Courses (Ele) Programme Specific Electives, Mini Project (0 - 4 credits), MOOC Courses (0 – 8 credits)	39
Project (MP)	6
Mandatory Learning Courses (MLC)	16
Total	**168**

Requirement for Honors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
5	15

Requirement for Minors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
5	15

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Department of Computer Science & Engineering (CS)
Bachelor of Computer Science & Engineering

Basic Science Core Courses (BSC)

CY110	Chemistry	(3-0-0)3
CY111	Chemistry Laboratory	(0-0-3)2
MA110	Engineering Mathematics - I	(3-0-0)3
MA111	Engineering Mathematics - II	(3-0-0)3
PH110	Physics	(3-1-0)4
PH111	Physics Laboratory	(0-0-2)1

Engineering Science Core Courses (ESC)

CS110	C Programming	(3-0-0)3
CS111	C Programming Lab	(0-0-3)2
ME110	Elements of Mechanical Engineering	(2-0-0)2
ME111	Engineering Graphics	(1-0-3)3
WO110	Engineering Mechanics	(3-0-0)3

Humanities and Social Science Core Courses (HSC)

SM110	Professional Communication	(3-0-0)3
SM300	Engineering Economics	(3-0-0)3
SM302	Principles of Management	(3-0-0)3

Program Core Courses (PC)

CS112	Discrete Mathematical Structures	(3-1-0)4
CS200	Theory of Computation	(3-1-0)4
CS201	Design of Digital Systems	(3-1-0)4
CS202	Data Structures and Algorithms	(3-1-0)4
CS203	Data Structures and Algorithms Lab	(0-0-3)2
CS204	Design of Digital Systems Lab	(0-0-3)2
CS251	Database Systems	(3-1-0)4
CS252	Operating Systems	(3-1-0)4
CS253	Design and Analysis of Algorithms	(3-1-0)4
CS254	Database Systems Lab	(0-0-3)2
CS255	Data Communication	(3-1-0)4
CS256	Computer Organization and Architecture	(3-1-0)4
CS257	Operating Systems Lab	(0-0-3)2
CS301	Computer Networks	(3-1-0)4
CS302	Computer Networks Lab	(0-0-3)2
CS303	Compiler Design	(3-1-0)4
CS304	Compiler Design Lab	(0-0-3)2
CS305	Software Engineering	(3-1-0)4
MA204	Linear Algebra and Matrices	(3-0-0)3
MA208	Probability Theory and Applications	(3-0-0)3

Programme Specific Elective Courses (PSE)

CS311	Cryptography and Applications	(3-1-0)4
CS312	Machine Learning	(3-0-2)4
CS313	Cryptography and Applications Lab	(0-0-3)2
CS314	Data Structures for Advanced Applications	(3-1-0)4
CS315	Graph Theory	(3-1-0)4
CS316	System Programming	(3-1-0)4
CS317	Big Data Analytics	(3-1-0)4
CS318	Network Management	(3-1-0)4
CS319	Microprocessor Systems	(3-1-0)4
CS320	Artificial Intelligence	(3-1-0)4
CS321	Full Stack Development	(3-1-0)4
CS322	Graph Drawing	(3-1-0)4
CS346	Computing in Autonomous vehicles	(3-1-0)4
CS351	Management Information Systems	(3-1-0)4
CS352	Soft Computing	(3-1-0)4
CS353	Computer Graphics	(3-1-0)4
CS354	Object Oriented Programming	(3-1-0)4
CS355	Computing with FPGAs	(2-0-3)4
CS356	Advanced Data Structures	(3-1-0)4
CS357	Digital Image Processing	(3-1-0)4
CS358	Digital Systems Testing	(3-1-0)4
CS359	Advanced Computer Networks	(3-1-0)4
CS360	Modern Formal Methods and Applications	(3-1-0)4
CS361	Quantum Computing	(3-1-0)4
CS362	Distributed Computing	(3-1-0)4
CS363	Cloud Computing	(3-1-0)4
CS364	Distributed Operating Systems	(3-1-0)4
CS365	Service Oriented Computing	(3-1-0)4
CS366	Internet of Things	(3-1-0)4
CS367	Foundations of Cyber-Physical Systems	(3-1-0)4
CS368	Security Engineering	(3-1-0)4
CS369	Approximation Algorithms	(3-1-0)4
CS370	Parameterized Algorithms	(3-1-0)4
CS371	Computational Complexity	(3-1-0)4
CS372	Randomized Algorithms	(3-1-0)4
CS410	Simulation and Modeling	(3-1-0)4
CS411	Software Testing	(3-1-0)4
CS412	Cyber-Physical Systems Verification	(3-1-0)4
CS413	Reversible Computing	(3-1-0)4
CS414	Web Engineering	(3-1-0)4
CS415	Computational Cyber-Physical Systems	(3-1-0)4
CS416	Data Warehousing and Mining	(3-1-0)4
CS417	Parallel Programming	(3-1-0)4
CS418	Topics in Information Security	(3-1-0)4
CS419	Algorithmic Graph Theory	(3-1-0)4
CS420	Autonomous Vehicles	(3-1-0)4
CS421	Computational Geometry	(3-1-0)4
CS422	Deep Learning	(3-1-0)4
CS423	Computer Vision	(3-1-0)4
CS424	Speech Processing	(3-1-0)4
CS425	Natural Language Processing	(3-1-0)4
CS426	Reinforcement Learning	(3-1-0)4
CS427	Cloud Security	(3-1-0)4
CS428	Cloud Networking	(3-1-0)4
CS429	Storage Systems	(3-1-0)4
CS430	Next Generation Multi-Cloud Architecture	(3-0-2)4
CS431	Digital Systems Verification	(3-1-0)4
CS432	Quantum Computer Architecture	(3-1-0)4
CS433	Wireless Networks	(3-1-0)4
CS434	Mobile Computing	(3-1-0)4
CS435	Open Source Networking Technologies	(3-1-0)4
CS460	Cyber-Physical Systems and Applications	(3-1-0)4
CS461	Trustworthy Cyber-Physical Systems	(3-1-0)4
CS462	High Performance Computing Paradigms	(3-1-0)4
CS463	Network Security	(3-1-0)4
CS464	Heterogeneous Parallel Computing	(3-1-0)4
CS465	Distributed Database Systems	(3-1-0)4
CS466	Social Network Analysis	(3-1-0)4
CS467	Information Storage Management	(3-1-0)4
CS468	Applications of Blockchain Technology	(3-1-0)4
CS469	Software Based Networks	(3-1-0)4

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CS470	Database Security	(3-1-0)4
CS471	Information Centric Networking	(3-1-0)4
CS472	Quantitative Computer Architecture	(3-1-0)4
CS300	Mini Project- I	(0-0-3)2
CS350	Mini Project – II	(0-0-3)2
CS400	Mini Project – III	(0-0-3)2
CS450	Mini Project – IV	(0-0-3)2
CS401	Cornerstone/capstone Project	(0-0-6)4

Project (MP)

CS402	Major Project	(0-0-9)6

Mandatory Learning Courses (MLC)

UC100	Introduction to Design Thinking	(2-0-0)2
CV110	Environmental Sciences	(1-0-0)1
SM111	Professional Ethics &Human Values	(1-0-0)1
CS398	Seminar	1
CS399	Practical Training	1
UC401	Liberal Arts – Category A, B, C	10

Honors Courses (Hn)

CS701	High Performance Computing	(3-0-2)4
CS750	Distributed Data Management	(3-0-2)4
CS751	Network Engineering	(3-0-2)4
CS850	Database Security	(3-0-2)4
CS851	Network Security	(3-0-2)4

Focus Area Courses (FAC)

Courses for Focus Area in Artificial Intelligence and Machine Learning

CS312M	Machine Learning	(3-0-2)4
CS320M	Artificial Intelligence	(3-1-0)4
CS422M	Deep Learning	(3-1-0)4
CS423M	Computer Vision	(3-1-0)4
CS490M	Project in AI/ML	(0-0-6)4

Courses for Focus Area in Distributed and Cloud Computing

CS362M	Distributed Computing	(3-1-0)4
CS363M	Cloud Computing	(3-1-0)4
CS428M	Cloud Networking	(3-1-0)4
CS430M	Next Generation Multi-Cloud Architecture	(3-0-2)4
CS491M	Project for Distributed & Cloud Computing	(0-0-6)4

Courses for Focus Area in Cyber-Physical Systems

CS367M	Foundations of Cyber-Physical Systems	(3-1-0)4
CS412M	Cyber-Physical Systems Verification	(3-1-0)4
CS460M	Cyber-Physical Systems and Applications	(3-1-0)4
CS461M	Trustworthy Cyber-Physical Systems	(3-1-0)4
CS492M	Project for Cyber-Physical Systems	(0-0-6)4

Courses for Focus Area in Networking

CS359M	Advanced Computer Networks	(3-1-0)4
CS433M	Wireless Networks	(3-1-0)4
CS435M	Open Source Networking Technologies	(3-1-0)4
CS469M	Software Based Networks	(3-1-0)4
CS493M	Project for Networking	(0-0-6)4

Courses for Focus Area in Security

CS311M	Cryptography and Applications	(3-1-0)4
CS418M	Topics in Information Security	(3-1-0)4
CS427M	Cloud Security	(3-1-0)4
CS463M	Network Security	(3-1-0)4
CS470M	Database Security	(3-1-0)4

Minor Courses (Mn) (Except for IT Students)

CS202M	Data Structures and Algorithms	(3-1-0)4
CS251M	Database Systems	(3-1-0)4
CS252M	Operating Systems	(3-1-0)4
CS301M	Computer Networks	(3-1-0)4
CS305M	Software Engineering	(3-1-0)4

Department specific course for Interdisciplinary Machine Learning Mnor

CS367M	Foundations of CPS	(3-1-0) 4
CS426M	Reinforcement Learning	(3-1-0) 4
CS473M	Project for ML Minors	(0-0-6) 4

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Suggested Plan of Study for B.Tech. in Computer Science and Engineering:

Sem→	I	II	III	IV	V	VI	VII	VIII
1	CY110	MA111	CS200	CS251	SM300	SM302	*Elective*	*Elective*
2	CY111	PH110	CS201	CS252	CS253	*Elective*	*Elective*	*Elective*
3	MA110	PH111	CS202	CS254	CS301	*Elective*	CS402*	CS402*
4	CS110	ME110	CS203	CS255	CS302	*Elective*	CS399	
5	CS111	ME111	CS204	CS256	CS303	*Elective*	UC401	
6	WO110	SM110	MA204	CS257	CS304	*Elective*		
7	CV110	CS112		MA208	CS305	CS398		
8	UC100	SM111						
9								

- Can be done in 7th Semester or 8th Semester

Requirements for B.Tech. in Computer Science and Engineering:

Category of Courses	**Minimum Credits to be Earned**
Foundation Courses Basic Science Core (BSC): 16 Engineering Science Core (ESC): 13 Humanities and Social Science Core (HSC): 9	38
Programme Core Courses (PC)	66
Electives Courses (Ele) Programme Specific Electives, Mini Project (0 - 4 credits), MOOC Courses (0 – 8 credits)	34
Project (MP)	06
Mandatory Learning Courses (MLC)	16
Total	**160**

Requirement for Honors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
5	20

Requirement for Minors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
5	20

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Department of Electrical and Electronics Engineering (EE)
Bachelor of Technology in Electrical and Electronics Engineering

Basic Science Core Courses (BSC)

CY110	Chemistry	(3-0-0) 3
CY111	Chemistry Laboratory	(0-0-3) 2
MA110	Engineering Mathematics – I	(3-0-0) 3
MA111	Engineering Mathematics - II	(3-0-0) 3
PH110	Physics	(3-1-0) 4
PH111	Physics Laboratory	(0-0-2) 1

Engineering Science Core Courses (ESC)

CS100	Python Programming	(3-0-0) 3
CS101	Python Programming Laboratory	(0-0-3) 2
ME110	Elements of Mechanical Engineering	(2-0-0) 2
ME111	Engineering Graphics	(1-0-3) 3
WO110	Engineering Mechanics	(3-0-0) 3

Humanities and Social Science Core Courses (HSC)

SM110	Professional Communication	(3-0-0)3
SM300	Engineering Economics	(3-0-0) 3
SM302	Principles of Management	(3-0-0) 3

Programme Core Courses (PC)

EE101	Analysis of Electric Circuits	(3-1-0) 4
EE143	Mathematics for Electrical Engineers	(3-1-0) 4
EE207	Electromagnetic Theory	(3-1-0) 4
EE213	Induction Motors and Transformers	(3-1-3) 6
EE224	Electrical Measurements and Measuring Instruments	(3-1-3) 6
EE226	Analog Electronic Circuits	(3-1-3) 6
EE256	Signals and Systems	(3-1-3) 6
EE258	Synchronous Machines and DC Machines	(3-1-3) 6
EE265	Power Transmission and Distribution	(3-1-0) 4
EE276	Digital Electronic Circuits	(3-1-3) 6
EE308	Power Electronics	(3-1-3) 6
EE326	Linear Control Systems	(3-1-3) 6
EE350	Power System Analysis	(3-1-3) 6

Programme Specific Elective Courses (PSE)

EE229	Polyphase Systems and Component – Transformations	(3-1-0) 4
EE260	Digital Computer Organization and Architecture	(3-1-0) 4
EE295	Electrical Machine Winding Calculations-I	(0-2-3) 4
EE296	Electrical Machine Winding Calculations-II	(0-2-3) 4
EE301	Data Structures and Algorithms	(3-0-2) 4
EE303	Distribution Systems Control and Automation	(3-1-0) 4
EE311	Digital System Design	(3-1-0)4
EE312	Power System Harmonics	(3-1-0) 4
EE313	Digital Signal Processing	(3-1-0) 4
EE319	Neural Networks and Applications	(3-1-0) 4
EE320	Electrical Safety, Operations, Regulations	(3-0-0) 3
EE321	Linear and Nonlinear Systems	(3-1-0) 4
EE324	Electronic Measurements and Instrumentation	(3-1-0) 4
EE328	Network Synthesis	(3-1-0) 4
EE329	Traveling Waves on Transmission Systems	(3-1-0) 4
EE335	Digital System Design Laboratory	(0-0-3) 2
EE337	Power System Harmonics Laboratory	(0-0-3) 2
EE343	Statistical Foundation for Electrical Engineers	(3-1-0) 4
EE359	Energy Auditing	(3-1-0) 4
EE360	Microprocessors and Microcontrollers	(3-1-0) 4
EE362	Operation and control of Power Systems	(3-1-0) 4
EE363	Advanced Digital Signal Processing	(3-1-0) 4
EE366	Special Machines and Drives	(3-1-0) 4
EE369	Embedded System Design	(3-1-0) 4
EE371	Power Electronics Applications to Power Systems	(3-1-0) 4
EE373	Electric Power Stations	(3-1-0) 4
EE374	Electric Energy Systems	(3-1-0) 4
EE376	Advanced Control Systems	(3-1-0) 4
EE385	Microprocessors and Microcontrollers Laboratory	(0-0-3) 2
EE386	Digital Signal Processing Laboratory	(0-0-3) 2
EE387	Advanced Digital Signal Processing Laboratory	(0-0-3) 2
EE389	Embedded System Design Laboratory	(0-0-3) 2
EE392	Power System Operation Laboratory	(0-0-3) 2
EE401	Time Series Analysis and Forecasting	(3-0-2) 4
EE402	HVDC Transmission	(3-1-0) 4
EE403	Deep Neural Network and Applications	(3-0-2) 4
EE404	Soft Computing and applications	(3-1-0) 4
EE406	Electromagnetic Compatibility	(3-1-0) 4
EE407	Modelling of Electrical Machines	(4-0-0) 4
EE408	Solid-State Drives	(3-1-0) 4
EE410	Power System Protection	(3-1-0) 4
EE411	Operation of Power Systems Under Deregulation	(3-1-0) 4
EE412	Random Signal Processing	(3-1-0) 4
EE418	Advanced Power Electronics	(3-1-0) 4
EE420	Power System Dynamics	(3-1-0) 4
EE422	Principles of Switchgear and Protection	(3-1-0) 4
EE423	Switchgear and Protection Laboratory	(0-0-3) 2
EE427	Computer Networks	(3-1-0) 4
EE428	The ARM Core: Architecture and Programming	(3-1-0) 4
EE430	Introduction to Robot Dynamics and Control	(3-1-0) 4
EE432	Introduction to Machine Learning	(3-1-2) 5
EE439	Advanced Power Electronics Laboratory	(0-0-3) 2
EE443	Mathematical Morphology & applications to signal processing	(3-1-0) 4
EE454	Flexible AC Transmission Systems	(3-1-0) 4
EE456	High-Voltage Engineering	(3-1-0) 4
EE458	Photovoltaics and Applications	(3-1-0) 4
EE450	Fundamentals of ElectricVehicles	(3-1-0) 4
EE464	Power Generation and Economics	(3-1-0) 4
EE466	Utilization of Electrical Energy	(3-1-0) 4
EE467	Industrial Electrical Systems	(3-0-0) 3
EE468	Advanced Electric Drives	(3-1-0) 4
EE469	New and Renewable Energy Systems	(3-0-0) 3
EE470	Computational Technique for large system analysis	(3-1-0) 4
EE471	Power System Simulation Laboratory	(0-0-3) 2
EE472	Insulation and Testing Engineering	(3-1-0) 4
EE476	Introduction to Nonlinear and Linear Optimization	(3-1-0) 4
EE489	Advanced Electric Drives Laboratory	(0-0-3) 2
EE491	Insulation and Testing Engineering Laboratory	(0-0-3) 2
EE500	System Analysis in Discrete Time	(3-1-0) 4
EE501	Analysis of Nonlinear Circuits	(3-1-0) 4
EE502	Cornerstone/capstone Project	(0-2-3) 4
EE347	Design & Development Task in Control Systems	(0-0-3) 2
EE348	Design & Development Task in Power Electronics & Drives	(0-0-3) 2
EE397	Design & Development Task in Signal Processing	(0-0-3) 2
EE398	Design & Development Task in Power Systems	(0-0-3) 2

Project (MP)

EE449	Major Project-I	(0-1-3) 3
EE499	Major Project-II	(0-1-3) 3

Mandatory Learning Courses (MLC)

CV110	Environmental Studies	(1-0-0) 1
SM111	Professional Ethics and Human Values	(1-0-0) 1
EE448	Seminar	01
EE498	Practical Training	01
UC100	Introduction to Design Thinking	(2-0-0) 2
UC401	Liberal arts courses/cocurricular/extracurricular activities	10

Honors Courses (Hn)

Students seeking Honors degree shall credit minimum 16 additional credits from Postgraduate courses offered by the Department of Electrical and Electronics Engg., as decided by DUGC.

Minor Courses(Mn) (Except for EC Students)

EE230M	Electric Circuits	(3-1-0) 4
EE261M	Basic Electric Machines	(3-1-0) 4
EE310M	Electric Power System	(3-1-0) 4
EE370M	Electrical and Electronics Measuring Instruments and Techniques	(3-1-0) 4
EE415M	Power Electronics in Power Control	(3-1-0) 4

Department specific course for Interdisciplinary Machine Learning Mnor

EE450M	Applications of Machine Learning Techniques to Problems in Electrical Engineering	(3-0-2) 4

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Suggested Plan of Study for B.Tech. in Electrical and Electronics Engineering:

Semester →	I	II	III	IV	V	VI	VII	VIII
1	CY110	MA111	EE207	EE224	SM300	SM302	Elective	Elective
2	CY111	PH110	EE213	EE258	EE326	EE308	Elective	Elective
3	MA110	PH111	EE226	EE265	EE350	Elective	EE498	EE499
4	CS100	ME110	EE256	EE276	Elective	Elective	EE449	EE448
5	CS101	ME111			Elective	Elective	UC401	
6	WO110	EE143						
7	EE101	SM110						
8	CV110	SM111						
9	UC100							

Requirements for B.Tech. in Electrical and Electronics Engineering:

Category of Courses	Minimum Credits to be Earned
Foundation Courses Basic Science Core (BSC): 16 Engineering Science Core (ESC): 13 Humanities and Social Science Core (HSC): 9	38
Programme Core Courses (PC)	70
Electives Courses Courses (Ele) Programme Specific Electives, Mini Project (0 - 4 credits), MOOC Courses (0 – 8 credits)	36
Project (MP)	06
Mandatory Learning Courses (MLC)	16
Total	**166**

Requirement for Honors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
To satisfy minimum credit earning requirement	16

Requirement for Minors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
5	20

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Department of Electronics and Communication Engineering (EC)
Bachelor of Technology in Electronics and Communication Engineering

Basic Science Core Courses (BSC)

CY110	Chemistry	(3-0-0) 3
CY111	Chemistry Laboratory	(0-0-3) 2
MA110	Engineering Mathematics – I	(3-0-0) 3
MA111	Engineering Mathematics – II	(3-0-0) 3
PH110	Physics	(3-1-0) 4
PH111	Physics Laboratory	(0-0-2) 1

Engineering Science Core Courses (ESC)

CS110	C Programming	(3-0-0) 3
CS111	C Programming Lab	(0-0-3) 2
ME110	Elements of Mechanical Engineering	(2-0-0) 2
ME111	Engineering Graphics	(1-0-3) 3
WO110	Engineering Mechanics	(3-0-0) 3

Humanities and Social Science Core Courses (HSC)

SM110	Professional Communication	(3-0-0) 3
SM300	Engineering Economics	(3-0-0) 3
SM302	Principles of Management	(3-0-0) 3

Program Core Courses (PC)

EC101	Joy of Electronics and Communication	(2-0-3) 4
EC102	Circuits and Systems	(3-1-0) 4
EC200	Digital System Design	(3-1-0) 4
EC201	Analog Electronics	(3-1-0) 4
EC202	Analog and Digital Communication	(3-1-0) 4
EC203	Linear Algebra and Probability Theory	(3-1-0) 4
EC204	Digital System Design Lab	(0-0-3) 2
EC205	Analog Electronics Lab	(0-0-3) 2
EC206	Microprocessors	(3-1-0) 4
EC207	Electromagnetic Waves and Transmission Lines	(3-1-0) 4
EC208	Digital Signal Processing	(3-1-0) 4
EC209	Control Systems	(3-1-0) 4
EC210	Microprocessors Lab	(0-0-3) 2
EC211	Digital Signal Processing Lab	(0-0-3) 2
EC300	VLSI Design	(3-1-0) 4
EC301	RF Components and Circuits	(3-1-0) 4
EC302	VLSI Design Lab	(0-0-3) 2
EC303	Communication Lab-I	(0-0-3) 2
EC304	Communication Lab-II	(0-0-3) 2

Programme Specific Elective Courses (PSE)

EC340	Computer Organization and	(3-1-0) 4
EC341	Computer Arithmetic	(3-1-0) 4
EC342	Embedded System Design	(2-0-3) 4
EC343	FPGA based System Design	(2-0-3) 4
EC344	Analog Integrated Circuits	(3-1-0) 4
EC345	Data Structures and Algorithms	(3-0-2) 4
EC346	Foundations of Machine Learning	(3-1-0) 4
EC347	Speech and Audio Processing	(3-1-0) 4
EC348	Image and Video Processing	(3-1-0) 4
EC349	Applied Number Theory	(3-1-0) 4
EC350	Numerical Analysis	(3-1-0) 4
EC351	Satellite Communications	(3-1-0) 4
EC352	Principles of Modern Radar and Techniques	(3-1-0) 4
EC353	Modern Electronic Navigation Systems	(3-1-0) 4
EC354	Communication Networks	(3-1-0) 4
EC355	Wireless Mobile Communication	(3-1-0) 4
EC356	Information Theory and Coding	(3-1-0) 4
EC357	Adhoc and Sensor Networks	(3-1-0) 4
EC358	Multimedia Communication	(3-1-0) 4
EC359	Software Defined and Cognitive Radio	(3-1-0) 4
EC360	Machin Learning for Wireless Communication Systems	(3-1-0) 4
EC361	Sparse Representations and Compressive Sensing	(3-1-0) 4
EC362	Deep Reinforcement Learning	(3-1-0) 4
EC363	Machine Leaarming Applications in Radar Signal Procesing	(3-1-0) 4
EC440	VLSI CAD	(3-1-0) 4
EC441	Mixed Signal Design	(3-1-0) 4
EC442	Advanced Computer Architecture	(3-1-0) 4
EC443	VLSI Testing and Testability	(3-1-0) 4
EC444	Synthesis and Optimization of Digital Circuits	(3-1-0) 4
EC445	Techniques in Low Power VLSI	(3-1-0) 4
EC446	Submicron Devices	(3-1-0) 4
EC447	Active Filters	(3-1-0) 4
EC448	Heterogeneous and Parallel Computing	(3-0-2) 4
EC449	Algorithms and Architectures for Signal Processing	(3-1-0) 4
EC450	Analog and Digital Filter Design	(3-1-0) 4
EC451	Advanced Digital Signal Processing	(3-1-0) 4
EC452	Real Time Signal Processing	(2-0-3) 4
EC453	Fourier and Wavelet Signal Processing	(3-1-0) 4
EC454	Mathematical Algorithms for Signal Processing	(3-1-0) 4
EC455	Digital Signal Compression	(3-1-0) 4
EC456	Dynamical Systems, Chaos and	(3-1-0) 4
EC457	Statistical Analysis	(3-1-0) 4
EC458	Stochastic Processes	(3-1-0) 4
EC459	Optimization and Applications	(3-1-0) 4
EC460	Neural Networks and Deep Learning	(3-1-0) 4
EC461	Spread Spectrum Communication	(3-1-0) 4
EC462	Error Control Coding	(3-1-0) 4
EC463	Optical Communication Systems and Networks	(3-1-0) 4
EC464	Radar Signal Processing	(3-1-0) 4
EC465	Algorithms for Parameter and State Estimation	(3-1-0) 4
EC466	Detection and Estimation Theory	(3-1-0) 4
EC467	Advanced Topics in Communication Engineering	(3-1-0) 4
EC468	Signal Integrity and EMI/ EMC	(3-1-0) 4
EC469	Introduction to Photonics	(3-1-0) 4
EC470	MIMO Communication Systems	(3-1-0) 4
EC471	RF IC Design	(3-1-0) 4
EC472	Principles of Modern Radar- Advanced Techniques	(3-1-0) 4
EC473	Electronic Defense Systems	(3-1-0) 4
EC474	Principles of Modern Sonar Systems	(3-1-0) 4
EC475	Advanced Electromagnetics	(3-1-0) 4

EC476	Milimeter Wave Communication	(3-1-0) 4
EC477	Imaging, Informatics and Computational Physics	(3-1-0) 4
EC478	Complex Analysis and Applications	(3-1-0) 4
EC479	Computational Inverse Problems and Applications	(3-1-0) 4
EC480	Remote Sensing: Principles, Techniques & Applications	(3-1-0) 4
EC481	Advanced Deep Learning and Applications	(3-1-0) 4
EC280	Mini Project in Electrical Circuits and Systems	(0-0-3) 2
EC281	Mini Project in Digital System Design	(0-0-3) 2
EC380	Mini Project in Communication Systems and Networks	(0-0-3) 2
EC381	Mini Project in Microprocessor and Embedded System	(0-0-3) 2
EC382	Mini Project in Analog System Design	(0-0-3) 2
EC383	Mini Project in VLSI Design	(0-0-3) 2
EC384	Mini Project in RF Design	(0-0-3) 2
EC385	Mini Project in Digital Signal	(0-0-3) 2
EC386	Mini Project in Image Processing	(0-0-3) 2
EC387	Mini Project in AI and Machine	(0-0-3) 2
EC388	Mini Project in Photonics	(0-0-3) 2
EC497	Cornerstone/capstone Project	4

Project (MP)

EC498	Major Project	6

Mandatory Learning Courses (MLC)

CV110	Environmental Studies	(1-0-0) 1
SM111	Professional Ethics & Human Values	(1-0-0) 1
EC390	Seminar	1
EC490	Practical Training	1
UC401	Liberal Arts courses/cocurricular/extra-curricular activities	10
UC100	Introduction to Design Thinking	(2-0-0) 2

Honor Courses (Hn)

Students opting for honors degree shall do their Major Project in the department

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
EC733	Optical Networks and Switching	(4-0-0) 4
EC734	Signal Detection and Estimation	(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
EC792	High Performance Computing Architectures	(4-0-0) 4
EC801	Logic Synthesis Techniques	(4-0-0) 4
EC803	Microelectronic Devices	(4-0-0) 4
EC804	Digital VLSI Testing & Testability	(4-0-0) 4
EC808	CMOS RF Integrated Circuits	(4-0-0) 4
EC832	MIMO Communication Systems	(4-0-0) 4
EC834	Error Control Coding	(4-0-0) 4
EC836	Radar Signal Processing and Applications	(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
EC864	Speech and Audio Processing	(4-0-0) 4
EC866	Deep Learning and Applications	(3-0-2) 4
EC872	Nonlinear Dynamics, Chaos and Fractals	(4-0-0) 4
EC873	Computational Imaging and Physics	(4-0-0) 4
EC875	Probabilistic Models in Machine Learning	(4-0-0) 4

Minor Courses (Mn) (Except for EE Students)

EC391M	Analog Electronic Circuits	(3-0-0) 3
EC392**M**	Digital Electronics	(3-0-0) 3
EC393M	Signals and Systems	(3-0-0) 3
EC394M	Communication Systems	(3-0-0) 3
EC395M	Data Communication and Networks	(3-0-0) 3

Department specific course for Interdisciplinary Machine Learning Mnor

EC500M	Machine Learning for Electronics and Communication Engineering	(3-1-0) 4

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Suggested Plan of Study for B.Tech. in Electronics and Communication Engineering:

Semester →	I	II	III	IV	V	VI	VII	VIII
1	CY110	MA111	EC200	EC206	SM300	SM302	Elective	Elective
2	CY111	PH110	EC201	EC207	EC300	EC304	Elective	Elective
3	MA110	PH111	EC202	EC208	EC301	Elective	Elective	Elective
4	CS110	ME110	EC203	EC209	EC302	Elective	Elective	EC498
5	CS111	ME111	EC204	EC210	EC303	Elective	EC498	
6	WO110	SM110	EC205	EC211	Elective	Elective	EC490	
7	EC101	EC102	Elective	Elective	Elective		UC401	
8	CV110	SM111			EC390			
9	UC100							

Requirements for B.Tech. in Electronics and Communication Engineering:

Category of Courses	**Minimum Credits to be Earned**
Foundation Courses Basic Science Core (BSC): 16 Engineering Science Core (ESC): 13 Humanities and Social Science Core (HSC): 9	38
Programme Core Courses (PC)	62
Electives Courses (Ele) Programme Specific Electives, Mini Project (0 - 6 credits), MOOC Courses (0 – 8 credits)	39
Project (MP)	06
Mandatory Learning Courses (MLC)	16
Total	**161**

Requirement for Honors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
4	16

Requirement for Minors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
5	15

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Department of Information Technology (IT)
Bachelor of Technology in Information Technology

Basic Science Core Courses (BSC)

MA110	Engineering Mathematics – I	(3-0-0) 3
PH110	Physics	(3-1-0) 4
PH111	Physics Laboratory	(0-0-2) 1
MA111	Engineering Mathematics – II	(3-0-0) 3
CY110	Chemistry	(3-0-0) 3
CY111	Chemistry Laboratory	(0-0-3) 2

Engineering Science Core Courses (ESC)

ME110	Elements of Mechanical Engineering	(2-0-0) 2
ME111	Engineering Graphics	(1-0-3) 3
WO110	Engineering Mechanics	(3-0-0) 3
CS110	C Programming	(3-0-0) 3
CS111	C Programming Lab	(0-0-3) 2

Humanities and Social Science Core Courses (HSC)

SM110	Professional Communication	(3-0-0) 3
SM300	Engineering Economics	(3-0-0) 3
SM302	Principles of Management	(3-0-0) 3

Programme Core (PC)

IT110	Digital System Design	(3-0-2) 4
IT150	Object Oriented Programming	(3-0-2) 4
IT200	Computer Communication and Networking	(4-0-0) 4
IT201	Computer Organization and Architecture	(3-0-0) 3
IT202	Data Structures and Algorithms-I	(3-0-0) 3
IT203	Discrete Mathematics	(3-0-0) 3
IT204	Signals and Systems	(3-0-2) 4
IT205	Computer Networking Lab	(0-0-3) 2
IT206	Data Structures and Algorithms-I Lab	(0-0-3) 2
IT250	Automata and Compiler Design	(3-0-2) 4
IT251	Data Structures and Algorithms-II	(3-0-2) 4
IT252	Database Systems	(3-0-2) 4
IT253	Operating Systems	(3-0-2) 4
IT254	Web Technologies and Applications	(3-0-2) 4
IT300	Design and Analysis of Algorithms	(3-0-2) 4
IT301	Parallel Computing	(3-0-2) 4
IT302	Probability and Statistics	(3-0-2) 4
IT303	Software Engineering	(3-0-2) 4
IT350	Data Analytics	(3-0-2) 4
IT351	Human Computer Interaction	(3-0-2) 4
IT352	Information Assurance and Security	(3-0-2) 4

Programme Specific Elective Courses (PSE)

IT360	Information Systems	(3-0-2) 4
IT361	Paradigms of Programming	(3-0-2) 4
IT362	Computer Graphics	(3-0-2) 4
IT363	Microprocessors and Interfacing	(3-0-2) 4
IT364	Performance Modeling	(3-0-2) 4
IT365	Advanced Computer Networks	(3-0-2) 4
IT366	Object Oriented Analysis and Design	(3-0-2) 4
IT372	Mobile Networks	(3-0-2) 4
IT400	Perceptual Audio Processing	(3-0-2) 4
IT401	Perceptual Video Processing	(3-0-2) 4
IT402	Soft Computing	(3-0-2) 4
IT403	Genetic Algorithms	(3-0-2) 4
IT404	Artificial Neural Networks	(3-0-2) 4
IT405	Fuzzy System Models	(3-0-0) 3
IT406	Distributed Computing Systems	(3-0-2) 4
IT407	Technologies for Internet of Things	(3-0-2) 4
IT408	Mobile Computing	(3-0-2) 4
IT409	Embedded Systems	(3-0-0) 3
IT410	Bioinformatics	(3-0-0) 3
IT411	Knowledge Management	(3-0-0) 3
IT412	Time Series Analysis	(3-0-0) 3
IT413	System Integration	(3-0-0) 3
IT414	Data Warehousing and Data Mining	(3-0-2) 4
IT415	Middleware Technologies	(3-0-2) 4
IT416	Computer Vision	(3-0-2) 4
IT417	Pattern Recognition	(3-0-2) 4
IT418	Cloud Computing	(3-0-2) 4
IT419	Wireless Sensor Networks	(3-0-2) 4
IT420	Mobile Adhoc Networks	(3-0-2) 4
IT421	Semantic Web Technologies	(3-0-2) 4
IT422	Virtual Reality	(3-0-2) 4
IT423	Rich Internet Applications	(3-0-2) 4
IT450	Web Services	(3-0-0) 3
IT451	Software Architecture	(3-0-0) 3
IT452	Advanced Computer Architecture	(3-0-0) 3
IT453	Transaction Processing	(3-0-0) 3
IT454	Software Quality Assurance	(3-0-0) 3
IT455	Information Technology for Healthcare	(3-0-0) 3
IT456	Enterprise Resource Planning and Systems	(3-0-0) 3
IT457	Natural Language Processing	(3-0-2) 4
IT458	Information Retrieval	(3-0-2) 4
IT459	Simulation and Modelling	(3-0-2) 4
IT460	E-Commerce	(3-0-0) 3
IT461	Advanced Database Systems	(3-0-2) 4
IT462	Number Theory and Cryptography	(3-0-2) 4
IT463	Linux Kernel Internals	(3-0-2) 4
IT464	Foundations of Machine Learning	(3-0-2) 4
IT465	Cryptocurrencies and Blockchain Technologies	(3-0-2) 4
IT466	Fundamentals of 5G	(3-0-2) 4
IT467	Robotic Process Automation	(3-0-2) 4
IT468	Quantum Computing	(3-0-2) 4
IT470	Cornerstone/capstone Project	4
IT482	Social Network Analysis	(3-0-2) 4
IT483	Narrowband Internet of Things	(3-0-2) 4
IT484	Randomized Algorithms	(3-1-0) 4

Project (MP)

IT449	Major Project-I	(0-0-3) 2
IT499	Major Project-II	(0-0-6) 4

Mandatory Learning Courses (MLC)

CV110	Environmental Studies	(1-0-0) 1
SM111	Professional Ethics and Human Values	(1-0-0) 1
UC100	Introduction to Design Thinking	(2-0-0) 2
UC401	Liberal art Courses/ cocurricular/ extracurricular activities	10
IT290	Seminar	1
IT440	Practical Training	1

Honor Courses (Hn)

Students seeking Honors degree shall credit minimum **TWENTY (20)** additional credits from minimum **FIVE** Postgraduate courses offered by the Department of Information Technology., as decided by DUGC.

Minor Courses (Except for CS and AI Students)

IT210M	Data Structures and Algorithms	(3-0-2) 4
IT252M	Database Systems	(3-0-2) 4
IT254M	Web Technologies and Applications	(3-0-2) 4
IT301M	Parallel Computing	(3-0-2) 4
IT350M	Data Analytics	(3-0-2) 4

Department specific course for Interdisciplinary Machine Learning Minor

IT479M	Machine Learning Minor Project	(0-0-6) 4

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Suggested Plan of Study for B.Tech. in Information Technology

Semester →	I	II	III	IV	V	VI	VII	VIII
1	CY110	MA111	IT200	IT250	SM300	SM302	Elective	Elective
2	CY111	PH110	IT201	IT251	IT300	IT350	Elective	Elective
3	MA110	PH111	IT202	IT252	IT301	IT351	Elective	Elective
4	CS110	ME110	IT203	IT253	IT302	IT352	Elective	IT499
5	CS111	ME111	IT204	IT254	IT303	Elective	IT449	
6	WO110	SM110	IT205	IT290			IT440	
7	IT110	IT150	IT206				UC401	
8	CV110	SM111						
9	UC100							

Requirements for B.Tech. in Information Technology:

Category of Courses	**Minimum Credits to be Earned**
Foundation Courses Basic Science Core (BSC): 16 Engineering Science Core (ESC): 13 Humanities and Social Science Core (HSC): 9	38
Programme Core Courses (PC)	77
Electives Courses (Ele) Programme Specific Electives, MOOC Courses (0 – 8 credits)	24
Project (MP)	06
Mandatory Learning Courses (MLC)	16
Total	**161**

Requirement for Honors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
5	20

Requirement for Minors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
5	20

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Department of Information Technology (IT)
Bachelor of Technology in Artificial Intelligence

Basic Science Core Courses (BSC)

CY110	Chemistry	(3-0-0) 3
CY111	Chemistry Laboratory	(0-0-3) 2
MA110	Engineering Mathematics – I	(3-0-0) 3
MA111	Engineering Mathematics – II	(3-0-0) 3
PH110	Physics	(3-1-0) 4
PH111	Physics Laboratory	(0-0-2) 1

Engineering Science Core Courses (ESC)

CS110	C Programming	(3-0-0) 3
CS111	C Programming Lab	(0-0-3) 2
EC100	Elements of Electronics & Communication Engineering	(2-0-0) 2
ME111	Engineering Graphics	(1-0-3) 3
WO110	Engineering Mechanics	(3-0-0) 3

Humanities and Social Science Core Courses (HSC)

SM110	Professional Communication	(3-0-0) 3
SM300	Engineering Economics	(3-0-0) 3
SM302	Principles of Management	(3-0-0) 3

Programme Core Courses (PC)

IT111	Fundamentals of Computer Systems	(4-0-0) 4
IT112	Computer Systems Lab	(0-0-2) 1
IT151	Python Programming	(3-0-0) 3
IT152	Python Programming Lab	(0-0-2) 1
IT207	Human Intelligence	(3-0-0) 3
IT208	Discrete Mathematics	(3-0-2) 4
IT209	Data Structures and Algorithms	(3-0-2) 4
IT211	Probability and Statistics	(3-0-2) 4
IT255	Artificial Intelligence	(3-0-2) 4
IT256	Applied Linear Algebra	(3-0-2) 4
IT257	Design and Analysis of Algorithms	(3-0-2) 4
IT258	Data Science	(3-0-2) 4
IT304	Optimization Techniques	(3-0-2) 4
IT305	Game Theory	(3-0-2) 4
IT306	Parallel and Distributed Problem Solving	(3-0-2) 4
IT307	Machine Learning	(3-0-2) 4
IT353	Deep Learning	(3-0-2) 4
IT354	Reinforcement Learning	(3-0-2) 4

Programme Specific Electives (PSE)

Cluster 1: Computing Core

IT213	Database Systems	(3-0-2) 4
IT355	Autonomous Agents	(3-0-2) 4
IT371	Operating Systems	(3-0-2) 4
IT431	Distributed Computing	(3-0-2) 4
IT436	Cloud Computing	(3-0-2) 4
IT437	Quantum Computing	(3-0-2) 4
IT472	Computer Networks	(3-0-0) 3
IT473	Cognitive Networks	(3-0-2) 4
IT474	Formal Languages & Automata Theory	(3-0-0) 3
IT475	Computer Organisation & Architecture	(3-0-0) 3
IT477	Digital System Design	(3-0-2) 4
IT479	Signals and Systems	(3-0-2) 4

Cluster 2: Human Machine Interaction

IT308	Brain Computer Interfaces	(3-0-2) 4
IT356	Natural Language Processing	(3-0-2) 4
IT357	Computer Vision	(3-0-2) 4
IT424	Computational Auditory Perception	(3-0-2) 4
IT425	Computational Visual Perception	(3-0-2) 4
IT432	Computational Photography	(3-0-2) 4
IT439	Sentiment Analysis	(3-0-0) 3
IT445	User Experience Design	(3-0-2) 4
IT476	Human Centered Computing	(3-0-2) 4

Cluster 3: Artificial Intelligence / Machine Learning

IT260	Robotics Programming	(3-0-2) 4
IT358	Soft Computing	(3-0-2) 4
IT359	Pattern Recognition	(3-0-2) 4
IT427	Genetic Algorithms	(3-0-2) 4
IT435	Computational Biology	(3-0-2) 4
IT443	Stochastic Processes	(3-0-2) 4
IT469	AI in Healthcare	(3-0-2) 4
IT485	Applied Algorithms	(3-1-0) 4

Cluster 4: Data Science and Applications

IT212	Intelligent Data Management	(3-0-2) 4
IT259	Data Visualization	(3-0-2) 4
IT367	Information Retrieval	(3-0-2) 4
IT369	Performance Modeling	(3-0-2) 4
IT370	Time Series Analysis	(3-0-2) 4
IT438	Big Data Analytics	(3-0-2) 4
IT480	Social Computing	(3-0-2) 4
IT478	Data Mining	(3-0-2) 4
IT481	Cornerstone/capstone Project	4

Cluster 5: Cyber-physical Systems

IT368	Internet of Things	(3-0-2) 4
IT426	Smart Systems Development	(3-0-2) 4
IT428	Industry 4.0	(3-0-2) 4
IT429	Number Theory and Cryptography	(3-0-2) 4
IT430	Quantum Cryptography	(3-0-2) 4
IT433	Blockchain Technology	(3-0-2) 4
IT434	Digital Forensics	(3-0-2) 4
IT442	Autonomous Cyber Physical Systems	(3-0-0) 3
IT471	Cyber Security	(3-0-2) 4

Major Project (MP)

IT448	Major Project-I	(0-0-3) 2
IT498	Major Project-II	(0-0-6) 4

Mandatory Learning Courses (MLC)

CV110	Environmental Studies	(1-0-0) 1
IT289	Seminar	1
IT447	Practical Training	1
UC100	Introduction to Design Thinking	(2-0-0) 2
SM111	Professional Ethics and Human Values	(1-0-0) 1
UC401	Liberal arts courses/cocurricular / extracurricular activities	10

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Suggested Plan of Study for B.Tech. in Artificial Intelligence

Semester	I	II	III	IV	V	VI	VII	VIII
1	CY110	MA111	IT207	IT255	SM300	SM302	Elective	Elective
2	CY111	PH110	IT208	IT256	IT304	IT353	Elective	Elective
3	MA110	PH111	IT209	IT257	IT305	IT354	Elective	IT498
4	CS110	EC100	IT211	IT258	IT306	Elective	IT448	
5	CS111	ME111	Elective	IT289	IT307	Elective	IT447	
6	WO110	SM110		Elective	Elective		UC401	
7	IT111	IT151						
8	IT112	IT152						
9	CV110	SM111						
10	UC100							

Requirements for B.Tech. in Artificial Intelligence:

Category of Courses	Minimum Credits to be Earned
Foundation Courses Basic Science Core (BSC): 16 Engineering Science Core (ESC): 13 Humanities and Social Science Core (HSC): 9	38
Programme Core Courses (PC)	64
Electives Courses (Ele) Programme Specific Electives, MOOC Courses (0 – 8 credits)	37
Project (MP)	06
Mandatory Learning Courses (MLC)	16
Total	**161**

Requirement for Minors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
5	19

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Department of Mathematical and Computational Sciences
Bachelor of Technology in Computational and Data Science

Basic Science Core Courses (BSC)		
CY110	Chemistry	(3-0-0)3
CY111	Chemistry Laboratory	(0-0-3)2
MA110	Engineering Mathematics - I	(3-0-0)3
MA111	Engineering Mathematics - II	(3-0-0)3
PH110	Physics	(3-1-0)4
PH111	Physics Laboratory	(0-0-2)1
Engineering Science Core Courses (ESC)		
CS100	Python Programming	(3-0-0)3
CS101	Python Programming Lab	(0-0-3)2
EC100	Elements of Electronics & Communication Engineering	(2-0-0)2
ME111	Engineering Graphics	(1-0-3)3
WO110	Engineering Mechanics	(3-0-0)3
Humanities and Social Sciences Core Courses (HSC)		
SM110	Professional Communication	(3-0-0)3
SM300	Engineering Economics	(3-0-0)3
SM302	Principles of Management	(3-0-0)3
Programme Core Courses (PC)		
MA112	Digital System Design	(4-0-0) 4
MA113	Linear Algebra	(4-0-0) 4
MA202	Discrete Mathematical Structures	(3-0-0) 3
MA207	Numerical Methods	(3-0-0) 3
MA208	Probability Theory and Applications	(3-0-0) 3
MA221	Data Structures	(3-0-0) 3
MA222	Computational Linear Algebra	(3-0-0) 3
MA223	Computer Org & Arch	(3-0-0) 3
MA224	DS Lab	(0-0-3) 2
MA225	COA Lab	(0-0-3) 2
MA226	Operating Systems	(3-0-0) 3
MA227	Database Systems	(3-0-0) 3
MA228	Operating Systems Lab	(0-0-3) 2
MA229	Database Systems Lab	(0-0-3) 2
MA302	Data Analysis, Time Series Analysis And Non-Parametric Methods	(3-0-0) 3
MA303	Integral Transforms and Applications	(3-0-0) 3
MA321	Fundamentals of Data Science	(3-0-0) 3
MA322	Design & Analysis of Algorithms	(3-0-0) 3
MA323	Statistical Methods Lab	(0-0-3) 2
MA324	DAA Lab	(0-0-3) 2
MA325	Machine Learning	(3-0-0) 3
MA326	Theory of Finite Automata, Formal Languages and Computation	(3-0-0) 3
MA327	Scientific Computing Lab	(0-0-3) 2
MA406	Statistical Design and Analysis of Experiments	(3-0-0) 3
MA421	Financial Mathematics	(3-0-0) 3
Programme Specific Elective Courses (PSE)		
MA201	Concrete Mathematics	(3-0-0) 3
MA206	Number Theory and Cryptography	(3-0-0) 3
MA401	Computational Fluid Dynamics	(3-0-0) 3
MA403	Mathematical Modelling	(3-0-0) 3
MA405	Reliability Theory and Applications	(3-0-0) 3
MA408	Stochastic Analysis and Applications	(3-0-0) 3
MA500	Capstone Project	4
MA506	Quadratic Forms and Linear Algebra	(3-0-0) 3
MA507	Image Processing	(3-0-0) 3
MA508	Soft Computing	(3-0-0) 3
MA509	Combinatorial Optimization	(3-0-0) 3
MA512	Numerical Solutions of Differential Equations	(3-0-0) 3
MA513	Modern Algebra	(3-0-0) 3
MA514	Pattern Recognition	(3-0-0) 3
MA515	Statistical Techniques for Data Mining	(3-0-0) 3
MA516	Software Engineering	(3-0-0) 3
MA517	Algorithmic Combinatorics	(3-0-0) 3
MA518	Selected Topics in Graph Theory	(3-0-0) 3
MA519	Systems Modelling and Simulation	(3-0-0) 3
MA520	Selected Topics in Computer Algorithms	(3-0-0) 3
MA521	Mobile Computing	(3-0-0) 3
MA523	Computer Networks	(3-0-0) 3
MA525	Computational Number Theory	(3-0-0) 3
MA526	Game Theory	(3-0-0) 3
MA527	Network Security	(3-0-0) 3
MA528	Introduction to Parallel Programming	(3-0-0) 3
MA529	Advanced Data Science	(3-0-0) 3
MA531	Statistical Quality Control	(3-0-0) 3
MA532	Big data Analytics	(3-0-0) 3
MA533	Wavelets in Data Science	(3-0-0) 3
MA534	Cloud Computing	(3-0-0) 3
MA535	Distributed Computing Systems	(3-0-0) 3
MA536	Advanced Database Systems	(3-0-0) 3
MA537	Optimization Techniques	(3-0-0) 3
MA538	Artificial Intelligence	(3-0-0) 3
MA539	Multivariate Statistical Analysis	(3-0-0) 3
Project (MP)		
MA498	Major Project I	(0-0-3) 2
MA499	Major Project II	(0-0-6) 4
Mandatory Learning Courses (MLC)		
MA490	Practical Training	1
MA491	Seminar	1
CV110	Environmental Sciences	(1-0-0)1
UC100	Introduction to Design Thinking	(2-0-0)2
SM 111	Professional Ethics and Human values	(1-0-0)1
UC401	Liberal arts courses/cocurricular/extracurricular activities	10

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Suggested Plan of Study for B.Tech. in Computational and Data Science:

Slot/Semester	I	II	III	IV	V	VI	VII	VIII
1	CY110	MA111	MA202	MA207	MA302	SM300	SM302	Elective
2	CY111	PH110	MA221	MA208	MA321	MA325	MA406	Elective
3	MA110	PH111	MA222	MA226	MA322	MA326	MA421	Elective
4	CS100	EC100	MA223	MA227	MA323	MA327	Elective	Elective
5	CS101	ME111	MA224	MA228	MA324	Elective	Elective	MA499
6	WO110	SM110	MA225	MA229	Elective	Elective	MA498	
7	MA112	MA113	MA303	Elective	MA490	MA491	UC401	
8	CV110	SM111						
9	UC100							

Requirements for B.Tech. in Computational and Data Science:

Category of Courses	**Minimum Credits to be Earned**
Foundation Courses Basic Science Core (BSC): 16 Engineering Science Core (ESC): 13 Humanities and Social Science Core (HSC): 9	38
Programme Core (PC)	70
Electives Courses (Ele) Programme Specific Electives, MOOC Courses (0 – 8 credits)	30
Project (MP)	06
Mandatory Learning Courses (MLC)	16
Total	**160**

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Department of Mechanical Engineering

Bachelor of Technology in Mechanical Engineering

Basic Science Core Courses (BSC)

CY110	Chemistry	(3-0-0)3
CY111	Chemistry Laboratory	(0-0-3)2
MA110	Engineering Mathematics - I	(3-0-0)3
MA111	Engineering Mathematics - II	(3-0-0)3
MA207	Numerical Methods	(3-0-0)3
MA208	Probability Theory and Applications	(3-0-0)3
PH110	Physics	(3-1-0)4
PH111	Physics Laboratory	(0-0-2)1

Engineering Science Core Courses (ESC)

CS100	Python Programming	(3-1-0)3
CS101	Python Programming Laboratory	(0-0-2)2
EC100	Elements of Electronics and Communications Engineering	(2-0-0)2
EE110	Elements of Electrical Engineering	(2-0-0)2
ME111	Engineering Graphics	(1-0-3)3
WO110	Engineering Mechanics	(3-0-0)3
WO217	Mechanics of Solids Lab	(0-0-2)1
WO317	Fluid Mechanics and Machinery Lab	(0-0-2)1

Humanities and Social Science Core Courses (HSC)

SM110	Professional Communication	(3-0-0)3
SM300	Engineering Economics	(3-0-0)3
SM302	Principles of Management	(3-0-0)3

Programme Core Courses (PC)

ME112	Materials Science and Engineering	(3-0-0)3
ME113	Mechanics of Deformable Bodies	(3-0-0)3
ME201	Basic Engineering Thermodynamics	(3-1-0)4
ME202	Fluid Mechanics and Machinery	(3-1-0)4
ME203	Mechanics of Machinery	(3-1-0)4
ME204	Basic Manufacturing Processes	(3-1-0)4
ME205	Workshop Practice	(0-0-3)2
ME251	Applied Thermodynamics	(3-0-0)3
ME252	Analysis and Design of Machine Components	(3-1-0)4
ME253	Computer Aided Engineering	(3-0-0)3
ME254	Manufacturing Technology	(3-0-0)3
ME255	Engineering Drawing	(1-0-3)3
ME301	Metrology and Instrumentation	(4-0-0)4
ME302	Heat Transfer	(3-0-0)3
ME303	Design of Mechanical Drives	(3-0-0)3
ME304	Automobile Engineering	(3-0-0)3
ME305	Mechatronic Systems	(3-0-0)3
ME306	Metrology and CAD Lab	(0-0-3)2
ME307	Machine Shop - 1	(0-0-3)2
ME308	Mechanical Lab - 1	(0-0-3)2
ME351	Energy Engineering	(3-0-0)3
ME352	Machine Dynamics and Vibrations	(3-1-0)4
ME353	Control Engineering	(3-0-0)3
ME354	Operations Research	(3-0-0)3
ME451	Mechanical Lab - II	(0-0-3)2
ME452	Machine Shop - II	(0-0-3)2

Programme Specific Elective Courses (PSE)

ME311	Finite Element Method	(3-0-0)3
ME312	Theory of Elasticity	(3-0-0)3
ME313	Hydraulics and Pneumatic Control	(3-0-0)3
ME314	Product Design and Development	(3-0-0)3
ME315	Theory of Metal Forming	(3-0-0)3
ME316	Welding Technology	(3-0-0)3
ME317	Basics of Computational Fluid Dynamics	(3-0-0)3
ME318	Principles of Turbomachinery	(3-0-0)3
ME319	Mini Project I	(0-0-3)2
ME320	Cryogenics	(3-0-0)3
ME411	Theory of Fatigue and Analysis	(3-0-0)3
ME412	Experimental Stress Analysis	(3-0-0)3
ME413	Synthesis of Mechanisms	(3-0-0)3
ME414	Microsystem Technology	(3-0-0)3
ME415	Automation Systems	(3-0-0)3
ME416	Robotics	(3-0-0)3
ME417	Non-Destructive Evaluation	(3-0-0)3
ME418	Production and Operations Management	(3-0-0)3
ME419	Composites Materials	(3-0-0)3
ME420	IC Engines	(3-0-0)3
ME421	Refrigeration and Air Conditioning	(3-0-0)3
ME422	Mechanics of Compressible Flow	(3-0-0)3
ME423	Multi Body Dynamics	(3-0-0)3
ME424	Vehicle Dynamics	(3-0-0)3
ME425	Contemporary Concepts in Product Design	(3-0-0)3
ME426	Automotive Electronics	(3-0-0)3
ME427	Introduction to Additive Manufacturing	(3-0-0)3
ME428	Non-Traditional Machining Processes	(3-0-0)3
ME429	Energy Auditing and Management	(3-0-0)3
ME430	Gas Turbines and Jet Propulsion	(3-0-0)3
ME431	Continuum Mechanics	(3-0-0)3
ME432	Analytical Mechanics	(3-0-0)3
ME433	Condition Monitoring	(3-0-0)3
ME434	Microfluidics	(3-0-0)3
ME435	Solar Energy	(3-0-0)3
ME436	Engineering Tribology	(3-0-0)3
ME437	Thermal Stress Analysis	(3-0-0)3
ME438	Injury Biomechanics	(3-0-0)3
ME439	Introduction to Flight	(3-0-0)3
ME441	Pollution Control and Environmental Management	(3-0-0)3
ME442	Aerodynamics	(3-0-0)3
ME443	Mechanical Vibrations and Acoustics	(3-0-0)3
ME444	Data Driven Modeling using Machine Learning	(3-1-0)4
ME497	Cornerstone/capstone Project	(0-0-4)3

Project (MP)

ME498	Major Project - 1	(0-0-4)2
ME499	Major Project - 2	(0-0-6)3

Mandatory Learning Courses (MLC)

SM111	Professional Ethics & Human Values	(1-0-0)1
CV110	Environmental Studies	(1-0-0)1
UC100	Introduction to Design Thinking	(2-0-0)2
ME440	Practical Training / Internship	(0-0-2)1
ME490	Seminar	(0-0-2)1
UC401	Liberal Arts courses/cocurricular/extra-curricular activities	10

Honor Courses (Hn)

Students seeking Honors degree shall credit minimum **FIFTEEN (15)** additional credits from minimum **FIVE** Postgraduate courses offered by the Department of Mechanical Engg., as decided by DUGC.

Minor Courses

ME501M	Manufacturing Engineering	(3-1-0) 4
ME502M	Thermal Engineering	(3-1-0) 4
ME503M	Mechanical Design	(3-1-0) 4
ME504M	Production Management	(3-1-0) 4
ME505M	Industrial Automation	(3-1-0) 4

Department specific course for Interdisciplinary Machine Learning Minor

ME496M	Application Project in Mechanical Engineering	(0-0-6) 4

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Suggested Plan of Study for B.Tech. in Mechanical Engineering:

Sem →	I	II	III	IV	V	VI	VII	VIII
1	MA110	CY110	MA207	MA208	SM302	SM300	ME451/ ME452	ME452/ ME451
2	PH110	CY111	ME201	ME251	ME301	ME351	Elective	Elective
3	PH111	MA111	ME202	ME252	ME302	ME352	Elective	Elective
4	EC100	CS100	ME203	ME253	ME303	ME353	Elective	Elective
5	EE110	CS101	ME204	ME254	ME304	ME354	ME497	ME499
6	ME111	WO110	WO217/ ME205	ME255	ME305	ME307 /ME306	ME498	ME490/ ME440
7	SM110	ME113/ ME112		ME205 /WO217	ME306 /ME307	ME308/ WO317	ME440/ ME490	
8	ME112/ ME113	CV110			WO317/ ME308	Elective	UC401	
9	SM111	UC100						

Requirements for B.Tech. in Mechanical Engineering:

Category of Courses	**Minimum Credits to be Earned**
Foundation Courses Basic Science Core (BSC): 22 Engineering Science Core (ESC): 17 Humanities and Social Science Core (HSC): 9	48
Programme Core Courses (PC)	79
Electives Courses (Ele) Programme Specific Electives, MOOC Courses (0 – 8 credits)	21
Project (MP)	05
Mandatory Learning Courses (MLC)	16
Total	**169**

Requirement for Honors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
5	15

Requirement for Minors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
5	20

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Department of Metallurgical and Material Engineering

Bachelor of Technology in Metallurgical and Materials Engineering

Basic Science Core Courses (BSC)

CY110	Chemistry	(3-0-0)3
CY111	Chemistry Laboratory	(0-0-3)2
MA110	Engineering Mathematics – I	(3-0-0)3
MA111	Engineering Mathematics – II	(3-0-0)3
PH110	Physics	(3-1-0)4
PH111	Physics Laboratory	(0-0-2)1

Engineering Science Core Courses (ESC)

CS100	Python Programming	(3-0-0)3
CS101	Python Programming Lab	(0-0-3)2
EC100	Elements of Electronics and Communication Engg	(2-0-0)2
EE110	Elements of Electrical Engg.	(2-0-0)2
ME110	Elements of Mechanical Engg.	(2-0-0)2
ME111	Engineering Graphics	(1-0-3)3
ME200	Workshop	(0-0-2)1
WO110	Engineering Mechanics	(3-0-0)3
WO200	Mechanics of Materials	(3-0-0)3

Humanities and Social Science Core Courses (HSC)

SM110	Professional Communication	(3-0-0)3
SM300	Engineering Economics	(3-0-0)3
SM302	Principles of Management	(3-0-0)3

Programme Core Courses (PC)

MT160	Introduction to Materials Science & Technology	(3-1-0)4
MT200	Testing of Materials	(2-0-1)3
MT201	Metallurgical Thermodynamics & Kinetics	(3-1-0)4
MT202	Physical Metallurgy	(3-1-0)4
MT203	Polymer Science and Technology	(3-0-0)3
MT251	Transport Phenomena	(3-1-0)4
MT252	Phase Diagrams	(3-1-0)4
MT253	Principles of Extractive Metallurgy	(3-1-0)4
MT254	X-ray Diffraction & Electron Microscopy	(3-1-0)4
MT255	Instrumental Methods of Analysis	(3-0-1)4
MT256	Measurements and Control	(3-0-0)3
MT300	Production of Iron and Ferro Alloys	(3-0-0)3
MT301	Heat Treatment	(3-1-0)4
MT302	Machine Design	(3-1-0)4
MT303	Electronic Properties of Materials	(3-0-0)3
MT304	Physical Metallurgy Lab	(0-0-3)2
MT305	Extractive Metallurgy Lab	(0-0-3)2
MT350	Production of Steel	(3-0-0)3
MT351	Ceramics and Refractories	(3-0-0)3
MT352	Metallography Lab	(0-0-3)2
MT353	Ceramics and Polymers Lab	(0-0-3)2
MT354	Heat Treatment Lab	(0-0-3)2
MT400	Corrosion Engineering	(3-0-1)4
MT401	Metal Forming	(2-0-1)3
MT403	Phase Transformations	(3-0-0)3

Programme Specific Elective Courses (PSE)

MT306	Fatigue, Fracture and Creep	(3-0-0)3
MT307	Fuels and Furnaces	(2-1-0)3
MT355	Powder Metallurgy	(3-0-0)3
MT356	Joining of Metals	(3-0-0)3
MT357	Aerospace Materials	(3-0-0)3
MT402	Foundry Technology	(2-0-1)3
MT404	Extraction of Non-Ferrous Metals	(3-0-0)3
MT405	Secondary Refining of Steels	(3-0-0)3
MT406	Process Plant Materials	(3-0-0)3
MT407	Advanced Engineering Materials	(3-0-0)3
MT408	Thin Films, Coatings and Applications	(3-0-0)3
MT409	Nuclear Materials	(3-0-0)3
MT410	Fracture of Engineering Materials	(3-0-0)3
MT451	Composite Materials	(3-0-0)3
MT452	Advanced Welding Technology	(3-0-0)3
MT453	Surface Engineering	(3-0-0)3
MT454	Modeling& Simulation in Materials Processes	(3-0-0)3
MT455	Science & Technology of Nanomaterials	(3-0-0)3
MT456	Advanced Microscopic Techniques	(3-0-0)3
MT457	Smart Materials and Sensors	(3-0-0)3
MT493	Cornerstone/capstone Project	(0-0-6)4

Project (MP)

MT442	Major Project – I	(0-0-2)1
MT492	Major Project – II	(0-0-6)3

Mandatory Learning Courses (MLC)

CV110	Environmental Studies	(1-0-0)1
SM111	Professional Ethics & Human Values	(1-0-0)1
UC100	Introduction to Design Thinking	(2-0-0) 2
UC401	Liberal Arts courses/cocurricular/extra-curricular activities	10
MT440	Practical Training	1
MT441	Seminar	1

Honor Courses (Hn)

Students seeking Honors degree shall credit minimum **FIFTEEN (15)** additional credits from minimum **FIVE** Postgraduate courses offered by the Department of Metallurgical and Materials Engg., as decided by DUGC

Minor Courses (Mn)

MT202M	Physical Metallurgy	(3-1-0)4
MT203M	Polymer Science and Technology	(3-0-0)3
MT252M	Phase Diagrams	(3-1-0)4
MT253M	Principles of Extractive Metallurgy	(3-1-0)4
MT351M	Ceramics and Refractories	(3-0-0)3

Department specific course for Interdisciplinary Machine Learning Mnor

MT494M	Project for Machine Learning Minor	(0-0-6) 4

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Suggested Plan of Study for B.Tech. in Metallurgical and Materials Engineering:

Semester ⟶	I	II	III	IV	V	VI	VII	VIII
1	MA110	CY110	ME200	MT251	SM302	SM300	MT400	Elective
2	PH110	CY111	WO200	MT252	MT300	MT350	MT401	Elective
3	PH111	MA111	MT200	MT253	MT301	MT351	MT403	Elective
4	EC100	CS100	MT201	MT254	MT302	MT352	Elective	MT492
5	EE110	CS101	MT202	MT255	MT303	MT353	Elective	
6	ME110	WO110	MT203	MT256	MT304	MT354	MT442	
7	ME111	MT160			MT305	Elective	MT440	
8	SM110	CV110				Elective	MT441	
9	SM111	UC100					UC401	
10								

Requirements for B.Tech. in Metallurgical and Materials Engineering:

Category of Courses	Minimum Credits to be Earned
Foundation Courses Basic Science Core (BSC): 16 Engineering Science Core (ESC): 21 Humanities and Social Science Core (HSC): 9	46
Programme Core Courses (PC)	81
Electives Courses (Ele) Programme Specific Electives, MOOC Courses (0 – 8 credits)	21
Project (MP)	04
Mandatory Learning Courses (MLC)	16
Total	**168**

Requirement for Honors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
5	15

Requirement for Minors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
5	18

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Department of Mining Engineering
Bachelor of Technology in Mining Engineering

Basic Science Core Courses (BSC)

CY110	Chemistry	(3-0-0)3
CY111	Chemistry Laboratory	(0-0-3)2
MA110	Engineering Mathematics - I	(3-0-0)3
MA111	Engineering Mathematics - II	(3-0-0)3
PH110	Physics	(3-1-0)4
PH111	Physics Laboratory	(0-0-2)1

Engineering Science Core Courses (ESC)

CS100	Python Programming	(3-0-0)3
CS101	Python Programming Lab	(0-0-3)2
EC100	Elements of Electronics and Communication Engineering	(2-0-0)2
EE110	Elements of Electrical Engg	(2-0-0)2
ME110	Elements of Mechanical Engg	(2-0-0)2
ME111	Engineering Graphics	(1-0-3)3
ME200	Workshop	(0-0-2)1
ME211	Thermodynamic & Fluid Mechanics	(3-0-0)3
WO110	Engineering Mechanics	(3-0-0)3

Humanities and Social Science Core Courses (HSC)

SM110	Professional Communication	(3-0-0)3
SM300	Engineering Economics	(3-0-0)3
SM302	Principles of Management	(3-0-0)3

Programme Core Courses (PC)

CV203	Mining Geology	(3-0-0)3
CV218	Mining Geology Laboratory	(0-0-3)2
MI101	Introduction to Mining Engineering	(3-0-0)3
MI201	Development of Mineral Deposits	(3-0-0)3
MI202	Mine Surveying	(3-1-0)4
MI203	Mine Surveying Lab	(0-0-3)2
	Mine Environment and Ventilation Engineering	(3-1-0)4
MI252	Mine Environment and Ventilation Engineering Lab	(0-0-3)2
MI253	Applied Mine Surveying Lab	(0-0-3)2
MI254	Mining Machinery	(3-1-0)4
MI255	Industrial Training in Mines–I	1
MI301	Surface Mining Technology	(3-1-0)4
MI302	Mine Hazards, Rescue and Recovery	(3-1-0)4
MI303	Underground Coal Mining Technology	(3-1-0)4
MI304	Industrial Training in Mines–II	1
MI351	Underground Metal Mining Technology	(3-1-0)4
MI352	Rock Mechanics	(3-1-0)4
MI353	Rock Mechanics Lab.	(0-0-3)2
MI354	Mine Systems Optimization	(3-1-0)4
MI355	Industrial and Professional Practice	1
MI356	Industrial Training in Mines–III	1
MI401	Mineral Processing Technology	(3-1-0)4
MI402	Mineral Processing Technology Lab.	(0-0-3)2
MI403	Rock Fragmentation Engineering	(3-1-0)4
MI404	Mine Design Laboratory	(0-0-3)2
MI405	Strata Mechanics	(3-0-0)3
MI451	Mine Legislation & Safety	(4-0-0)4
MI452	Ore Reserve Estimation and Mine Valuation	(3-0-0)3

Programme Specific Elective Courses (PSE)

MI210	Drilling & Blasting Engineering	(3-0-0)3
MI211	Seabed Mining	(3-0-0)3
MI260	Applied Mine Surveying	(3-0-0)3
MI261	Electrical Machinery in Mines	(3-0-0)3
MI310	Noise Pollution & Control Engg.	(3-0-0)3
MI311	Rock Reinforcement Engg.	(3-0-0)3
MI312	Mine Power Systems	(3-0-0)3
MI360	Mine Health and Safety Engg.	(3-0-0)3
MI361	Advanced Surface Mining Technology	(3-0-0)3
MI362	Production Drilling for Oil Wells	(3-0-0)3
MI363	Mechanization and Materials Handling	(3-0-0)3
MI410	Advanced U/G Coal Mining Technology	(3-0-0)3
MI411	Geostatistics	(3-0-0)3
MI412	Applications of IT in Mining Projects	(3-0-0)3
MI413	Cornerstone/capstone Project	4
MI460	Coal Washing and Handling	(3-0-0)3
MI461	Surface Mine Design	(3-0-0)3
MI462	Underground Coal Mine Design	(3-0-0)3
MI463	Underground Metal Mine Design	(3-0-0)3
MI464	Environmental Management and Sustainable Development	(3-0-0)3
MI471	Reliability Analysis of Engg. Systems	(3-0-0)3
MI472	Rock Excavation in Mines and Infrastructure Projects	(3-0-0)3
MI473	Stability of Rock Slopes	(3-0-0)3
MI474	Tunneling Engineering	(3-0-0)3
MI475	Numerical Modeling Techniques	(3-0-0)3
MI476	Industrial Engineering & Management	(3-0-0)3
MI477	Remote Sensing & Geoinformatics	(3-0-0)3
MI478	Safety Engineering	(3-0-0)3
MI479	Energy Resources Utilization and Climate Change	(3-0-0)3

Project (MP)

MI449	Mine Design Project-I	(0 -0-3)2
MI499	Mine Design Project-II	(0 -0-6)4

Mandatory Learning Courses (MLC)

CV110	Environmental Studies	(1 -0-0)1
SM111	Professional Ethics and Human Values	(1 -0-0)1
MI453	Mine Projects Exposure	1
MI490	Seminar	1
UC100	Introduction to Design Thinking	(2-0-0) 2
UC401	Liberal Arts courses/cocurricular/extra-curricular activities	10

Honor Courses (Hn)

MI901	Applied Rock Mechanics	(3-1-0)4
MI804	Underground Space Technology	(3-1-0)4
MI916	Risk and Safety Management in Mines	(3-1-0)4
MI705	Project Management	(3-1-0)4
MI855	Reclamation Rehabilitation and Risk	(3-1-0)4

Minor Courses (Mn)

MI480M	Mining Technology	(3-1-0)4
MI481M	Rock Excavation Engineering	(3-1-0)4
MI482M	Mine Safety Engineering	(3-1-0)4
MI483M	Mine Mechanisation	(3-1-0)4
MI484M	Environmental Managemnet	(3-1-0)4

Department specific course for Interdisciplinary Machine Learning Mnor

MI485	Project for Machine Learning Minor	(0-0-6) 4

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Suggested Plan of Study for B.Tech. in Mining Engineering:

Semester →	I	II	III	IV	V	VI	VII	VIII
1	MA110	CY110	CV203	ME200	SM302	SM300	MI401	MI451
2	PH110	CY111	CV218	ME211	MI301	MI351	MI402	MI452
3	PH111	MA111	MI201	MI251	MI302	MI352	MI403	Elective
4	EC100	CS100	MI202	MI252	MI303	MI353	MI404	Elective
5	EE110	CS101	MI203	MI253	MI304	MI354	MI405	MI499
6	ME110	WO110	Elective	MI254	Elective	MI355	Elective	MI453
7	ME111	MI101		MI255		MI356	MI449	MI490
8	SM110	CV110		Elective		Elective	UC401	
9	SM111	UC100						

Requirements for B.Tech. in Mining Engineering:

Category of Courses	Minimum Credits to be Earned
Foundation Courses Basic Science Core (BSC): 16 Engineering Science Core (ESC): 21 Humanities and Social Science Core (HSC): 9	46
Programme Core Courses (PC)	81
Electives Courses (Ele) Programme Specific Electives, MOOC Courses (0 – 8 credits)	21
Project (MP)	06
Mandatory Learning Courses (MLC)	16
Total	**170**

Requirement for Honors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
5	20

Requirement for Minors:

Minimum No. of Courses to be Registered	Minimum Credits to be earned
5	20

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

Minor Programmes

Minor in Chemical Engineeirng

CH150M	Process Calculations	(2-2-0)4
CH202M	Chemical Engineering Thermodynamics	(3-1-0)4
CH203M	Transport Phenomena	(2-2-0)4
CH252M	Chemical Reaction Engineering I	(2-1-0)3
CH302M	Process Dynamics and Control	(3-1-0)4

Minor in Civil Engineeirng

WO200M	Mechanics of Materials	(3-0-0)3
CV201M	Elements of Surveying	(3-0-0)3
CV252M	Soil Mechanics	(3-0-0)3
CV301M	Environmental Engineering	(3-0-0)3
CV254M	Highway and Traffic Engineering	(3-0-0)3
CV401M	Estimation, Costing and Specification	(3-0-0)3

Minor in Computer Science and Engineeirng (Except for IT Students)

CS202M	Data Structures and Algorithms	(3-1-0)4
CS251M	Database Systems	(3-1-0)4
CS252M	Operating Systems	(3-1-0)4
CS301M	Computer Networks	(3-1-0)4
CS305M	Software Engineering	(3-1-0)4

Minor in Electrical and Electronics Engineeirng (Except for EC Students)

EE230M	Electric Circuits	(3-1-0) 4
EE261M	Basic Electric Machines	(3-1-0) 4
EE310M	Electric Power System	(3-1-0) 4
EE370M	Electrical and Electronics Measuring Instruments and Techniques	(3-1-0) 4
EE415M	Power Electronics in Power Control	(3-1-0) 4

Minor in Electronics and Communication Engineering (Except for EE Students)

EC391M	Analog Electronic Circuits	(3-0-0) 3
EC392**M**	Digital Electronics	(3-0-0) 3
EC393M	Signals and Systems	(3-0-0) 3
EC394M	Communication Systems	(3-0-0) 3
EC395M	Data Communication and Networks	(3-0-0) 3

Minor in Information Technology (Except for CS and AI Students)

IT210M	Data Structures and Algorithms	(3-0-2) 4
IT252M	Database Systems	(3-0-2) 4
IT254M	Web Technologies and Applications	(3-0-2) 4
IT301M	Parallel Computing	(3-0-2) 4
IT350M	Data Analytics	(3-0-2) 4

Minor in Mechanical Engineeirng

ME501M	Manufacturing Engineering	(3-1-0) 4
ME502M	Thermal Engineering	(3-1-0) 4
ME503M	Mechanical Design	(3-1-0) 4
ME504M	Production Management	(3-1-0) 4
ME505M	Industrial Automation	(3-1-0) 4

Minor in Metallurgical and Materials Engineering

MT202M	Physical Metallurgy	(3-1-0)4
MT203M	Polymer Science and Technology	(3-0-0)3
MT252M	Phase Diagrams	(3-1-0)4
MT253M	Principles of Extractive Metallurgy	(3-1-0)4
MT351M	Ceramics and Refractories	(3-0-0)3

Minor in Mining Engineeirng

MI480M	Mining Technology	(3-1-0)4
MI481M	Rock Excavation Engineering	(3-1-0)4
MI482M	Mine Safety Engineering	(3-1-0)4
MI483M	Mine Mechanisation	(3-1-0)4
MI484M	Environmental Managemnet	(3-1-0)4

Minor in Chemistry

CY804M	Spectroscopy, Applications in Chemistry	(3-0-0) 3
CY703M	Organic Chemistry-I	(3-0-0) 3
CY704M	Physical Chemistry – I	(3-0-0) 3
CY751M	Inorganic Chemistry – II	(3-0-0) 3
CY754M	Spectroscopy	(3-0-0) 3

Minor in Mathematics

MA501M	Real Analysis	(3-0-0) 3
MA502M	Algebra	(3-0-0) 3
MA503M	Complex Analysis	(3-0-0) 3
MA504M	Partial Differential Equations	(3-0-0) 3
MA504M	Topology	(3-0-0) 3

Minor in Physics

PH701M	Mathematical Methods-1	(3-1-0)4
PH702M	Classical Mechanics	(3-1-0)4
PH703M	QuantumMechanics-1	(3-1-0)4
PH751M	Mathematical Methods-2	(3-1-0)4
PH752M	Quantum Mechanics-2	(3-1-0)4
PH754M	Electromagnetic Theory	(3-1-0)4

Minor in Management

SM200M	Financial Management	(3-0-0) 3
SM250M	Human Resource Management	(3-0-0) 3
SM305M	Business Analytics and Decision Making	(3-0-0) 3
SM350M	Entrepreneurship	(3-0-0) 3
SM405M	Marketing Management	(3-0-0) 3

Minor in Economics

SM205M	Microeconomics	(3-0-0) 3
SM255M	Macroeconomics	(3-0-0) 3
SM310M	Introduction to Industrial Economics and Organization	(3-0-0) 3
SM355M	Financial Economics	(3-0-0) 3
SM410M	Development Economics	(3-0-0) 3

Interdisciplinary Minor

Minor in Machine Learning
(Except for AI Students)

Common Courses

MA212M	Mathematics for Machine Learning	(4-0-0) 4
MA309M	Mathematical Foundations of Data Science	(3-1-0) 4
IT340M	Machine Learning	(3-0-2) 4
CS422M	Deep Learning	(3-1-0) 4

Parent Department Specific Courses

Chemical Engineering

CH459M	Machine Learning Applications in Chemical Engineering	(0-0-6) 4

Civil Engineering

CV448M	Machine Learning Applications in Civil Engineering	(0-0-6) 4

Computer Science and Engineering

CS367M	Foundations of CPS	(3-1-0) 4
CS426M	Reinforcement Learning	(3-1-0) 4
CS473M	Project for ML Minors	(0-0-6) 4

Electrical and Electronics Engineering

EE450M	Applications of Machine Learning Techniques to Problems in Electrical Engineering	(3-0-2) 4

Electronics and Communication Engineering

EC500M	Machine Learning for Electronics and Communication Engineering	(3-1-0) 4

Information technology

IT479M	Machine Learning Minor Project	(0-0-6) 4

Mechanical Engineering

ME496M	Application Project in Mechanical Engineering	(0-0-6) 4

Metallurgical and Materials Engineering

MT494M	Project for Machine Learning Minor	(0-0-6) 4

Mining Engineering

MI485M	Project for Machine Learning Minor	(0-0-6) 4

Suggested Plan of Study:

Semester →	III	IV	V	VI	VII
1	MA212M	MA309M	IT340M	CS422M	Parent Department Specific Course

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

COURSE CONTENTS - UG

Departments

Department of Chemical Engineering

CH150/CH150M PROCESS CALCULATIONS (2-2-0) 4

Introduction to Engineering Calculations. Physical and chemical properties of compounds and Mixtures. Techniques of problem solving. Concepts of unsteady state processes and material balance equation. Steady State Material Balances. Material balances involving Recycle, By-pass and purge- calculations. Multiphase systems. Single component phase Equilibrium. Solutions of Solids in Liquids. Humidity charts and their uses. Energy balances.

D.M.Himmelblau, Basic Principles and calculations in Chemical Engg. 5th Edition, Prentice Hall of India. 1992
R.M.Felder, R.W.Rlusseau, Elementary Principles of chemical processes 2nd Edition. John Wiley & Sons Inc. 1986

CH200 MOMENTUM TRANSFER (3-1-0)4

Properties of fluids. Fluid statics. Introduction to fluid flow. Basic equations of fluid flow. Laminar Flow. Turbulent flow. Fluid flow around immersed bodies - Boundary layer and friction drag. Flow through packed bed or porous medium : Ergun's equation.Motion of particles through fluids. Fluidization principles. Similitude and Dimensional analysis. Mixing of liquids. Compressible flow. Flow measurement. Fluid transportation machinery.

McCabe W.L. , Smith J.C., P Harriot ,Unit Operations in Chemical Engineering, McGraw Hill, New York, 7th edition.2014
J R Backhurst, J H Harker, J.F. Richardson, J.M. Coulson, R.P. Chhabra,*Coulson and Richardson's Chemical Engineering Volume I* Butterworth-Heinemann*6th Edition. 1999*

CH201 PARTICULATE TECHNOLOGY (2-1-0)3

Particle Size Analysis. Industrial Screening. Storage and Conveyance of Solids. Size Reduction. Size Enlargement. Classification. Centrifugal Separation. Gas cleaning. Solid - Liquid Separation. Thickening. Froth Flotation. Magnetic separation. Electrical separation. Sorting (Separation of solids).Mixing and Agitation. *Richardson J.F and Coulson J.M, Chemical Engineering (SI Units) Vol 2; 5thEdiiton*
McCabe W.L. , Smith J.C., P Harriot ,Unit Operations in Chemical Engineering, McGraw Hill, New York, 7th edition.2014

CH202/CH202M CHEMICAL ENGINEERING THERMODYNAMICS (3-1-0) 4

Basic Concepts of Thermodynamics. PVT relationships, First law of Thermodynamics for closed and open systems. Heat effects, Second Law of Thermodynamics and relationships involving entropy. Relations among thermodynamic properties. Thermodynamic properties of fluids. T-S diagrams and construction of thermodynamic charts. Third Law of thermodynamics. Refrigeration and Liquefaction Cycles. Solution Thermodynamics and principles of Phase Equilibria..

Smith, J.M, and H.C. Van Ness -Introduction to Chemical Engineering Thermodynamics, 4th edition, McGraw - Hill. Hougen, A., K.M. Watson and R.A. Ragatz - Chemical Process Principles, Vol. 2 (Thermodynamics), Asia Publishing House, 1960.
Rao, Y.V.C. - Introduction to Chemical Engineering Thermodynamics, Wiley Eastern, 1994.
Narayanan, K.V. - A textbook of Chemical Engineering thermodynamics, Prentice Hall Eastern Economy Edition, 2004.

CH203/CH203M TRANSPORT PHENOMENA (2-2-0) 4

Shell balances for momentum, energy and mass transfer. Introduction to general transport equations for momentum, energy and mass transfer in Cartesian - cylindrical and spherical coordinates - simple solutions in one dimension. Simplification of general equations with time and spatial coordinates for momentum, energy, mass transport, boundary layer concepts of momentum energy and mass transport. Macroscopic balances for isothermal systems, non-isothermal systems and multi component systems.

Robert S. Brodkey and Harey C. Hershey - Transport Phenomena - A Unified Approach, Brodkey Publishing*.,*
2003 R.B.Bird, W.E.Stewart and E.W.Lightfoot - Transport Phenomena, John Wiley &Sons, 2007.
Beek W.J. andMutzall K.M.K., - Transport Phenomena, 2nd edition ,John Willey and Sons Ltd., 2000.

CH204 COMPUTER SIMULATION LAB (0-0-3) 2

Numerical methods: Use of computational, plotting and programming abilities for solving problems relevant to chemical engineering: solving linear and nonlinear algebraic equations. Curve fitting and regression-linear and non-linear, Data analysis and handling, Solution of differential equations : initial value problems (IVP) and boundary value problems (BVP) .

Finlayson, B. A., Introduction to Chemical Engineering Computing, John Wiley & Sons, New Jersey, 2006
Steven C. Chapra, Applied numerical methods with MATLAB for Engineers and Scientists, Fourth Edition, McGraw Hill Publishers, 2017

CH250 HEAT TRANSFER (3-1-0) 4

Heat transfer fundamentals: Modes of heat transfer - conduction, convection, radiation Steady state conduction.Transient conduction. heat transfer with internal heat source; heat transfer from extended surfaces, Insulation - critical thickness of insulation. Heat transfer with heat generation. Heat Transfer by convection. analogies and correlations. Design of heat exchangers, Heat Transfer with packed and fluidized beds. Heat Transfer in Jacketted vessels. Cryogenic heat transfer. Heat transfer with change of phase: Boiling and Condensation, Radiation heat transfer, Evaporation: -Concept and applications.

Incropera, F.D. and DeWitt, D.P., 5th edition, Fundamentals of Heat and Mass Transfer, Wiley, New York.2006 Holman, J.P. 1986. Heat Transfer, 6th Edition, McGraw Hill, New Delhi.
Krieth - Fundamentals of Heat Transfer, 4th Edition, Harper & Law, 1986.
Backhurst *J R,* Harker *J H,* Richardson *J F, CoulsonJ.M ,* Chhabra *R.P., Coulson and Richardson's Chemical Engineering Volume I Butterworth-Heinemann 6th Edition. 1999*
McCabe W.L. , Smith J.C., P Harriot ,Unit Operations in Chemical Engineering, McGraw Hill, New York, 7th edition.2014

CH251 MASS TRANSFER-I (3-1-0) 4

Introduction to Mass Transfer operations. Diffusion Mass Transfer. Unsteady state diffusion. Concept of Mass Transfer Coefficient, Convective mass transfer, mass transfer correlations, interphase mass transfer: Mass transfer theories, Equilibrium stages and transfer units: number and height of transfer units; stage efficiency. Gas –liquid operation : Gas absorption, plate and packed column design, Distillation fundamentals, Batch distillation, flash vaporization, Steam Distillation, Continuous distillation, Azeotropic distillation;. Introduction to multicomponent distillation.

TreybalR .E- Mass-Transfer Operations, Third Edition, McGraw-Hill International Edition(1981).
Dutta B.K- Principles of Mass Transfer and Separation Processes, Prentice-Hall of India Private Ltd. (2007).
Geankoplis C J, Hersel A H,Lepek D H -Transport Processes and Separation Process Principles.Fifth Edition, Prentice Hall(2018)
McCabe W.L. , Smith J.C., Harriot P ,Unit Operations in Chemical Engineering, McGraw Hill, New York, 7th edition.2014

CH252/CH252M CHEMICAL REACTION ENGINEERING –I (2-1-0) 3

Chemical Reaction Equilibrium. Kinetics of Homogeneous Reactions. Single Homogeneous Reactor Design. Reactor Sizing. Multiple Reactor Systems. Multiple ReactionSystems.

Levenspiel, O. - Chemical Reaction Engineering, 3rd edition, Wiley Eastern Limited,2001
Fogler, H.S - Elements of Chemical Reaction Engineering, 2nd edition, Prentice Hall of India,2001

CH253 MOMENTUM TRANSFER LAB (0-0-3) 2

Experiments based on Momentum Transfer course

CH254 PARTICULATE TECHNOLOGY LAB (0-0-3) 2

Experiments based on Particulate Technologycourse

CH300 CHEMICAL REACTION ENGINEERING–II (2-1-0) 3

Non-ideal Flow Reactors. Non-isothermal Homogeneous Reactions. Non-catalytic heterogeneous Reaction Kinetics.
Catalytic Heterogeneous Reaction Kinetics.

Smith J.M., "Chemical Engineering Kinetics", 3rd Edn. McGraw Hill International Editions,1981
Levenspiel O, Chemical Reaction Engineering, 3rd Ed, Wiley & Sons ,2001.
Fogler, H.S., Elements of Chemical Reaction Engineering, 2nd Ed., Prentice-Hall, Englewood Cliffs.2001

CH301 MASS TRANSFER-II (3-1-0) 4

Mass Transfer Operations: Liquid-liquid Extraction:Ternary liquid-liquid equilibrium, cross-current extraction, continuous counter current extraction.Leaching: Equilibria, Stagewise and Counter current leaching. Adsorption: Physical and chemical adsorption, adsorbents, adsorption equilibrium and isotherms, Single and multi-stage cross-current operations, design principles for continuous fixed bed contactor, breakthrough curve. Humidification and

Dehumidification: Basic concepts, Operations, design calculations, Mechanical Draft towers, Cooling towers. Drying.:Equilibrium, Drying rate curve, rate and time of batch drying. Mechanisms of batch drying, continuous drying.Crystallization: delta L law, crystallizers

Treybal R E- Mass-Transfer Operations, Third Edition, McGraw-Hill International Edition(1981).
Dutta B K- Principles of Mass Transfer and Separation Processes, Prentice-Hall of India Private Ltd. (2007).
Geankoplis C J, Hersel A H, LepekD H-Transport Processes and Separation Process Principles.Fifth Edition, Prentice Hall(2018)
McCabe W.L. , Smith J.C., P Harriot ,Unit Operations in Chemical Engineering, McGraw Hill, New York, 7th edition.2014

CH302/CH302M PROCESS DYNAMICS & CONTROL (3-1-0) 4

Introduction .Transient analysis of open loop systems : First and second order systems, Interacting and non-interacting systems. Feed back control system, Modes of control action. Transient analysis of closed loop control systems, Stability analysis: Routh Stability Criteria, Root locus method, Frequency response analysis, Controller Tuning: Zeigler Nichols and Cohen Coon tuning method, Introduction to advanced control strategies.

Coughanowr D R, Process Systems Analysis and Control, Second Edition, McGraw Hill, (1991).
Seborg D W, Edger T F, Millichamp D A, Process Dynamics and Control, 3rd Edition, John Wiley & Sons (2010)
George Stephanopoulos, Chemical Process Control, Prentice Hall PTR (2001)

CH303 HEAT TRANSFER OPERATIONS LAB. (0-0-3) 2

Experiments based on Heat Transfer course.

CH350 CHEMICAL PROCESS INDUSTRIES (3-0-0) 3

Inorganic chemical industries: Manufacture of sulfuric acid, nitric acid, ammonia, urea, different fertilizers, phospohric acid and important phosphate salts. Chlor-alkali industries, Pulp and Paper, Fuel gases, organic chemical industries: C1, C2, C3, C4 compounds and their important derivatives, aromatic compounds, Synthetic fibers.

Marshall Sittig, M. Gopala Rao, Dryden's Outlines of Chemical Technology for the 21st Century 3rd Edition 3rd Edition), 3rd edition,WEP East West Press, 2010
Austin G. T. - Shreves Chemical Process Industries, McGraw Hill Book Co., 5th Edition, 1997.
Kirk-OthmerEncyclopedia of Chemical Technology 5th Edition, Kirk-Othmer Publishing,

CH351 PROCESS DESIGN OF CHEMICAL EQUIPMENT (3-1-0) 4

Introduction to Chemical Equipment Design, Design Considerations of Heat Exchanges, Design methodology of Double pipe heat ex-changers, Design methodology of Shell and Tube Heat ex-changers (Kern method and Bell's method), Design Methodology of Calandria Evaporator. Design Considerations of Mass Transfer Equipment, Design Methodology of Packed and Tray towers for Absorption and distillation..

Kern D Q - Process Heat Transfer, Tata Mcgraw Hill Publishing Co Ltd ,2013
.CoulsonJ M and Richardson J.F -ChemicalEngineering,Vol.6, Design, Second Edition, Pergaman Press,1993.
Perry R H and Don Green - Chemical Engineers' Hand Book, 6th Edition, McGraw Hill Book Co. Douglas J.M., Conceptual design of Chemical Processes McGraw Hill, New York, 1988. Seider J D Daniel R L, Product and Process Design Principles, Wiley, 2004.

CH352 MASS TRANSFER OPERATIONS LAB (0-0-3)2

Experiments based on Mass Transfer I & II.

CH353 DESIGN AND SIMULATION LAB (0-0-2)1

Simulation: Property evaluation using simulator, Thermodynamic and kinetic Models and its limitations, Rating Methodology for the equipment listed in Process Design of Chemical Equipment course, Dynamic and steady state simulations.

CH400 POLLUTION CONTROL & SAFETY IN PROCESS INDUSTRIES (3-0-0) 3

Importance of environment for human kind, flora and fauna, Types of pollution damages due to environmental pollution (industrial gas, liquid and solid effluents). Legislations to environmental pollution problems. Indian standards waste recycling. Noise pollution and its control. Waste water treatment. Air Pollution. Pollution control of effluents from different industries. Scientific and Engineering aspects of safety in industry. OSHAS.

Mahajan S P - Pollution Control in Process Industries - Tata McGraw Hill, 1990.
Rao C S- Environmental Pollution Control Engineering, Wiley Eastern, 1992.

CH401 CHEMICAL REACTION ENGG. AND PROCESS CONTROL LAB (0-0-3)2
Experiments based on Reaction Engg. I & II and Process Dynamics and Control courses.

CH440 PRACTICAL TRAINING 1
A student may complete the training before the beginning of 7th semester (or as stipulated by DUGC) and register for it in 7th semester. The duration and details shall be decided by the faculty advisor, with approval from DUGC.

CH448 SEMINAR 1
This course to be completed during 7th semester. The student will make presentations on topics of academic interest.

CH449 MAJOR PROJECT-I (0-0-3)2
The Students jointly or individually will be assigned an experimental or a theoretical problem, to be carried out under the supervision of a guide. The project has to be completed in the VII & VIII semester. The students should complete the preliminary literature survey and a part of the work in the VII semester. Their work will be reviewed and evaluated.

CH499 MAJOR PROJECT–II (0-0-6)4
Extension and completion of Major project -I started in the previous semester (CH449). Their work will be reviewed and evaluated.

CH450 PROCESS INSTRUMENTATION (3-0-0)3
Introduction: Temperature measurement, Pressure measurement, Flow measurement, Level measurements Viscosity measurement, Moisture and humidity measurements. Conductivity meter- pH meter, Analytical instruments – Liquid chromatography – HPLC – Mass spectroscopy - Computer aided analysis – process instruments and automatic analysis.
Nakra B.C and Chaudhry K Instrumentation, Measurement and Analysis, , Tata McGrow Hill Co., New Delhi, l985.
LiptakB.G ,Encyclopadia of Instrumentation,.,Vol.l, and supplement Chelton Book Co., New York, 1969.
Willard, Merru, Dean and Settle, C.B.S, Instrumental Methods of Analysis,. publication, New Delhi,1986
R.K.Jain, , Mechanical and Industrial Measurements, Khanna Publishers, New Delhi, 1982.

CH451 ENERGY TECHNOLOGY (3-0-0)3
Energy Scenario in India -Conventional/non-conventional renewable non renewable sources. Principles of efficient use of fuels, energy conservation and auditing. Solid liquid and Gaseous fuels. Combustion, Furnaces.Draught and chimney height. Nuclear Energy - Classification and Components. Unconventional fuels, renewable energy sources.
Sharma S.P.andChander Mohan -Fuels and Combustions- Tata McGraw Hill Book Co., 1982.
Shaha A.K. - Combustion Engineering and Fuel Technology, Oxford Press.
Gilchrist J.D. - Fuels, Furnaces and Refractors, Pergamon Press, 1977.
Ronald F. Probstein and Hicks R.E. - Synthetic Fuels - McGraw Hill Book Co., 1982.
Manon L Smith and Keri W Stinson - Fuels and Combustion - McGraw Hill Book Co., 1952.

CH452 PETROLEUM REFINING PROCESSES (3-0-0)3
Introduction.Composition and evaluation of properties of crude oil and refinery products. Refining of petroleum. Types of pipe still furnaces used in refineries and their design consideration. Cracking processes. Rebuilding processes. Product treatment processes.
Robert A. Meyers, Hand Book of Petroleum Refining Processes, McGraw Hill Book Co., l986.
BhaskerRao B.K,.Modern Petroleum Refining Processes, Oxford & IBM Publishing Co., 1984.

CH453 BIOCHEMICAL ENGINEERING (3-0-0)3
Introduction to biochemical engineering and its applications, Role of microbes and microbiology in development of biochemical engineering. Types of organisms, their nomenclature. Introduction to medium formulation for microorganisms and types of media used. stoichiometry of biological reactions, Growth kinetics of microorganisms,Bioreactor configurations. yield coefficient and its importance in media development. Introduction to mass transfer in bioreactors, determination of transfer rates, Enzyme catalysed reactions and kinetics.
Bailey J E, Ollis D.F. Biochemical Engineering Fundamentals, , 2nd Edn, McGraw-Hill, USA,

2010 Doran P M, Bioprocess Engineering Principles, Academic Press, 2008 Shuler M L, Kargı F, Bioprocess Engineering, , Prentice Hall PTR, 2017

CH454 INTRODUCTION TO MOLECULAR SIMULATIONS (2-0-2) 3

Introduction and basics of molecular simulations – model systems, interaction potentials, periodic boundaries, minimum image convention, Equations of motion. Elementary statistical mechanics: ensembles, Boltzmann's distribution, and free energy. Measure and control of temperature and stress in molecular systems. Length and time scale limits of simulation methods. Molecular dynamics of simple model fluids such as hard spheres.Structure of a simulation program and introduction to programming methods. Applications in solids, liquids, and biomolecules. Demonstration using LAMMPS (Large-scale Atomic/Molecular Massively Parallel Simulator).

Allen, M.P., Tildesley, D.J. Computer Simulation of Liquids, Oxford University Press
Frenkel, D., Smit, B., Understanding Molecular Simulations: From algorithm to applications, Academic Press.
Rapport, D.C., The Art of Molecular Dynamics Simulation, Cambridge University Press.
Donald Allan McQuarrie, Statistical Mechanics, University Science Books.

CH455 ENERGY CONSERVATION AND MANAGEMENT IN PROCESS INDUSTRIES (3-0-0)3

Energy Outlook, Energy conservation and its importance, Energy intensive industries, Global industrial energy efficiency benchmarking, Engineering fundamentals related to energy efficiency, Principles on energy management, Energy Audit, Detailed thermodynamic analyses of common unit operations, Opportunities and techniques/methods for energy conservation in equipment and utility systems in process industries, Process synthesis, Thermo-economics, Energy Management Information Systems (EMIS). Software tools for industrial energy efficiency and savings, Case studies on energy conservation and management in process industries

Kenney W F, Energy Conservation in the Process Industries. Academic Press Inc., 1984.
Stepanov V S Analysis of Energy Efficiency of Industrial Processes. 1st Edition, Springer-Verlag, 1993.
Jakob de SwaanArons, Hedzer van der Kooi, Krishnan Sankaranarayanan, Efficiency and Sustainability in the Energy and Chemical Industries, 1st Edition, Marcel Dekker, Inc., 2004

CH456 FUEL CELL ENGINEERING (3-0-0)3

Overview of Fuel Cells, Classification, Basic chemistry and thermodynamics. Fuels for Fuel Cells: Hydrogen, Hydrocarbon fuels. Fuel cell electrochemistry: electrode kinetics. Fuel cell process design: PEM fuel cell components. Fuel cell operating conditions: pressure, temperature, flow rates, humidity. Components of solid-oxide fuel cells. Fuel processing: Direct and indirect internal reforming, steam reformation, CO2 and partial oxidation, Direct electro-catalytic oxidation of hydrocarbons, Impurity removal, renewable fuels for SOFCs

Gregor Hoogers, Fuel Cell Technology Hand Book, CRC Press, 2003.
Karl Kordesch& Gunter Simader, Fuel Cells and Their Applications, VCH Publishers, NY, 2001.
Barbir F, PEM Fuel Cells: Theory and Practice (2nd Ed.) Elsevier/Academic Press, 2013.
Subhash C. S and Kevin Kendall, High Temperature Fuel Cells: Fundamentals, Design and Applications, 2003

CH457 CHEMICAL PROJECT ENGINEERING (3-0-0)3

Introduction. Components of Techno-economic feasibility report. Site selection factors, prefeasibility analysis, Capital and operating costs, cashflow statement, project evaluation. project scheduling: Gantt charts, CPM, PERT, network formulation and scheduling, project handover and documentation. Project financing, annual report analysis.

Chandra Prasanna, Projects: planning, analysis, selection, implementation and review, Tata McGrawHill, 8th edition, 2014.
Turton, R., Bailey, R.C., Whiting, W.B., and Shaewitz, J.A., Analysis, synthesis and design of chemical proceses, 4th edition, Pearson 2012
Mahajani, V.V. and Mokashi, S.D., Chemical Project Economics, 1st edition, Macmillan India, New Delhi, 2005.

CH458 BIOLOGY FOR CHEMICAL ENGINEERS (3-0-0) 3

Science and Engineering: Differences in perspectives-Biological molecules-Chromosome structure-eukaryotic-bacterial- DNA replication-Replication errors-mutations-repair-homologous-non-homologous-recombination-bacterial gene expression-transcription-translation. Recombinant engineering-plasmids-restriction endonucleases-DNA cloning and assembly methods-site specific recombination-Genetics- Mendelian and non-Mendelian Inheritance-pedigree analysis-Gene-Interactions-Immunological reactions-innate immunity receptors- Systems biology-autoregulation-bistability-robustness-feed forward loops- Bacterial chemotaxis and kinetic proof reading-introduction to bioinformatics-enzyme as catalysts.

Scott Freeman (2002). Biological Science. Prentice Hall, 1st edition
Craig et al., (2010) Molecular biology: principles of Genome function, Oxford university press, 1st edition

CH460 CORNERSTONE/CAPSTONE PROJECT **4**

For details refer to clause 3.2 under Regulations specific to Undergraduate Programmes.

UC100 INTRODUCTION TO DESIGN THINKING (2-0-0) 2

Need and Definition of Design Thinking. Framework for Design Thinking. Engineering Design Process. Need Identification, Specification, Concept Generation, Product Architecture and Detailed Design. Prototyping – Virtual and Physical. Testing Methodology

Christian Muller-Roterberg, "Handbook of Design Thinking", 2018
Eli Woolery, "Design Thinking Handbook" Invision Pub, 2019
Nigel Cross, "Design Thinking"
Max Answell "Mastering Design Thinking", 2019
Karl T. Ulrich, Steven D. Eppinger and Maria C Yang, "Product Design and Development", McGraw Hill, 7ed, 2020
George e Dieter, Linda C Schmidt, "Engineering Design", Mc Graw Hill, 4ed, 2009

UC401 LIBERAL ARTS COURSES/CO-CURRICULAR/EXTRACURRICULAR ACTIVITIES 10

CATEGORY A : Maximum 3 credits, CATEGORY B : Maximum 3 credits, CATEGORY C : Minimum 4 Credits and Maximum 7 credits.

10 Credits have to be earned from 1st Semester to 7th Semester by choosing Category (A + B + C) OR Category (A + C) or Category (B + C) courses combination . Registration for 10 Credits has to be done in 7th Semester.

For details of CATEGORY A, CATEGORY B and CATEGORY C refer to clause 3.2 (f) under Regulations specific to Undergraduate Programmes.

Department of Chemistry

CY110 CHEMISTRY (3-0-0) 3

Electrochemical Cells: Nernst equation, electrochemical series, types of electrodes, Polarization, Decomposition potential, Overvoltage, factors effecting electroplating, Electroless plating – PCB preparation. Corrosion: Types, Theory and factors affecting, Corrosion control, Galvanic series, Measurement of corrosion rate. Water Technology: Hardness of water, Boiler troubles, Internal and external treatments, Desalination. Energy: Fuels, Classification, Calorific value and its determination, Coal and its analysis, Petroleum, Catalytic cracking, Synthetic petrol, Power alcohol, Biodiesel, Hydrogen as a source of energy. High Polymers: Addition, Condensation and Coordination polymerization, Copolymerization, Molecular weights and their determinations, Methods of polymerization, Tg & Tm and factors affecting them; Elastomers - Compounding, SBR and Silicone rubbers, Conducting, biodegradable polymers. Chemistry of Nano-materials - Nano-carbons, ZnO, TiO2. Green chemistry, Semiconductor chemistry.

P. C. Jain and Monika Jain, Engineering Chemistry, Dhanpat Rai & Sons, Delhi, Revised 14th Edn. 2004.
Gowariker et al., Polymer Science and Technology, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
C. N. R. Rao, Chemistry of Nanomaterials, Volume I and II, Wiley Publication, 2004.
Industrial Organic Chemicals (3rd Ed.) by Harold A. Wittcoff, Bryan G. Reuben, and Jeffrey S. Plotkin, Wiley, ISBN 978-0-470-53743-5

CY111 CHEMISTRY LABORATORY (0-0-3) 2

Volumetric estimations involving metal-ion, redox, self and precipitation type indicators - analysis of water (hardness and chlorides), ores (haematite and pyrolusite); Instrumental methods of analysis - potentiometry, colorimetry, conductometry and refractometry; Analysis of polymers, metals, alloys, and related engineering materials.

Engineering Chemistry Lab Manual, written by Faculty, Dept of Chemistry, NITK, Surathkal. Furnis et al (ed.), Pearson, Vogel's Text book of 'Quantitative Chemical Analysis', Pearson, 2006

CY201 PRINCIPLES OF ORGANIC SYNTHESIS (3–0–0) 3

Formation of C-C bonds: Organometallic reagents. Formation of aliphatic C-C bonds, base/acid catalyzed. Formation of aliphatic C-N bonds. Pericyclic reactions. Electrophilic aromatic substitution. Nucleophilic aromatic substitution reactions. Molecular rearrangements: Rearrangement to electron-deficient carbon, nitrogen and oxygen. Aromatic rearrangements. Photochemical reactions. Free radical reactions. Oxidation & reduction reactons.

J. March, Advanced Organic Chemistry, 4th edition, McGraw Hill, New York, 1994.
R. O. C. Norman and J. M. Coxon, Principles of Organic Synthesis, Blackie Academic and Professional, Glasgow, NewYork, 1993.

CY202 UNIT PROCESSES IN ORGANIC SYNTHESIS (3-0- 0) 3

Bond breaking, bond forming, synchronous bond breakage and formation, intramolecular migration, electron transfer, types of reactions. Electrophilic addition. Nucleophilic addition. Radical addition. Elimination. Substitution reactions. Intramolecular rearrangements and intermolecular rearrangements. Oxidation and reduction reactions.

P. H. Gorggins, Unit Processes in Organic Synthesis, 5th edition, McGraw-Hill, 1958.
J. March, Advanced Organic Chemistry, 3rd edition, McGraw Hill, New York, 1985.

CY205 ORGANIC CHEMISTRY (3-0- 0) 3

Strengths of organic acids and bases: Various Acid-base concepts, HSAB theory & its applications. Heterocyclic compounds: synthesis, reactions, reactivity of some five and six member heterocyclic compounds & their industrial importance. Reagents of synthetic importance: synthesis, uses, mechanism, applications of some important reagents.

Named organic reactions: mechanism and applications of some industrially important organic reactions.

Stereochemistry: types of stereo-isomers, Optical activity, Enantiomers, Diastereomers, conformations & conformational analysis of some cyclic derivatives. Dyes: Colour and constitution, different classification of dyes, synthesis and applications of some important dyes of different types. Photochemistry and photochemical organic reactions.

M. K. Jain and S. C. Sharma, Organic Chemistry, Shoban Lal Chand. & Co., 2000.
K. Venkataraman, The chemistry of synthetic dyes, Academic Press Inc. 1980.
I. L. Finar, Organic Chemistry volume I & II by I. L. Finar, Pearosn publishers R. T.

Morrison and R. N. Boyd, Organic chemistry, Prentice-Hall India, New Delhi

CY206 INSTRUMENTAL ANALYSIS LAB. (0–0–4) 2

Potentiometry. Conductometry. Colorimetry. Refractometry. Gravimetric estimations. Demonstration of UV and IR spectrophotometer.

A. I.Vogel, A Text Book of Quantitative Inorganic Analysis Including Elementary Instrumental Analysis, ELBS, Longman Group, UK, III Edition, 1962.

J. Basset, R. C. Denny, CH Jaffery and J. Mendhan, Vogel's Text Book of Quantitative Inorganic Analysis, including elementary analysis, ELBS, London, 5th Edition, 1989.

CY251 POLYMER SCIENCE AND TECHNOLOGY (3–0–0) 3

Basic concepts, configuration and conformation. Thermoplastic and thermosetting polymers. Condensation, addition, coordination, ring opening, metathesis polymerization. Copolymerization. Chemical reactions of polymers and polymer degradation. Analysis and testing of polymers. Rheology and mechanical properties: Kinetic theory of rubber elasticity, glassy state and glass transition, mechanical properties, crystalline melting point, property requirements and polymer utilization. Polymer processing: Molding, extrusion, calendaring, casting, coating, thermoforming, foaming. Multipolymer systems and composites. Additives and Compounding. Fibre and elastomer technology.

F. W. Billmeyer, Textbook of Polymer Science, Wiley Interscience Publication, 1984.

Joel R. Fried, Polymer Science and Technology, Prentice Hall, NJ, 1995.

CY252 INDUSTRIAL CHEMISTRY (3–0–0) 3

Synthetic Organic Chemical Industries: Petrochemicals – Chemicals from C1, C2, C3, C4 compounds. Chemicals from aromatics. Phenols and alkyl phenols. Isomerization, Dehydrogenation. Oxidation of paraffins. Pesticides and Pharmaceutical Industries. Polymer Industries: PE, PVC, Teflon, SBR, NBR, Neoprene, Silicone rubber, Nylon, Dacron. Starch and cellulose derivatives. Natural product industries: Oils. Soaps. Detergents. Essential oils. Paints and Varnishes. Food industries. Fermentation industries. Explosives and propellants.

E. Riegel, Industrial Chemistry, 6th ed,, J. A. End, Reinhold Publishing Corp., 1962.

R. N. Shreve, Chemical Process Industries, 3rd ed., McGraw-Hill Book, 1967.

CY255 TECHNICAL ANALYSIS LAB. (0–0–4) 2

Demonstration about laboratory safety and First aid, Experiments involving Organic estimations, organic preparations, Electroanalytical methods: Conductometric and potentiometric titrations, Beer-Lambert's law and its deviations, Viscometry, Gravimetric analysis

Willard, Merritt, Dean & Settle, Instrumental methods of analysis, 6th Ed., CBS Publishers & Distributors, Delhi, 1986.

G. Chatwal and S. Anand, Instrumental Methods of Chemical Analysis, S. D. Himalaya Publishing House, 2000.

B.S. Furniss, A.J. Hannaford, P.W.G. Smith, A.R. Tachell Vogel's text book of Practical organic Chemistry, Longman group, UK, 1989.

CY300 INSTRUMENTAL METHODS OF ANALYSIS (3–0–0) 3

Electroanalytical methods: Conductometric and potentiometric titrations. Polarography - theory and applications. Amperometric titrations. Spectroanalytical methods: Molecular spectra, Microwave, IR, UV-visible spectroscopy – theory, instrumentation and applications. Beer-Lambert's law and its deviations. Atomic absorption spectroscopy: Thermal methods of analysis: TGA, DTA, DTG, instrumentation and applications. Solvent extraction: Principle, distribution coefficient, separation factor and efficiency, applications. Chromatography: Paper chromatography, TLC, GC, HPLC – theory, instrumentation, experimental techniques and applications.

Willard, Merritt, Dean & Settle, Instrumental methods of analysis, 6th Ed., CBS Publishers & Distributors, Delhi, 1986.

D.A. Skoog, F.J. Holler, S.R. Crouch, Instrumental Analysis, 2008.

G.H. Jeffery, J. Bassett, J. Mendhem, R.C. Denney, Vogel's Textbook of quantitative Chemical analysis, ELBS, 5th Edn, 1989.

G. Chatwal and S. Anand, Instrumental Methods of Chemical Analysis, S. D. Himalaya Publishing House, 2000.

CY301 ADVANCED ELECTRO CHEMISTRY (3–0–0) 3

Introduction. Theory of electrolytic conductance: Debye-Huckel theory, transport numbers, Faradays laws and ionic velocities, Hittorff's methods of determination. Ion-solvent interaction: Born model and expression for free energy of ion-solvent interaction, Fick's law of diffusion. Polarography: DME, Ilkovic equation, half-wave potential, theory and applications. Special polarographic techniques: Chronopotentiometry, Chronoamperometry,

Linear sweep voltammetry, like Cyclic voltammetry, Oscillographic polarography, Amperometry.
Samuel Glasstone, An Introduction to Electrochemsitry, Affiliated East West Press, New Delhi.
J. O. M. Bockris and A. K. N. Reddy, Modern Electrochemistry, Plenum Press, 1970.

CY302 BIOCHEMISTRY (3–0– 0) 3

Chemistry of biomolecules: Basic aspects of carbohydrates, lipids, amino acids, proteins, nucleic acids and biological membranes. Enzymes: structure, functions, mechanism of action, specificity, kinetic considerations, multi enzyme systems and immobilized enzymes. Bioenergetics: ETS, ATP. Biochemistry of nutrition and digestion: Metabolism of carbohydrates, lipids, and amino acids. Interrelation. Flow of genetic information: Genetic code, replication of DNA, transcription and translation. Biosynthesis of proteins.
Albert L. Lehninger, David L. Nelson, Michael M. Cox, Principles of Biochemistry, CBS Publishers and Distributors, Indian Edition, 1993.
Eric E. Conn. Paul K. Stumpf, George Breening & H. Roy Doi, Outlines of Biochemistry, 5th Edition, John Wiley and Sons, 1987.

CY305 INORGANIC AND PHYSICAL CHEMISTRY (3–0– 0) 3

Chemistry of d-block elements: Periodic properties. Coordination compounds: Theory of complexes, VBT, CFT, LFT and MOT for complexes, optical and magnetic properties, factors affecting stability and isomerism. Surface Chemistry: Adsorption -Freundlich and Langmuir's adsorption isotherms, applications. Catalysis – Types, mechanism, kinetics of surface reactions, autocatalysis. Solutions: Raoult's law, ideal and nonideal solutions, Gibb's-Dichem Margules equation, thermodynamics of ideal solution, binary solutions, fractional distillation, Henry's law.
J.E. Huhey, Inorganic Chemistry – Principles of structure and reactivity, Harper & Row Publishers, Singapore.
B. R. Puri, L. R. Sharma and M. S. Pathania, Principles of Physical Chemistry, S. N. Chand & Co., Jalandhar, 31st edition, 1990.

CY350 ENVIRONMENTAL CHEMISTRY (3–0– 0) 3

Introduction, Environmental segments, Natural cycles of the environment. Atmosphere: Composition, structure, evolution. Chemical and photochemical reactions. Green house effect, Ozone hole, E1-Ninophenomena. Water resources: Complexation in natural waste water. Microbially mediated acquatic chemical reactions. Composition of Lithosphere, water, air, and inorganic components in soil. Nitrogen pathways. Wastes and pollutants in soils. Toxic chemicals in the environment. Air and water pollution, causes, bad effects and control.
C. N. Sawyer, P. L. McCarty and G. F. Parkin, Chemistry for Environmental Engineering, McGraw-Hill, 1990.
A. K. De, Environmental Chemistry, New Age Intl. (Pvt)Ltd., 1998.

CY351 PHYSICAL CHEMISTRY OF POLYMERS (3-0- 0) 3

Kinetics of free radical, ionic, coordination and step polymerization, copolymerization. Phase transitions: Kinetics and mechanism of polymer crystallization.Amorphous polymers. Thermodynamics and theory of polymer solutions, Flory Huggins theory, UCST and LCST. Determination of molecular weights of polymers –osmometry, viscometry, light scattering methods. Rheological properties of solutions and polymer melt. Liquid crystalline state. Electrical properties of polymers. Elastomers – theory of elasticity.
A. Tager, Physical Chemistry of Polymers, MIR Publishers, 1972.
Anil Kumar and Santhosh K Gupta, Fundamental of Polymer Science and Engineering, Tata Mcgraw-Hill Publishing Co. Ltd. India, New Delhi, 1970.

CY352 PHARMACEUTICAL CHEMISTRY (3–0–0) 3

Introduction, classification and nomenclature of drugs. Theories of drug action and factors affecting. Assay of drugs and their metabolism. Sedatives. Analgesics. Antihistamins. Antiinflammetory, Antimalarial. Antifungal, Antiviral agents. Steroids. Sulphonamides and Antibiotics. Organic pharmaceutical aids. Chemical models and mimics for enzymes, receptors, carbohydrate and other bioactive molecules, catalytic antibodies. Molecular modeling, conformational analysis, qualitative and quantitative structure and activity relationships.
Ed. Manfred E. Wulf, Burger's Medicinal Chemistry and Drug Discovery, Vol. 1-6, John Wiley, New York, 1995.
G. R. Chatwal, Pharmaceutical Chemistry, Vol. I and II, Himalaya Publishing House, Delhi, 2nd edition, 1997.

CY353 FOOD CHEMISTRY (3–0–0) 3

Components of food: Carbohydrates, Fats and oils, Proteins, Vitamins, Minerals. Food Microbiology: Interaction between microorganism and food, mechanism of spoilage, food borne illness and fermentation. Cryogenic food preservation. Water activity and storage stability. Drying techniques. Food and food by-products processing

industries. Food preservatives, Fragrances. Flavours. Food additives. Interesterification of oils. Food packing, materials, and methods. Analysis of food proteins, fats, carbohydrates, vitamins, etc.
T. P. Coultate, Food – The Chemistry of Components, RSC, 2002; C. W. Hall, Encyclopedia of Food Engineering, AVI publishing, 1971. M. Karel and D. B. Lund, Principles of Food Science, M. Decker, New York, 1975.

CY356 CERAMIC AND POLYMER LAB. (0–0–3) 2
Experiments involving evaluation of thermal, electrical, mechanical, optical, and miscellaneous properties of polymeric materials and ceramics. Chemical analysis of polymers and ceramics. Molecular weights, MFI, Strength, hardness, Specific gravity, Particle size distribution, T_g and Softening point, Refractive index, Haze, Water permeability, Spalling resistance, Refractoriness, Chemical characterization, Identification of plastics.
Cyus Klings, Physics & Chemistry of Ceramics & Refractories, Ed. Breach Science,1963
Vishu Shah, Hand Book of Plastic Testing Technology, Wiley-Interscience Publication, New York, 1984.

CY400 BIO-INORGANIC CHEMISTRY (3–0–0) 3
Introduction. Transport and storage of metal ions. Elements of Biology and Medicine. Energy of biological systems. Hydrogen Biochemistry. The functional value of the chemical elements in Biological systems. Sodium, Potassium, Chlorine, Magnesium, Cadmium, Zinc, Iron, Manganese, Copper, Cobalt, Molybdenum, Vanadium, Tungsten, Phosphorus, Sulphur, Sele-nium, Halogen. Metal based drugs. Environmental application and toxic effects of metal ions.
M. Satake & Y. Mido, Bioinorganic Chemistry, Discovery Publ House, New Delhi, 2001.
H. Siegel & T. G. Spiro, Metalions of Biological Systems, Mercel-Dekker,1980 to present.

CY401 CHEMISTRY OF DYES AND PIGMENTS (3–0–0) 3
Dyes – Color and constitution, chromophores and auxochromes, insulating groups, Classification based on chemical constitution and applications. Preparation, properties and uses of dye intermediates and dyes. Photochemistry – Principles, photo induced reactions, oxidation, reduction, isomerization, addition reactions. Woodward Hoffmann's rule. Inks – composition, pigments, vehicles, ink additives, Ink manufacture, printing methods and screen printing. Inorganic pigments.
The chemistry of synthetic dyes and pigments, American Chemical Society Monograph Series, Hagger Pub. Co., 1970.
K. Venkataraman, The chemistry of synthetic dyes, Academic Press Inc. 1980.
D. E. Bissett, Printing Ink Technology, Northwood, 1978.

CY402 SURFACE MODIFICATIONS (3–0–0) 3
Introduction. Plating and Coating Processes: Basic principles and methods. Hardfacing. Anodising. PVD. CVD. Thermal spraying. Electrodeposition. Electroless deposition. Hot dipping. Composite coating. Surface alloying. Alloy plating. Thermal processes: Laser -hardening, glazing, surface alloying, cladding. Electron beam hardening. Implantation and special processes: Ion implantation. CMM coating. Applications and recent developments.
T. S. Sudarshan (Ed), Surface Modification Technologies, Marcel Dekker, 1989.
V. Vasantasree and P. S. Sidky, Metallic and Ceramic Coatings, Longman Scientific and Technical, UK, 1989.

CY403 WATER AND SOIL CHEMISTRY (3–0–0) 3
Water resources. Physical chemistry of sea water. Complexation in natural water and waste water. Microbialy mediated redox reactions. Ion-water interactions. Water Pollution: Water pollutants, waste water treatment, trace elements in water, water quality parameters and standards, sampling, preservation and monitoring techniques. Soil-ion interactions and chemical cycles. Solute-solute interactions. Weathering and soil development processes. Soil organic matter. Soil and microorganism. Cation, anion and molecular interactions in soils. Acid soils and salt affected soils. Soil pollution. Radiation effect.
K. H. Tan, Principles of Soil Chemistry, Dekker, New York, 1982.
R. A. Home, Chemistry of our Environment, Plennum, New York, 1975.

CY450 ADVANCED INSTRUMENTAL METHODS OF ANALYSIS (3–0–0) 3
Magnetic Resonance Spectroscopy: NMR. FTNMR. ESR. NQR. X-ray methods: Absorption, Fluorescence, Diffraction. Radiochemical methods. Electron and Ion Spectroscopy. XPS. UPS. EIS. AES. ISS. Photoacoustic Spectroscopy. Basic principles and applications.
G. W. Ewing, Instrumental Methods of Analysis, McGraw-Hill, New Delhi, 1990.
Willard, Merritt, Dean & Settle, Instrumental methods of analysis, 6th Ed., CBS Publishers & Distributors, Delhi, 1986.

CY451 CHEMISTRY OF NATURAL PRODUCTS (3–0–0) 3

Alkaloids: Introduction, occurrence, functions, nomenclature, classification, isolation, properties, determination of molecular structure. Terpenoids: occurrence, isolation, classification, general characteristics, structural features, isoprene rule. Steroids and hormones. Natural Pigments. Biosynthesis of some natural products: Biosynthesis of carbohydrates and photosynthesis, biosynthesis of terpenoids and steroids.

I. L. Finar, Organic Chemistry, Volume 1: The Fundamental Principles, and Volume 2, Stereochemistry and Chemistry of Natural Products, VI Edition, ELBS, 1989.

O..P. Agarwal, Chemistry of organic natural products, (volumes 1 & 2), Goel Publishing house, Meerut, 1993.

CY452 BIO-PHYSICAL CHEMISTRY (3–0–0) 3

Molecular species in solution. Energy and equilibria. Enzyme and Enzymatic catalysis – Kinetics and mechanism of enzymatic reactions and their specificity. Bioenergetics – Notions of TD, application to chemical reactions in living organisms. ATP energetics.

C. R. Canter and P. R. Sehimmell, Biophysical Chemistry, Freeman, Sanfransisco.

G. M. Barrow, Physical Chemistry of Life Sciences, McGraw-Hill, New Delhi.

CY453 POLYMERS FOR ELECTRONICS AND OPTOELECTRONICS (3-0-0) 3

Conducting polymers. Electrodepositable resists: Electrodepositable resins formulation. Thermotropic liquid crystal polymers: fundamentals, processing. Photoconductive polymers: charge-carrier generation, charge injection, charge transport and charge trapping; electron-transporting and bipolar polymers. Polymers for optical data storage: Principles of optical storage, polymers in recording layer. Nonlinear materials: NLO properties, NLO effects, wave guide devices and through-plane modulators.

A. B. Kaiser (Eds. H. Kuzmany, M. Mehring and S. Roth), Electronic properties of conjugated polymers – basic models and applications, Springer-Verlag, Berlin, 1989.

Ed. J. A. Chilton & M. T. Goosy, Special polymers for electronics and optoelectronics, Chapman & Hall, 1995.

Courses for B.Tech. with Chemistry Minor (Refer M.Sc Chemistry curriculum for details)

CY804M SPECTROSCOPY, APPLICATIONS IN CHEMISTRY (3-0-0) 3
CY703M ORGANIC CHEMISTRY-I (3-0-0) 3
CY704M PHYSICAL CHEMISTRY – I (3-0-0) 3
CY751M INORGANIC CHEMISTRY – II (3-0-0) 3
CY754M SPECTROSCOPY (3-0-0) 3

Department of Civil Engineering

CV100 CIVIL ENGINEERING MATERIALS AND CONSTRUCTION (3-1-0) 4

Traditional materials : stone, brick, tiles-roofing and flooring, steel, timber, lime, cement, their manufacture, properties and codal requirements. Mortar, cement concrete, properties, specifications and tests for quality control. Reinforced concrete, fibre reinforced concrete and ferrocement applications. Paints, enamels, varnishes, tar, bitumen, asphalt, properties and use. Modern materials: plastics, rubber, polymer, fibre reinforced plastics, manufacture, properties and use. Introduction to composites and smart materials. Building Construction: Foundations; Stone Masonry - Random rubble and Ashlar,; Brick Masonry -Rules for bonding, stretcher and header bonds and English Bond for 1 and 1 V brick thickness,; Doors and Windows; RCC Stairs and design of a dog-legged stair; Pitched Roofs and Simple Trusses; RC Constructions - Lintels and sunshades, beams and one-way and two-way slabs.

S.K. Duggal, Building Materials, Oxford & IBH publishing Co. Ltd., New Delhi 2000 M.S. Shetty, Cement Technology, Theory and Practice, S.C. Chand & Co. Ltd., 2002 B.C.Punmia, Building Construction

CV110 ENVIRONMENTAL STUDIES (1-0-0) 1

Definition, scope and importance of Environmental Studies, Need for public awareness. Natural Resources Renewable and Non-renewable Resources. Natural resources and associated problems. Concept of an ecosystem: Structure and function of an ecosystem, Producers, consumers and decomposers, Energy flow in the ecosystem, Ecological succession, Food chains and ecological pyramids, Biodiversity and Its Conservation, Environmental Pollution: Definition, Causes, effects and control measures. Pollution case studies. Disaster management, Social Issues and the Environment, Environmental ethics, Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Wasteland reclamation,

Consumerism and waste products, Acts related to Environment Protection, Issues involved in enforcement of environmental legislation, Human Population and the Environment, Field work equal to 5 lecture hours. R. Rajagopalan, Environmental Studies, Oxford IBH Pub,2011.

Benny Joseph, Environmental Studies, McGraw Hill Pub,2008.

ErachBharucha, Textbook for Environmental Studies, Pub., UGC,2004.

Masters, Gilbert M. Introduction to Environmental Engineering and Sciences, Prentice Hall India,2008.

CV201/CV201M ELEMENTS OF SURVEYING (3-0-0) 3

Introduction to Surveying, Chain Surveying, Compass Surveying, Errors, Accuracy and precision. Introduction to plane table surveying. Levelling, contouring, Theodolite traverse. Introduction to tacheometric surveying and Trigonometric leveling. Horizontal curves. Introduction to vertical curves.

Electronic distance measurements - Introduction. Minor Instruments, Digital Theodolite and total Station. B.C. Punmia,Surveying Vol. I and II -STD

K. R. Arora,Surveying Vol-I &II- STD Book, New Delhi.

S.K. Roy,Fundamentals of surveying -Prentice - Hall of India, New Delhi.

CV202 ENGINEERING GEOLOGY (3-0-0) 3

General Geology, Physical Geology, Mineralogy, Petrology. Study of Igneous, Sedimentary, Metamorphic rocks, Physico - mechanical properties of rocks.

Structural geology : Study of folds, faults, Joints, unconformities: resource engg., remote sensing applications, Hydrogeology : Aquifers, geophysical exploration, selection of dam sites, tunnels, landslide control measures, environmental geology.

Parbin Singh, Engineering and General Geology, Katson Pub., Delhi, Sixth edition 2001.

Blyth. F.G.H & De Freitas M.H. Engineering Geology, ELBS, 7th Edition, 1984

D.V.Reddy, Engineering Geology for Civil Engineers, Oxford IBH Publishers,1995,1997.

CV203 MINING GEOLOGY (3-0-0) 3

Physical Geology; Interior of the earth, Geological processes, Geological hazards. Mineralogy; physical properties, Quartz, Silicates, carbonate minerals, petrology; study of Igneous, Sedimentary, Metamorphic rocks. Stratigraphy; principles, geological time scale, Dharwars, Gondwana, tertiary systems. Paleontology; fossils and their uses, fossil fuels; coal and petroleum geology.

Parbin Singh, Engineering and General Geology, Katson Pub. Delhi, 6th Edition 2001

MukerjeeP.K. A text book of Geology, World Press Pvt. Ltd. 11th Edition, 1990

CV216 CIVIL ENGINEERING MATERIALS LAB (0-0-3) 2

Sampling and testing of materials as per BIS specifications and codal requirements. Cement, fine and coarse aggregates, bricks, roofing and flooring tiles.

V.V. Sastry&M.L.Gambhir, Laboratory Manual of Concrete Testing (Part - I), Dhanpat Rai & Sons, New Delhi 1992.

Relevant BIS codes for testing of materials.

CV218 MINING GEOLOGY LABORATORY (0-0-3) 2

Mineralogy; Megascopic study of minerals, Microscopic study of minerals, Petrology; Megascopic study of rocks, Microscopic study of rocks.

Paleontology; Identification and description of fossils Crystallography; Study of crystals through crystal models Simmons &Schuden guide, Rocks and Minerals

Cornelius S. Hurlbut. Jr. Dana's manual of Mineralogy, John Wiley and Sons, 1985

CV251 DESIGN OF RCC STRUCTURES (3-0-0) 3

Strength properties and behaviour of concrete and reinforcing steel. Basic principles of working stress design. Limit state design concepts. Designing of members subjected to flexure, shear, torsion, axial forces and combinations, uniaxial and biaxial bending of columns. Design of simply supported and continuous beams and slabs; two-way slabs, isolated and combined footings. Computation of deflection and crack width. Ashok K Jain, Reinforced Limit State Design, Nem Chand & Bros. Roorkee, 1998.

Unnikrishna Pillai and Devadas Menon, Reinforced Concrete Design, Tata- McGrawhill, 1997.

CV252/CV252M SOIL MECHANICS (3-0-0) 3

Soil formation, Three-phase system, Index properties of soils, Soil classification, Hydraulics of soils, Stress distribution in soils, Soil compaction, One dimensional consolidation, Effective stress and pore water pressure, Shear strength of soils.

T.W.Lambe and R.V.Whitman, Soil Mechanics, John Wiley and Sons, Inc, New York. V.N.S.Murthy, Soil Mechanics and Foundation Engineering, Dhanpat Roy and Sons, New-Delhi. Relevant IS Codes(Latest editions).

CV253 STRUCTURAL ANALYSIS (3-0-0) 3

Conditions of equilibrium, degrees of freedom, determinate and indeterminate structures, Linear and non- linear structural systems. Deflection of beams: Moment area method and conjugate beam method, the first theorem of Castigliano,Betti's law, Clark Maxwell's Theorem of reciprocal deflection, strain energy method and unit load method. Redundant Structures: The second theorem of Castigliano, Consistent deformation method, slope deflection method. Rolling loads and influence lines: Statically determinate beams and bridge trusses, series of loads and uniformly distributed loads, criteria for maximum and absolute maximum moments and shears. Three-hinged arches, influence lines,Cables and suspension bridges, suspension bridge with three hinged stiffening girders and influence line diagrams.

Norris and Wilber, Elementary structural analysis.

C.K. Wang, Statically indeterminate structures

CV254/CV254M HIGHWAY AND TRAFFIC ENGINEERING (3-0-0) 3

Introduction: Initial recommendations for highway planning in India, saturation system, Third 20 year road development plan and fundamentals of transportation systems, planning on trip generation, distribution, assignment and modal split.

Traffic Engineering: Vehicular and road user characteristics, traffic studies, junctions and signals, traffic control devices Highway alignment and geometric design: Highway alignment, cross-sectional elements, horizontal alignment and vertical alignment Highway design and construction: design of flexible and rigid pavements, WBM and bituminous concrete roads and highway maintenance.

S.K. Khanna and C.E.G. Justo, Highway Engineering, Nemchand Bros., Roorkee

L.R. Kadiyali, Traffic and Transport Planning, Khanna Publishers, New Delhi

CV265 SURVEYING PRACTICE (0-0-3) 2

Chain, Compass, Plane table leveling theodolite and tacheometric surveying, curve Setting, Demonstration of Total Station.

P.C. Punmia,Surveying Vol. I and II -STD

K. R. Arora,Surveying Vol-I &II- STD Book, New Delhi.

CV266 GEOLOGY LAB (0-0-3) 2

Mineralogy: Identification and description of important rock -forming and ore minerals. Petrology: Identification and description of Igneous, Sedimentary, Metamorphic rocks.
Structural Geology: Interpretation of geological and Structural geological maps, Solving Dip and strike problems.
K.M. Gurappa, Structural geology Manual
B.S. SathyaNarayanaswamy Engineering Geology Laboratory Manual, Eurasia pub.

CV267 SOIL MECHANICS LAB (0-0-3) 2

Identification of soils, Index properties of soils, Soil permeability, Light compaction test, Coefficient of consolidation, Direct shear test, Unconfined comp. Test, Triaxial comp. Test and Vane shear test, CBR test.
T.W.Lambe, Soil Testing for Engineers, John Wiley and Sons, Inc, New York. SP36 Part 1 and Part 2 (Latest editions).

CV301/CV301M ENVIRONMENTAL ENGINEERING (3-0-0) 3

Essentials of water and wastewater engineering systems, quantities, sources, water distribution systems, planning and analysis. Wastewater collection. House drainage. Water and wastewater characteristics.
Drinking water standards. Unit operations and processes of water and wastewater treatment. Design of treatment units.
Fair & Geyer, Water Supply and Waste water disposal, John Wiley Publications
B.C. Punmia& Ashok Jain, Water supply Engineering & Wastewater Engineering, Arihant Publications

CV316 BUILDING DESIGN AND DRAWING (1-0-3) 3

Foundations; Doors and Windows; Stairs - proportioning and designing of different types of staircases for residential and commercial buildings; Different types of roofs and trusses. Functional design of buildings: To draw the line-diagram, plan, elevation and sectionand line-sketches of different types of buildings (school, hospital, hostel, residential, office etc.). Introduction to AutoCAD.
Shah and Kale, Principles of Building Drawing Sharma and Kaul, Text of building construction B.C. Punmia, Building construction

CV351 DESIGN OF STEEL STRUCTURES (3-0-0) 3

General principles of elastic method of design of steel structures. Bolted and welded connections, Tension and compression members, laterally supported and unsupported beams, unsymmetrical bending, built up beams, plate girders, members subjected to axial force and uniaxial and biaxial moments. Introduction to the limit state design philosophy of steel structures.
A.S. Arya and J.L. Ajmani, Design of steel structures, Nem Chand Bros, Roorkee.
Ramachandra, Vol I & II, Design of steel structures, Standard Book House, New Delhi.
S.K. Duggal, Design of Steel Structures, Tata McGraw Hill, Publishing Co. Ltd., New Delhi. Related IS Codes

CV366 HIGHWAY MATERIALS AND CONCRETE TESTING LAB (0-0-3) 2

Tests on highway materials, aggregates and bituminous materials; tests on fresh concrete; workability tests; tests on hardened concrete; strength tests; destructive and non-destructive testing; tests on R.C. beams and columns.
S.K. Khanna and C.E.G. Justo, Highway materials Testing - Nem Chand Bros, Rookee
V.V. SastryandM.L. Gambir, Laboratory manual on concrete testing (Part II).

CV367 ENVIRONMENTAL ENGINEERING LAB (0-0-3) 2

pH, colour, turbidity; Solids - suspended, dissolved, settleable and volatile; Dissolved oxygen, BOD, COD;Determination of fluorides and iron; hardness, chlorides; Nitrite-Nitrogen and Ammonical -nitrogen; Available chlorine in bleaching powder, residual chlorine in water and chlorine demand; Bacteriological quality of water-presumptive test, confirmation test and determination of MPN; Jar test
Kotaiah B. and Kumaraswamy N, "Environmental Engineering Laboratory Manual", Charitor Publishing House, India.
APHA, "Standard Methods for testing of water and wastewater, 21st Edition, American Public Health Association, Washington, D. C.
BIS-10500: Indian Standards Code for Water
BIS-3025: Indian Standards Code for Testing of Water

CV401/CV401M ESTIMATION, COSTING AND SPECIFICATIONS (3-0-0) 3

Methods of estimating, measurements, taking out quantities, typical estimates for buildings, and Civil Engineering

works, Specifications for all types of building items. Analysis of rates, data for various building items, Earthwork calculations. Introduction to Departmental procedures, tender,contracts, arbitration, valuation of buildings.
B.N. Dutta, Estimating and Costing in Civil Engineering Theory and Practice.
M. Chakroborti, Estimating, Costing & Specifications in Civil Engineering.
S.C. Rangawala - Valuation of Real Properties, Charotar Publishing House.

CV417 STRUCTURAL DESIGN AND DRAWING PREREQ: CV251, CV351 **(1-0-3) 3**
R.C. design- R.C. staircases, retaining walls - Cantilever and Counterfort type, Water tank- rectangular and circular tanks, underground and resting on ground. Framed structures.
Steel design - Connections: Column splices, column bases, beam - columns, Steel purlins and roof trusses, connection between roof truss and supporting column, bracing systems.
N. Krishna Raju, Structural Design and Drawing - R.C. and Steel, University Press, Hyderabad.
D. Krishna Murthy, Structural Design & Drawing, Vol II&III, C.B.S.Publishing Co., New Delhi.

CV268 ADVANCED MINING GEOLOGY (3-0-0) 3
Structural Geology; Dip and Strike, study of folds, faults, Joints, unconformities, Economic Geology; Magmatic, Hydrothermal, Sedimentary, Metamorphic deposits, oxidation and supergene enrichment, study of Gold, Iron, copper, lead, Zinc Chromite, manganese, bauxite, mica, asbestos, magnetite, borytes deposits.
Exploration Geology; Principles, Stage of mineral exploration, Geological, Geophysical, geochemical and remote sensing methods of exploration. Applied Geology; Sampling, guides for locating ore deposits,geological mapping, Hydrogeology.
ArogyaSwamy, Courses in Mining Geology, Oxford & IBH, 1988 Bateman A.M., Economic mineral deposits, John Wiley & Sons Billings, Structural Geology

CV321 APPLIED SOIL ENGINEERING PREREQ: CV 252 (3-0-0) 3
Soil exploration, Earth pressure and its determination, Bearing capacity – Theoretical methods and Insitu tests, Stability of slopes by various approaches, Load carrying capacity of single and group of piles.
B.M. Das, Principles of Geotechnical Engineering,
V.N.S. Murthy, Soil Mechanics and Foundation Engineering, DhanpatRai & Sons, New Delhi.

CV322 CONCRETE TECHNOLOGY (3-0-0) 3
Concrete making materials - Manufacture of Cements, types of cements and aggregates, properties and testing, Water, admixtures. Fresh concrete, workability, Compaction, Curing. Strength of Concrete, elasticity, shrinkage and creep. Durability of Concrete. Testing of hardened concrete, destructive and non-destructive testing methods, Concrete mix design, Quality Control and acceptance Criteria. Special Concretes, Concrete chemicals.
A.M. Neville, Properties of Concrete, The English Language Book Society and Pitman Publishing Co. London, U.K.
M.S. Shetty, Concrete Technology - Theory and Practice, S. Chand & Co. Ltd., New Delhi.

CV323 ARCHITECTURE AND TOWN PLANNING (3-0-0) 3
Town Planning and Architecture: An overview of ancient human settlements; Indus Valley, Manasura's classification of villages, Dantaka Village, Slums, Housing Bye-laws, Neighbourhood units, objectives and principles of town planning, Master-Plan, Zoning, Aesthetics and Principles of Architectural Composition.
S.C.Rangawala, Principles of Town Planning
Sir. Banister Fletcher, Comparative Architecture
Talbot Hamlin, Forms and Functions of Twentieth Century Architecture; Vol II

CV324 ANALYSIS OF INDETERMINATE STRUCTURES (3-0-0) 3
Analysis of statically indeterminate Structures, Moment distribution Method, Kani's Method, Matrix method: introduction to flexibility and stiffness methods, two hinged arches, influence lines for indeterminate beams and arches, analysis of multistorey frames by approximate methods, substitute frame, portal and cantilever methods, plastic analysis of simple beams and portal frames.
S.P. Timoshenko, Theory of structures
M.B. Kanchi, Matrix method of structural analysis

CV325 STRUCTURAL MASONRY AND ALTERNATIVE BUILDING TECHNOLOGIES (3-0-0) 3
Stresses in masonry, Strength of masonry in compression, Brick – Mortar Bond strength, Elastic properties of masonry materials and masonry, Design of masonry walls under vertical gravity loads;

Analysis and design of masonry domes and vaults, Construction of masonry domes and vaults, Problem of lateral thrust; Concepts in alternate roofing systems, Filler slab roofs, Composite beam and panel roofs; Alternatives to wall construction, Rammed earth, Stabilized mud blocks; Energy in building materials and buildings, environmental friendly and cost effective building technologies.

Hendry, A. W., Sinha, B. P., and Davies S. R., Design of Masonry Structures, 3rd edition, E & FN Spon 2004.

Drysdale, R. G., and Hamid, A. A., Masonry Structures: Behavior and Design,4th edition, The Masonry Society, 2018

Jagadish, K. S., Venkatarama Reddy, B. V., and Nanjunda Rao, K. S., Alternative Building Materials and Technologies, Second edition, New Age International Publishers, 2018

IS : 1905 – 1987, Code of Practice for Structural Use of Unreinforced Masonry, Third Revision, Bureau of Indian Standards, (Reaffirmed 2002)

CV326 DISASTER MANAGEMENT & MITIGATION (3-0-0) 3

Concepts of disaster; Types of disasters - natural and manmade: Cyclone, flood, landslide, land subsidence, fire and earthquake, tsunami, coastal erosion, river erosion, chemical spills, nuclear disasters, mine disasters etc.; Psychological and Social Dimensions in Disasters, Trauma and Stress. Techniques of monitoring and design against disasters; forecasting and early warning; communications & IT Tools; disaster risk reduction through prevention, preparedness, mitigation, response, recovery, rehabilitation and reconstruction. Management issues related to disaster, national Policy on disaster management, legislative responsibilities; mitigation through capacity building, disaster mapping, assessment, pre-disaster risk & vulnerability reduction, post disaster recovery & rehabilitation; Participation by voluntary Agencies & Community at various stages of disaster management; disaster related infrastructure development.

http://ndma.gov.in/ (Home page of National Disaster Management Authority).

http://www.ndmindia.nic.in/ (National Disaster Management in India, Ministry of Home Affairs).

National Disaster Management Plan 2018. National Disaster Management Authority, Ministry of Home Affairs, Government of India.

Tushar Bhattacharya, 2012. Disaster Science and Management. Tata McGraw Hill, New Delhi. ISBN (13): 978-1-25-900736-1, ISBN (10): 1-25-900736-7

Asian Development Bank, 2008. Disaster Management: a Disaster Manager's Handbook ISBN 978-971-561-006-3

Pradeep Sahni, 2004, Disaster Risk Reduction in South Asia, Prentice Hall.

Ghosh G.K., 2006, Disaster Management, APH Publishing Corporation.

CV371 RAILWAYS, TUNNELS, HARBOURS AND AIRPORTS (3-0-0) 3

Railways: Rail gauges; coning; adzing; railway track components, functions, requirements, and width of formation; creep; tractive resistance; geometric design; points and crossings; stations and yards; signaling and interlocking.
Docks & Harbors: Types of harbors, tides, wind and waves, breakwaters, docks, quays, Transit sheds, warehouses, navigational aids

Tunnels: Introduction to tunneling, tunneling through soils, soft and hard rocks, tunnel ventilation
Airports: Introduction to airport planning and development, Airport design standards, airport planning

S.P. Arora & S.C. Saxena, A text Book of Railway Engineering Srinivasan, Docks, Harbors and Tunnels.

S.K. Khanna, M.G. Arora and S.S. Jain, Airport Planning and Design

CV372 DESIGN OF P.S.C. STRUCTURES (3-0-0) 3

Materials- Pre and post tensioning methods; losses in pre-stressing; stresses in concrete due to pre-stress and loads; prediction of long term and short term deflections; limit state of collapse in flexure and shear -Limit state of serviceability; transmission length; anchorage zone stresses; design of end-block; design of pre and post-tensioned beams; analysis of continuous beams; concordant cable profiles; analysis of composite beams; determination of stress distribution in a composite sections.

N. Krishna Raju, Pre-stressed concrete, Tata-McGraw Hill, New Delhi.

T. Y. Lin and N. H. Burns, Design of pre-stressed concrete structures, John Wiley and Sons, New York.

CV373 PROBABILITY METHODS IN CIVIL ENGINEERING (3-0-0) 3

Role of probability in civil engineering problems; Definition of basic random events; Application of set theory in definition of composite event operations; Probability of events and definition of probability axioms; Random variables; Probability definitions; Moments and expectations; Functions of random variables; Common probability models; Statistics and sampling; Regression and correlation analyses; Estimation of distribution parameters from

statistics; Hypothesis testing and significance; Bayesian updating of distributions; Uncertainty quantification; Probabilistic analysis; Methods of structural reliability; Applications to design of civil engineering systems.

A.H-S. Ang& W.H. Tang, Probability Concepts in Engineering: Emphasis on Applications to Civil and Environmental Engineering, Wiley, 2006

A. Haldar& S. Mahadevan, Probability, Reliability, and Statistical Methods in Engineering Design, Wiley, 1999

CV374 Transportation Systems Planning (3-0-0) 3

Pre-requisites:Highway and Traffic Engineering (CV254)

Introduction-Transportation Modes, Urban and Intelligent Transportation Systems. Transportation Planning-Background, the historical development of transportation systems in India, development of formal transportation planning process, planning studies and methods, and planning issues. Travel-Demand Forecasting-Background, trip generation, trip distribution, mode choice, trip assignment, trip behaviour of individuals and households. Transportation Impact-Traffic impact studies, Parking studies, Air pollution, Noise Pollution, Energy consumption, and introduction to the latest developments in urban mobility and technologies

S.Ponnuswamy and D.J.Victor, Urban Transportation: Planning, Operation, and Management (McGraw Hill Education (India) Private Limited: New York,2012)

P.K.Sarkar, V.Maitri, and Joshi,G.J., Transportation Panning: Principles, Practices and Policies, 3rd Edition, PHI Learning, Delhi.

P.D.Prevedouros, and C.S.Papacostas, Transportation Engineering and Planning, Pearson Education,2015.

L.R.Kadiyali, Traffic Engineering and Transport Planning,9th Edition, Khanna Publishers, Delhi.

P.Chakraborty and A.Das, Principles of Transportation Engineering, 2nd Edition, PHI Learning, Delhi

NPTEL: "Urban Transportation Systems Planning"

CV375 ROCK MECHANICS (3-0-0) 3

Introduction to rock mechanics, Engineering classification of rocks, Engineering properties of intact rocks, Determinationof in situ properties - shear strength, deformation, in situ stress, strength of jointed rocks, application to rock slopes, rock blasting, ground improvement techniques in rocks and bearing capacity.

Jaegar and Cook, Foundation of rock masses.

Goodman, Introduction to rock mechanics, Wiley international

CV376 Disaster Management with Spatial Methods (3-0-0)3

Scientific principles of geographic data and information. Map projections, coordinate systems and basic principles of cartography. Geographic Information Systems and allied technologies. GIS for disaster situation awareness, spatial analysis, and data models. International disaster management community and GIS. Global perspectives on GIS and disaster management. Disaster management cycle and the role of GIS within disaster management policy and practice. Application of GIS for disaster planning and preparedness, response, recovery, and mitigation based on case studies and hands-on approach.

Brian Tomaszewski, 2021, Geographic Information Systems (GIS) for Disaster management. Routledge, New York. ISBN: 978-1-138-48986-8

National Technical Document for Establishing Cartographic Base in India, 2016. National Disaster Management Authority of India, Government of India.

Asian Development Bank, 2008. Disaster Management: A Disaster Manager's Handbook ISBN 978-971-561-006-3

CV380 MINIPROJECT-I (0-0-3)2

Experimental work either in the field or in the laboratory or design task of relatively smaller magnitude compared to Major project and inline with the guidelines formulated by the DUGC.

CV381 MINI PROJECT - II (0-0-3)2

Experimental work either in the field or in the laboratory or design task of relatively smaller magnitude, as compared to a Major project and in-line with the guidelines formulated by the DUGC.

CV385 GEOINFORMATICS (3-0-0) 3

Introduction to geinformatics: Principles of Remote sensing Satellites and Sensors, Aerial photography, elements of photo-grammetry, Satellite data products, Visual interpretation, Digital interpretations. Introduction to GIS principles, Generation of thematic maps, Georeferencing, Digitization, overlay analyses, Map projections : Global positioning system: Application of RS and GIS in mining; Geological mapping, geomorphological mapping, oil and mineral exploration,Ground water and surface water potential mapping, Natural hazard and disaster (Earthquakes,volcanic eruptions, Landslides, Avalanches, flood, drought etc.) Zone mapping, Forecasting,

estimaton of losses and management, monitoring ocean productivity and coastal zone management, computer applications in mining.
Lillesand, Thomas and Kiefer, Remote Sensing and image interpretation, John Wiley and Sons.
Burrough and Mc Dennell, principles of Geographical information systems, Oxford University Press.

CV386 Applied Rock Engineering (3-0-0) 3

Pre-requistics: CV375 –Rock Mechanics

Introduction: Rock mass failure mechanism and its influencing factors –IS Standards in Rock Engineering – Types of excavations in rocks: - Tunnels and Slopes – Design methods in massive, stratified and jointed rock mass – Tunneling: Methods of Tunneling – Excavation of large tunnels, hazards in tunnelling –Rock Slope: Mechanics of rock slope failure- Factor affecting rock slope stability – slope stability – analysis and rating –Rock reinforcement techniques – Monitoring of rock deformation in slope and underground space

Engineering rock mechanics-Introduction to principles –J.A.Hudson; J.P.Harrison (1997) Elsevier Pergamon Publications Engineering rock mass classification – Tunneling, Foundations and Landslides R K Goel, Bhawani Singh (2011),Elsevier Butterworth – Heinemann Publications Support of Underground Excavations in Hard Rock – Hoek; Kaiser; Bawden (2000) ,CRC Press Rock Slope Engineering (IV Eds) – D.C.Wyllie; C.W.Mah (2004), Spon Press-Taylor & Francis Group

CV387 APPLIED GEOLOGY (3-0-0) 3 PREREQ: CV202

Introduction, interior of the earth, Geological process, Geological hazards, Natural resources; Minerals, rocks, water, soil; Engineering properties of rocks, Structural geology, stratigraphy, Hydrogeology; artificial recharge structures, rain water harvesting, ground water exploration, geophysical exploration, Remote sensing and GIS applications. Economic Geology, process of formation of mineral deposits, ore genesis, ore dressing, Indian mineral deposits, Environmental geology, Application of geology in Civil Engg. projects like Dams, tunnels, bridges etc.,
Blyth, F.G.H & De Freitas M.H., Engineering Geology, ELBS, 7thEdition, 1984.
Robert F. Legget, Geology and Engineering, Mcgraw Hill

CV388 ADVANCED SURVEYING (3-0-2) 4 PREREQ CV201

Introduction to tacheometricsurveying, tacheometric levelling and errors in tacheometriclevelling; Fundamentals of geodetic surveying; theory of errors and triangulation adjustments; Electronic distance measurement; Hydrographic surveying including three-point problems; photogrammetric surveying including aerial photogrammetry; fundamentals on the use of digital theodolites and total stations.
B.C. Punmia, Surveying Vol. 2 and 3
T.P. Kanetkar& Kulkarni, Surveying and leveling Vol. 2
S.K. Roy, Fundamentals of surveying
David Clark, Plane and geodetic surveying Vol.2

CV389 ADVANCED STRUCTURAL ANALYSIS (3-0-0) 3

Matrix method of structural analysis: flexibility and stiffness formulation - Direct stiffness method. Analysis of Beams of non-uniform cross-section. Unsymmetrical bending of beams. Analysis of beams curved in plan. Introduction to analysis of shell roofs.
Genaro, Advanced Structural Analysis.
G.S. Ramaswamy, Design and Construction of shell roofs.

CV390 SEMINAR (0-0-2) 1

This course is a 1 credit course to be completed during 6thsemester. The student will make presentations on topics of academic interest.

CV400 CORNER STONE/CAP STONE PROJECT ((0-0-2) 1 × 4) 4

For details refer to clause 3.2 under Regulations specific to Undergraduate Programmes.

CV421 BRIDGEENGINEERING PREREQ:CV251 (3-0-0)3

Bridge site investigation and planning, bridge hydrology, Standards of loading for highway and railway bridges, Culverts, bridge superstructures, Design of R.C.C. beam and slab bridges, load distribution methods, Bearings, Design of bridge substructures and foundations, Design principles of prestressed concrete, steel and composite bridges, Introduction to cable stayed and suspension bridges, flyovers, temporary and movable bridges, construction and maintenance of bridges and flyovers.

D.J.Victor, Essentials of Bridge Engineering, Oxford & IBH Publishing Co. Pvt .Ltd. NewDelhi.
N.KrishnaRaju, Design of Bridges, Oxford & IBH Publishing Co. Pvt. Ltd. NewDelhi.

CV422 ADVANCED DESIGN OF STRUCTURES – I (3-0-0) 3 PREREQ: CV251

Design of R.C.flatslabs, continuous beams and portal frames, redistribution of moments. Yieldline analysis of slabs, Deep beams, Curved beams, Elevated water tanks and supporting structures, Chimneys, Silos and Bunkers.

N. Krishna Raju, Advanced Reinforced Concrete Design, C.B.S. Publishers and Distributors, Delhi.

P.C. Varghese, Advanced Reinforced Concrete Design, Prentice - Hall of India, Pvt. Ltd., New Delhi.

CV423 DESIGN OF FOUNDATIONS, EARTH AND EARTH RETAINING STRUCTURES

PREREQ: CV252, CV321 (3-0-0)3

Loads for foundation design, Depth of foundation, proportioning of footings, Geotechnical and structural design of isolated, combined and raft foundations. Analysis of pile groups. Design of piles and pile cap. Design of cantilever, counterfort and soil reinforced retaining walls.

Swami Saran, Design of Substructures, Oxford and IBH Publishers.

J.E. Bowles, Analysis & Design of Foundations, Mc Graw Hill. Relevant IS Codes.

CV424 ADVANCED ENVIRONMENTAL ENGINEERING (3-0-0) 3 PREREQ: CV350

Water-pollution control: Effluent standards. Disposal of wastewater. Stream sanitation. Water quality indices; Solid waste management: Characteristics, treatment disposal; Air Pollution Control: Sources and Characteristics, effects, Control; Noise Pollution Control, measurement & analysis; Hazardous solid waste: Classified wastes, Disposal of hospital wastes; EIA: Introduction, case studies

Metcalf & Eddy, Waste Water Engineering Treatment, Disposal & Reuse, Tata Mcgraw Hill Publishers

Sincero&Sincero, Environmental Engineering, Prentice Hall Inc.

CV425 COMPUTER AIDED DESIGN & APPLICATIONS IN CIVIL ENGINEERING (2-0-3) 4

Object oriented programming, Application programs to solve problems in structural analysis, surveying, soil mechanics, transportation engineering and numerical analysis. Design of structural elements and programming concepts. Programs for the design of beams, slabs and columns by Limit state theory.

E. Balaguruswamy, Object oriented programming in C++,McGraw Hill Publishers

V.L.Shah, Computer aided design in reinforced concrete, Structures publishers.

CV426 SOLID WASTE MANAGEMENT (3-0-0) 3

Characterization of Municipal wastes; Waste Collection, Disposal and Management-Laws and guidelines; Utilization of municipal wastes for bio-gasification and manure; landfill; Recent technological advances in composting and thermal gasification; utilization and management of nonhazardous and hazardous waste; Case studies.

George Tchobanoglous, Frank Kreith, Handbook of Solid Waste Management, McGraw-Hill, 2002. CPHEEO Manual on Solid Waste Management, 2000.

Asian Productivity Organization Report on Solid-Waste Management: Issues and Challengesin Asia, Environmental Management Centre, 2005

Thomas H. Christensen, Solid Waste Technology& Management: Volume 1 & 2, A John Wiley& Sons, 2010

Michael D. LaGrega, Phillip L. Buckingham, Jeffrey C. Evans. Hazardous Waste Management, Waveland Press Inc., 2010

CV427 STRUCTURAL DYNAMICS AND WIND ENGINEERING (3-0-0) 3

Vibration of SDOF systems - Free and Forced vibrations, effect of damping, response spectrum, MDOF systems - Natural frequencies and modes, Eigenvalue problem, mode superposition method, Wind effects- Mean Wind speed, turbulence, spectrum of turbulence, Aerodynamic instabilities, Aerodynamic damping, Along - wind and Across - wind responses.

Cloush and Penzien, Dynamics of Structures, McGraw Hill, New York.

J.W. Simth, Vibration of Structures, Chapman and Hall Ltd., New York. Scanlan and Sachi, Wind Engineering

CV440 PRACTICAL TRAINING 1

This course is a 2 credit course. A student may complete the training before the beginning of 7th semester (or as stipulated by DUGC) and register for it in the 7th Semester. The practical training should have a minimum duration of 4 weeks in a Civil Engineering organisation with approval from DUGC.

CV471 ADVANCED DESIGN OF STRUCTURES – II (3-0-0) 3 PREREQ: CV251

R.C. domes and shell roofs, membrane and beam method of analysis, Multistoried building systems; Grid floors, Composite steel and in-situ concrete beams & slabs. Communication and transmission line steel towers. P.

Dayaratnam, Design of Reinforced concrete structures, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
P. Dayaratnam, Design of Steel Structures, A.H. Wheeler & Co. Ltd. Allahabad.
N. Krishna Raju, Advanced Reinforced Concrete Design, C.B.S. Pub. and Distributors, New Delhi.

CV472 GROUND IMPROVEMENT TECHNIQUES (3-0-0) 3 PREREQ; CV252, CV321

Need and Objectives, Mechanical Modification-Compaction control, Vibro flotation, Hydraulic modification - Dewatering methods, Electro-Osmosis, Vertical drains, Physical and chemical modification - grouting, shortcreting, ground freezing. Modification by inclusions and Confinement. Stone columns, lime columns, Sand drains and Compaction piles.

M.R. Hausmann(1990) Engineering Principles of Ground Modifications, McGraw Hill Publishing Co.
Purushotham Raj, Ground Improvement Techniques, Laxmi Publications, New Delhi.

CV473 FEM APPLICATIONS IN CIVIL ENGG. (3-0-0) 3

Types of elements - Boundary value and initial value problems - Approximate methods - Principles and steps in Finite Element Analysis - Generalized and natural co-ordinates - Direct stiffness approach- Analysis of 2D Trusses, beams, and Plane frames. Introduction to continuum problems - Triangular elements for plane stress problems - Numerical Integration.

T.R. Chandrupatla& Ashok D. Belegundu , Introduction to Finite Elements in Engg. - Prentice Hall.
O. C. Zienkiewicz and K Morgan, Finite Elements & Approximation, John Wiley & Sons.

CV474 ELEMENTS OF EARTHQUAKE ENGINEERING (3-0-0) 3

Engineering seismology - Plate tectonics, Earthquake mechanism, Seismic zoning map of India, seismic waves, earthquake magnitude and intensity, seismic vulnerability, hazard and risk, Introduction to the theory of vibrations - simple SDOF systems, response spectra, Performance of structures, Lessons from past earthquakes, causes of failure and damage

Aseismic design of structures - Philosophy & Principles of earthquake resistant design, building forms and architectural design concepts, Introduction to seismic codes, Calculation of equivalent static earthquake forces. Restoration and retrofitting of existing structures.

A.K.Chopra, Dynamics of Structures, Prentice Hall, 2002 IITKanpur, Earthquake Tips,www.nicee.org

CV475 OIL AND NATURAL GAS EXPLORATION (3-0-0) 3

Geology of oil and Natural gas fields: Introduction to petroleum, Economic Importance, Geological factors, Reservoir Sedimentology and Sequence Stratigraphy of oil and natural, Structural Geology and Basin Development, oil and natural gas deposit distribution in India, Gas hydrated deposits in India and in the world. Exploration of oil and natural gas deposits: Remote Sensing, GIS, GPS, geological, geophysical and geochemical methods of exploration of oil and natural gas deposits.

Reservoir Engineering; Drilling and Production Engineering (drilling Methods of oil and natural gas wells, drilling technologies for deep water areas); Refining Engineering.

Safety and Environmental Engineering: Safety norms and regulations; Environmental norms and regulations; safety auditing; environmental auditing; carbon credits; preparation of EIA reports; principles of developing green belt around petroleum installations to minimize carbon footprints.

A. I. Levorsen, 1967, Geology of Petroleum
Reddy D V, 2010, Engineering Geology, Vikas Publishers.
Azar J J, Samuel G R, 2007, Drilling Engineering. Pennwell Corporation.
Edwin S. Robinson and CahitCoruh, 1988, Basic Exploration Geophysics, John Wiley and Sons.

CV477 SEISMORESISTANT CONCRETE STRUCTURES (3-0-0)3

Introduction to dynamic response of structures- Dynamic equilibrium, SDOF and MDOF. Earthquake ground motion and response spectra- Characteristics of ground motion, earthquake response spectra. Seismoresistant architecture, IS 1893(Part1):2002 codal provisions, Simplified modal response spectrum analysis- Example problems. Earthquake resistant design of RC elements, Shear walls - Response of concrete and steel to monotonic cyclic loading, Codal provisions of IS 13920:1993. Design example of a multi-storey building. Seismic retrofitting strategies – considerations, classification, case studies. (IS 13935:1993) Base isolation-Isolation system components, Isolator design procedures.(Mini project on analysis and design of a multi storey building)

The Seismic Design Handbook., Farzad Naeim, International code council, Kluwar Academic publishers (USA), 2001
George. G. Penelis and Andreas J. Kappos, Earthquake resistant concrete structures, E & FN Spon Chapman, Hall London, 1997
FarzadNaeim and James M Kelley, Design of seismic isolated structures, John Wiley and sons Inc. 1999

IS codes: IS 1893(Part1):2002, IS 13920:1993, IS 13935:1993
A.K. Chopra, Dynamics of structures - Theory and applications to earthquake engineering, Pearson Education, 2001
Pankaj Agarwal, Manish Shrikhande Earthquake Resistant Design of Structures, Prentice- Hall India, 2006

CV485 AIR POLLUTION AND NOISE POLLUTION (3-0-0) 3

Natural and man-made air pollution, sources, effects, control. Noise pollution - sources, measurement, mitigation.
Wark Kenneth and Warner C.F., Air Pollution its Origin and Control, Harper and Row, Publ.
Sincero A.P. and Sincero G.A. Environmental Engineering. Prentice Hall.

CV486 ENVIRONMENTAL IMPACT ASSESSMENT (3-0-0) 3

Introduction of EIA - Environmental impact Statement (EIS) and Environmental Impact Analysis (EIA) - Meaning and objective of EIA; Environmental Impact Prediction - Planning and Management of Impact Studies - ISO 14000 Series - Environmental monitoring and mitigation measures. Canter, R.L., Environmental Impact Assessment, McGraw Hill Inc.,
John G.Rau and David C. Wooten (Ed)., Environmental Impact Analysis Handbook, McGraw Hill Book,1980.
Peter Wathern (Ed)., Environmental Impact Assessment, Theory and Practice, Unwin Hyman Ltd., London, 1988.
Munn, R.E., (Ed)., Environmental Impact Assessment, Principles and Procedures, Published on behalf of Scope, Unwin Brothers Ltd., Surrey, London, 1979.

CV487 CONSTRUCTION AND PROJECT MANAGEMENT (3-0-0) 3

Introduction: project forms, management objectives and functions; organizational chart of a construction company; manager's duties and responsibilities; public relations; Leadership and team - work; ethics, morale, delegation and accountability. Man and Machine: Man-power planning, training, recruitment, motivation, welfare measures and safety laws; machinery for Civil Engg., earth movers and hauling costs, factors affecting purchase, rent, and lease of equipment, and cost-benefit estimation. Planning, scheduling and Project Management: Planning stages, construction schedules project specification, monitoring and evaluation; Bar-chart, CPM, PERT, network-formulation and time computation. Departmental Procedures: specifications, tendering, contracting and arbitration
Lionel Stebling, Project and Quality Management
P.P. Dharwadkar, Management in Construction Industry, Oxford IBH, New Delhi J.O.Brien, Construction Management, Mcgraw Hill
J.M.Antill& R.W. Woodhead, Critical Path Methods in Construction, Wiley
B.C. Punmia&K.K.Khandelwal, Project Planning and control with PERT and CPM, PWD Codes A and D

CV488 GROUND WATER DEVELOPMENT AND MANAGEMENT (3-0-0) 3

Hydrological cycle, Hydrological properties of rocks, Distribution of ground water, Ground water movement- Darcy's law, Flow nets. Aquifer parameters, Parameter estimation, pump test and recovery test-Thei's, Theim's, Jacob's equations. Ground water exploration-Geophysical techniques RS, GIS, GPS, Construction of wells, Springs. Ground water recharge, Rain Water harvesting, Water conservation techniques. Ground water quality, Ground water pollution, Environmental issues. Ground waterbuget, Ground water management. Ground water legislation
Todd D. K, Ground water hydrology, 3rd edition, Wiley, 2008.
Walton, W. C., Ground water resource evaluation. McGraw Hill, 1970. Raghunath, H. M, Ground water, New Age International, 3rd edition, 1998.
Karanth, K. Groundwater Assessment and Management, Tata McGraw Hill, 2007.

CV489 RETROFITTING AND REHABILITATION OF STRUCTURES (3-0-0) 3

Introduction, Causes of Deterioration, Deterioration process, Planning, Investigation and diagnosis, Assessment of distress structures, Assessment procedure for evaluation of structures and demolition procedures, Testing techniques, Interpretation of results, Repair and renovation Repair materials**,** techniques, Surface coatings, Protection, Seismic retrofitting.
Allen, R.T.L. and Edwards, S.C., 'The repair of concrete structures'
Key, T., 'Assessment and renovation of concrete structures'
Emmons, P.H., 'Concrete repair and maintenance illustrated'

CV490 NON DESTRUCTIVE TESTING & EVALUATION FOR CONCRETE STRUCTURES (3-0-0)3

Fundamentals and basic concepts of Non Destructive Testing and Evaluation . Principle and applications of different Non Destructive Evaluation tools viz., Ultrasonics, radiography , electromagnetic methods, acoustic

emission , thermography for testing and evaluation of concrete structures.
Guidebook on non destructive testing of concrete structures-International Atomic Energy Agency, Vienna , 2002
Nondestructive Evaluation –Theory Techniques and Applications by P.J Shull Marcell Decker Inc., NY 2002
Non destructive Testing and Evaluation of Materials Tata McGraw Hill Education Private Limited Second Edition 2011
Acoustic Emission testing –Basic for Research-Applications in Civil Engineering Chriastan U Grosse, MasayasuOhtsu , Springer:2008 Current Literature

CV491 BITUMINOUS MATERIALS, MIXTURES, AND PAVEMENTS (3-0-0)3

Introduction to bituminous materials, processing of petroleum crude. Bituminous binders - types, characteristics, test protocols, and recent developments in binder modifications. Aggregates - production, properties, test methods, grading, and blending. Bituminous mixtures - types, characteristics, mix design methods, and tests. Bituminous pavement construction - mixture production, transportation, placement, compaction and finishing operation. Bituminous Pavements - different bituminous layers, and specifications.
Hot Mix Asphalt Materials, Mixture Design and Construction, Third Edition, National Asphalt Pavement Association, Research and Education Foundation, Lanham, Maryland, 2009.
Bituminous Road Construction in India, by P.S.Kandhal, PHI Learning Private Limited; Revised edition, 2016.
Relevant Standards and Guidelines published by the Bureau of Indian Standards (BIS) and the American Standard for Testing and Materials (ASTM) International.

CV492 Reinforced Earth Structure (3-0-0)3

Concept of reinforced earth, mechanisms, types of reinforcements, Sustainable Infrastructures, 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. Behaviour of reinforced earth walls, the basis of wall design, internal and external stability conditions, field application of RE, randomly reinforced earth, analysis of reinforced soils, testing of soil reinforcements.

Geosynthetic Reinforced Soil (GRS) Walls by Jonathan T.H. Wu Wiley, 2019
Saran, S. (2017) Reinforced soil and its engineering applications. IK International Pvt Ltd.
Jones, C.J.F.P., Earth Reinforcement and Soil Structures, Butterworths, London

CV449 Major Project I (0-0-3)2

The students, in groups of 1-4, will select a project work based on a topic of interest under the supervision of project guide and work on the said topic for two semesters. The work under the Project will be evaluated first at the end of 7th semester. The evaluation is based on the work completed during the semester, quality of work, report made by the group, relative contributions by each individual student to the project (as ascertained by the project guide) and individual performance in the semester-end viva –voce.

CV499 Major Project II (0-0-6)4

Extension and completion of Major Project-I initiated in the VII semester under the supervision of the same guide. The total project work will be evaluated at the end of the VIIIth semester. Evaluation parameters are the same as in VII semester.

UC100 INTRODUCTION TO DESIGN THINKING (2-0-0) 2

Need and Definition of Design Thinking. Framework for Design Thinking. Engineering Design Process. Need Identification, Specification, Concept Generation, Product Architecture and Detailed Design. Prototyping – Virtual and Physical. Testing Methodology

Christian Muller-Roterberg, "Handbook of Design Thinking", 2018
Eli Woolery, "Design Thinking Handbook" Invision Pub, 2019
Nigel Cross, "Design Thinking"
Max Answell "Mastering Design Thinking", 2019
Karl T. Ulrich, Steven D. Eppinger and Maria C Yang, "Product Design and Development", McGraw Hill, 7ed, 2020
George e Dieter, Linda C Schmidt, "Engineering Design", Mc Graw Hill, 4ed, 2009

UC401 LIBERAL ARTS COURSES/CO-CURRICULAR/EXTRACURRICULAR ACTIVITIES 10

CATEGORY A : Maximum 3 credits, CATEGORY B : Maximum 3 credits, CATEGORY C : Minimum 4 Credits and Maximum 7 credits.
10 Credits have to be earned from 1st Semester to 7th Semester by choosing Category (A + B + C) OR Category (A + C) or Category (B + C) courses combination . Registration for 10 Credits has to be done in 7th Semester.
For details of CATEGORY A, CATEGORY B and CATEGORY C refer to clause 3.2 (f) under Regulations specific to Undergraduate Programmes.

CS100 PYTHON PROGRAMMING (3-0-0)3

Introduction to computer, Introduction to Python, Python Fundamentals and input and output function, Operators and expression, Conditional Loops, working with lists, python data structure, strings, python functions, python modules,error and exceptions, file handling.

Kenneth A Lambert, The Fundamentals of Python: First Programs, 2011. Cengage learning.
Think Python First Edition, by Allen B Downey, Orielly publishing
Lutz M, 2001, Programming python. "O'Reilly Media, Inc."
Learn Python the Hard Way: 3rd edition, Zed A Shaw
Python Programming: An Introduction to Xomputer Science, John M. Zelle

CS101 PYTHON PROGRAMMING LAB (0-0-3) 2

Basic UNIX shell commands, Installing and setting up python environment, execution of program. Basic input-output and data types operators and expressions. List, tuples, dictionary, sets. Decision making, branching and looping. Functions and modules, exception handling, file handling, simple application development.

CS110 C PROGRAMMING (3-0-0) 3

Introduction to computer hardware, Computer Security, Introduction to C Programming language, C fundamentals, C input/output functions, Operators and Expressions in C, Decision making and branching, Decision making and Looping, Arrays, Strings, Functions in C, Structures and Unions, Pointers in C,File management in C, Problem solving approaches using C.

Brian Kernighan and Dennis Ritchie "The C Programming Language" Prentice Hall; 2 edition, April 1988 Byron S Gottfried "Programming with C", Schaum's Outline Series, Tata McGraw-Hill, 2005
R.G.Dromey, "How to solve it by computer" Pearson Education India; 1 edition, 2006 Deitel & Dietel, "C++ How To Program" Pearson; 10 edition, March 2016

CS111 C PROGRAMMING LAB (0-0-3) 2

UNIX shell commands, Basic Input-Output functions, Operators and Expressions, Decision making and Branching constructs, Decision making and looping constructs, Arrays, Strings, Functions and Recursions, Structures and Union, Bit Operations, Pointers, Files and file operations, Laboratory Instructions.

B Brian Kernighan and Dennis Ritchie "The C Programming Language" PrenticeHall; 2 edition, April, 1988.
Yashwanth Kanetker, "Let Us C", BPB Publications, BPB Publications; 15th edition, July 2016
E.Balagurusamy, "Programming in ANSIC", McGraw Hill Education India Private Limited; Seventh edition, July 2017.
Byron S Gottfried "Programming with C", Schaum's Outline Series, Tata McGraw-Hill, 2005.
Balagurusamy,"Object oriented programming using C++", PHI, August 2010.
Herbert Schildt,"C: The Complete Reference",McGraw Hill Education;4th edition July 2017.

CS112 DISCRETE MATHEMATICAL STRUCTURES (3-1-0)4

Fundamentals of Discrete Mathematics: Counting, Logic, Set Theory, Proof Techniques, Relations and Functions: Generating functions, Recursive relations; Introduction to Graph Theory: Vertex degrees, paths, Planar graphs, Trees; Basic Algebra:Groups, Monoids, Rings.

R.P.Grimaldi, B.V.Ramana, Discrete and Combinatorial Mathematics: An Applied Introduction, 5th Edition, Pearson, 2008.
B.Kolman,R.C.Busby,S.C.Ross,Discrete Mathematical Structures, Pearson Education India;6 edition, 2015.
Kenneth Rossen, Discrete Mathematics and its Application, 7th Edition, McGraw-Hill, 2011.
Lovasz, Combinatorial Problems and Exercises, 2nd Edition, North Holland,1993

MA208 PROBABILITY THEORY AND APPLICATION (3-0-0) 3

Refer MA208 syllabus in MACS dept.

CS200 THEORY OF COMPUTATION (3-1-0)4

Formal Languages and Automata Theory: Generative grammar, Chomsky hierarchy, Finite state Automata: Definition, Concept of Non-determinism, Equivalence of deterministic and Non-deterministic Automata, regular languages; Closure properties. Push down Automata: Definition, Equivalence between NPDA and context free grammars, Pumping Lemma for C.F.L's, Decision problems, Closure properties.Turing machines: Definition, extension to Turing machines: Multi-track, Multi-tape, and Non determinism. TM as an acceptor,TM as a computing

device; P,NP,NP-Hard & NP-Complete problems

J.E.Hopcroft and J.D.Ullman, Introduction to automata, Languages and computation, Addison Wesley. 1969
L. Sipser, Theory of Computation, Cengage, 2013.
H.E.Lewis and C.H.Papadimitiou, Elements of the Theory of Computation, Prentice-Hall of India,1981.Derickwood,Theory of Computation, John Wiley & Sons, 1987.

CS201 DESIGN OF DIGITAL SYSTEMS (3-1-0)4

Number systems; Switching algebra and logic circuits; Combinational and sequential circuits and their algorithmic synthesis; Logic optimization: two level, multi-level, circuits; Computer aided synthesis and optimization; Hardware modeling using VHDL; Introduction to VLSI design: MOS devices, system level design; Introduction to VLSI testing: fault models, testing combinational and sequential circuits.

Alan B.Marcovitz,"Introduction To Logic Design",Mc Graw-Hill,3rd Edition, 2009.
Giovanni De Micheli, "Synthesis and Optimization of Digital circuits",McGraw-Hill., 2003
Zvi Kohavi, "Switching and finite automata theory",McGraw-Hill. 1978.
Morris Mano,"Digital Design with an Introduction to Verilog",Pearson Education India,5th Edition, 2013

CS202/CS202M DATA STRUCTURES AND ALGORITHMS (3-1-0)4

Introduction to basic data structures and algorithms, Dynamic memory allocation, Algorithm analysis and design techniques. Classical Searching & Sorting Algorithms, Linked List and its applications, Stacks and Queues. Recursion and evaluation of arithmetic expressions. Introduction to Tree: Tree Traversals, Binary Search Trees, AVL Tree, Priority queues and Binary Heaps, Introduction to Graphs: Graph representations, Graph Traversals, Shortest path algorithms, Topological sort, Minimum spanning Trees, Graph applications, Hashing.

Alfred V Aho, John E Hoperoft, Jeffrey D Ullman, "Data Structures and Algorithms", Addison Wesley, 2003.
Horowitz and Sahni, "Fundamentals of Data Structures and Algorithms in C++", Universities Press, 2007.
Clifford A Shaffer, A Practical Introduction to Data Structures and Algorithms, Prentice Hall International, 1997.
Willam K Pratt, Digital Image Processing, Wiley-Interscience Publication, Third Edition, 2001.
Mark Allen Weiss, Algorithms Datastructures and problem solving with C++, Addison Wesley,
1996 J Kleinberg, E Tardos, "Algorithm Design", Addison-Wesley, 2005.
Jean Paul Trembley and Paul G Sorenson, "An Introduction to Data Structures with Applications", Tata McGraw Hill, 2001.

CS203 DATA STRUCTURES AND ALGORITHMS LAB (0-0-3)2

Experiments based on creating and manipulating various datastructures: Arrays, Lists, Stacks, Queues, Trees, Heaps, Hash Tables, Balanced Trees, Graphs. Algorithms for sorting and searching, Order Statistics, Depth-First and Breadth-First Search, Shortest Paths and Minimum Spanning Tree.

Alfred VAho, John E Hopcroft, Jeffrey D Ullman, "Data Structures and Algorithms", Addison Wesley, 2003.
Horowitz and Sahni, "Fundamentals of Data Structures and Algorithms in C++", Universities Press, 2007.
Mark Allen Weiss, Algorithms Datastructures and problem solving with C++, Addison Wesley, 1996

CS204 DESIGN OF DIGITAL SYSTEMS LAB (0-0-3)2

Design of basic gates, adders, subtractors, encoders, decoders, shifters: up, down, up-down, counters, flip-flops, code conversion, multiplexors. Structuring modeling: adders, subtractors, encoders, decoders, multipliers. Design of FSM: Moore machine, Mealy Machine.

Alan B.Marcovitz,"Introduction To Logic Design", McGraw-Hill, 3rd Edition, 2009.
Giovanni De Micheli, "Synthesis and Optimization of Digital circuits", McGraw-Hill., 2003
Zvi Kohavi, "Switching and finite automata theory", McGraw-Hill. 1978.
Morris Mano, "Digital Design with an Introduction to Verilog", Pearson Education India, 5th Edition,2013

SM300 ENGINEERINGECONOMICS (3-0-0)3

Refer SM300 syllabus in School of Management dept

MA204 LINEAR ALGEBRA AND MATRICES (3-0-0)3

Refer MA204 syllabus in MACS dept.

CS251/ CS251M DATABASESYSTEMS (3-1-0)4

Database system concepts and architecture, Database design and ER models, Relational model, Relational algebra and SQL, Functional dependencies, Normal forms, Database storage and indexing, Query processing, Query optimization, Concurrency control, Database recovery, Database security, No SQL databases.

Elmasri, R.,Navathe, S., Fundamentals of Database Systems, Fifth Edition, Addison-Wesley, 2006.

Silberschatz, H.F. Korth, and S. Sudarshan, Database System Concepts, Sixth Edition, McGraw-Hill, 2011.
Raghu Ramakrishnan & Johannes Gehrke, Database Management Systems, Third Edition, WCB/McGrawHill, 2003
Peter Rob and Carlos Coronel, Database Systesm-Design, Implementation and Management(7/e), Cengage Learning, 2007.

CS252/CS252M OPERATING SYSTEMS (3-1-0)4

Introduction to operating systems, Process concepts, Scheduling algorithms, CPU scheduling, Multithreading models, Concurrent processes, Deadlocks, Virtual and physical memory management, Disk scheduling, File systems Performance evaluation, Operating system security, Case studies - The UNIX operating system.

Silberschartz, Galvin & Gagne, "Operating System Concepts", 9th Edition, John Wiley & Sons, 2013
Melin Milenkovic,"OperatingSystems: Concepts and Design", McGraw Hill, New York, 2000.
Andrew S. Tanenbaum, Vrije University, Amsterdam, The Netherlands, Herbert Bos,"Modern Operating Systems" 2015
Sumitabha Das,Unix Concept and applications, Tata Mcgraw-Hill, 2003

CS253 DESIGN AND ANALYSIS OF ALGORITHMS (3-1-0)4

Models of computation, Algorithm analysis, Time and spacec omplexity, Average and worst case analysis, Lower bounds.Algorithm design techniques: Divide and conquer, Greedy, Dynamic programming, Amortization, Randomization. Problem classes: P, NP, PSPACE; Reducibility, NP-hard and NP-complete problems. Approximation algorithms for some NP-hard problems.

Cormen, Leiserson, Rivest,and Stein, "Introduction to Algorithms", MIT Press ,Third Edition, 2009. Dasgupta, Papadimitrou and Vazirani, "Algorithms", McGraw-Hill Education, 2006. Horowitz, Sahni, and Rajasekaran, "Computer Algorithms" Silicon Press, 2007.
Kleinberg and Tardos, "Algorithm Design", Pearson, 2005.
Goodrich and Tamassia, "Algorithm Design", Wiley, 2001.

CS254 DATABASE SYSTEMS LAB (0-0-3)2

Design database using data modeling tools, Understanding integrity constraints, Learning various SQL statements to create, update, Query and manage a database. Writing complex queries using join and subquery. Design of database applications and user interfaces using web or mobile app frontends. Learn advanced database concepts through realtime case studies.

Ramez Elmasri and Shamkant B. Navathe, Fundamentals of Database Systems, Pearson Education, 7th edition, 2016. Raghu Rama Krishnan, Database Management Systems, Tata Mcgraw Hill,3rd Edition, 2014.
Vikram Vaswani, MySQL (TM): The Complete Reference, McGraw Hill Education; 1edition, 2017
James Groff *(Author),* Paul Weinberg *(Author),* And Oppel, *SQL The Complete Reference, 3rd Edition, 2017*

CS255 DATA COMMUNICATION (3-1-0)4

Physical Layer and Media: Data and Signals, Digital Transmission, Analog Transmission, Bandwidth Utilization: Multiplexing and Spreading, Transmission Media, Switching, Using Telephone and Cable Networks for Data Transmission. Data Link Layer: Error Detection and Correction, Data Link Control, Multiple Access, Wired LANs: Ethernet, Wireless LANs, Connecting LANs, Backbone Networks, and Virtual LANs, Wireless WANs: Cellular Telephone and Satellite Networks, Virtual-Circuit Networks: Frame Relay and ATM.

Behrouz A Forouzan, Data Communications and Networking, 5th Edition, Tata McGraw Hill, 2013.
William Stallings, Data and Computer Communications, 10th Edition, Pearson, 2013.
James F. Kurose and Keith W. Ross, Computer Networking – A Top Down Approach, 6th Edition, Pearson, 2017.

CS256 COMPUTER ORGANIZATION AND ARCHITECTURE (3-1-0)4

Introduction to computers and data. High level system block diagram. Definitions. Representation of integer and floating point numbers. Example RISCISA–encoding, programming. Compilation stages, Objectcode. ALU design, Process or data path, Control unit design. Memory hierarchy. I/O subsystem concepts. Introduction to parallelism.

David A Patterson and John L Hennessy. Computer Organization and Design–The Hardware/Software Interface. 4e (ARMEdition), 2012/5e (MIPS Edition) ,2014/6e (RISC-VEdition), 2017. Elsevier. M. Morris Mano. Computer System Architecture. 3e. Pearson. 2007.
Hamacher, Vranesic, Zaky. Computer Organization. 5e. Tata McGraw Hill. 2011. John P Hayes. Computer Architecture and Organization. 3e. McGraw Hill. 1998.
David M. Harrisand Sarah L. Harris, Reference for some of the assignments, Digital Design and Computer Architecture. 2e. Elsevier. 2013

CS257 OPERATING SYSTEMS LAB (0-0-3)2

Linux and/or other OS based exercises to practice/simulate: scheduling, memory management algorithms; concurrent programming; use of threads and processes; kernel reconfiguration, device drivers and systems administration of different operating systems, Writing utilities and OS performance tuning

Silberschartz,Galvin&Gagne,"OperatingSystemConcepts",9thEdition,JohnWiley&Sons,2013
MelinMilenkovic,"OperatingSystems:ConceptsandDesign",McGrawHill,NewYork,2000.
AndrewS.Tanenbaum,VrijeUniversity,Amsterdam,TheNetherlands,HerbertBos,"ModernOperatingSystems"2015
SumitabhaDas,UnixConceptandapplications, Tata McGraw-Hill,2003

SM110 PROFESSIONAL COMMUNICATION

Refer SM110 syllabus in School of Managemen tdept

SM302 PRINCIPLES OF MANAGEMENT (3-0-0)3

Refer SM302 syllabus in School of Management dept

CS301/CS301M COMPUTER NETWORKS (3-1-0)4

Different components of One Way Delay(OWD), Decoupling bandwidth and latency, Network architecture vs application architecture, Process to process communication, Services offered by TCP and UDP, Application layer protocols (HTTP,FTP,SMTP,DNS), IPv4 and IPv6 addressing, Dynamic Host Configuration Protocol (DHCP) and Network Address Translation (NAT), Principles of reliability and congestion control, Internals of TCP and UDP, Routing algorithms for the internet and virtual circuits.

Kurose,JamesF.Computernetworking:Atop-down approach featuring the internet, 6/E. Pearson Education India, 2005/2012
Kevin R Falland W.Richard Stevens.TCP/IP illustrated, volume1: The protocols. Addison-Wesley, 2011.
Ilya Grigorik, High Performance Browser Networking: What every webdeveloper should know about networking and web performance."O'ReillyMedia,Inc.",2013.
Peterson,L.L.,& Davie, B.S. Computernetworks: A Systems Approach. Elsevier, 2007.
Tanenbaum, A.S., & Wetherall, D.(1996). Computer networks(pp.I-XVII).Prenticehall,1996.

CS302 COMPUTER NETWORKS LAB (0-0-3)2

Design and analysis of various network topologies and protocols (HTTP, TCP, UDP, DHCP, IP{v4,v6} and NAT), Socket programming (BSD, Zero MQ), Analysis of packets using Wireshark, Network simulations, Understanding linux network stack.

James F.Kurose, Computer networking: Atop-down approach featuring the internet, 6/E. Pearson Education India, 2005/2012
Ilya Grigori, High Performance Browser Networking: What every web developer should know about networking and web performance. "O'Reilly Media, Inc.", 2013.
Online Resources: Interactive animations, Video notes from Kurose and Ross 2012, Wire shark assignments, Presentation slides, interactive exercises from the following
link:http://wps.pearsoned.com/ecs_kurose_compnetw_6/216/55463/14198700.cw/

CS303 COMPILER DESIGN (3-1-0)4

Introduction to language processing; Lexical analysis, Regular languages and finite automata; syntactic analysis, Context-free languages; Semantic analysis and syntax-directed translation; Error analysis; Intermediate representation and intermediate code generation; The procedure abstraction, Run-time environments and storage allocation; Code generation, Instruction selection, Register allocation; Code optimization, Data-flow analysis and control flow analysis.

Aho, Lam, Sethi, Ullman Compilers: Principles, Techniques, and Tools, Addison-Wesley, (2007/2013) ISBN-10:0321486811
Y.N.Srikant and Priti Shankar: The Compiler Design Handbook: Optimizations and Machine Code Generation, CRCPress, 2002. ISBN084931240X
Tremblay and Sorenson: The Theory and Practice of Compiler Writing, McGraw-Hill, 1985.
Grune, Bal, Jacobs, Langendoen: Modern Compiler Design, John Wiley and Sons,(2000)
Steven Muchnick: Advanced Compiler Design and Implementation, Morgan Kaufmann, 1997. ISBN1-558-60320-4.Keith Cooper, Linda Torczon: Engineering a Compiler, Morgan Kaufmann; 2 edition(2011)
Andrew Appel :Modern Compiler Implementation in Java, Cambridge University Press, (2002)

CS304 COMPILER DESIGN LAB (0-0-3)2

Implement a lexical analyser for the C programming language using the grammar for the language given in the

book "The C Programming Language", 2e, by B Kernighan and D Ritchie .(Uselex/flex for creating the lexical analyser). Implement a desk calculator using operator precedence parsing. Implement a parser for the C programming language using YACC/Bison.
Implement a semantic checker for the C programming language (perform semantic analysis such as type and scope analysis and declaration processing, and integrate such analyses with the parser) using YACC/Bison.
Create a translator that would translate input into three-address intermediate code using LEX and YACC.
Andrew Appel: Modern Compiler Implementation in Java, Cambridge University Press, (2002).
John R. Levine, Tony Mason, Doug Brown: Lex & Yacc, 2nd/updated edition, O'Reilly & Associates, (October1992). Robert Morgan: Building an Optimizing Compiler, Digital Press, 1998. ISBN1-55558-179-X

CS305/ CS305M SOFTWARE ENGINEERING (3-1-0)4

Introduction to software engineering, Software development life cycle & various models, Requirements engineering, Software specification, Software metrics, Software design, Objectoriented software engineering, Software testing & various testing mechanisms, Software verification and validation, Verifying performances, Verifying reliability, Software cost estimation models, Software complexity analysis models, Economics of software development, Software development tools including CASE tools, Software project management, Automated testing and analysis of large-scale modern software systems, Applications-cloud computing, Big Data & others.
Roger S. Pressman, Software Engineering: A Practitioner's Approach, McGraw-Hill, Eight Editions. Ian Sommerville, Software Engineering, Addison-Wesley, 9th edition, 2010.
R.Fairley, Software Engineering Concepts McGraw-Hill, 1995.
Rajib Mall, Fundamentals of Software Engineering, Prentice HallIndia, 2009. Pankaj Jalote, An Integrated Approach to software Engineering, Narosa Pub. ,2002.

CS311/ CS311M CRYPTOGRAPHY AND APPLICATIONS (3-1-0)4

Cyber security and cybercrimes, Types of attacks, Case study, Elementary number theory, Primality, abstract algebra., Symmetric cryptography, Asymmetric cryptography, Key management, Integrity and authentication, Cryptographic application in data networks, Applications in software systems, Security aware software development life cycle, Ethical hacking and secure coding.
Neal Koblitz, A Course in Number Theory and Cryptography, Springer, 1987.
Ivan Niven, Herbert S. Zuckerman. Hugh L. Montgomery, An Introduction to The Theory of Numbers, John Wiley, 2008.
Alfred Menezes, Paul van Oorschot, Scott Vanstone, Hand book of Applied Cryptography, CRC, 1997. William Stalling, Cryptography and Network Security-Principle and Practice, Prentice Hall, 2016.

CS312/CS312M MACHINE LEARNING (3-0-2)4

Introduction to machine learning, Supervised learning, Generative and discriminative learning, Regression, Parametric and non-parametric learning, Classification, Principal component analysis, Model selection and generalization, cross validation and resampling methods, Measuring classifier performance, Confusion matrix, Decision tree, Neural Networks, Support Vector Machine, Naive Bayes,Voting Bagging boosting, Hidden Markov Model, Unsupervised learning-Clustering methods, dimensionality reduction, kernel methods.
Bishop, Christopher. Neural Networks for Pattern Recognition. New York, NY: Oxford University Press, 1995. ISBN: 9780198538646.
Duda, Richard, Peter Hart, and David Stork. Pattern Classification. 2nd ed. New York, NY: Wiley-Interscience, 2000. ISBN: 9780471056690.
Hastie, T., R. Tibshirani, and J. H. Friedman. The Elements of Statistical Learning: Data Mining, Inference and Prediction. New York, NY: Springer, 2001. ISBN: 9780387952840.
MacKay, David. Information Theory, Inference, and Learning Algorithms. Cambridge, UK: Cambridge University Press, 2003. ISBN: 9780521642989.
Mitchell, Tom. Machine Learning. New York, NY: McGraw-Hill, 1997. ISBN: 9780070428072.

CS313 CRYPTOGRAPHY AND APPLICATIONS LAB (0-0-3) 2

Implementation of different number theory primitives, Primality test, Symmetric and asymmetric ciphers, Hash functions, Digital signatures, Key exchange protocols.
Neal Koblitz, A Course in Number Theory and Cryptography, Springer, 1987.
Ivan Niven, Herbert S. Zuckerman. Hugh L. Montgomery, An Introduction to The Theory of Numbers, John Wiley, 2008.
Alfred Menezes, Paul van Oorschot, Scott Vanstone, Hand book of Applied Cryptography, CRC, 1996. William Stalling, Cryptography and Network Security-Principle and Practice, Prentice Hall, 2016.

CS314 DATA STRUCTURES FOR ADVANCED APPLICATIONS (3-1-0)4

Introduction to Advanced Data structures, Introduction to Applications, Applications of Trees, Heaps, Advanced graph algorithms and applications, Internet Algorithms and its applications,
Compression algorithms, Advanced Search engine Applications, Spiders and crawlers, Integer and polynomial arithmetic, Modular arithmetic, NP-Completeness and approximation algorithms.

Thomas Cormen, Charles E Leiserson and Ronald D River, Introduction to Algorithms, PHI, 2001.
Mark Allen Weiss, Algorithms, Data Structures and Problem Solving with C++, Addison Wesley, 2002.
Fundamentals of data structures in C++, by E. Horowitz, S. Sahni, and D. Mehta, Second Edition, Silicon Press, 2007

CS315 GRAPH THEORY (3-1-0)4

Graphs, Preliminaries on Graphs, Matchings in Bipartite graphs- Konig 's theorem, Hall's theorem. Matchings in general graphs- Tutte's theorem, 2-connected graphs, Ear-decomposition, Menger's theorem, Dirac's extensions for Menger 's theorem. Edge connectivity, Vertex coloring- Greedy coloring, Degeneracy of graphs, Coloring of planar graphs, Brook's theorem, Edge coloring- Konig's theorem, Vizing's theorem, Perfect graphs. Hamiltonian graphs, Ramsey theoretic problems, Structure of minimum cuts in a graphs, Discharging method, Network flows.

R. Diestel, Graph Theory, Second edition, Springer, 2000.
D. West, Introduction to Graph Theory, Second Edition, PHI, 2003.
J. A. Bondy and U. S. R. Murty, Graph Theory with Applications, North Holland, 1976.
A. Schrijver, A course in Combinatorial Optimization, Cambridge university press, 2000.

CS316 SYSTEM PROGRAMMING (3-1-0)4

System APIs, GNU libc. UNIX systems, File I/O, filters and file manipulation. Command line arguments and environment variables. Terminal handling and text based screen applications. Interrupt handling. Finding the time. Mixing C and scripts. Resource management algorithms. Distributed systems concepts, Concurrent programming.

Anthony Richard John, Systems Programming: Designing and Developing Distributed Applications, Morgan Kaufamnn, 2015.
Adam Hoover, System Programming with C and Unix, Pearson,2009 Robert Love, Linux Kernel Development. Addison-Wesley Professional,,2010 Robert Love, Linux System Programming, O'Reilly Media; 2 edition.2013

CS317 BIG DATA ANALYTICS (3-1-0)4

Big Data Characteristic Features, Structure of Big Data, Best Practices for Big data Analytics, Lamba 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.

CS318 NETWORK MANAGEMENT (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.

CS319 MICROPROCESSOR SYSTEMS (3-1-0)4

Microprocessor architecture, 8086, Instruction set, Subroutines, Programming examples, Software development with interrupts; Intel 80286, 80386; Programmable peripheral devices, 8255, 8253,8259, 8257, Motorola 68000 processors, 68020, 68030; Mother boards, I/O bus, I/O channel, BIOS, DOS, PC bus, Multibus I & II, VME, CRT

controller, Floppy disc controller, Hard disc controller, CDROM drive, Serial communication controller, Pen drive, Mouse drive.

Douglas V. Hall, Microprocessors & Interfacing Barry B. Brey, "The Intel Microprocessors: Architecture, Programming & Interfacing" PHI, 6th Edition, 2003.

Lice & Gibson, "Microcomputer System 8086 / 8088" PHI, 2nd Edition

CS320/CS320M ARTIFICIAL INTELLIGENCE (3-1-0)4

AI introduction, history and applications, Production systems. State Space Search, Proposition and first order logic, inference and deduction, resolution refutation, answer extraction, knowledge based systems, logic programming and constrained logic programming, non-monotonic reasoning, State-space, plan space and partial order planning, planning algorithms, Probabilistic reasoning, belief networks, Inductive learning, decision trees, logical approaches, computational learning theory, neural networks, reinforcement learning, Intelligent agents, natural language understanding, Applications.

1. Stuart Russell, Peter Norvig, Artificial intelligence : A Modern Approach, Prentice Hall, Fourth edition, 2020.

2. Nils J. Nilsson, Artificial Intelligence: A New Synthesis, Morgan-Kaufmann, 1998.

3. Judea Pearl, Heuristics: Intelligent Search Strategies for Computer Problem Solving, Addison-Wesley Publishing Company, 1984.

4. Biere, A., Heule, M., Van Maaren, H., Walsh, T., Handbook of Satisfiability, IOS Press, 2009.

CS321 FULL STACK DEVELOPMENT (3-1-0)4

Full Stack Development- Frameworks, Libraries , Technologies. Version control- Concepts, tools, actions, git, github. Python and Javascript for full stack. Databases for full stack –MySQL, MongoDB, Mongoose, REST API. Front-end Development –HTML, React, Virtual DOM, Angular CSS. Back-end Runtime Environment and Frameworks- Node.js, Express, Django. APIs-concepts, development, architecture, testing.

Chris Northwood, The Full Stack Developer: Your Essential Guide to the Everyday Skills Expected of a Modern Full Stack Web Developer, A Press.

Philip Ackermann, Full Stack Web Development The Comprehensive Guide. SAP Press.

Riaz Ahmed, Full stack Web Development For Beginners: Learn Ecommerce Web Development using HTML5,CSS3, Bootstrap, JavaScript, MySQL, and PHP. Independent Publisher.

FrankZammetti, Modern Full-Stack Development: Using TypeScript, React, Node.js, Webpack, and Docker (First Edition). A press.

CS322 Graph Drawing (3-1-0) 4

Prerequisite course: Data Structures and Algorithms

Planarity testing, canonical ordering, force-directed embedding, Schnyder woods, Tutte embedding, Spring embedding with repulsion, Graph-distance preserving embedding, Rectangle and Square Representation: Rectangle and Square Representations of Planar Graphs, Square tilings with prescribed combinatorics, Blocking and anti-blocking pairs of polyhedral, map labelling, edge bundling, contact representation and visibility representation. Orthogonal Graph Drawing.

Di Battista, G., Eades, P., Tamassia, R., Tollis, I., Graph Drawing: Algorithms for the Visualization of Graphs, Prentice Hall, Upper Saddle River, 1999.

Trudeau, R., Dots and Lines, Kent State University Press, 1976.

Preparata, F., Shamos, M., Computational Geometry: An Introduction, Springer-Verlag, New York, 1985.

Thulasirama, K., Swamy, M., Graphs: Theory and Algorithms, John Wiley and Sons, New York, 1992. ity Press, 2009.

Handbook of Graph Drawing and Visualization, Roberto Tamassia, Editor, CRC Press, 2013.

Planar Graph Drawing, Takao Nishizeki, MdSaidur Rahman, World Scientific Publishing Company, 2004.

CS346 COMPUTING IN AUTONOMOUS VEHICLES (3-1-0)4

Autonomous driving technologies, algorithms. Localization- GNSS, LiDAR, HD Maps, Visual and Wheel Odometry. Perception – Detection, Segmentation, Stereo Optical Flow, Scene Flow, Tracking, CNNS for Perception. Prediction & Routing. Planning and control- Traffic Prediction, Motion Planning, Feedback Control, Reinforcement based planning and control .Cloud platforms for autonomous driving.

Shaoshan Liu, Liyun Li, Jie Tang, Shuang Wu, Jean-Luc Gaudiot . Creating Autonomous Vehicle Systems. Morgan & Claypool.

Lance Eliot, Michael Eliot. Autonomous Vehicle Driverless Self-Driving Cars and Artificial Intelligence: Practical

Advances in AI and Machine Learning. LBE Press Publishing.
Michael E. McGrath. Autonomous Vehicles: Opportunities, Strategies and Disruptions. Independent.

CS351 MANAGEMENT INFORMATION SYSTEMS (3-1-0)4

Functions of management, Organization environment, Organization structure, System concepts, Stakeholders analysis, Framework for information systems (IS), Decision making process, Problem solving process, Definition of Management Information System (MIS), EIS, DSS, Artificial intelligence, Expert systems, Computer hardware, Hardware standards, Computer software file and database management, Communication systems, Common network components, Distributed systems, Design of MIS, Applications of MIS to business, Case studies.

Kenneth C. Laudon and Jane Price Laudon, Management Information Systems, Managing the Digital firm, Pearson Education, Asia, 2002.
Gordon B. Davis, Management Information System: Conceptual Foundations, Structure & Development, McGraw-Hill, 1974.

CS352 SOFT COMPUTING (3-1-0)4

Introduction to soft computing, Fuzzy logic, Applications of fuzzy logic, Genetic algorithms, Artificial neural networks; Supervised, unsupervised and reinforcement learning; Basic neural network models, Adaline, Linear and nonlinear activation functions, Loss functions, Gradient descent method, Back propagation algorithm, Multi-layer neural networks.

J.-S. R. Jang, C.-T. Sun, and E. Mizutani, Neuro-Fuzzy and soft Computing, PHI Learning, 2009.
G. J Klir and B Yuan. "Fuzzy Sets and Fuzzy Logic: Theory and Applications", Prentice Hall. Martin T Hagan et.al., "Neural network design" (2nd edition), 2014
Melanie Mitchell, An Introduction to Genetic Algorithms, MIT Press, 2000.
Taqiq Rashid, "Make your own Neural Network", 2016
David E. Goldberg, Genetic Algorithms In Search, Optimization And Machine Learning, Pearson Education, 2002

CS353 COMPUTER GRAPHICS (3-1-0)4

Introduction to computer graphics: Basic raster graphics algorithms for drawing 2D primitives, 2D transformations, Window-to-viewport transformation, Input devices and interactive techniques. 3D graphic: Viewing in 3D, Projections, Basics of solid modeling, 3D transformations. Multimedia building blocks: Audio - basic sound concepts, Music, Speech, MIDI versus digital audio, Audio file formats, Sound for the web, Images and graphics-basic concepts, Computer image processing. Video and animation –basic concepts, Animation techniques, Animation for the web.

Foley J. D., Van Dam A., Feiner S. K. & Hughes J. F., Computer Graphics Principles and Practice, Second Edition, Addison Wesley
Hearn D. & Baker P.M, Computer Graphics, Prentice Hall India Koegel Buford J. F., Multimedia System, Addison Wesley

CS354 OBJECT ORIENTED PROGRAMMING (3-1-0)4

Programming paradigms, Software design principles, Objects and classes, Operator overloading, Inheritance, Exception handling, Templates, Case studies.

BJarne Stroustrup, "The C++ Programming Language", Addison Wesley, 2004. Stanley B Lippman, "The C++ Primer", Addison Wesley, 2005.
Grady Booch, James Rumbaugh, Ivar Jacobson, "Unified Modeling Language User Guide", Addison-Wesley Professional, 1998.
Craig Larman, "Applying UML and Patterns: An Introduction to Object-Oriented Analysis and Design and Iterative Development", Prentice Hall Edition, 2004.

CS355 COMPUTING WITH FPGAs (2-0-3)4

Behavioral modeling and simulation. Hardware description languages: Combinational and sequential design, state machine design, synthesis issues, test benches. Overview of FPGA architectures and technologies: Logic block architecture, I/O block architecture, Programmable interconnects. Unified Computer Infrastructure API Case Studies: OneAPI. Applications – Computer Architecture prototypes on FPGAs, ML accelerators on FPGAs. Simulation / Implementation exercises on Xilinx / Intel-Altera boards.

Frank Bruno, FPGA Programming for Beginners, Packt Publishing Ltd., 2021
Monk, Programming FPGAs: Getting Started with Verilog , McGraw-Hill Education, 2016
Robert Dunne, Computer Architecture Tutorial Using an FPGA: ARM & Verilog Introductions, Gaul Communications, 2020.
Ashenden, Digital Design using Verilog, Elsevier, 2007

Clive Maxfield, The Design Warriors's Guide to FPGAs, Elsevier, 2004

CS356 ADVANCED DATASTRUCTURES (3-1-0)4

Data structures and its operations, Trees, Heaps, Advanced graph algorithms and applications, Internet Algorithms, Compression algorithms, Search engine algorithms, Spiders and crawlers, Integer and polynomial arithmetic, Modular arithmetic, NP-Completeness and approximation algorithms.

Thomas Cormen, Charles E Leiserson and Ronald D River, Introduction to Algorithms, PHI, 2001. Mark Allen Weiss, Algorithms, Data Structures and Problem Solving with C++, Addison Wesley, 2002. Fundamentals of data structures in C++, by E. Horowitz, S. Sahni, and D. Mehta, Second Edition, Silicon Press, 2007

CS357 DIGITAL IMAGE PROCESSING (3-1-0)4

Introduction to image processing, Sampling and quantization, basic gray level transformations, point operations, histogram processing, convolution and correlation, image smoothing and sharpening, Fourier transform, Noise models, Noise reduction in spatial domain, Noise reduction in frequency domain, state-of-the-art filters for denoising images corrupted with various kinds of noise, morphological image processing, image segmentation, color image processing.

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.
Willam K Pratt, Digital Image Processing, Wiley-Interscience Publication, Third Edition, 2001.
AL Bovik (Editor), "Handbook of Image and Video Processing", Academic Press

CS358 DIGITAL SYSTEMS TESTING (3-1-0)4

Introduction to Testing: Testing Philosophy, Role of Testing, Analog and Digital Circuit Testing, Types of Testing. Fault Modeling: Defects, Errors, and Faults; Functional Versus Structural Testing; Levels of Fault Models; Fault Equivalence and Fault Collapsing. Test Methods: Logic and Fault Simulation, Simulation for Design Verification, Simulation for Test Evaluation, Modeling Circuits for Simulation, Algorithms for Fault Simulation. Test Generation: Combinational Circuit Test Generation- Structural vs. Functional Test, ATPG Algebras, Test Generation Systems, Test Compaction; Sequential Circuit Test Generation. Memory Test and Built-In-Self-Test: Memory Density and Defect Trends, Memory Test Levels, March Tests, RAM Test Hierarchy, Cache RAM and Functional ROM Chip Testing, Memory Built-In Self-Test. Delay Test: Delay Test Problem, Path-Delay Test, Transition Faults, Delay Test Methodologies. Logic Fault Diagnosis: Combinational Logic Diagnosis, Scan Chain Diagnosis, Logic BIST Diagnosis.

Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits, Michael L. Bushnell, Vishwani D. Agrawal, KLUWER ACADEMIC PUBLISHERS, 1 st Edn., 2002.
Testing of Digital Systems, N. K. Jha and S. Gupta, Cambridge University Press, 2003.
Digital Systems Testing and Testable Design, Miron Abramovici, Melvin A. Breuer, Arthur D. Friedman, IEEE Press, 1994.
VLSI Test Principles and Architectures: Design for Testability, Laung-Terng Wang, Cheng-Wen Wu, Xiaoqing Wen, Morgan Kaufmann, 2006.
An Introduction to Logic Circuit Testing, Parag K. Lala, Morgan and Claypool Publishers, 2009.

CS359/CS359M ADVANCED 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.

Kurose, James F. Computer networking: A top-down approach featuring the internet, 6/E. Pearson Education India, 2005/2012
Grigorik, Ilya. 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.). (2015). Handbook on data centers. Springer, 2015. Peterson, L. L., & Davie, B. S. Computer networks: A Systems Approach. Elsevier, 2007.

CS360 MODERN FORMAL METHODS AND APPLICATIONS (3-1-0)4

Basics of Discrete mathematics- Set Theory and Functions, Basic Set Definitions, Propositional Logic, and Predicate Logic. Fundamentals of Formal Methods- Formal methods in computing specification; Formal description techniques in communication, software, and hardware systems. Behavioral Specifications- Unity, Transition Systems. Verification Tools- Verification by model checking, LTL, CTL, SAT. Deduction Systems- Proof methods and techniques, Applications to Automated Theorem Proving, Abstract Data Types and Algebraic Specification. Type Systems and Constructive Logics- Binary decision diagrams, Algorithms for reduced OBDDs, Symbolic model checking. Case Studies of Selected Applications.

Formal Methods in Computer Science, Jiacun Wang and William Tepfenhart, Chapman and Hall/CRC, 1st Edn., 2019.
Formal Methods, Flemming Nielson and Hanne Riis Nielson, Springer, 2019.
Theory and Practice of Formal Methods, Erika Ábrahám, Marcello Bonsangue, and Einar Broch Johnsen, Springer, 1st Edn., 2016.
Formal Methods: Industrial Use from Model to the Code, Jean-Louis Boulanger, Wiley-ISTE, 2012.
Logic in Computer Science- Modelling and Reasoning About Systems, Michael Huth and Mark Ryan, Cambridge University Press, 2005.

CS361 QUANTUM COMPUTING (3-1-0)4

Introduction to Quantum Computing: Quantum Bits, Bloch Sphere Representation of a Qubit, Multiple Qubits. Linear Algebra Revisits: Complex Numbers Versus Real Numbers, Vectors, Scalar Multiplication, Vector Addition, and Bases.
Introduction to Quantum Mechanics: The Postulates of Quantum Mechanics, EPR Paradox, Quantum Physics Essentials, Atoms, Elementary Particles, And Molecules, Hilbert Spaces, and Uncertainty.
Quantum Circuits: Single Qubit Gates and Operations, Multiple Qubit Gates and Operations, Design and Simulation of Quantum Circuits.
Quantum Algorithms: Introduction to Quantum Algorithms, Deutsch's Algorithm, Deutsch's-Jozsa Algorithm, Shor's Algorithm, Grover's Algorithm and Generalizations, etc.
Quantum Information Processing and Error Correction: Quantum Noise and Quantum Operations, Classical Noise and Markov Processes, Quantum Operations, Distance Measures for Quantum Information; Quantum Error-Correction- Classical Error Correction, Classical Three-Bit Code, Fault Tolerance and Error Recovery.

Quantum Computing, Bernhardt, Chris, MIT Press, 1 st edn., 2019.
Quantum Computation and Quantum Information, Michael A. Nielsen, Isaac L. Chuang, Cambridge University Press, 10 th Ed., 2010.
Quantum Mechanics: The Theoretical Minimum, Leonard Susskind and Art Friedman, ,Latest Edition ,Penguin .2015
Fundamentals of Quantum Computing Theory and Practice, Venkateswaran Kasirajan, Springer, 1 st Edn., 2021.
An Introduction to Quantum Computing, Phillip Kaye, Raymond Laflamme, Michele Mosca, Oxford University Press, 1 st Edn., 2007.
Linear Algebra and Its Applications, David C. Lay, Steven R. Lay, Pearson, 5th Edition, 2015.
Quantum Computing, Parag K. Lala, McGraw-Hill Education, 1st Edition, 2019.

CS362/CS362M DISTRIBUTED COMPUTING (3-1-0)4

Distributed systems and applications, Message passing mechanisms IPC and RPC. Processes: Threads, Clients, Servers, Code Migration, Agents. Naming: Naming entities, Mobile entities, Distributed operating systems, Distributed file systems and services. Synchronization: logical clocks, Global state, Distributed transactions, Consistency and replication: models, protocols, examples. Fault tolerance: Process resilience, Reliable communication, Recovery. Security management. Distributed file and Web-based systems, Social computing.

Andrew S. Tanenbaum and Maarten Van Steen, Distributed Systems: Principles and Paradigms, John Wiley & Sons, Inc ISBN number: 9780132392273, 2004.
Pradeep Sinha, Distributed Operating Systems Concepts and Design, PHI, 2000.
George Couloris, Jean Dollimore & Time Kindberg, Distributed Systems: Concepts & design, 2nd ed Addision Wesley 2003.
Gerard Tel. Introduction to Distributed Algorithms, Cambridge University press, 2000.

CS363/CS363M CLOUD COMPUTING (3-1-0)4

Concept of cloud computing and evolution. Define SLAs and SLOs and illustrate their importance in Cloud Computing, Threats in cloud security, Common cloud providers and their associated cloud stacks and popular cloud use case scenarios. Cloud infrastructure: Cloud Reference Architecture. Cloud software deployment considerations such as scaling strategies, Load balancing, Fault tolerance, and Optimizing for cost. Cloud

resource management: Virtualizing CPUs, full virtualization, Para-virtualization, and Memory virtualization. Cloud storage: Organization of data and storage. Various types of data within the data taxonomy and classify different data types within the data taxonomy. HDFS, Google GFS, Big-Table. Programming models: Fundamental aspects of parallel and distributed programming models. Cloud programming models (Map reduce, Spark, Graph Lab and Spark Streaming).The main execution flow, scheduling and fault tolerance concepts in the Map-reduce programming model.

Anthony T Velte, Cloud Computing: A Practical Approach, McGraw Hill,2010
J. Lin and C. Dyer, Data Intensive Text Processing with MapReduce, , Morgan and Claypool, 2010
T. Velte, A. Velte, R. Elsenpeter, Cloud Computing, A Practical Approach, McGraw Hill, 2009
Rajkumar Buyya, James Broberg, Andrzej M., Cloud Computing: Principles and Paradigms, Wiley, 2010. Jimmy Lin and Chris Dyer, Data-Intensive Text Processing with Mapreduce Morgan and Claypool, 2010.
Dan Marinescu, Cloud Computing:Theory and Practice , Morgan Kaufmann, 2013

CS364 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)

CS365 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

CS366 INTERNET OF THINGS (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 Holler, 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.

CS367/CS367M FOUNDATIONS OF CYBER-PHYSICAL SYSTEMS (3-1-0)4

CPS concepts and requirements, CPS architectures, Key Features of CPSs, Applications, etc. Models of physical systems, Reactive Components, Properties of Components, Composing Components, Synchronous Designs, and Safety Requirements. Asynchronous Processes, Asynchronous Design Primitives, Asynchronous Coordination Protocols. Continuous and Timed Models, Hybrid Dynamical Models, Designing Hybrid Systems. Linear Hybrid Automata, Analysis of Elementary Cyber-Physical Systems. Resource scheduling, temperature and power management, real-time communication. Operating systems and hardware architecture support for CPS, CPS software synthesis.

Cyber-Physical Systems: Foundations, Principles and Applications, Houbing Song Danda Rawat Sabina Jeschke Christian Brecher, 1 st Ed., Elsevier, 2016.
Principles of Cyber-Physical Systems, Rajeev Alur, 1 st Ed., MIT Press, 2015.
Cyber-Physical Systems- From Theory to Practice, Danda B. Rawat, Joel J.P.C. Rodrigues, Ivan Stojmenovic 1 st Edn., CRC Press, 2016.

CS368 SECURITY ENGINEERING (3-1-0)4

Basics of Security, Security Requirements, Significance of Psychology in Security, Social Engineering, Vulnerabilities, Threats and Exploits, Attacks and Countermeasures, Security Analysis and Risk Assessment, Security Models and Policies, Secure Coding and Configuration Security Standards and regulations

Anderson, R., Security engineering: a guide to building dependable distributed systems. John Wiley & Sons.
Bishop, Matt,. Introduction to computer security.
Schneier, Bruce., Beyond fear: Thinking sensibly about security in an uncertain world. New York: Copernicus books.

CS369 APPROXIMATION ALGORITHMS (3-1-0) 4

NP-optimization approximation ratios, design techniques for approximation algorithms: greedy, local search and other combinatorial techniques, dynamic programming and approximation schemes, randomized techniques, LP based techniques: randomized rounding, primal-dual, iterative rounding, local ratio, dual-fitting and semi-definite programming based techniques. Hardness of approximation: approximation classes, non-approximability results, gap technique, approximation preserving reductions and the PCP theorem.

David P. Williamson and David B.Shmoys., The design of Approximation Algorithms Cambridge University Press 2011
Vijay V.Vazirani Approximation Algorithms, First Editions, Springer – Verlag Berlin Heidelberg, 2003
G.Ausiello et al., Complexity and Approximation: Combinatorial Optimization Problems and their Approximability Properties, Springer, Second corrected printing 2003.
SarielHar-Peled, Geometric Approximation Algorithms, AMS Series in mathematical Surveys and Monographs 2011

CS370 PARAMETERIZED ALGORITHMS (3-1-0) 4

Introduction: Review of NP-hardness, approaches to NP-hardness, motivation to parameterized algorithm, notion of fixed-parameters tractability, formal definitions of the key concepts. Basic toolkit: Kernelization, branching and bounding-depth search trees, iterative compression, greedy localization. Kernelization Techniques: Crown decomposition, sunflower lemma, expansion lemma, kernels based oin linear programming. Randomized methods: Randomness in parameterized algorithms, the color coding technique, the chromatic coding technique, basic pseudo-random objects and derandomization. Treewidth: Parameterized algorithms based on dynamic programming over tree decomposition, computing/approximating treewidth. Lower bounds: Notion of fixed-parameter intractability, W-hierarchy, notion of parameterized reductions and examples, kernelization lower bounds.

M.Cryan, F.V.Fomin, L.Kowalik, D.Lokshtanov, D. Marx, M.Pilipczuk, M.Pilipczuk, and S. Saurabh, Parametrized Algorithms, Springer, June 2015
R.Niedermeier, Invitation to fixed-parameter algorithms, Oxford university press 2006
R.G.Downey and M.R. Fellows, Fundamentals of Parameterized Complexity, Springer 2013

CS371 COMPUTATIONAL COMPLEXITY (3-1-0)4

Review of complexity classes: L, NL, P, NP, PSPACE and EXP, log-space and polynomial reductions, completeness, Hierarchy theorems Savitch, and Immerman theorems. Circuit complexity, P/Poly, NC and AC, P-completeness, polynomial hierarchy, Karp Lipton theorem alternation, relationship between circuit depth and space complexity. Randomized complexity classes: Adleman's theorem SipserGacs theorem, counting class, ≠P, Valiant's Theorem, Toda's theorem (no proof). Arthur Merlin games, Graph Isomorphism problem, Goldwasser-Sipser theorem, Interactive Proofs, Shamir's theorem

S. Arora and H. Barak, Computational Complexity: A Modern Approach, Cambridge University Press, 2009.
C. H. Papadimitriou, Computational Complexity, 1/e, Addison Wesley, 1993
R. Motwani and P. Raghavan, Randomized Algorithms, Cambridge University Press, 1995.
V. Vazirani, Approximation Algorithms, 1/e, Springer, 2004.

CS372 RANDOMISED ALGORITHMS (3-1-0)4

Prerequisite course Data Structures and Algorithms

Tail Bounds: Review of discrete probability spaces, probabilistic method, Markov and Chebyshev inequalities, and moments of a random variable, Chernoff bounds, Martingales, Hoeffding and Azurma inequalities. Randomised Data Structures and Algorithms: Randomised data structures and algorithms Skip lists, hashing, randomised min-cut, verifying matrix multiplication, randomised quicksort, randomised selection, coupon collector's algorithm, randomized pattern matching. Number theoretic algorithms: primality testing-Miller Rabin test. Markov Chain Monte

Carlo Markos chains and random walks, stationarity, Markov chain Monte Carlo (MCMC) methods, volume estimation, randomised complexity classes. Derandomization: Probabilistic method and derandomization, the basic counting argument, expectation argument, derandomization using conditional expectation, sample and modify method, second Moment method, constructive Lovasz Local Lemma (LLL), Schwartz-Zippel lemma.

R. Motwani and P. Raghavan, Randomized Algorithms, Cambridge University Press, 1995., 2009.

M. Mitzenmacher and E. Upfal, Probability and Computing: Randomization and probabilistic techniques in algorithms and data analysis, 2/e, Cambridge University Press, 2017.

C. H. Papadimitriou, Computational Complexity, Addison Wesley, 1994.

M. Jerum, Counting, Sampling and Integrating: Algorithms and Complexity, 3rd Edition,Birkhauser, 2003.

CS410 SIMULATION AND MODELING (3-1-0)4

Introduction to Modeling and simulation concepts. Levels of simulation for digital, analog & mixed mode circuits. IC CAD Overview. Device Simulation. Electrical simulation techniques. Relaxation based simulation techniques. Gate level simulation, Switch level timing simulation. Mixed mode interface, Simulation and implementation, Analog multi-level simulation. Discrete time models, Event driven simulation, Logic simulation, Timing verification in ICs, Setup and hold times for clocked devices.

R. Saleh, S. Jou & A.R.Newton, Mixed mode simulation and analog multilevel simulation, Kluwer Academic Pub. 1994.

V.Litovski & M. Zwolinski, VLSI circuit simulation & Optimization, Chapman & Hall, 1997. J Baker, Li & Boyce, CMOS Circuit Design & Simulation, PHI, 2000

CS411 SOFTWARE TESTING (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, Testing in practice, State-of-art testing and bug detection techniques, Evaluating software quality, Test automation, Testers' workbench.

Ilene Burnstein, "Practical Software Testing", Springer Professional Computing, 2003. Glenford J. Myers, The Art of Software Testing, John Wiley & Sons, 1979

Cem Kaner, Jack Falk, Hung Quoc Nguyen, Testing Computer Software, 2nd Ed, Intl. Thomson Computer Press, 2008.

Ron Patton, "Software Testing", Second Edition, Sams Publishing, Pearson education, 2007.

Renu Rajani, Pradeep Oak, "Software Testing – Effective Methods, Tools and Techniques", Tata McGraw Hill, 2004

CS412/CS412M CYBER-PHYSICAL SYSTEMS VERIFICATION (3-1-0) 4

Elementary Cyber-Physical Systems- Choice & Control, Safety & Contracts, Dynamical Systems & Dynamic Axioms.

Modeling Cyber-Physical Systems- Various Modeling Techniques of System Designs, Synchronous CPS Modeling, Asynchronous CPS Modeling, Hybrid CPS Modeling. Design Verification of Cyber-Physical Systems via Formal Verification Techniques, Verified Models & Verified Runtime Validation. Comprehensive CPS Correctness-Axioms &

Uniform Substitutions, Virtual Substitution, Real Equations and Arithmetic. Adversarial Cyber-Physical Systems-Hybrid Systems & Games, Game Proofs & Separations.

Logical Foundations of Cyber-Physical Systems, Andr´e Platzer, 1st Ed., Springer, 2018.

Cyber-Physical Systems: Integrated Computing and Engineering Design, Fei Hu, 1st Edn., CRC Press, 2014.

Logic in Computer Science- Modelling and Reasoning About Systems, Michael Huth and Mark Ryan, Cambridge University Press, 2004.

CS413 REVERSIBLE COMPUTING (3-1-0)4

An Overview About Reversible Computing and Its Applications. Reversible Logic Synthesis- Reversible Logic, Reversible Function, Reversible Logic Gate, Computing Metrics like Delay, Power, Area, Hardware Complexity. Reversible Circuits- Reversible Adder and Subtractor Circuits, Reversible Multiplier Circuit, Reversible Division Circuit. Reversible Sequential Circuits- Reversible Counter, Decoder, and Encoder Circuits, Reversible Barrel Shifter and Shift Register. Reversible Multiplexer and Demultiplexer with Other Logical Operations. Reversible Programmable Logic Devices. Reversible Numerical Computation and Applications, Reversible Random Number Generation, Computation,
and Applications.

Reversible Computing: Fundamentals, Quantum Computing, and Applications, Alexis De Vos,
Wiley, 1st Edn., 2011.

Introduction to Reversible Computing, Kalyan S. Perumalla, Chapman and Hall/CRC, 1st Edn., 2013.

Reversible and DNA Computing, Hafiz Md. Hasan Babu, Wiley, 1st Ed., 2021.
Reversible Computation: Extending Horizons of Computing Hardcover, Irek Ulidowski and Ivan Lanese, and Ulrik Pagh Schultz, Street Press, 1st Edn., 2020.
Reversible Logic Circuits, Ri-Gui Zhou and Naihuan Jing, Nova Science Publisher, UK, 2015.

CS414 WEB ENGINEERING (3-1-0)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.
Martin , Geert-Jan , Daniel , Bebo White, Journal of Web Engineering, Rinton Press, IEEE & ACM Publication, 2002.
Cato & John, User Centered web design, Pearson Education, 2001.
Kappel, G., Proll, B. Reich, S. & Retschitzegger, W. Web Engineering, 1s ed. Wiley & Sons.

CS415 COMPUTATIONAL CYBER-PHYSICAL SYSTEMS (3-1-0)4

Overview of CPS Fundamentals; Modeling, Control, and Formalisms- Synchronous, Asynchronous, and Hybrid Models; Validation &Verification of CPS by Formal Methods- Temporal logic, Model-Checking; Resource Management in CPS; CPS Reliability Issues- Data Reliability, Security, and Privacy Challenges in CPS. Security and Privacy in CPS. Case Studies- Healthcare CPSs, Agriculture CPSs, Smart Grid CPSs, Mission-Critical CPSs.
Cyber-Physical Systems: A Computational Perspective, Gaddadevara Matt Siddesh Ganesh Chandra Deka, Krishnarajanagar GopalaIyengar Srinivasa, Lalit Mohan Patnaik, 1st Edn., CRC Press, 2016.
Cyber-Physical Systems: Foundations, Principles and Applications, Houbing Song Danda Rawat Sabina Jeschke Christian Brecher, 1st Ed., Elsevier, 2016.
Logic in Computer Science- Modelling and Reasoning About Systems, Michael Huth and Mark Ryan, Cambridge University Press, 2004.

CS416 DATA WAREHOUSING AND MINING (3-1-0)4

Data warehousing, design, indexing. 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.

CS417 PARALLEL PROGRAMMING (3-1-0)4

Programming paradigms: Multithreaded parallel programming, Shared memory parallel programming, Message passing parallel programming, General purpose graphics processing units parallel programming, OpenCL, Many integrated core parallel programming. Important publications from literature
*Bil Lewis, Daniel J Berg, Pthreads Primer – A guide to Multithreaded Programming. Prentice Hall. (*SunSoft Press, 1996)
Barbara M Chapman, Using Open MP, The MIT Press, 2007.
William Gropp, Ewing Lusk, and Anthony Skjellum, Using MPI. 3e. The MIT Press. 2014. Wen-Mei W Hwu, David B Kirk, Programming Massively Parallel Processors: A Hands-on Approach, Morgann Kaufmann, 3e, 2016.
Rezaur Rahman, Intel Xeon Phi Coprocessor Architecture and Tools, Apress Open, 2013

CS418/CS418M TOPICS IN INFORMATION SECURITY (3-1-0)4

Introduction of computer/information security, Design Principles, Access control matrix, Security policies, Confidentiality policies, Integrity policies, Integrity Model, Hybrid policies, Discretionary Access Control, Mandatory Access Control, Role-based access control and its variants, Attribute-based access control, Administrative model.
Matt Bishop, Computer Security: Art and Science, Addison Wesley, 2002.
Matt Bishop, Introduction to Computer Security, Addison Wesley, 2005.

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.

CS419 ALGORITHMIC GRAPH THEORY (3-1-0)4

Graphs, Preliminaries on graphs, Cardinality matching in bipartite graphs, Weighted matching in bipartite graphs, Edmonds matching algorithm for general graphs, Algorithms for vertex cover in bipartite graphs. Flow networks, Ford-fulkerson algorithm, Dinitz algorithm, Application of flows, Connectivity, Structure of min-cuts, Algorithms for interval graphs, Chordal graphs, Tree-width, Algorithms based on tree-decompositions, Approximation algorithms, Parameterized algorithms, Exact exponential algorithms.

R. Diestel, Graph Theory, Second edition, Springer, 2000.
D. West, Introduction to Graph Theory, Second Edition, PHI, 2003.
J. A. Bondy and U. S. R. Murty, Graph Theory with Applications, North Holland, *1976.*
A. Schrijver, A course in Combinatorial Optimization, Cambridge University Press, 2004.
T.H Cormen, C.E Leiserson, R.L. Rivest, C. Stein, Introduction To Algorithms, Third edition, PHI, 2009.
J. Kleinberg and E. Tardos, Algorithm Design, Pearson Education, 2006.

CS420 AUTONOMOUS VEHICLES (2-0-3) 4

Introduction to Autonomous Vehicles: Components, Architecture, Technologies, Operating Systems. Localization: GNSS, LIDAR, Visual Odometry. Perception: Detection, Segmentation, Stereo, Optical flow, and Scene flow, Tracking. Prediction & Routing: Planning and control, Traffic Prediction, Lane Level Routing. Computer Vision Basics: Image formats, Edge detection, Convolution, Masking RoI, Corner detection, Histograms, Feature extraction. Machine Learning: Linear and Logistic regression, SVMs and SVCs, Detecting Cars using SVMs. Exercises using Deep Learning models and FPGAs: Line detection, Corner detection, Vehicle speed determination, Traffic sign detection, Object recognition and tracking, Localization algorithm implementation.

Liu, et. al., Creating Autonomous Vehicles – Synthesis Lectures in Computer Science, Morgan Claypool – e1 - 2017, e2 – 2020
Michael E McGrath, Autonomous Vehicles: Opportunities, Strategies and Disruptions, 2e, Independent, 2019.
Hanky Sjafrie, Introduction to Self-Driving Vehicle Technology, Routledge (T&F), 2019
Ranjan & Senthamilarasu, Applied Deep Learning and Computer Vision for Self-Driving Cars, Packt Publishing; 1st edition, 2020.

CS421 COMPUTATIONAL GEOMETRY (3-1-0)4

Introduction: Historical perspective, Geometric preliminaries. Convex hulls algorithms in 2D and 3D, lower bounds. Triangulations: Polygon triangulations, Representations, Point-set triangulations. Voronoi diagrams: Algorithms, Closest pair problems. Delaunay triangulations: algorithms (divide-and-conquer, flip, incremental), Duality of voronoi diagrams, Properties (min-max angle). Geometric searching: Point-location, 2D linear programming with prune and search. Visibility: Algorithms for weak and strong visibility, Visibility with reflections, Art-gallery problems. Arrangements of lines: 2D arrangements, zone theorem, Many-faces complexity, algorithms. Sweep techniques: Plane sweep for segment intersections, Fortune's sweep for Voronoi diagrams, Topological sweep for line arrangements. Combinatorial geometry: Ham-sandwich cuts, Helly's theorems, k-sets. Rectilinear geometry: Intersection and union of rectangles, Rectangle searching. Robust geometric computing. Applications of computational geometry.

Mark de Berg, Otfried Schwarzkopf, Marc van Kreveld and Mark Overmars, Computational Geometry: Algorithms and Applications, Springer.
F. P. Preparata and Michael I. Shamos, Computational Geometry: An Introduction, Springer. Joseph O' Rourke, Computational Geometry in C, Cambridge University Press.
Lecture Notes by David Mount.

CS422/CS422M DEEP LEARNING (3-1-0)4

Machine learning basics, Basic neural network models [McCulloch-Pitts Model of Neuron, Perceptron], Adaline, linear and non linear activation functions, loss functions, gradient descent method, back propagation algorithm, Deep feed forward networks, Regularization for deep learning, Convolutional neural networks, Optimization for training deep models, RNN, Autoencoders, Popular deep learning architectures published in the last 10 years, Limitations of CNN, Semi-supervised deep learning, Applications (image classification and segmentation).

Goodfellow, I., Bengio, Y., Courville, A. Deep learning (Vol. 1). Cambridge: MIT press.
Martin T hagan etc, Neural network design (2nd edition), 2014
Taqiq Rashid, Make your own Neural Network, 2016
Tom Mitchell, Machine Learning, McGraw-Hill, 1997

Y. S. Abu-Mostafa et .al , Learning from Data, AMLbook.com

CS423/CS423M COMPUTER VISION (3-1-0)4

Introduction to computer vision, Image formation : Geometric primitives and transformation, Photometric image formation, Point operators, Linear filters, Fourier transform, Edge detection, Hough transform, Harris corner detector, HoG, SIFT, LBP, Texture, Segmentation, Feature based alignment, Structure from motion, Image stitching, Stereo Correspondence, Image based rendering, Object detection and recognition, Deep learning in computer vision, Applications.

David Forsyth, Jean Ponce, Computer Vision : A Modern Approach, Pearson Education Ltd., 2015.
Richard Szeliski, Computer Vision : Algorithms and Applications,2010.
Goodfellow, I., Bengio, Y., Courville, A., Deep learning. Cambridge: MIT press, 2016
Aurelien Geron, Hands-On Machine Learning with Scikit-Learn & TensorFlow, SPD, 2017

CS424 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 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, 1999

CS425 NATURAL LANGUAGE PROCESSING (3-1-0)4

Introduction to Natural Language Understanding, NLP tasks in Syntax, Semantics and Pragmatics, Text representation in computers, encoding schemes, Linguistics resources, Regular expressions, Finite State Automata, word recognition, lexicon, Morphology, acquisition models, Finite State Transducer, N-grams, smoothing, entropy, HMM, ME, SVM, CRF, Stochastic POS tagging, HMM, Transformation based tagging (TBL), Handling of unknown words, named entities, multi word expressions, Parsing, Semantics, Word Sense Disambiguation, Discourse, Applications of NLP, Machine Translation.

1. Daniel Jurafsky and James H Martin. Speech and Language Processing, 2e, Pearson Education, 2009
2. James A.. Natural language Understanding 2e, Pearson Education, 1994
3. Bharati A., Sangal R., Chaitanya V.. Natural language processing: a Paninian perspective, PHI, 2000
4. Siddiqui T., Tiwary U. S.. Natural language processing and Information retrieval, OUP, 2008

CS426 REINFORCEMENT LEARNING (3-1-0)4

Introduction and Basics of RL, Defining RL Framework and Markov Decision Process Polices, Value Functions and Bellman Equations, Exploration vs. Exploitation,Tabular methods and Q-networks,Deep Q-networks,Policy optimization, Vanilla Policy Gradient Reinforce algorithm and stochastic policy search, Actor-critic methods, Advanced policy gradient, Model-based RL approach, Meta-learning, Multi-Agent Reinforcement Learning, Partially Observable Markov Decision Process, Ethics in RL, Applying RL for real-world problems.

1. Reinforcement Learning: An Introduction, Sutton and Barto, 2nd Edition.
2. Reinforcement Learning: State-of-the-Art, Marco Wiering and Martijn van Otterlo, Eds.
3. Artificial Intelligence: A Modern Approach, Stuart J. Russell and Peter Norvig
4. Deep Learning, Ian Goodfellow, Yoshua Bengio, and Aaron Courville.

CS427/CS427M CLOUD SECURITY (3-1-0)4

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 for the cloud, Data distribution and information dispersal techniques Data encryption/decryption methodologies, Trustworthy cloud infrastructures, Cloud related regulatory and compliance issues.

Tim Mather, Subra Kumaraswamy, and Shahed Latif. Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance, O'Reilly.

Mather, T.,Kumaraswamy S., and Latif, S. Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance.

O'Reilly Media. Stallings, W. Cryptography and Network Security: Principles and Practice, 5th Edition. Prentice Hall.

CS428/CS428M CLOUD NETWORKING (3-1-0)4

Data centers applications and their traffic patterns, Physical network structure, Cloud Topology, Data center network stack, Routing and switching for physical and virtual machines and congestion control, management and sharing of network infrastructure data centers, cloud networking ecosystem: inter-data center WAN connectivity, content distribution networks, end-user Internet connectivity, and application interactions with the network, Geo-distributed Cloud topology.

Cloud Native Data–Center Networking: Architecture, Protocols, and Tools, by Dinesh G. Dutt
Released November 2019, O'Reilly Media, Inc.
Cloud Data Center Network Architectures and Technologies, Lei Zhang, Le Chen, April 22, 2021 by CRC Press.

CS429 STORAGE SYSTEMS (3-1-0)4

Storage System Components, Storage System Organization, Distributed File Systems, Network-Attached Storage, Cloud Storage, Big Data Storage, Data Protection, Disaster Recovery, High-Performance Parallel File Systems, Virtualization, Decentralized storage, Multi-Device Arrays, Mirroring and RAID, SSD/HDD Hardware and Firmware, SSD/HDD Performance Enhancement File System and Database structures, Crash Recovery, Integrity Maintenance.

Susanta Duta, Computer Storage Fundamentals, BPB, 2018.
Alexander Thomasian , Storage Systems, Morgan Kaufmann, 2021

CS430/CS430M NEXT GENERATION MULTI-CLOUD ARCHITECTURE (3-0-2)4

Next Generation Cloud Computing, Modern Cloud Architectures
Challenges in Typical Cloud Architecture, Resource Relocation Technique (Virtual Machine and Container Migration), Federation Architectures, Container Management Techniques. Edge-Fog-Cloud architecture, Research and Development on Advanced Cloud Architectures (Serverless).

Distributed and Cloud Computing: From Parallel Processing to the Internet of Things, Kai Hwang, Jack Dongarra, Geoffrey C. Fox,Morgan Kaufmann, ISBN: 9780128002049, December 2013
Cloud Computing: Principles, Systems and Applications, Editors: Nikos Antonopoulos, Lee Gillam, Springer, 2012
Cloud Computing Bible, Barrie Sosinsky, Wiley-India, 2010
Cloud Computing: Principles and Paradigms, Editors: Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, Wile, 2011

CS431 DIGITAL SYSTEMS VERIFICATION (3-1-0)4

Simulation Approaches for Systems Verification: Simulation-Based Verification Techniques for System-Level Designs, Simulation Types, High-Level Simulation Tools, Limitations of Simulation-Based Verification, Coverage Metrics. Formal Verification Techniques: Equivalence Checking Combinational Equivalence Checking, Model Checking, Semi-Formal Verification Techniques, Static Checking of Higher-Level Design Descriptions, Finite Automata and Temporal Logic. Universal Verification Methodology (UVM): Verification Testbenches, Analog/Mixed-Signal Verification, Use of ATPG algorithms, Programmable Hardware. Component Verification: GPU Verification, CPU Verification, Cache Verification, SoC Verification, Challenges in Component Verifications. New Directions in Verification: Integrated Design Validation System, Machine Learning and AI in System's Verification, System's Security and Safety Verification; Increase System's and Tools Capacity.

Verification Techniques for System-Level Design, Masahiro Fujita, Indradeep Ghosh, and Mukul Prasad, Morgan Kaufmann Publishers, 2008.
Digital System Verification- A Combined Formal Methods and Simulation Framework, Lun Li, Mitchell A. Thornton, Morgan Claypool Publishers, 2010.
Logic in Computer Science-Modelling and Reasoning About Systems, Michael Huth and Mark Ryan, Cambridge University Press, 2004.
Scalable Hardware Verification with Symbolic Simulation, Valeria Bertacco, Springer, 2006.
Verification of Digital and Hybrid Systems, Kemallnan, Robert P. Kurshan, Springer, 2000.
Recent Research Articles on Selected Topics.

CS432 QUANTUM COMPUTER ARCHITECTURE (3-1-0)4

Quantum Architecture and Hardware: Quantum Computing Overview, Classical Logic Gates and Circuits; Quantum Gates and Circuits. Quantum Building Blocks: Single-Qubit Quantum Systems, Multiple-Qubit Systems, Quantum State Transformations, Quantum Versions of Classical Computations. Quantum Algorithms: Computing with Superposition, Quantum Subroutines, Deutsch's Problem, Deutsch's-Jozsa Algorithm, Shor's Algorithm, Grover's Algorithm, etc. Robust Quantum Computer Architecture: Robust Quantum Stages, Fault Tolerance, Fault-Tolerant Using Steane's Code, Robust Computing Through Concatenated Coding, Classical Error Corrections, Quantum Error Corrections.

Quantum Computing, Eleanor Rieffel, Wolfgang Polak, The MIT Press, 1 st Edn, 2011.

Quantum Computing, Bernhardt, Chris, MIT Press, 1 st edn., 2019.
Quantum Computing Fundamentals, Chuck Easttom II, Pearson Education, 2021.
Quantum Computation and Quantum Information, M. Nielsen and I. Chuang, Cambridge University Press, 10 th Edn.,2010.

CS433/CS433M WIRELESS NETWORKS (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 adaptations 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.

Ilya Grigori, High Performance Browser Networking: What every web developer should know about networking and web performance. " O'Reilly Media, Inc.", 2013.
C. S. R. Murthy, Ad hoc wireless networks: Architectures and Protocols. Pearson Education India, 2004. Online Resources: Technical papers in course related topics and IEEE Standards documents.

CS434 MOBILE COMPUTING (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: The 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 Management.

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.

CS435/CS435M OPEN SOURCE NETWORKING TECHNOLOGIES (3-1-0)4

Introduction to Open Source Networking, Open Source and Software Defined Networking Landscape, Disaggregated Hardware, IO Abstraction and Datapath, Network Operating Systems, Network Control, Orchestration and Virtual Management, Network Virtualization, Network Function Virtualization, Network Automation, Network Data Analytics, Introduction to Linux Network Namespaces, Introduction to open source network simulators, Introduction to remote network testbeds.

Grigorik, Ilya. High Performance Browser Networking: What Every Web Developer Should Know About Networking and Web Performance. " O'Reilly Media, Inc.", 2017.
Goransson, P., Black, C., & Culver, T. Software defined networks: a comprehensive approach. Morgan Kaufmann, 2016.
Kurose, James F. Computer networking: A Top-Down Approach Featuring the Internet, 6/E. Pearson Education India, 2005/2016

CS460/CS460M CYBER-PHYSICAL SYSTEMS AND APPLICATIONS (3-1-0)4

CPS Basics- CPS evolution, CPS architectures, Key Features of CPSs., Overview of CPS Applications. Healthcare CPSs- Cyber-Physical Medication Systems and Devices to Improve Health Care. Agriculture CPSs- Precision Agriculture, UAV-Based ACPSs, GIS-Based ACPSs. Transportation CPSs- Networked and Automotive Cyber-Physical Systems. Smart Grid CPSs- Cyber-Physical Communications in Smart Grid, Issues on Smart Grid. Mission-Critical CPSs- Characterization of Mission-Critical CPS, Transformation. Green CPSs- Energy Efficient Building, Socio-Ecological Energy System and Human–Building–Computer Interaction.

Applied Cyber-Physical Systems, Sang C. Suh, U. John Tanik, John N. Carbone, Abdullah Eroglu, 1st Edn., Springer, 2014.
Cyber-Physical Systems Raj Rajkumar Dionisio de Niz Mark Klein, 1st Edn., Addison Wesley, 2017.
Cyber-Physical Systems and Control, Dmitry G. Arseniev, Ludger Overmeyer, Heikki Kälviäinen, Branko Katalinić, 1st Ed., Springer, 2020.
Cyber-Physical Systems: Architecture, Security and Application, Song Guo, Deze Zeng, 1st Ed., 2019.

CS461/CS461M TRUSTWORTHY CYBER-PHYSICAL SYSTEMS (3-1-0)4

Overview of Security and Privacy in Cyber-Physical Systems- Defining Security and Privacy, Cybersecurity and Privacy, Physical Security and Privacy, and Cyber-Physical Terrorism. Privacy Issues for Cyber Physical Systems- CPS Reference Model, Device Level, Security and Privacy Threats in CPSs, Local Network Security for CPSs, Secure Device Bootstrapping. Security and Privacy for Cloud-Interconnected CPSs- Securely Storing CPS Data in the Cloud, Protection of CPS Data, Securely Processing CPS Data in the Cloud, and Privacy for Cloud-Based CPSs. Theoretic Metrics Quantifying Privacy in Cyber-Physical Systems- Social Perspective and Motivation. Cyber-Physical Systems and National Security Concerns- Future Attacks. Legal Considerations of Cyber-Physical Systems and the Internet of Things.

Security and Privacy in Cyber-Physical Systems- Foundations, Principles, And Applications, Fink, Glenn A., Jeschke, Sabina, Song Houbing, IEEE Press, 1 st Edn., 2018.

Cyber-Physical Systems: Architecture, Security and Application, Song Guo, Deze Zeng, Springer, 1st Ed., 2019.

Secure and Trustworthy Transportation Cyber-Physical Systems, Yunchuan Sun and Houbing Song, Springer, 1 st Edn., 2017.

CS462 HIGH PERFORMANCE COMPUTING PARADIGMS (3-1-0)4

Modern Processor Architecture, Basic Optimizations on Serial programs, Parallel computer architecture, Parallelization Basics, Shared Memory Parallel Programming, Distributed Memory Parallel Programming.

Georg Hager and Gerhard Wellein, Introduction to High Performance Computing for Scientists and Engineers,Chapman & Hall/CRC Computational Science, 2010.

M. W. Berry, K. A. Gallivan, E. Gallopoulous, A. Grama, B Phillippe, Y. Saad, F. Saied, "High-Performance Scientific Computing: Algorithms and Applications", Springer London,2012.

Marco Vanneschi, High Performance Computing – Parallel Processing Models and Architectures, Pisa University Press, 2014.

CS463/CS463M NETWORK SECURITY (3-1-0)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.

CS464 HETEROGENEOUS PARALLEL COMPUTING (3-1-0)4

Graphics Processing Units: Architecture, Programming frameworks. General Purpose GPU programming. Xeon Phi: Architecture and Programming. Heterogeneous parallel algorithms and case studies. FPGA Computing – OneAPI and similar frameworks.

Wen-Mei W Hwu, David B Kirk, Programming Massively Parallel Processors A Hands-on Approach, Morgan Kaufmann, 3e. December 2016

Rezaur Rahman, Intel Xeon Phi Coprocessor Architecture and Tools, Apress Open, 2013. Recent publications in IPDPS, PACT, and similar.

CS465 DISTRIBUTED DATABASE SYSTEMS (3-1-0)4

Introduction, Design issues, DDBMS architecture, DDBMS design, Database integration, Data and access control, Overview of query processing, Query decomposition and data localization, optimization of distributed queries, Multi-database query processing, Transaction management, Distributed concurrency control, Distributed DBMS reliability, Data replication, Overview of parallel database systems, Introduction to peer-to-peer and Web data management.

M.T. Ozsu and P. Valduriez, Principles of Distributed Database Systems, Third Edition, Springer-Verlag New York, 2011.

Ceri and Pelagatti, Distributed Database Principles and Systems, McGraw Hill. 2017

D. Bell and J. Grimson, Distributed Database Systems, Addison-Wesley, 1992.

CS466 SOCIAL NETWORK ANALYSIS (3-1-0)4

Emergence of the Social Web, Statistical Properties of Social Networks, Network analysis -concepts and measures, Community detection, Influence maximization, Link mining and prediction, Social network based recommender systems, Anomaly detection in social networks, Mining Discussion networks, Visualizing Online Social Networks,

Evolution in Social Networks.
Ajith Abraham, Aboul Ella Hassanien, Václav Snášel, - Computational Social Network Analysis: Trends, Tools and Research Advances, Springer, 2012
Borko Furht, ―Handbook of Social Network Technologies and Applications, Springer, 1st edition, 2011
Charu C. Aggarwal, ―Social Network Data Analytics, Springer; 2014
Giles, Mark Smith, John Yen, ―Advances in Social Network Mining and Analysis, Springer, 2010.
Reza Zafarani, Mohammad Ali Abbasi, Huan Liu, "Social Media Mining", Cambridge University Press, 2014.

CS467 INFORMATION STORAGE MANAGEMENT (3-1-0)4

Storage technology, challenges in data storage and data management, Core elements of a data center infrastructure, Storage system Architecture, integrated and modular storage systems, an intelligent storage system, networked storage, Monitoring and managing data centers, Storage security and storage visualization.
EMC Corporation, "Information Storage and Management: Storing, Managing, and Protecting Digital Information", Wiley, India, 2010
Marc Farley, ―Building Storage Networks, Tata McGraw Hill, Osborne, 2001. Robert Spalding, ―Storage Networks: The Complete Reference―, Tata McGraw Hill , Osborne, 2003

CS468 APPLICATIONS OF BLOCKCHAIN TECHNOLOGY (3-1-0)4

Introduction and History, Brief Overview of Distributed System, Cryptography and Other Technical Foundations, The consensus layer and basic Properties, Byzantine Agreement,
Proof of Work (PoW), Proof of Stake (PoS) based Chains - Hybrid models (PoW + PoS)
Introduction to Blockchain, Applications of blockchain technology, Case Study, Cryptocurrency basics, Transactions and Mining, Introduction to Smart Contracts, Privacy, Safety and Security Issues in blockchain, Ethereum - Ethereum Virtual Machine (EVM) - Wallets for Ethereum - Solidity - Smart Contracts - some attacks on smart contracts.
Roger Wattenhofer, The Science of the Blockchain, Inverted Forest Publishing, First Edition, 2016.
Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder. Bitcoin and cryptocurrency technologies: a comprehensive introduction. Princeton University Press, 2016.
Don Tapscott, Alex Tapscott, Blockchain Revolution: How the Technology Behind Bitcoin and Other Cryptocurrencies is Changing the World, Portfolio Penguin, 2018.
Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, Steven Goldfeder, Bitcoin and Cryptocurrency Technologies - A Comprehensive Introduction, Princeton University Press, 2016.
Andreas M. Antonopoulos, Mastering Bitcoin: Programming The Open Blockchain, Shroff/O'Reilly, Second edition, 2017.

CS469/CS469M SOFTWARE BASED NETWORKS (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 Open Daylight 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.

CS470/CS470M DATABASE SECURITY (3-1-0)4

Security architecture, Database Security, Operating system security, Application Security Models, Access Control models, Statistical DB security, Database auditing, Compliance Storage, Data Privacy, Steganographic File 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)

CS471 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.

CS472 QUANTITATIVE COMPUTER ARCHITECTURE (3-1-0)4

Instruction Level Parallelism: Pipelining, Hazards, Compiler techniques for ILP, Branch prediction, Static and Dynamic Scheduling, Speculation, Limits of ILP. Multicore Memory Hierarchy: Cache tradeoffs, 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. VLSI: Transistor Theory. Moore's Law. Delay, Power, Energy, Temperature dependence in integrated circuits.

John Hennessy and David Patterson. Computer Architecture - A Quantitative Approach. 6ed or 5ed. Morgan Kaufmann, 2011
John P. Shen and Mikko H. Lipasti. Modern Processor Design - Fundamentals of Superscalar Processors. Tata McGraw Hill, 2010
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.

CS300, CS350, CS400, CS450 – Mini Project I, II, III, IV (0-0-3) 2

Experimental design/implementation/problem solving tasks of relatively minor intensity and scope as compared to the Major Project and in line with the guidelines formulated by DUGC - CSE.

CS399 PRACTICAL TRAINING (0-0-2) 1

The Student has to undergo a training programme or any equivalent programme fixed by the DUGC of the department. This will be done during vacation period of the third year (6 to 8 weeks). A report will be submitted by the student. Evaluation is based on the seminar and report.

CS401 CORNERSTONE/CAPSTONE PROJECT (0-0-6)4

For details refer to clause 3.2 under Regulations specific to Undergraduate Programmes.

CS402 MAJOR PROJECT (0-1-9)6

The student individually will select a project work based on a topic of interest under the supervision of project guide for a duration of a Semester. The project work will be evaluated periodically.

CS490M, CS491M, CS492M, CS493M – Focused Project Courses (0-0-6) 4

Experimental design/implementation/problem solving tasks related to the respective Minor.

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.

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

CS751 NETWORK ENGINEERING (3-0-2)4

Internet working: 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

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.

UC100 INTRODUCTION TO DESIGN THINKING (2-0-0) 2

Need and Definition of Design Thinking. Framework for Design Thinking. Engineering Design Process. Need Identification, Specification, Concept Generation, Product Architecture and Detailed Design. Prototyping – Virtual and Physical. Testing Methodology

Christian Muller-Roterberg, "Handbook of Design Thinking", 2018
Eli Woolery, "Design Thinking Handbook" Invision Pub, 2019
Nigel Cross, "Design Thinking"
Max Answell "Mastering Design Thinking", 2019
Karl T. Ulrich, Steven D. Eppinger and Maria C Yang, "Product Design and Development", McGraw Hill, 7ed, 2020
George e Dieter, Linda C Schmidt, "Engineering Design", Mc Graw Hill, 4ed, 2009

UC401 LIBERAL ARTS COURSES/CO-CURRICULAR/EXTRACURRICULAR ACTIVITIES 10

CATEGORY A : Maximum 3 credits, CATEGORY B : Maximum 3 credits, CATEGORY C : Minimum 4 Credits and Maximum 7 credits.

10 Credits have to be earned from 1st Semester to 7th Semester by choosing Category (A + B + C) OR Category (A + C) or Category (B + C) courses combination . Registration for 10 Credits has to be done in 7th Semester.

For details of CATEGORY A, CATEGORY B and CATEGORY C refer to clause 3.2 (f) under Regulations specific to Undergraduate Programmes.

EE110 ELEMENTS OF ELECTRICAL ENGINEERING (2-0-0) 2

Review of circuit elements, voltage sources, current sources, source transformation, mesh current and node voltage analysis of circuits. Network reduction techniques. Concept of the magnetic circuit. AC analysis of single-phase systems, wave forms, phasor representation, the j-operator, concepts of real and reactive power and power factor. Extension of AC analysis to symmetrical 3-phase systems, phase sequence, measurement of three-phase power under balanced condition. Introduction to transformers and Electro-mechanical energy conversion.

Fitzgerald, D. E. Higginbotham, A. Grabel, Basic Electrical Engineering, 5th Edition, McGraw-Hill, 2009.
William H. Hayt Jr. , Jack E. Kemmerly, Steven M. Durbin, Engineering Circuit Analysis, 6th Edition,TMH, 2002
Olle I. Elgerd, Basic Electric Power Engineering, Addison-Wesley, 1977. Edward Hughes, Electrical Technology, 7th Edition, Longman, 1995.

EE101 ANALYSIS OF ELECTRIC CIRCUITS (3-1-0) 4

Review of network geometry and network reduction techniques. Network theorems. Network variables, identification of the number of degrees of freedom, the concept of order of a system, establishing the equilibrium equations, network modeling based on energy-indicating (state) variables in the standard form, natural frequencies and natural response of a network. Introduction to system functions, inclusion of forcing functions, solution methodology to obtain complete solution in the time-domain – the vector-matrix approach. Analysis of network response (in the time-domain) for mathematically describable excitations. Solution strategy for periodic excitations. The phenomenon of resonance and its mathematical analysis. Sinusoidal steady state analysis. Introduction to to three-phase systems. Magnetic circuit calculations.

Ernst A. Guillemin, Introductory Circuit Theory, John Wiley and Sons, 1953.
Norman Balabanian and Theodore A. Bickart – Electrical Network Theory, John Wiley and Sons, Inc. 1969
Charles A. Desoer, Ernest S. Kuh, Basic Circuit Theory, McGraw-Hill, 1969.
Russell M. Kerchner, George F. Corcoran, Alternating Current Circuits, 4 th Edition, Wiley Eastern, 1960.

EE143 MATHEMATICS FOR ELECTRICAL ENGINEERS (3-1-0) 4

Linear Systems: Systems of linear equations and their solution sets. Matrix Algebra: Matrix Operations, Determinants, Properties of Determinants and Linear transformations. Vector Spaces; Linear Maps, Isomorphism and Norms on vector spaces. Eigen Functions: Eigen Values, Eigen Vectors. Orthogonality and Orthogonal spaces. Integral Transforms: Laplace transforms of elementary functions, Inverse Laplace transforms and applications, Fourier series, Fourier transforms, Fourier cosine and sine integrals, Dirichlet integral, Inverse Fourier transforms

David C. Lay, Linear Algebra and Its Applications, Third Edition, Pearson
Gilbert Strang, Linear Algebra and Its Applications, Fourth Edition, Academic Press, Cengage Learning
Kenneth Hoffmann and Ray Kunze, Linear Algebra,, Prentice Hall India
R. A. Horn and C. R. Johnson, Matrix Analysis, Cambridge University Press.
Erwin Kreyszig, Advanced Engineering Mathematics, Wiley Eastern.
Larry C. Andrews, Bhimsen K. Shivamoggi, Integral Transforms for Engineers, PHI
Ronald N Bracewell, The Fourier transform and its applications. McGraw-Hill;

EE207 ELECTROMAGNETIC THEORY (3-1-0) 4

Static electric and magnetic fields. E-fields, D-fields, potential fields & Laplace's equation. Time varying fields. Discussion of various laws like Ohm's, Kirchhoff's, Faraday' s laws from the field theory point of view. Maxwell' equations. Concept of electromagnetic wave propagations, uniform plane wave. Introduction to computational methods in electromagnetics. Applications and analysis of few power engineering related problems.

William Hayt Jr. , Engineering electromagnetic, John A Buck, 8th Edtn. McGraw Hill Publication, 2012.
Mathew N O Sadiku, Elements of electromagnetic, 5th edtn, Oxford unvieristy press, 2010.
John D Kraus and Keith R Carver, Electromagnetics, 2nd Edtn, McGraw Hill Publication, 2012.
Julius Kdame Strattion, Electromgantics, IEEE press, John Wiley and Sons inc publications, 1981.
Paul G Huray, Maxwell's equations, IEEE press, John Wiley and Sons inc publications, 2010

EE213 INDUCTION MOTORS AND TRANSFORMERS (3-1-3) 6

Review of power network structures, principle of energy conversion. Transformers: Principle, construction (single-phase, three-phase), development of equivalent circuit through coupled circuit approach, phasor diagram, regulation, efficiency, autotransformers, vector groups and parallel operation of three-phase transformers, tap changers, phase conversion, energisation of transformer and harmonics. Induction machines: Principle, construction, classification, equivalent circuit, phasor diagram, characteristics, starting techniques, Introduction to Solid- state speed control,

operation under unbalanced supply conditions and harmonics, effect of single-phasing, induction generator operation. Single-phase induction motor. Testing and diagnostic procedures for machines. Linear induction motor. Laboratory exercises and assignments to supplement the course.

M. G. Say, Performance and design of A. C. Machines, CBS, 1983
D P Kothari, I J Nagrat, Electric Machines, 4th edition, TMH, 2010
A. E. Fitzgerald, Charles Kingsley, Jr. , Stephan D. Umans, 6th edition, TMH, 2003 O I Elgerd,Patrick D,Electric Power Engineering,2nd edition, Chapman &Hall,1998.

EE224 ELECTRICAL MEASUREMENTS AND MEASURING INSTRUMENTS (3-1-3) 6

Review of units, standards, dimensional analysis. Measurement basics: significant figures, errors, calibration. Measuring instruments: Analog and digital-Concept of true rms, DVM, multimeter DMM, resolution, sensitivity. Oscilloscope: specifications, applications. Measurement of voltage, current, power, power factor, frequency and energy; Power analyzer. Extension of meter ranges: Shunts & multipliers, CTs and PTs. Measurement of low, high resistances and applications. Measurement of earth resistance, dissipation factor and dielectric strength. Basics of cable fault location. Transducers: Classification, strain gauge, RTD, pressure transducers, inductive LVDT, capacitive, thermocouple, piezo-electric. Photo-electric, Hall effect. Laboratory exercises and assignments to supplement the course.

Golding and Widdis, Electrical Measurements and Measuring Instruments, Wheeler Publishing House, New Delhi 1979.
K. Sawhney, A Course in Electrical Measurement and Measuring Instruments, Dhanpat Rai and Sons, New Delhi 2007
M. B. Stout, Basic Electrical Measurements
C. T. Baldwin, Fundamentals of Electrical Measurement

EE226 ANALOG ELECTRONIC CIRCUITS (3-1-3) 6

Terminal, switching and thermal characteristics of semiconductor devices, establishment of quiescent point, biasing considerations, load line concept, control of devices in switching and active zones, device cooling requirement. Introduction to usage of SPICE device models and simulation. Power amplifiers, feedback in amplifiers, filters, operational amplifiers: configurations, characteristics, applications. Sample and hold, A/D, D/A Converters. Multivibrators, voltage regulators, voltage controlled oscillators, phase locked loop. Laboratory exercises and assignments to supplement the course.

Jacob Millman and A. Grabel, Microelectronics, Tata McGraw-Hill, 1999
Ramakant Gayakwad, Op-amps and Linear Integrated circuits, Pearson Education, 2007.
J. V. Wait, L. P. Huelsman and GA Korn, Introduction to Operational Amplifier theory and applications, 2nd Edition, McGraw Hill, New York, 1992.
P. *Horowitz and W. Hill, The Art of Electronics, 2nd edition, Cambridge University Press, 1989.*
A. S. Sedra and K. C. Smith, Microelectronic Circuits, Saunder's College Publishing, 4th Edition.

EE229 POLYPHASE SYSTEMS AND COMPONENT-TRANSFORMATIONS (3-1-0) 4

Balanced poly-phase circuits: Generation of poly-phase voltages, Phase sequence, three-phase 3-wire and 4-wire systems, wye and delta connections, n -phase star and mesh, power calculations in balanced systems, harmonics in wye- and delta-systems. Unbalanced poly-phase circuits: unbalanced loads, wye-wye system with and without neutral connections, neutral shift, wye-delta system, phase-sequence effects, extensions to non-sinusoidal behaviour. Introduction to symmetrical components: A brief historical review, application of the method. Calculation of unbalance faults. Multiphase systems: Resolution of multiphase systems into symmetrical components, 2-phase and 4-phase systems, Irregular systems.

Edith Clarke, Circuit Analysis of AC Power Systems – Volumes I and II, John Wiley and Sons, 1950.
C. F. Wagner, R. D. Evans. Symmetrical Components, McGraw-Hill, 1933.
J. L. Blackburn, Symmetrical Components for Power System Engineering, Marcel-Dekker,1993.

EE230M ELECTRIC CIRCUITS (3-1-0) 4

Review of network geometry and network reduction techniques. Network theorems. Network variables, identification of the number of degrees of freedom, the concept of order of a system, establishing the equilibrium equations, network modeling based on energy-indicating (state) variables in the standard form, natural frequencies and natural response of a network. Introduction to system functions, inclusion of forcing functions, solution methodology to obtain complete solution in the time-domain - the vector-matrix approach. Analysis of network response (in the time-domain) for mathematically describable excitations. Solution strategy for periodic excitations. The phenomenon of resonance and its mathematical analysis. Sinusoidal steady state analysis. . Introduction to to three-phase systems.

Magnetic circuit calculations.
Ernst A. Guillemin, Introductory Circuit Theory, John Wiley and Sons, 1953.
Charles A. Desoer, Ernest S. Kuh, Basic Circuit Theory, McGraw-Hill, 1969.
Russell M. Kerchner, George F. Corcoran, Alternating Current Circuits, 4 th Edition, Wiley Eastern, 1960.

EE256 SIGNALS AND SYSTEMS (3-1-3) 6

Signals and Systems – Classification, time-domain analysis of continuous-time and discrete-time systems, continuous-time system analysis using the Laplace transform, discrete-time system analysis using the z-transform. Fourier series, Fourier transform, sampling, applications. Laboratory exercises and assignments to supplement the course.
B. P. Lathi, Linear Systems and Signals, 2nd Edition, Oxford University Press, 2005.
Simon Haykin, Barry Van Veen, Signals and Systems, John Wiley Asia, 2003.
A. V. Oppenheim, A. S. Willsky, S. H. Nawab, Signals and Systems,2nd. Edition, Prentice-Hall Signal Processing Series, 1997.

EE258 SYNCHRONOUS MACHINES AND DC MACHINES (3-1-3) 6

Synchronous machines: Construction, prime-mover and excitation control systems. Steady state characteristics, handling of harmonics, voltage regulation calculations for salient and non salient pole machines, parallel operation, load sharing and associated capacity curves, load-generation balance. Dynamic characteristics, Park transformation, simplified generator models, electromechanical oscillations, concept of power system stability. Introduction to Synchronous motors and condensors, Permanent magnet synchronous motors, Switched reluctance motors. DC Machines: Construction, classification, emf and torque equations, characteristics of DC motors, speed control – Solid-state techniques. Introduction to brushless DC motor, stepper motor, servomotor. Laboratory exercises and assignments to supplement the course.
M. G. Say, Performance and Design of Alternating Current Machines, CBS, 1983.
Fitzgerald, Kingsley, Umans, Electric Machinery, 5th Edition, McGraw-Hill, 1992
Arthur R. Bergen, and Vijay Vittal, Power System Analysis, 1st Edition, Pearson Education Asia, 2001.

EE260 DIGITAL COMPUTER ORGANIZATION AND ARCHITECTURE (3-1-0) 4

Evolution of computers, instruction set design, processor design: functional unit design, micro-programmed and hardwired approaches, different architectures, control unit design, memory organization, input-output organization, introduction to system software, operating system basics.
J. P. Hayes, Computer Architecture and Organisation, 2nd Edition, McGraw-Hill, 1988.
M. Rafiquzzaman, Rajan Chandra, Modern Computer Architecture, Galgotia, 1999.

EE261M BASIC ELECTRIC MACHINES (3-1-0) 4

Review of power network structures, principle of energy conversion. Transformers: Principle, construction, development of equivalent circuit through coupled circuit approach, phasor diagram, regulation, efficiency, autotransformers. Induction machines: Principle, construction, classification, equivalent circuit, phasor diagram, characteristics, starting techniques, speed control, effect of single-phasing. Single-phase induction motor. DC Machines : Construction, classification, emf and torque equations, characteristics of DC motors, speed control, brushless DC motor. Stepper motor: Construction, principle of operation and control. Synchronous machines: Construction, prime-mover and excitation control systems. Steady state characteristics, voltage regulation calculations by synchronous impedance method. Synchronous motors and condensors, Permanent magnet synchronous motors, Switched reluctance motors.
M. G. Say, Performance and Design of Alternating Current Machines, CBS, 1983.
Fitzgerald, Kingsley, Umans, Electric Machinery, 5 th Edition, McGraw-Hill, 1992
Arthur R. Bergen, and Vijay Vittal, Power System Analysis, 1st Edition, Pearson Education Asia, 2001.
N. N. Parker Smith, Problems in Electrical Engineering, CBS Publications

EE265 POWER TRANSMISSION AND DISTRIBUTION (3-1-0) 4

Electrical energy sources, power network structure and its components. AC, AC-DC, and DG- based systems, forms of field energy, concepts of real and reactive powers and their conventions, per unit representation, single-line diagram representation, impedance diagram. Analysis of system transients: time-range of transients, traveling waves, low frequency transients. Transmission lines: Design, modeling and performance analysis. Cables, insulators, grounding and safety. power generation and demand management – load factor, diversity factor etc., tariff structure.
Olle I. Elgerd, Electric Energy Systems Theory – An Introduction, TMH, 1982.
W. D. Stevenson Jr. , Elements of Power System Analysis, McGraw-Hill, 1968.

Arthur R. Bergen, and Vijay Vittal, Power System Analysis, Pearson Education Asia, 2001.
I. J. Nagrath, D. P. Kothari, Power System Engineering, TMH.

EE276 DIGITAL ELECTRONIC CIRCUITS (3-1-3) 6

Logic families: TTL, ECL, NMOS, CMOS. Number systems, logic gates, boolean algebra, Karnaugh map. Combinational logic circuits: adders, subtractors, multiplexers, de-multiplexers, encoders, decoders, line drivers. Sequential logic circuits: latches and flip flops, registers and counters. Design of following finite state sequential machines using D flip-flops: Sequential code converters, sequence detectors, sequence generators and system controllers. Memories: read only and read/write memories, programming EPROM and flash. Laboratory exercises and assignments to supplement the course.

M. Mano, "Digital Design", 3rd Ed. , Prentice Hall, India.
D. D. Givone, "Digital Principles and Design", Tata McGraw Hill.
J. F. Wakerly, "Digital Design Principles and Practices", Practice Hall.
R. J. Tocci, "Digital Systems Principles and Applications", Prentice Hall
Charles H Roth: Digital Systems Design using VHDL, Thomson Learning, 1998

EE295 ELECTRICAL MACHINE WINDING CALCULATIONS-I (0-2-3)4

An exposition of the magnetic and electric circuits of commutator-wound machines. Exercises involving: the geometrical layout of the armature windings, brush placement, interpoles, equalizing rings. Detailing of the process of commutation and of armature reaction. Calculations in respect of winding design and of estimation of machine parameters from design data.

Clayton A. E. , Hancock N. N. , "The Performance and Design of Direct Current Machines", 3rd Edition, Oxford & IBH, 1986 (Indian Reprint).
Taylor O. E. , "The Performance and Design of AC Commutator Motors", A. H. Wheeler & Co. , 1988 (Indian Reprint).

EE296 ELECTRICAL MACHINE WINDING CALCULATIONS-2 (0-2-3)4

An exposition of the magnetic and electric circuits of open-wound (AC) machines. Salient- and non-salient-pole windings. Exercises involving: the geometrical layout of armature windings, armature reaction, harmonics and their quantification, cage rotor, and damper windings. Estimation of machine parameters from design data.

Say M. G. , "The Performance and Design of Alternating Current Machines", 3rd Edition, CBS, 1983 (Indian Reprint).
Langsdorf A. S. , "Theory of Alternating Current Machinery", 2nd Edition, Tata McGraw-Hill, 1974.

EE301 DATA STRUCTURES AND ALGORITHMS (3-0-2) 4

Introduction to Data Structures and Algorithms, Recursions, Array- based Sequences, Stacks, Queues, Linked Lists, Trees, Priority Queues, Maps, Hash Tables and Sets, Search Trees, Sorting Algorithms, Graph Algorithms, Text Processing, Memory Management and B-Trees. Laboratory exercises to implement the algorithms and conduct experiments to evaluate their performance.

Alfred V Aho, John E Hoperoft, Jeffrey D. Ullman. "Data structures and Algorithms", Addison
Wesley, 2003 TH Cormen, CF Leiserson, RL Rivest, C Stein, "Introduction to Algorithms", 3rd Ed., MIT Press;2009.
MT Goodrich, R Tamassia, DM Mount, "Data Structures and Algorithms in Python", Wiley, 2013
Kent D Lee, Steve Hubbard, "Data Structures and Algorithms with Python", Springer, 2015

EE303 DISTRIBUTION SYSTEMS CONTROL AND AUTOMATION (3-1-0) 4

Distribution systems, their importance in energy transfer, distribution loss minimization techniques, radial and ring system, voltage regulation, reconfiguration, capacitor placement, power flow analysis, sizing of conductors and transformers, fault analysis, data acquisition and control, remote reading of energy meter, role of computers in distribution system operation, state of the art.

T. M. Gonen, Electrical Energy Distribution. C.
L. Wadhwa. , Electrical Energy Distribution.
Recent publication in reputed journals and conference proceedings of relevance.

EE308 POWER ELECTRONICS (3-1-3) 6

Devices:Characteristics-diode,BJT,IGBT,MOSFET,IPMs,Thyristorbaseddevices:SCRs/TRIAC/GTOs. Reactive elements: capacitors, inductor, transformer, pulse transformer. Data sheets, switching and conduction losses, heat dissipation- heat sink, loss calculation. Drive circuit, current and voltage sensors, opto-couplers. Functional classification ofconverters: DC-DCconverters- switchedmodebuck converter, switched mode boostconverter: control circuit, snubber, applications. Inverters: H-Bridge, single-phase, three-phase inverters. Rectifiers: single-phase and

three-phase rectifiers. AC power controllers. Laboratory exercises and assignments to supplement the course.

Ned Mohan,Undeland, Robbins, Power Electronics, 3rd edition, John Wiley. M H Rashid, Power Electronics, 3rd edition, PHI.

P C Sen, Power Electronics, Tata McGraw-Hill Publishing Company Ltd. Bimal K Bose, Modern power electronics and ac drives,PHI.

L Umanand, Power Electronics, Wiley India Pvt Ltd

EE310M ELECTRIC POWER SYSTEM (3-1-0) 4

Electrical energy sources, power network structure and its components. per unit representation, single-line diagram representation. AC, AC-DC, and DG- based systems, forms of field energy, concepts of real and reactive powers and their conventions. Power system operation and control: State of operation of a power system, voltage and frequency control mechanisms, power generation, Introduction to tariff structure. Transmission lines: Design, modeling and performance analysis. Cables, insulators, grounding and safety. System modeling. Steady state analysis: power flow – NR Method. balanced and unbalanced short circuit analysis. Stability analysis: Classification, rotor angle stability of SMIB -- solution method using equal-area criteria.

Olle I. Elgerd, Electric Energy Systems Theory – An Introduction, TMH, 1982.

Arthur R. Bergen, and Vijay Vittal, Power System Analysis, Pearson Education Asia, 2001.

I. J. Nagrath, D. P. Kothari, Power System Engineering, TMH.

John J. Grainger and W. D. Stevenson, Power Systems Analysis, McGraw-Hill, 1994

EE311 DIGITAL SYSTEM DESIGN (3-1-0) 4

Review of combinational logic design using PLD, design of synchronous sequential logic systems, introduction to VHDL, design of system controllers, design of systems using PLD / FPGA, fundamentals of data converters.

C. H. Roth, Digital System Design, PWS, 1998.

J. F. Wakerly, Digital Design, PHI, 3rd Edition. , 2001

W. Fletcher, An Engineering Approach to Digital Design, PHI.

M. J. Sebastian Smith, Application Specific Integrated Circuits, Addison-Wesley, 1999.

EE312 POWER SYSTEM HARMONICS (3-1-0) 4

Harmonic Sources: Power electronic converters, transformers, rotating machines, arc furnaces, fluorescent lighting. Harmonic effects within power system- resonances, harmonic torques, static power plant, control systems, power system protection, consumer equipment, measurements, and on power factor. Harmonic effects related to communication interference: telephone circuit susceptiveness, harmonic weights, I-T and kV-T products, shielding. Harmonic effects related to biological effects. Power theory, single and three-phase, non -sinusoidal conditions, Fryez and Budeno's methods. Power quality parameters. Transducers and data transmission, Hall effect voltage and current sensors. Harmonic mitigation techniques: passive filters, active filters. Algorithms for extraction of harmonic current in the line.

J. *Arrillaga, Power System Harmonics, IEE Press.*

G. T. Heydt, Power Quality, Stars in a Circle, 1991.

M. G. Say, Alternating Current Machines, ELBS.

EE313 DIGITAL SIGNAL PROCESSING (3-1-0) 4

Review of FT, DTFT, DFT. Circular Convolution, DFT computation methods: Radix FFTs: Decimation in time and Decimation in frequency FFT, DCT. IIR Filters: Analog filters: properties and design of Butterworth, Chebychev and Elliptical filters. Frequency transformation. Review of Z-transform and its properties. Structure of digital filters. Methods of converting analog filters to digital filter (IIR): bilinear transformation, pole-zero mapping, Impulse invariant transformation. Methods of designing the FIR filters: window- based methods, frequency sampling method. Introduction to the programmed digital systems. General architecture of Digital Signal Processors, programming of the TMS320F243, application of DFT for linear filtering.

John G. Proakis, D. G. Manolakis, Digital Signal Processing.

Ashok Ambardar, Analog and Digital Signal Processing.

L. R. Rabiner, B. Gold, Theory and Applications of Digital Signal Processing, PHI, 1975

Richard G. Lyons, Understanding Digital Signal Processing.

Roman Kuc, Introduction to Digital Signal Processing.

EE319 NEURAL NETWORKS AND APPLICATIONS (3-0-2) 4

Introduction: Biological neuron, Mc-Culloch -Pitts neuron model. Various threshold functions, Feature vectors and feature space. Classification techniques – nearest neighbor classification. Distance metrics, linear classifiers, decision

regions. The single layer and multilayer perception, multilayer perception algorithm, solution of the XOR problem, visualizing the network behaviour in terms of energy functions, Mexican hat function. Learning in neural networks, linearly non-separable pattern classification, delta learning rule. Error back-propagation training algorithms, Feedback networks-Hopfield network, energy landscape, storing patterns, recall phase, Boltzmann machine, traveling salesman problem. Associative memories, retrieval and storage algorithm, stability considerations. Application of neural systems - linear programming, modeling networks, character recognition, control system applications, robotic applications. Implementation of various Neural Networks and Applications algorithms, Mini projects to design solutions for various real-world problems using deep learning tools.Laboratory exercises and assignments to supplement the course.

Yegnanarayana, B., Artificial Neural Network PHI learning Pvt Ltd, 2009
Golub, G.H., and Van Loan, C.F., Matrix computation, JHU Press, 2013
Simon S. Haykin, Neural Networks and Learning Machines, 3rd Ed, Pearson, 2009.
R. Beale, T. Jackson, Neural Computing: An Introduction, IOP Publishing Ltd., 1990.
Jack H. Zaruda, Introduction to Artificial Neural Systems, Jaico Publications.

EE320 ELECTRICAL SAFETY, OPERATIONS, REGULATIONS (3-0-0) 3

Electrical safety: Safety of the self. Safety of the equipments, Safety of the public. PPE. General guidelines on earthing and protection. Operations: Sign boards, tagging system and procedures. Safe operating procedures, case studies and, safety audit basics. Regulations: IS, IEEE standards, Indian Electricity rules and regulations.

HSC- A Practical guide VOL. 1 to 4, National Safety Council, India.
IS 5216 (Part I)- 1982, "Recommendations on safety procedures and practices in electric work".
SP 30 -1985 Special publication-National Electric Code, "Section-14: Electric Aspects of building services".
IEEE Standard 902.

EE321 LINEAR AND NONLINEAR SYSTEMS (3-1-0) 4

Characteristics of linear systems, modeling and analysis of linear time-invariant systems using state-space approach, analysis of linear time-variant systems. Characteristics of nonlinear systems, common types of nonlinearities, phase-plane analysis, describing function analysis.

Thomas Kailath, Linear Systems, Prentice-Hall, 1980.
K. *Ogata, State-Space Analysis of Control Systems, Prentice-Hall, 1967. John E. Gibson, Non linear Automatic Control, McGraw-Hill, 1963.*

EE324 ELECTRONIC MEASUREMENTS AND INSTRUMENTATION (3-1-0) 4

Measurement systems, electromechanical instruments, bridges, electronic instrumentation, oscilloscopes, signal analysis, frequency, time interval measurements, physical parameter measurements, transducers, data acquisition systems.

B. H. Oliver, J. M. Cage, Electronic Measurements and Instrumentation, McGraw-Hill, 1975
Albert D. Helfrick, William D. Cooper, Modern Electronic Instrumentation and Measurement Techniques, PHI.

EE326 LINEAR CONTROL SYSTEMS (3-1-3) 6

Introduction, classification, mathematical modeling of physical systems, transient response analysis, design specifications and performance indices, concept of stability and algebraic criteria, Root locus analysis, frequency responseanalysis,Bodediagrams,polarplots,Nyquistplots,stabilityinthefrequencydomain,basiccontrolactionsandresponseofcontrolsystems.Introductiontocontrolsystemdesignusingtherootlocusandfrequency-domainapproach. Introduction to state space approach to modeling of dynamic system, canonical forms, concept of controllability, observability, design by state-feedback. Laboratory exercises and assignments to supplement the course.

K. Ogata, Modern Control Engineering, 5th Edition, PHI.
Richard C Dorf, Modern Control Systems, 12th Edition, Pearson Education India.
I. J. Nagrath, M. Gopal, Control Systems Engineering, 6th Edition, New Age International.

EE328 NETWORK SYNTHESIS (3-1-0) 4

Review of mathematics for network synthesis Partial -fraction expansion, Continued – fraction expansion, Bilinear transformation. The positive real concept - Hurwitz polynomials, analytic tests for positive real functions, positive -- definite and positive -- semi -- definite quadratic forms. Realizability conditions for networks with and without transformers (magnetic coupling) Realization of driving -- point functions -- Canonical forms – LC, RC, and RL driving -point functions.

Louis Weinberg, Network Analysis and Synthesis, McGraw – Hill, New York, 1962 M. E.
Van Valkenburg, Modern Network Synthesis, Prentice – Hall, New Jersey

EE329 TRAVELING WAVES ON TRANSMISSION SYSTEMS (3-1-0) 4

Introduction to the line equations. Attenuation and distortion of traveling waves. Reflection of traveling waves. Successive reflections: The reflection lattice, construction and use of the lattice-diagram, Charging of a line from various sources, Reflection between a capacitor and a resistor, effect of short lengths of cable, effect of insulator capacitance. Traveling waves on multi conductor systems. Theory of ground-wires: Direct stroke to a tower, effect of reflections up and down the tower, tower grounding. The counterpoise: Multi velocity waves on the counterpoise, tests on the counterpoise, successive reflections on the insulated counterpoise. Induced lightning surges: The field gradient, induced surges with ideal ground wires. Arcing grounds: Normal frequency arc extinction – single-phase and three-phase, oscillatory- frequency arc extinction, high-frequency effects, interruption of line-charging currents, cancellation waves, initiated waves, steady-state waves, recovery voltage, restriking phenomena.

L. V. Bewley, Traveling Waves on Transmission Systems, John Wiley and Sons, 1951.
H. H. Skilling, Electric Transmission Lines, McGraw-Hill, 1951.
L. F. Woodruff, Principles of Electric Power Transmission, John Wiley and Sons, 1952 .

EE335 DIGITAL SYSTEM DESIGN LABORATORY (0-0-3) 2

VHDL / Verilog programming, design exercises on ECAD software, hardware realization on FPGA / CPLDs, to provide additional support to EE311.

EE337 POWER SYSTEM HARMONICS LABORATORY (0-0-3) 2

Laboratory Exercises and assignments to provide additional support to EE312. Experiments around MATLAB®, PSCAD®, OrCAD™ and laboratory measurement exercises.

EE343 STATISTICAL FOUNDATION FOR ELECTRICAL ENGINEERS (3-1-0) 4

Probability: Axioms, Sample spaces (continuous & discrete), Density, Distribution and Mass functions and their applications. Random Variable: Single, Multiple, Continuous and Discrete, statistical operations and limit theorems. General Distributions and their practical significance. Functions of random variables: Probability distribution functions of functions of random variables. Random Process: Concept, Classification, Temporal and Spectral characterization, and Statistical Estimation: Estimation of variables, Estimation of parameters. Testing of hypothesis. Analysis of linear systems to Random signals and optimum linear systems, and Optimum Wiener Solutions.

Davenport W. B Jr, Probability and Random Process, An Introduction for Applied Scientists and Engineers, McGraw-Hill.
Peyton Z. Peebles JR, Probability, Random Variables & Random Signal Principles, 4thEdition, McGraw-Hill.
Leon-Garcia, Probability and Random Process for Electrical Engineering, Addition-Wesley.
Viniotis Y, Probability and Random Process for Electrical Engineers, McGraw-Hill.
Papoulis A, Probability, Random Variables and Stochastic Processes, McGraw-Hill.
Mayer P. L. , Introductory Probability and Statistical applications, Second Edition, Oxford and IBH publishing Co. Pvt. Ltd. , New Delhi.

EE347 DESIGN AND DEVELOPMENT TASK IN CONTROL SYSTEMS (0-0-3)2

Analog and Digital controller design and implementation for specific problems. Stability analysis, performance comparison, and optimal controller. Simulation and implementation issues.

EE348 DESIGN & DEVELOPMENT TASK IN POWER ELECTRONICS AND DRIVES (0-0-3)2

Design of a specified power electronics converter. Simulation and implementation of some algorithms for power electronics controller applications.

EE350 POWER SYSTEM ANALYSIS (3-1-3) 6

Review of modeling of power system components: transmission lines, transformers, synchronous machines, loads etc.. System modeling. Steady state analysis: power flow methods. Balanced and unbalanced short circuit analysis. Stability analysis: Classification, rotor angle stability of SMIB -- solution method using equal-area criteria. Laboratory exercises and assignments to supplement the course.

John J. Grainger and W. D. Stevenson, Power Systems Analysis, McGraw-Hill, 1994
P. Kundur, Power System Stability and Control, McGraw-Hill, 1994.
Olle I. Elgerd, Electric Energy Systems Theory- An introduction, TMH, 1982
P. W. Sauer and M. A. Pai, Power System Dynamics and Stability, Prentice Hall, Upper Saddle River, New Jersey, 1998

EE359 ENERGY AUDITING (3-1-0) 4

Introduction to energy audit. Purpose, methodology, case studies of few selected industries, analysis of results and inference, standards, instruments used in energy auditing.

Shirley J. Hansen, James W. Brown, Jim Hansen, Investment Grade Energy Audit, Marcel Dekker, 2003.
Donald R. Wulfinghoff, Energy Efficiency Manual, Energy Institute Press.

EE360 MICROPROCESSORS AND MICROCONTROLLERS (3-1-0) 4

Basics of finite state machines, Von Neumann Architecture, functional blocks of a microcomputer, architecture of 8-bit/16-bit Microprocessors/Microcontrollers [viz. Intel 8051 family, MOTOROLA 68HXX, ARM Core etc.]. Programmers' model of any one microprocessor/microcontroller chosen for detailed study, instruction set, chip configuration and programming, use of development and debug tools, interface applications. Laboratory exercises.

Intel Corporation, 8-bit Microcontroller Handbook, Intel Corporation, 1990.
ARM® Core Processor Hand book.
John B. Peatman, Design with Microcontrollers, McGraw-Hill, 1995.
Andrew N. Sloss, Dominic Symes, Chris Wright, John Rayfield, ARM System Developer's Guide, Designing and Optimizing System Software, Elsevier, 2004.

EE362 OPERATION AND CONTROL OF POWER SYSTEMS (3-1-0) 4

Economic operation of power systems: Economic load dispatch, unit commitment. Load frequency control: Modeling of components of generating systems, concept of coherent units, operation of single area. Introduction to multi-area systems. Sources of reactive power. Introduction to contingency analysis. State estimation: Importance of state estimation, DC state estimation. Energy interchange evaluation.

O. I. Elgerd, Electric Energy Systems Theory: An Introduction, McGraw-Hill, 1971.
I. J. Nagrath, D. P. Kothari, Modern Power System Analysis, TMH. S.
S. Rao, Optimisation Theory and Applications.
Allen J. Wood, Bruce F. Wollenberg, Power Generation Operation and Control, 2nd Edition, John Wiley and Sons,1996.

EE363 ADVANCED DIGITAL SIGNAL PROCESSING (3-1-0) 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. Wavelets 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. 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, PH, 1993.
S. J. Orfanidis, Optimum Signal Processing, McGraw-Hill, 1989.
John G. Proakis, D. P. Manolakis, Introduction to DSP, Pearson, 2002.
E. C. Ifeachor, B. W. Jervis, Digital Signal Processing: A Practical Approach, Pearson Education.

EE366 SPECIAL MACHINES AND DRIVES (3-1-0) 4

Method of control and application of brushless DC motor, PMSM, stepper motor, AC servomotor, universal motor. Electric drive, motor rating, heating effects, electric braking, modification of speed- torque characteristic of an induction motor by V/f control, starting and braking. Synchronous motor --Speed torque and torque angle characteristics by V/f control, braking.

G. K. Dubey, Fundamentals of Electrical Drives, Narosa.
A . E. Fitzerald, C. Kingsley, S. D Umans, Electric Machinery, McGraw-Hill.
S. K. Pillai, A First Course on Electric Drives, Wiley Eastern, 1990.

EE369 EMBEDDED SYSTEM DESIGN (3-1-0) 4

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.

Charles H. Roth, Digital System Design using VHDL, PWS, 1998.
User manuals of Microprocessor /DSPs

EE370M ELECTRICAL AND ELECTRONICS MEASURING INSTRUMENTS AND TECHNIQUES (3 -1-0)4

Review of units, standards, dimensional analysis. Measurement basics: accuracy, precision, significant figures, errors (quantification and analysis), calibration. Measuring instruments: Analog and digital, Concept of true rms, DVM, multi-meter DMM, resolution, sensitivity. Oscilloscope: specifications, applications. Measurement of voltage, current, frequency, impedance, harmonics, power, power factor, and energy. Extension of meter ranges: Shunts & multipliers, CTs and PTs. Measurement of R, L, C and applications. Indicating, recording and integrating type of instruments. Measurement of non-electrical quantities (Displacement, Pressure, Temperature, Strain, Acoustic, flow and Photo measurement etc.) and instrumentation. Basics of transducers.

Golding and Widdis, 'Electrical Measurements and Measuring Instruments', Wheeler Publishing House, New Delhi 1979.
K. Sawhney, 'A Course in Electrical Measurement and Measuring Instruments', Dhanpat Rai and Sons, New Delhi 2007
M. B. Stout, 'Basic Electrical Measurements'
C. T. Baldwin, 'Fundamentals of Electrical Measurement'
B. S. Sonde, 'Transducers and Display Systems', Published by McGraw-Hill Inc. ,US, 1978.

EE371 POWER ELECTRONICS APPLICATIONS TO POWER SYSTEMS (3-1-0) 4

HVDC systems: Classical HVDC systems, CCC systems, HVDC Light systems. Application of FACTS devices such as SVC, TCSC, SSS, UPFC to improve steady state and dynamic behaviour of power systems. Modeling of HVDC systems and FACTS devices to perform system studies.

N. *G. Hingorani, L. Gyugi, Understanding FACTS, IEEE Press, 2001.*
P. Kundur, Power System Stability and Control, McGraw-Hill, 1994.

EE373 ELECTRIC POWER STATIONS (3-1-0) 4

Choice of site for power plants. Thermal power plant: General layout, air and flue-gas circuit, fuel and ash handling circuit, cooling water circuit, steam and feed water circuit. Nuclear power plant: General layout, heat exchangers, moderators, coolants, control rods. Hydro power plant: Site selection, general layout, type of hydropower plants, hydrographs. Characteristics of hydro turbines. Electrical equipment in generating stations: General layout, excitation systems and voltage regulation. Substation layout, components of substation. bus-bar arrangements, current-limiting reactors and their location. Safety and coordination. Load forecasting and sharing: Load curve and load duration curves, load factor, diversity factor, plant factor and plant use factor, demand factor, load sharing between base and peak load stations.

M. *V. Deshpande, Electrical Power Stations.*
Tata Electric Co. , Operator Training Manual.

EE374 ELECTRIC ENERGY SYSTEMS (3-1-0) 4

Conventional and non- conventional energy sources and systems: Generation, transmission and distribution schemes, energy conservation systems, energy efficient equipment and controllers. Energy audit.

Olle I. Elgerd, Electric Energy System Theory: An Introduction, TMH, 1982.
I. J. Nagrath, D. P. Kothari, Power System Engineering, TMH.

EE376 ADVANCED CONTROL SYSTEMS (3-1-0) 4

Introduction, review of state space approach to modeling of dynamic system. Introduction to discrete time control system, Signal processing in digital control, models of digital control devices and systems, z -plane analysis of discrete time control system, transient response analysis, design specifications and performance indices, design of digital control algorithms, state variable analysis of digital control systems, Pole placement design and state observers, linear quadratic optimal control

K. *Ogata, Discrete Time Control Systems, 2nd Edition, Pearson Education.*
M. Gopal, Digital Control and State Variable Methods, TMH.

EE385 MICROPROCESSORS AND MICROCONTROLLERS LABORATORY (0-0-3) 2

Programming and interfacing experiments on the target processor / microcontroller discussed in EE360.

EE386 DIGITAL SIGNAL PROCESSING LABORATORY (0-0-3) 2

Laboratory exercises and assignments to enhance learning of DSP.
MATHEMATICA®, LabVIEW™, DSP programming. Exercises around
MATLAB®, *S. Burrus et al, ComputerBased Exercises for Signal Processing, PH, 1994. S. K. Mitra, DSP: A Computer-Based Approach, TMH, 1998.*
TMS 320c54x Users Manual, Texas Instruments, 1997.

EE387 ADVANCED DIGITAL SIGNAL PROCESSING LABORATORY (0-0-3) 2

Laboratory exercises and assignments to to provide enhance learning of advanced DSP techniques and algorithms.

MathWorks Inc. , MATLAB® Signal Processing Toolbox Users Guide, MathWorks Inc.
C. S. Burrus et al, Computer-Based Exercises for Signal Processing, PH, 1994.
S. K. Mitra, DSP: A Computer-Based Approach, TMH, 1998.
TMS 320c54x Users Manual, Texas Instruments, 1997.

EE389 EMBEDDED SYSTEM DESIGN LABORATORY (0-0-3) 2

Laboratory exercises and assignments to provide additional support to EE369.

EE392 POWER SYSTEM OPERATION LABORATORY (0-0-3) 2

Simulation exercises and assignments to provide additional support to EE362. Experiments around MATLAB®, PSCAD®, PowerWorld™ and SKM® packages.

EE397 DESIGN AND DEVELOPMENT TASK IN SIGNAL PROCESSING (0-0-3)2

Application of digital Signal processing techniques for power systems or any specific applications in communication, feature extraction, or data compressions. Simulation or DSP implementation.

EE398 DESIGN AND DEVELOPMENT TASK IN POWER SYSTEMS (0-0-3)2

Problem solving in the area of power system dynamics, distribution systems and high voltage engineering.

EE401 TIME SERIES ANALYSIS AND FORECASTING (4-0-0) 4

Background for Time Series Data Analysis and Forecasting: Some Examples of Time Series Data, Numerical Description of Time Series Data, Use of Data Transformations and Adjustments, General Approach to Time Series Modelling and Forecasting, Evaluating and Monitoring Forecasting Model Performance.

Regression Analysis and Forecasting: Least Squares Estimation in Linear Regression Models, Statistical Inference in Linear Regression, Regression Models for General Time Series Data, Model Adequacy Checking, Exponential smoothing Methods.

Autoregressive integrated moving Average (ARIMA) models: Finite order auto regressive process AR(p), Finite order moving average process MA(q), Mixed autoregressive–moving average processes, ACF and PACF of ARMA(p, q) process, some examples of ARIMA(p, d, q) processes, forecasting ARIMA processes

Other Forecasting Methods: Multivariate time series models and forecasting, ARCH and GARCH models, State space models and Kalman Filter, Neural Networks and Forecasting.

TimeSeriesAnalysisandForecasting,2ed.Author:DouglasC.Montgomery,CherylL.Jennings and Murat Kulahci : John Wiley & Sons: 2015.

OtherResource Materials:

Shumway, R. H., and Stoffer, D. S. (2006). Time Series Analysis and Its Applications with R Examples, 2 ed. Springer, New York, NY 2.

Chatfield,C.(2000).TimeSeriesForecasting.Chapman&Hall/CRC,BocaRaton,FL.

Box, G. E. P., Jenkins, G. M., &Reinsel, G. C. (1994). Time Series Analysis: Forecasting and Control. Prentice - Hall, Inc., Upper Saddle River, NJ.

Yaffee,R.andMcGee,M.(2000).IntroductiontoTimeSeriesAnalysisandForecastingwith Applications of SAS and SPSS. Academic Press, Inc., San Diego, CA.

Wei, W. W. S. (2006). Time Series Analysis: Univariate and Multivariate Methods (2ed.).Pearson, Boston, MA

EE402 HVDC TRANSMISSION (3-1-0) 4

Need, Basic principle of conversion, economics of different configurations, The Graetz bridge circuit, analysis, overlap, firing delay, inversion, converter control, tap-changing control, power reversal, measuring devices, filters, circuit breaker, lighting arrester, DCCT, MRT. MTDC systems, interaction between AC and DC Systems, voltage stability, power modulation, Introduction to Voltage Source Converter based HVDC System, future of the HVDC transmission systems, research and development

E. W. Kimbark, Direct Current Transmission.
K. *R. Padiyar, Power Transmission by Direct Current, Wiley Eastern, 1990.*
Recent Publications of relevance.

EE403 DEEP NEURAL NETWORK AND ITS APPLICATIONS (3-0-2)4

A brief history of deep learning and its success stories. Perceptron's, Sigmoid neurons and Multi-Layer Perceptron's

(MLP) with specific emphasis on their representation power and algorithms used for training them (such as Perceptron Learning Algorithm and Backpropagation). Gradient Descent (GD) algorithm and its variants like Momentum based GD, AdaGrad, Adam etc Principal Component Analysis and its relation to modern Autoencoders. The bias variance trade off and regularisation techniques used in DNNs (such as 12 regularisation, noisy data augmentation, dropout, etc). Different activation functions and weight initialization strategies Convolutional Neural Networks (CNNs) such as AlexNet, ZFNet, VGGNet, InceptionNet and ResNet. Recurrent Neural Network (RNNs) and their variants such as LSTMs and GRUS (in particular, understanding the vanishing/exploding gradient problem and how LSTMS overcome the vanishing gradient problem) Applications of CNN and RNN models for various computer vision and Natural Language Processing (NLP) problems. Laboratory exercises to implement the algorithms and conduct experiments to evaluate their performance

Goodfellow, 1, Bengio, Y, and Courville, A., Deep Learning, MIT Press, 2016
Bishop, C., M., Pattern recognition and Machine learning, Springer, 2006
Yegnonarayana, B., Artificial Neural Network PHI learning Pvt Ltd, 2009
Golub, G.H., and Van Loan, C.F., Matrix computation, JHU Press, 2013
Simon S. Haykin, Neural Networks and Learning Machines, 3rd Ed, Pearson, 2009.

EE404 SOFT COMPUTING AND APPLICATIONS (3-1-0) 4

Introduction to intelligent systems and soft computing, Intelligent systems, Knowledge-based systems, Knowledge representation and processing. Soft computing, Fundamentals of fuzzy logic systems, Fuzzy Sets, operations, relations, fuzzy logic, fuzzy control, Composition and inference, Considerations of fuzzy decision-making, neural networks – Single layer, multilayer networks, Features of artificial neural networks, learning, Fundamentals of connectionist modelling, BP algorithm, Major classes of neural networks, The multilayer perceptron, Radial basis function networks, Kohonen's self-organizing network, Industrial and commercial applications of ANN such as optimal control, manufacturing, power systems, robotics, etc. , neuro-fuzzy systems, Architectures of neuro-fuzzy systems, Neural network- driven fuzzy reasoning, Hybrid neuro-fuzzy systems, Construction of neuro-fuzzy systems, Evolutionary computing, Integration of genetic algorithms with neural networks, Integration of genetic algorithms with fuzzy logic, Known issues in GA and applications.

Karray, Fakhreddine O. , and Clarence W. De Silva. Soft computing and intelligent systems design: theory, tools, and applications. Pearson Education, 2004.
J. *S. R. Jang, C. T. Sun, E. Mizutani, Neuro-Fuzzy and Soft Computing – A Computational Approach to Learning and Machine Intelligence, PHI, 2002.*
M. Negnevitsky, Artificial Intelligence, A Guide to Intelligent Systems, Pearson Publishing, 2006
C. T. Lin and C. S. Lee, Neural Fuzzy Systems, Prentice Hall Publishing, 1995
Timothy J. Ross, Fuzzy Logic with Engineering Applications, McGraw-Hill, 1997. Simon Haykin, Neural Networks – A Comprehensive Foundation, Prentice Hall, 1999.
David E. Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning, Pearson Education, 2003.

EE406 ELECTROMAGNETIC COMPATIBILITY (3-1-0) 4

Review of EM theory. EMI from apparatus and circuits. EMI measurements. Shielding and grounding. EMI filters. Electrostatic discharge. EMC standards.

H. W. Ott, Noise Reduction Techniques in Electronic Systems.
V. Prasad Kodali, Engineering Electromagnetic Compatibility, S. Chand & Co.

EE407 MODELLING OF ELECTRICAL MACHINES (4-0-0) 4

Basics of Electromagnetic Energy Conversion, modellingof electromechanical systems, basic concepts of Rotating Machines, Modelling of DC Machine, Three phase induction machines – Types, modelling, analysis of transformation methods Salient pole synchronous machines- modelling, analysis of transformation methods Permanent magnet synchronousmachine:operatingprincipleof surfacepermanent magnet and interior permanent magnet machines. square and sinusoidal back emf type, modelling, analysis of transformation methods.

W.Leonhard,ControlofElectricalDrives,SpringerVerlag,1985.
P.C.Krause,AnalysisofElectricMachinery,McGrawHill,NewYork, 1987.
Electric motor drives: modelling, analysis, and control, Ramu Krishnan, Pearson Education India, 2001, 1st Edition.

EE408 SOLID-STATE DRIVES (3-1-0) 4

Separately excited dc motor drive: Operation and performance, single-phase fully controlled converter, operation on dual converter. Chopper drive: operation and performance calculation on class A, class C, and class E choppers. Induction motor drive: Stator voltage control with constant supply frequency, qualitative comparison of converter combinations, slip energy recovery scheme, VSI fed induction motor, CSI fed induction motor, synchronous motor

drive, VSI drive, brushless excitation, true synchronous and self-controlled operation, performance with PMSM and synchronous reluctance motor.

S. B. Dewan, G. R. Slemon, A. Straughen, Power Semiconductor Drives, John Wiley and Sons, 1984.
W. Shepherd, L. N. Halley, D. T. W. Liang, Power Electronics and Motor Control, 2nd Edition, Cambridge University Press, 1998.
Vedam Subrahmanyam, Electric Drives – Concepts and Applications, TMH, 1994.
G. K. Dubey, Power Semiconductor Controlled Drives, Prentice Hall, 1989.

EE410 POWER SYSTEM PROTECTION (3-1-0) 4

Introduction to power system protection, Review of conventional power system protection schemes, power apparatus protection: viz. transformer, motor, generator, bus bar, transmission and distribution line protection schemes, Introduction to computer aided protection, numeric relay hardware design, digital protection algorithms, recent trends in power apparatus protection methodology, concepts of adaptive relaying and application of soft computing methods in numeric relaying.

Warrington, Protective Relays – Their theory and practice, Volumes. I, II, and III, Chapman and Hall.
Arun G. Phadke, J. S. Thorpe, Computer Relaying for Power Systems, Research Studies Press.
Gerhard Ziegler, Numerical Distance Protection: Principles and Applications.
A. T. Johns, S. K. Salman, Digital Protection for Power Systems, IEE, 1995.
M. *S. Sachdev (Coordinator), IEEE Tutorial Course on Advancement in Microprocessor-based Protection and Communication, IEEE, 1979.*

EE411 OPERATION OF POWER SYSTEMS UNDER DEREGULATION (3-1-0) 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, M. H J Bollen and J. E Daalder, "Operation of Restructured Power Systems", Kluwer Academic Publisher, USA, 2001.
L. Philipson and H. L. Willis, "Understanding Electric Utilities and Deregulation", Marcel Dekkar Inc. 1999.
M. Shahidehpour and M. Alomoush, "Restructured Electrical Power Systems, Operation, Trading and Volatility", Marcel Dekkar Inc. 2001.
Steven Stoft, "Power System Economics: Designing Markets for Eligibility". John Wiley & Sons, 2002

EE412 RANDOM SIGNAL PROCESSING (3-1-0) 4

Random signal processing: Review of probability and random variables, Mathematical description of random signals, response of linear systems to random inputs, Wiener filtering,. basic estimation theory, discrete Kalman filter, state-space modeling and simulation, nonlinear estimation.

Athanasios Papoulis, Probability, Random variables, and Stochastic Processes, McGraw-Hill, 1991.
R. G. Brown, P. Y. C. Hwang, Introduction to Random Signals and Applied Kalman Filtering, John Wiley and Sons, 1997.
A. P. Sage, James L. Melsa, Estimation Theory with Applications to Communications and Control, McGraw-Hill, 1971.

EE415M POWER ELECTRONICS IN POWER CONTROL (3-1-0) 4

Devices: Characteristics- diode, BJT, IGBT, MOSFET, IPMs, Thyristor based devices: SCRs/TRIAC/GTOs. Reactive elements: capacitors, inductor, transformer, pulse transformer. Data sheets, switching and conduction losses, heat dissipation- heat sink, loss calculation. Drive circuit, current and voltage sensors, opto-couplers. Functional classification of converters: DC-DC converters - switched mode buck converter, switched mode boost converter: control circuit, snubber, applications. Inverters: H-Bridge, single-phase, three-phase inverters. Rectifiers: single-phase and three-phase rectifiers. AC power controllers. Simulations of power electronic converters.

Ned Mohan,Undeland, Robbins, Power Electronics, 3rd edition, John Wiley.
M H Rashid, Power Electronics, 3rd edition, PHI.
P C Sen, Power Electronics, Tata McGraw-Hill Publishing Company Ltd.
Bimal K Bose, Modern power electronics and ac drives,PHI.
L Umanand, Power Electronics, Wiley India Pvt Ltd

EE418 ADVANCED POWER ELECTRONICS (3-1-0) 4

Power devices, design of inductors, transformers, selection of core, design of capacitors, selection of capacitors for different applications. AC to DC converters, multilevel inverters, DC to DC converters, hard switch converters,

design and analysis, isolated converters, resonant converters.
Ned Mohan, Undeland, Robbins, Power Electronics.
M. H. Rashid, Power Electronic Circuits – Devices and Applications.

EE420 POWER SYSTEM DYNAMICS (3-1-0) 4

Power system component modeling for dynamic studies: Synchronous generator modeling, exciter and turbine modeling, load modeling. System stability analysis: Angle stability (small signal and large signal), voltage stability, frequency stability.
K. R. Padiyar, Power System Stability and Control, Interline, 1996.
Prabha Kundur, Power System Stability and Control, McGraw-Hill, 1994.

EE422 PRINCIPLES OF SWITCHGEAR AND PROTECTION (3-1-0) 4

Fuses and switches, methods of earthing, Circuit breakers. circuit breaker ratings, auto reclosure. Protective relaying, fundamental characteristics. Relay classifications, differential protection schemes. Transformer protection. Buchholtz relay. Alternator protection: Negative phase sequence relay, loss of field protection. Line protection: Over current relays and schemes, distance relays and schemes, carrier current relaying. Induction motor protection: Abnormal operating conditions. Solid state relays: Comparators, duality between phase and amplitude comparators. Realization of directional, Ohm, reactance, impedance and Mho characteristics using the general characteristic equation, static distance relays. Computer aided relaying: Introduction to microcomputer based relays, General functional diagram of microcomputer-based relays.
Ravindranath, Chander, Power System Protection and Switchgear, Wiley Eastern, 1994.
C. L. Wadhwa, Electrical Power Systems, 2nd Edition, PHI, 1993.
Arun G. Phadke, S H Horowitz, Power System Relaying, 2nd Edition, John Wiley, 1995.
Badriram, D. N. Vishwakarma, Power System Protection and Switchgear, TMH, 1995.

EE423 SWITCHGEAR AND PROTECTION LABORATORY (0-0-3)2

Laboratory exercises and assignments to provide additional support to EE422. The course will have experiments related to: Fuses and fuse elements. Study of Induction motor starters. Study of MCCB and ELCB. Circuit breakers and their control circuits. Over current, Earth fault, Differential protection, Phase unbalance, Under frequency, Thermal and other relays and protective schemes

EE427 COMPUTER NETWORKS (3-1-0) 4

Introduction, physical layer, data link, media Access, network layer, transport layer, ATM, applications.
Andrew S. Tanenbaum, Computer Networks, Pearson Education.

EE428 THE ARM CORE: ARCHITECTURE AND PROGRAMMING (3-1-0) 4

The ARM design philosophy, ARM processor fundamentals – registers, current program status register, pipeline, exceptions, interrupts and the vector table, core extensions, architecture revisions, ARM processor families. The ARM instruction set: Data processing instructions, branch instructions, load-store instructions, software interrupt instructions, program status register instructions, conditional execution. The THUMB instruction set, THUMB register usage, ARM-THUMB interworking. Writing assembly code, profiling and cycle counting, instruction scheduling, register allocation, looping constructs, bit manipulation, efficient switches, unaligned data handling. GNU assembler. Optimized primitives, exception and interrupt handling. Rudimentary aspects of embedded operating systems.
David Seal (Ed.), ARM Architecture Reference Manual, 2nd Edition, Addison-Wesley, 2001.
Steve Furber, ARM Sytem-on-Chip Architecture, 2nd Edition, Addison-Wesley, 2000.
Andrew N. Sloss, Dominic Symes, Chris Wright, ARM System Developer's Guide, Elsevier, 2004.
ARM Limited, ARM v7-M Architecture Application Level Reference Manual, ARM Limited, 2006.

EE430 INTRODUCTION TO ROBOT DYNAMICS AND CONTROL (3-0-2) 4

Introduction to robotics: History of robots, components and structures of robots, rigid motion and homogeneous transformations: representing position and rotation, rotational transformations, composition of rotations, parameterization of rotation, homogeneous transformations, Forward Kinematics, Inverse kinematics, velocity kinematics- the manipulator Jacobian, Dynamics: Euler-Lagrange equations, generalized expression for potential and kinetic energy, properties of robot dynamic equations, equation of motion, Independent joint control: set point tracking using classical control. Laboratory exercises and assignments to supplement the course.
M. W. Spong, S. Hutchinson and M. Vidyasagar, Robot Dynamics and Control by, John Wiley & Sons, 2008.
Craig, John J. Introduction to robotics: mechanics and control. Vol. 3. Upper Saddle River: Pearson Prentice Hall,

2005.
Sciavicco L, Siciliano B. Modelling and control of robot manipulators. Springer Science & Business Media; 2012

EE432 INTRODUCTION TO 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.
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.
T. *Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2e, 2008.*
Christopher Bishop. Pattern Recognition and Machine Learning. 2e.

EE439 ADVANCED POWER ELECTRONICS LABORATORY (0-0-3) 2

Laboratory exercises and assignments to provide additional support to EE418.

EE443 MATHEMATICAL MORPHOLOGY AND APPLICATIONS TO SIGNAL PROCESSING (3-1-0) 4

Introduction to Mathematical morphology: Minkowski addition and Minkowski subtraction, Introduction to the lattice theory, Structuring elements and its decomposition. Fundamental Morphological Operators: Erosion, Dilation, Opening, Closing, Binary vs Greyscale Morphological operations. Hit-or-Miss transform, Skeletons, Morphological reconstructions, Thinning, Thickening: Hit-or -Miss transformation, Skeletonization, Coding of binary image Via Skeletonization, Skeletonization by influence Zones(SKIZ), Weighted SKIZ, Medial Axis Transformation(MAT), Skeletonization Via Euclidean Distance Transformation, Partial Skeletons, Morphological Shape Decomposition(MSD), Morphology Thinning, Thinking, pruning, MSD Vs SKIZ. Morphological Filtering and Segmentation:Multi- scale Morphological Transformation, Top – Hat and Bottom Hat Transformation, Alternative Sequential filtering, Segmentation, Watershed Segmentation, Connected Operators for Segmentation, Hierarchical Segmentation Vs Watersheds, Markers, Hierarchical Segmentation, Geodesic active contours. Geodesic Transformation and Metrics: Geodesic Morphology, Graph – Based Morphology. Euclidean Metric, Geodesic Distance (Shortest path), Dilation distance, Hausdorff Dilation and Erosion distances. Applications of Mathematical Morphology

J. Serra, Image Analysis and Mathematical Morphology, Academic Press London, 1982.
J. Serra, Image Analysis and Mathematical Morphology: Theoretical Advance, Academic Press, 1988.
N. A. C. Cressie, Statistics for Spatial Data, John Wiley, 1991.
P. Soille, Morphological Image Analysis, Principles and Applications, 2nd Edition, Springer Verlag. 2003.
L. Najman and H. Talbot (Eds.), Mathematical Morphology, Wiley, 2010.
B. Chanda and D. Dutta Majumdar, Digital Image Processing and Analysis, 2nd edition, New Delhi: PHI Learning Pvt. Ltd. , 2011,
B. S. Daya Sagar, Mathematical Morphology in Geomorphology and GISci, Chapman & Hall/CRC Press, FL. 2013,

EE448 SEMINAR 01

This course is a 1 credit course to be completed during 8th semester. The student will make presentations on topics of academic interest.

EE449 MAJOR PROJECT-I (0-1-3) 3

EE450 Fundamentals of Electric Vehicles (3-1-0) 4

Introduction to EVs, configurations of EVs, design & sizing of EV power train, EV Battery and management system, state-of-art power electronics for EVs, introduction to wired and wireless chargers, Charging infrastructure, EV motors,
EV standards, case studies.

G Abas Goodarzi and John G. Hayes, "Electric Powertrain. Energy Systems, Power Electronics and Drives for Hybrid,
Electric and Fuel Cell Vehicles, Wiley Publishers, November 2017
CC Chan, KT Chou: Modern Electric Vehicle Technology, Oxford University Press Inc.New York 2001
Mehrdad Ehsan, Vimi Gao, Sebastian E. Giay, All Emad Modern Electric, frybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004
Holthem Abu-Rub, Manusz Malinowski, Kamal Al-Haddad, "Power Electronics for Renewable Energy Systems, Transportation and Industrial Applications", Wiley Publishers, June 2014
Stephen Chapman Electric Machinery Fundamentals, 4th Edition (McGraw-Hill Series in Electrical and Computer Engineering)-McGraw-Hill, 2003

EE454 FLEXIBLE AC TRANSMISSION SYSTEMS (3-1-0) 4

Transmission system performance, compensation approaches, static var systems, VSI based FACTS controllers – STATCOM, UPFC, TCSC, TCPAR, TCBR. Applications: Transient stability improvement. Introduction to custom power.

K. R. Padiyar, Power System Dynamics, Stability and Control, 2nd Edition, B. S. Publishers.
Prabha Kundur, Power System Stability and Control, McGraw-Hill EPRI Power System Engineering Series, 1994.
Narain G. Hingorani, Laszlo Gyugyi, Understanding FACTS – Concepts and Technology of Flexible AC Transmission Systems, IEEE Press, 2001.

EE456 HIGH-VOLTAGE ENGINEERING (3-1-0) 4

Electric breakdown in solid, liquid and gas dielectrics. Generation of high AC, DC and impulse voltages. Impulse current generators. Methods of measuring high AC, DC and impulse voltages and current. Partial discharge.

E. Kuffel, Zengal, High Voltage Engineering.
D. Kind, An Introduction to High Voltage Experimental Techniques.
Kamaraju, Naidu, High Voltage Engineering.
C. L. Wadhwa, High Voltage Engineering.

EE458 PHOTOVOLTAICS AND APPLICATIONS (3-1-0) 4

Overview of PV systems, relevance and adaptology, economics and efficiency, insolation and its measurement, types of cells. Elements of solar cell operation, light absorption and carrier generation in semiconductors,conversion efficiency and factors affecting it, Processing techniques. Concentrators, stand-alone inverters, grid operation, issue of energy storage, general applications, large PV power systems, rural power supply systems, Issues in developing countries, unconventional cell systems.

Chenming Hu, R. M. White, Solar cells- From Basic to Advanced Systems, McGraw-Hill.

EE464 POWER GENERATION AND ECONOMICS (3-1-0) 4

Hydro, thermal and nuclear power plants. Electrical equipments in generating stations. Load forecasting and sharing. Economic operation of power systems. Economic choice of transformers and electric motors.

M. *V. Deshpande, Elements of Power Station Design.*
G. P Chalotra, Electrical Engineering Economics.
S. Domkundwar, S. C. Arora, A Course in Power Plant Engineering.

EE466 UTILIZATION OF ELECTRICAL ENERGY (3-1-0) 4

Electric Traction: Requirements of an ideal traction system, requirements of ideal traction motors, comparison and control of traction motors, mechanics of train movement, tractive effort for acceleration,train resistance, gradient, coefficient of adhesion, speed time curves, specific energy consumption. Electric heating: methods of heat transfer, resistance heating, design of heating element, induction heating, eddy current heating, dielectric heating. Electric welding: resistance welding, arc welding. Electrolytic processes: Faraday's laws of electrolysis, Calculation of current required and related definitions, Factors governing the character of deposits, preparation of work for electroplating, electro-extraction. Illumination : Laws of illumination, lighting calculations, polar curves, Rousseau's construction.

Partab, Art and Science of Utilization of Electrical Energy.
E. O. Taylor, Utilization of Electric Energy.
C. L Wadhwa, Generation,Distribution and Utilization of Electrical Energy.

EE467 INDUSTRIAL ELECTRICAL SYSTEMS (3-0-0) 3

Overview of electrical systems in manufacturing, chemical, metallurgical, process industries, electric traction, electric heating, electric welding, electroplating, illumination and case studies.

Partab, Art and Science of Utilization of Electrical Energy.
E. O. Taylor, Utilization of Electric Energy.
C. L Wadhwa, Generation,Distribution and Utilization of Electrical Energy.

EE468 ADVANCED ELECTRIC DRIVES (3-1-0) 4

Electric Drives: DC drives, modeling, analysis and simulation. Space phasors, modeling of brushless DC motor, modeling of induction motor, vector control of brushless DC motor. Induction motor drive: V/f control, vector control of induction motor, DT control of induction motor drives.
W. *Leonhard, Electric Drives, Springer Verlag.*
B. K. Bose, Power Electronics and AC Drives.

EE469 NEW AND RENEWABLE ENERGY SYSTEMS (3-0-0) 3

Concept of renewable energy, design and implementation aspects of renewable energy systems employing solar energy, wind energy, chemical energy sources. Energy from the ocean and tides. MHD generation, thermo electric power. Geothermal energy. Energy from bio-mass.
G. *D. Rai, Non-conventional Energy Sources.*
P. S. Sukhatme, Solar Energy.

EE470 COMPUTATIONAL TECHNIQUES FOR LARGE SYSTEM ANALYSIS (3-1-0) 4

Solution of linear system of equations, solution of nonlinear system of equations, sparsity techniques, numerical integration techniques: explicit methods, implicit methods, fixed step methods, variable step methods, stability and accuracy-analysis of numerical methods, numerical calculation of eigenvalues, EMTP simulation techniques.
Steven C. Chapra, R. P. Canale, Numerical Techniques for Engineers, TMH, 2000.
*Mariessa Crow, Computer Techniques for Large Electric Power Systems, CRC Press, 2003***.**

EE471 POWER SYSTEM SIMULATION LABORATORY (0-0-3)2

Developing computer programs related to some of the techniques/methods and its application to power system analysis to provide additional support to EE470.

EE472 INSULATION AND TESTING ENGINEERING (3-1-0) 4

Introduction, review of test sources and measurement associated with insulation studies. Insulation types: solids, liquids, gases and vacuum, properties and characteristics. Dielectric strength and permittivity, methods of measurements, theories of breakdown. Testing of transformer oil, Schering bridges for tan-delta measurement. Measurement of insulation resistance of solids: Bulk and surface. PD measurements. Testing of cables IR, PI, step test, tan delta, PD. Treeing tracking. Radio interference measurements, RI and RIV. Testing of insulators, power transformers, Impulse testing, testing of rotating machines. Accelerated ageing tests and life estimation. Testing of surge diverters, bushings, insulators. Testing of rubber mats. Testing of Gas Insulated Substations.
Kamaraju, Naidu, High Voltage Engineering.
Kuffel, Zeangle, High Voltage Engineering.
Relevant Indian standards and Technical papers.

EE476 INTRODUCTION TO NONLINEAR AND LINEAR OPTIMISATION (3-1-0) 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.

EE489 ADVANCED ELECTRIC DRIVES LABORATORY (0-0-3) 2

Laboratory exercises and assignments to provide additional support to EE468.

EE491 INSULATION AND TESTING ENGINEERING LABORATORY (0-0-3) 2

Laboratory exercises and assignments to provide additional support to EE472**.**

EE498 PRACTICAL TRAINING 01

This course is a 1 credit course. A student may complete the practical training before the beginning of 7^{th} semester (or as stipulated by DUGC) and register for it in 7^{th} Semester. The duration and the details shall be decided by the faculty advisor, with approval from DUGC.

EE499 MAJOR PROJECT-II (0-1-3) 3

EE500 SYSTEM ANALYSIS IN DISCRETE TIME (3-1-0) 4

The calculus of finite differences; Operators and their properties; Inverse operators. Difference equations and their solutions. Linear difference equations with constant coefficients, general and particular solutions. Discretization of differential equations. Modeling and analysis of LTI lumped-parameter systems in discrete time.

Kelley W. G. , Peterson A. C. , " Difference Equations: An Introduction with Applications", 2nd Edition, Elsevier, 2001.

Goldberg S. , "Introduction to Difference Equations", 2nd Edition, Dover, 1986.

Elaydi S. , "An Introduction to Difference Equations", 3rd Edition, Springer International Edition, 2008.

EE501 ANALYSIS OF NONLINEAR CIRCUITS (3-1-0)4

Nonlinear circuit elements, v-i characteristics, energy and power considerations. Time-varying elements, multiterminal elements. Resistive nonlinear circuits, graphical analysis. Dynamic nonlinear networks, autonomous and non-autonomous networks. Analysis of memristive circuits.

Chua L. O. , "Introduction to Nonlinear Network Theory", McGraw-Hill, 1969.

Chua L. O. , Desoer C. A. , Kuh E. S. , "Linear and Nonlinear Circuits", McGraw-Hill, 1987.

EE502 CORNERSTONE/CA|STONE PROJECT (0-2-3) 4

For details refer to clause 3.2 under Regulations specific to Undergraduate Programmes.

UC100 INTRODUCTION TO DESIGN THINKING (2-0-0) 2

Need and Definition of Design Thinking. Framework for Design Thinking. Engineering Design Process. Need Identification, Specification, Concept Generation, Product Architecture and Detailed Design. Prototyping – Virtual and Physical. Testing Methodology

Christian Muller-Roterberg, "Handbook of Design Thinking", 2018

Eli Woolery, "Design Thinking Handbook" Invision Pub, 2019

Nigel Cross, "Design Thinking"

Max Answell "Mastering Design Thinking", 2019

Karl T. Ulrich, Steven D. Eppinger and Maria C Yang, "Product Design and Development", McGraw Hill, 7ed, 2020

George e Dieter, Linda C Schmidt, "Engineering Design", Mc Graw Hill, 4ed, 2009

UC401 LIBERAL ARTS COURSES/CO-CURRICULAR/EXTRACURRICULAR ACTIVITIES 10

CATEGORY A : Maximum 3 credits, CATEGORY B : Maximum 3 credits, CATEGORY C : Minimum 4 Credits and Maximum 7 credits.

10 Credits have to be earned from 1st Semester to 7th Semester by choosing Category (A + B + C) OR Category (A + C) or Category (B + C) courses combination . Registration for 10 Credits has to be done in 7th Semester.

For details of CATEGORY A, CATEGORY B and CATEGORY C refer to clause 3.2 (f) under Regulations specific to Undergraduate Programmes.

EC100 ELEMENTS OF ELECTRONICS & COMMUNICATION ENGINEERING (2-0-0) 2

(For Computer Science,Mechanical, Civil, Mining, Metallurgy, Chemical Engineering branches only)
RC & RL Circuits – low pass, high pass, transient analysis for pulse input; Diode: Principle, Characteristics, Applications & Types, Transistor: Principle, Operation, Biasing (DC analysis of CE, CB and CC configuration), Transistor as a switch; Digital Circuits: Basic Logic gates, Universal gates, Boolean Algebra, Combinational circuits, Op-amps & their Applications, Introduction to few systems (only Block level) : ADC, DAC, Linear power supply, SMPS, UPS, Principles of Communication Systems.

Albert Malvino, Electronic Principles, Tata McGraw Hill, 1995
Boylstead and Nashelsky, Electronic Devices and Circuits, PHI, 1998
George Kennedy & Bernard Davis, Electronic Communication System, Tata McGraw Hill,
1996 Wayne Tomasi, Electronic Communication Systems, Pearson Education, 2003 Ramakant
A Gayakwad, OP-AMPS and Linear Integrated Circuits, Prentice Hall, 1999

EC101 JOY OF ELECTRONICS AND COMMUNICATION (2-0-3) 4

Study and hands on exposure of Electronic devices, instruments and circuits required for system design. Validation of relevant concepts using hardware/software tools.

Class notes and lab manual

EC102 CIRCUITS AND SYSTEMS (3-1-0) 4

DC Circuit Analysis - Circuit concept, circuit elements, independent and dependent sources, network reduction techniques (star-delta), network equations, node voltage and mesh current analysis, Network Theorems - Superposition, Thevenin' s and Maximum power transfer theorems. First order systems - Analysis of RL and RC circuits, representation of systems using differential equations, solution of differential equations, Transient and steady state response, time constant, initial conditions, coupled circuits. Laplace Transform: Definition and properties, inverse transforms, partial fraction expansion. Second order systems - RLC circuits, characteristic equation, damping, natural frequency, time domain specifications of systems. Transform domain analysis of circuits, equivalent sources for initial conditions, transform circuits, Impedance functions and Network Theorems, transfer function, impulse response, convolution, linear time invariant systems, poles and zeros, stability, steady state sinusoidal response. Discrete time signals - sampling of sinusoids, complex exponentials and phasor, Spectrum representation – spectrum of sum of sinusoids, Periodic signals, Fourier series representation, sinusoidal synthesis, spectrum view on sampling, aliasing, sampling theorem, reconstruction. Discrete time systems – moving average filter, general FIR filter, impulse response, implementation of FIR filter, convolution, linear time-invariant systems, frequency response of FIR systems, examples of FIR filtering in signal denoising

W.Nillson and SA Riedel, Electric Circuits, PHI, 2000
RC.Dorf and J.A. Svoboda, Introduction to Electric Circuits, Wiley, 2009
Mc Chellan, R.W. Schafer & Yoder, Signal Processing First, Pearson 2003.

EC200 DIGITAL SYSTEM DESIGN (3-1-0) 4

Introduction to Digital Systems and Boolean Algebra Binary, Logic Minimization and Implementation, Karnaugh-maps, NAND and NOR implementation, Quine-McCluskey method, Logic families, Combinational Logic Multi levelgate circuits, Parity circuits and comparators, Representation of signed numbers, Introduction to HDL (VHDL/Verilog), Register transfer language, Sequential Logic Latches and flip-flops, Registers and counters, HDLdescription of sequential circuits, State Machine Design, State machine as a sequential controller, Moore and Mealy state machines, Derivation of state graph and tables, Sequence detector, equivalent state machines, State machine modelling based on HDL, Linked state machines, Advanced Topics: Static and Dynamic hazards; race free design;

Charles. H. Roth, Jr., Fundamentals of Logic Design, Fifth Edition, Thomson Brooks /Cole, 2005.
J.F.Wakerly,Digital Design Principles and Practices, PH, 1999.
D.D. Givone, Digital Principles and Design, TMH, 2002
Morris. M. Mano, Michael D. Ciletti, Digital Design, Fourth Edition, Prentice-Hall India. 2008.
S. Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Second Edition, Pearson Education, 2004.
S. Brown and Z. Vranesic, Fundamentals of digital logic with Verilog design, Third Edition, McGraw-Hill, 2013
Charles. H. Roth, Jr., Digital System Design using VHDL, Indian Edition, Thomson Brooks /Cole, 2006.

EC201 ANALOG ELECTRONICS (3-1-0) 4

Voltage and current sources, Controlled sources, Two port networks:, ladder networks, Feedback Concepts: Feedback topologies, Positive and Negative feedback, Sensitivity factor, Basic amplifiers and their two port representation, Effect of Negative feedback on basic amplifiers, Instability in amplifiers, Barkhousen condition for Oscillations,

Nyquist stability criterion, Operational Amplifiers, Non-idealities of opamps and their effects: Finite gain, finite bandwidth, Offset voltages and currents, Common-mode rejection ratio, Power supply rejection ratio, Slew rate, Filters : Second order filter transfer function (low pass, high pass, band pass and band reject) , Butterworth response, Emulation of inductor using Transconductors,, Sallen-Key biquadratic filters, Tow-Thomas biquad, Realization of higher order filters, All-pass filter (active phase shifters), Comparator, Schmitt trigger (inverting & non inverting), astable multivibrator, Triangular wave generator, Precision rectifiers, Voltage Controlled Oscillators, Phase Locked Loops

Behzad Razavi, Fundamentals of Microelectronics, Second edition, Wiley, 2013
A. Sedra, K. Smith, Microelectronic Circuits: Theory and Applications OUP 6th Ed. 2013
Sergio Franco, Design with OPAMPS and Linear Integrated circuits, Tata McGraw Hill, 2002.

EC202 ANALOG & DIGITAL COMMUNICATION (3-1-0) 4

Review of Communication Signals and Systems, Amplitude Modulation, Analytical signals, Complex envelope representation, FDM, Super Heterodyne receiver, Angle Modulation: FM and PM signal generation, Demodulation of FM signals, FM broadcasting, and FM stereo, Noise Performance of Analog Communication Systems, Capture effect, Pre-emphasis and De-emphasis in FM Systems. Digital Communications: Sampling theorem for low pass & band pass signals; Baseband Modulation: Pulse modulation, Pass band Modulation: ASK, FSK,PSK, M-ary systems. Matched filter, Correlation receiver, performance of optimum detector, Synchronization. CPM, Digital Transmission through Band-limited AWGN Channels: Zero-ISI (Nyquist criterion), Partial response signals, Detection of partial response signals, Maximum likelihood sequence detection, Error probability, Channel Equalization: ZF, MSE, Adaptive Equalizers.

M. F. Mesiya, "Contemporary Communication Systems", McGrawHill, 2013.
Taub and Schilling, "Principles of Communication systems", Second Edition, Tata McGrawHill, 2006 (34th reprint).
Proakis and Salehi, "Fundamentals of Communication Systems", Second Edition, Pearson International, 2014.
U. Madhow, "Fundamentals of Digital Communication," Cambridge University Press, 2008.
Won Y Yang , Prashanth Kumar H., "MATLAB/Simulink for Digital Communication", Second Edition, SIP-Hongrung (S. Korea), 2012.
Simon Haykin, "Communication Systems", Fourth Edition, Wiley, 2000.

EC203 LINEAR ALGEBRA AND PROBABILITY THEORY (3-1-0) 4

System of Equations, basic solutions, Echelon matrices, Linear independence, Rank, Inverse, Similarity, Eigen value analysis and Diagonalization, Vector Spaces: Linear Transformations, Subspaces, Linear Independence, Basis, Orthogonal Transformations. Probability – Review of probability, Joint and Conditional probability, Bayes theorem. Random Variable - Definition, discrete and continuous, probability distribution and density, mass functions, Joint and conditional distributions, Expectation, random vectors, vectorised expectation – mean and covariance, Random processes – definition, characterization, Stationarity. Gaussian random process, Central limit theorem.

Gilbert Strang: Linear algebra and its applications, Thomson Brooks, 2006.
Edgar G. Goodaire, Linear Algebra: A Pure & Applied First Course, World Scientific, 2014.
Dimitri 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, 1994.
A Papoulis , S Pillai, Probability, Random Variables and Stochastic Processes, 4th Ed, McGraw-Hill, 2002.

EC204 DIGITAL SYSTEM DESIGN LAB (0-0-3) 2

Experiments using basic logic gates; Design of combinational circuits using HDL. Design of adders and magnitude comparators; realization using multiplexers and other approaches; Design of sequential circuits including flip-flops, counters and registers.

Class notes & Lab manual

EC205 ANALOG ELECTRONICS LAB (0-0-3) 2

Design of full wave rectifier; Regulated Power Supply, Design with RC circuits – AC analysis, OPAMPS Linear applications, OPAMP non-linear applications. *Simulation Experiments:* Above experiments will be validated through simulation.

Class notes & Lab manual

EC206 MICROPROCESSORS (3-1-0) 4

Introduction to computer organization, CISC and RISC processors, concept of pipelining, concept of Microcomputer and microcontroller. Introduction to ARM based processor: Processor overview, introduction to programming model, processor and memory organization, concept of stack, introduction to processor instruction set, addressing modes,

instruction encoding. Processor implementation, organization and execution: Instruction datapath, timing, processor modes, exceptions, protected mode operation. Hardware interfacing: Introduction to memory, IO interfacing, Concepts of memory mapped and IO, mapped IO.

Steve Furber, "ARM System Architecture", Edison Wesley Longman, 1996.
William Hohl, "ARM Assembly Language- Fundamentals and Techniques ", CRC Press, 2009
Andrew N. Sloss, Dominic Symes, Chris Wright, "ARM System Developer's Guide: Designing and Optimizing System Software", Elsevier, 2004.
D.A. Patterson and J. Hennessy, Computer Organization & Design, The Hardware/software interface, Elsevier Inc, ARM Edition, 2010.
Lab manuals Online ARM programming reference and guide

EC207 ELECTROMAGNETIC WAVES AND TRANSMISSION LINES (3-1-0) 4

Review of coordinate systems, vector calculus, static electric and magnetic Fields; derivation and solution to Maxwell's Equations. Plane wave propagation in different media. Power and Poynting 's Theorem. Reflection, Transmission, and Refraction of Waves at Media Interfaces, Polarization. Comparison of circuit and field theory concepts. Guided Waves in Transmission Lines, Smith Charts, Transients in Transmission Lines, Impedance matching, Metallic Waveguides, Introduction to planar and dielectric Waveguides.

Martin A. Plonus, Applied Electromagntics, McGrawHill, 1988
Matthew N. O. Sadiku, Elements of Electromagnetics 6th Edition, Oxford University Press 2015
Umran S. Inan and Aziz Inan, Engineering Electromagnetics, Prentice Hall, 1999
David H. Staelin, Ann W. Morgenthaler, Jin Au Kong, Electromagnetic Waves, Prentice Hall, 1994.
John D Ryder, Networks, Lines and Fields, Second Edition, 2015.
Basu B. N, Engineering Electromagnetics Essentials, Universities Press, 2015.

EC208 DIGITAL SIGNAL PROCESSING (3-1-0) 4

Time domain analysis of discrete-time systems - Basic discrete time signals, operations and properties, mathematical view, Introduction to sampling, Nyquist theorem. Systems – properties, linear time invariant systems, impulse response, convolution, causality and stability. Difference equations. Transform domain analysis of discrete-time systems -Z Transform – definition and properties, ROC, transfer function, poles and zeroes, application to discrete systems.

Representation of systems – signal flow graph, realization of z-domain transfer function. Frequency domain analysis of discrete-time systems -Fourier series and fourier transform. Relation between continuous and discrete time spectra, aliasing, reconstruction. DFS properties, Properties and applications of DTFT. Relationship between time, Z and frequency domains, Relation between frequency domain representation in continuous and discrete domain.

Sampling in frequency domain, DFT, Properties of DFT. Linear convolution using DFT. FFT- DIT and DIF, Basics of Multirate signal processing Decimation and interpolation. Digital Filter Design- Characteristics of Digital Filters, Filter structures, FIR filter design – window method, frequency sampling method, Relation between S and Z domains, IIR filter design – Butterworth and Chebyshev

J. G. Proakis and D. G. Manolakis, Digital Signal Processing Principles, Algorithms and Applications Fourth Edition, 2011
A. V. Oppenheim and R.W. Schafer, Discrete Time Signal Processing, 2002
Paolo Prandoni and Martin Vetterli, Signal Processing for Communications, (http://www.sp4comm.org/download.html), 2013
Ifeachor and Jervis, DSP – A practical approach, Pearson, 2002

EC209 CONTROL SYSTEMS (3-1-0) 4

History of control and feedback, linear systems, dynamic systems, modeling and analysis, electrical and mechanical systems, block diagram and signal flow graphs, continuous and discrete time representation, time domain and frequency domain analysis, root-locus, Bode plot, phase and gain margins, polar plots, Nyquist plots, concept of stability, controllability, observability, transfer function approach to modeling, transient analysis and frequency domain analysis, quantization and error effects, design of control systems, design specifications, lead and lag compensator, PI, PD, PID controllers, state-space representation of dynamic systems, state space transfer function, design based on state space models, quadratic optimum control.

Bernard Friedland, Control System Design: An Introduction to State-Space Methods, Dover 2005.
Farid Golnaraghi, Benjamin C. Kuo; Automatic Control Systems, 9th ed, John Wiley & Sons, 2010.
Katsuhiko Ogata; Modern Control Engineering, 5th ed, Pearson India Education Services Pvt Ltd, 2015.
Richard C. Dorf, Robert H. Bishop; Modern Control Systems, 12th ed, Pearson Education Limited, 2014.

EC210 MICROPROCESSOR LAB (0-0-3) 2

The lab experiments will introduce students to assembly language programming and embedded programming. Students will create embedded programs on an ARM processor to generate analog traces, interface to peripherals. Advanced experiments will explore performance issues.

Class notes and Lab manual.

EC211 DIGITAL SIGNAL PROCESSING LAB (0-0-3) 2

Simulation exercises on linear equation solvers: Digital Filter Design, DFT and spectral analysis, identification of sinusoids in noise. Speech processing, Image processing, Real time experiments using fixed point DSP processor (Assembly language programming) Waveform generation, Data I/O effect of sampling and quantization, Digital Filter Implementation FIR and IIR filter, Implementation of FFT.

EC300 VLSI DESIGN (3-1-0) 4

Introduction to MOSFETs, MOSFET Equivalent Circuits. MOSFET logic circuits: NMOS inverter, CMOS inverter, CMOS Processing Technology. Layout design rules. CAD tools for VLSI Design. MOSFET Logic gates. CMOS combinational, sequential logic circuits, Flip flop and latch timings, Clocking. Circuit characterization and performance estimation: Resistance, capacitance estimation, Switching characteristics, Delay models. Power dissipation, Packaging, Scaling of MOS transistor dimensions. CMOS subsystem design. Datapath operations: Addition, Multiplication, Counters, Shifters, Memory elements.

Jan M. Rabaey, A. Chandrakasan, and B. Nikolic, Digital Integrated Circuits: A design Perspective, Pearson Education, 2002

S. M. Kang & Y. Leblebici, CMOS Digital Integrated Circuits, McGraw Hill,

2002 Ken Martin, Digital Integrated Circuit Design, Oxford Press, 2000.

Neil H. E. Weste, David Money Harris, Integrated Circuit Design, Fourth Edition, 2011

EC301 RF COMPONENTS AND CIRCUITS (3-1 -0) 4

Review of Electromagnetic Theory, Hertzian Dipole; Antenna Characteristics, Wireless Systems and Friis Transmission Formula; Types of Antennas, Antenna Arrays, Microstrip antennas; Radio wave propagation. Impedance matching, S-parameters, passive and active microwave components. Ferrite devices, microwave filters, noise and nonlinearity, mixers and amplifiers. Introduction to radar systems.

C. A. Balanis, Antenna Theory: Analysis and Design. 4th edition. John Wiley, 2012.

Harish, A.R.; Sachidananda, M., Antennas and Wave Propagation, Oxford University Press, 2007

Warren Stutzman and Gary Thiele, Antenna Theory and Design, 3rd edition, John Wiley & Sons, 2013.

David M. Pozar, Microwave Engineering, 4th Edition, Wiley, 2011

Samuel Y. Liao, Microwave Devices and Circuits, Pearson, 3rd Edition, 2008

M. Kulkarni, Microwave and Radar Engineering, Umesh Publishing House, 5th Edition, 2014.

EC302 VLSI DESIGN LAB (0-0-3) 2

Design, Simulation and layout of basic digital blocks, Design project using EDA tools

Class notes and Lab manual.

EC303 COMMUNICATION LAB- I (0-0-3) 2

Design experiments (both hardware design and simulation) to support the contents of Analog and Digital communication and Electromagnetic Waves and Transmission Lines, Use of Simulation tools to simulate and verify various fundamental ideas in the above courses.

Class notes & Lab manual

EC304 COMMUNICATION LAB- II (0-0-3) 2

Design experiments (both hardware design and simulation) to support the contents of Electromagnetic Waves and Transmission Lines, RF Circuits and Components, Communication networks Use of Simulation tools to simulate and verify various fundamental ideas in the above courses.

Class notes & Lab manual

EC340 COMPUTER ORGANIZATION AND ARCHITECTURE (3-1-0) 4

Digital Computer Organization, CPU Design, CPU Design Tirning and Control, Micro programmed Control, Pipeline Concept, Memory Organization, Cache Memory Architecture, RAM Architecture SRAM and DRAM Architectures, Secondary Storage Organization.

John Hayes, Computer Architecture and Organization, 3rd Ed. McGraw Hill 2017.

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

EC341 COMPUTER ARITHMETIC (3-1-0) 4

Number Representation : Numbers and Arithmetic, Representing Signed Number, Redundant Number Systems, Residue Number Systems, Double base number systems, Addition/Subtraction: Basic Addition and Counting, Carry-Look ahead Adder, Variations in Fast Adders, Multi-Operand Addition, Multiplication: Basic Multiplication Schemes, High-Radix Multipliers, Tree and Array Multipliers, Variations in Multipliers, Division: Basic Division Schemes, High-Radix Dividers, Variations in Dividers, Division by Convergence, Real Arithmetic: Representing the Real Numbers, Floating-Point Arithmetic, Arithmetic Errors and Error Control, Precise and Certifiable Arithmetic, Function Evaluation: Square-Rooting Methods, The CORDIC Algorithms, Variations in Function Evaluation, Arithmetic by Table Lookup, Implementation Topics : High Throughput Arithmetic, Low-Power Arithmetic, Fault-Tolerant Arithmetic, Past, Present, and Future

I. Koren, Computer Arithmetic Algorithms, 2nd Edition, A. K. Peters (part of CRC Press),
2002 M. Ercegovac and T. Lang, Digital Arithmetic, Morgan Kaufman, 2003.
B. Parhami, Computer Arithmetic: Algorithms and Hardware Design, Oxford University Press 2000.
Literature from the web including the proceedings of IEEE Intl. Conference on Computer Arithmetic.

EC342 EMBEDDED SYSTEM DESIGN (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.
J.W. Valvano, Embedded Microcomputer System: Real Time Interfacing, Brooks/Cole, 2000.
David Simon, An Embedded Software Primer, Addison Wesley, 2000.
H. Kopetz, Real-time Systems, Kluwer, 1997
R. Gupta, Co-synthesis of Hardware and Software for Embedded Systems, Kluwer 1995.
Gomaa, Software Design Methods for Concurrent and Real-time Systems, Addison-Wesley, 1993.
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.

EC343 FPGA BASED SYSTEM DESIGN (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, Hardware description languages, combinational and sequential design, state machine design, synthesis issues, test benches. Overview of FPGA architectures and technologies: FPGA Architectural options, granularity of function and wiring resources, coarse vs fine grained, vendor specific issues (emphasis on Xilinx and Altera), Logic block architecture: FPGA logic cells, timing models, power dissipation I/O block architecture: Input and Output cell characteristics, clock input, Timing, Power dissipation, Programmable interconnect - Partitioning and Placement, Routing resources, delays; Applications - Embedded system design using FPGAs, DSP 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

EC344 ANALOG INTEGRATED CIRCUITS (3-1-0) 4

MOSFET - Review of current equation, regions of operation, small signal model. Current mirrors, Single-ended amplifiers: CS amplifier CG and CD amplifiers, CMOS differential amplifiers: DC analysis and small signal analysis of differential amplifier with Resistive load, current mirror load and current source load, Input common-mode range and Common -mode feedback circuits. OTAs vs Opamps. Slew rate, CMRR, PSRR. Two stage amplifiers,

Compensation in amplifiers (Dominant pole compensation).
Behzad Razavi, Fundamentals of Microelectronics, Second edition, Wiley,
2013 Sedra and Smith, Microelectronics Circuits, Oxford Univ. Press, 2004

EC345 DATA STRUCTURES AND ALGORITHMS (3-0-2) 4

Algorithm analysis, Asymptotic notations. Divide and Conquer algorithms, Analysis of divide and conquer algorithms, master method, examples - merge sort, quick sort, binary search, Data structures, Linked list, stacks and queues, insertion/deletion and analysis, Binary search trees Hash Tables – hash function and properties, collision handling, bloom filters, Greedy algorithms and Dynamic programming examples. Graph traversal , DFS, BFS, shortest path algorithms Dijkstra's and Bellman Ford algorithm, Minimum spanning trees, min cut . *Sartaj Sahni, Data Structures, Algorithms and Applications in C++, Universities Press, 2005 A.V. Aho, J.E. Hopcroft and J. D. Ullman, Data structures and Algorithms, Pearson, 2004. T.H.Cormen, C.E. Leiserson, R.L. Rivest, C. Stein, Introduction to Algorithms, PHI, 2004. Mark Allen Weiss, Algorithms, Data structures and problem solving with C++, Pearson, 2002.*

EC346 FOUNDATIONS OF MACHINE LEARNING (3-1-0) 4

Statistical foundations, Different Paradigms of Pattern Recognition, Probability estimation, Proximity measures, Feature extraction, Feature extraction, Different approaches to Feature selection, Nearest Neighbour Classifier and variants, Efficient implementations, Prototype selection. Bayes classification. Linear models, regression, logistic regression, neural networks, objective function and learning, backpropagation. 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

EC347 SPEECH AND AUDIO PROCESSING (3-1-0) 4

Speech Production–human speech production mechanism, acoustic theory of speech production, digital models for speech production. Speech perception– human hearing, auditory psychophysics, JND, pitch perception, auditory masking, models for speech perception. Speech Analysis–Time and frequency domain analysis of speech, speech parameter estimation, Linear prediction. Speech compression –quality measures, waveform coding, source coders, Speech compression standards for personal communication systems. 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–Segmental feature extraction, DTW, HMMs, approaches for speaker, speech and language recognition and verification
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

EC348 IMAGE AND VIDEO PROCESSING (3-1-0) 4

Digital image fundamentals–image acquisition, representation, visual perception, quality measures, sampling and quantization, basic relationship between pixels, imaging geometry, color spaces, Video spaces, analog and digital video interfaces, video standards. Two dimensional systems – properties, analysis in spatial, frequency and transform domains. Image transforms - DFT, DCT, Sine, Hadamard, Haar, Slant, KL transform, Wavelet transform. Image enhancement–point processing, spatial filtering, Image restoration–inverse filtering, de-blurring Video processing–display enhancement, video mixing,video scaling, scan rate conversion, Image compression–lossless and lossy compression techniques, standards for image compression-JPEG, JPEG2000. Video compression–motion estimation, intra and interframe prediction, perceptual coding, standards- MPEG, H.264 Image segmentation–feature extraction, region oriented segmentation, descriptors, morphology, Image recognition
R. C. Gonzalez and R E Woods, Digital Image Processing, Pearson Education, 2002 A K Jain, Fundamentals of Digital Image Processing, Pearson Education,1989 W Pratt, Digital Image Processing, Wiley , 2001
Al Bovik, Handbook of Image and Video, Academic Press, 2000 Keith Jack, Video Demystified, LLH 2001

EC349 APPLIED NUMBER THEORY (3-1-0) 4

Prime numbers, Divisibility and GCD, Congruences, Powers, Fermat's Little theorem, Euler's theorem, Euler's totient function, Chinese Remainder theorem, Diophantine equations, Residue Number system (RNS), Double base number

system(DBNS), Signal Processing and Number Theory: Review of DFT and circular convolution, Number theory and DFT, Consequences of Euler's theorem for Signal Processing, Communication Engg: PN sequences, Polynomials and Euclidean algorithm, Generation of PN sequences application of PN sequences.

Thomas Koshy, Elementary Number Theory with Applications, 2nd Ed, Associated Press, 2007.
Amos R. Omondi and Benjamin Premkumar, Residue Number Systems: Theory and Implementation, World Scientific, 2007.
Hari Krishna Garg, Digital Signal Processing Algorithms: Number Theory, Convolution, Fast Fourier Transforms, and Applications, 1st Ed, CRC Press, 2000.

EC350 NUMERICAL ANALYSIS (3-1-0)4

Preliminaries on numerical analysis, Errors and measuring efficiency , Review of Linear Algebra, Iterative techniques in matrix algebra, elimination method, inverse of a matrix, ill conditioned systems, eigen values, eigen vectors, LU and QR factorization. Solving nonlinear equations, bisection, Newton's method, Mullers method, fixed point interpolation, steepest descent. Interpolation and curve fitting: interpolating polynomials, spline curves, interpolation on a surface, least square approximations. Approximation of functions: Fourier basis and orthogonal polynomials, rational function approximation. Numerical differentiation and integration, solution of ordinary differential equations: Taylor series method, Euler method, Runge-Kutta method. Solution of partial differential equations, finite element methods, optimization.

Francis B. Hildebrand, Introduction to Numerical Analysis, 2nd Ed, Dover.
SD Conte, C de Boor, Elementary numerical analysis: An algorithmic approach, 3rd Ed, Mc Graw Hill, 1981.
R.L. Burden & J.D. Faires, Numerical Analysis, 9th Ed, Brooks/Cole, Cengage Learning, 2011.

EC351 SATELLITE COMMUNICATIONS (3-1-0) 4

Introduction to satellite Communications, Space craft, space craft sub systems, Altitude and orbit control systems, Telemetry, tracking and command, Power Systems, Communication sub systems, description of communication systems, transponders, Space craft antennas, Equipment reliability and space qualification, Multiple access systems, FDMA, FDM/FM/FDMA, TDMA, CDMA spread spectrum transmission and reception. Applicability of CDMA to commercial systems, demand access in the INTELSAT. TDMA system, SPADE, the INMARSAT system, Earth station, Satellite television networks.

T. Pratt, Satellite communications, John Wiley, 2002
T. T. Ha., Digital satellite communication, Collier Macmillan, 1986

EC352 PRINCIPLES OF MODERN RADAR AND TECHNIQUES (3-1-0) 4

Introduction and Radar Overview, The Radar Range Equation, Radar Search and Overview of Detection in Interference; External Factors: Propagation Effects and Mechanisms, characteristics of Clutter Target Reflectivity, Target Fluctuation Models, Doppler Phenomenology and Data Acquisition Subsystems: Radar Antennas, Radar Transmitters, Radar Receivers, Radar Exciters, and The Radar Signal Processor

Mark A Richards, Principles of modern radar (POMR)-Basic principles(Vol-1), Scitech publishers
R. Skolnik, Modern Radar Systems, 3rd edition, Mc-Graw Hill Publishers

EC353 MODERN ELECTRONIC NAVIGATION SYSTEMS (3-1-0) 4

GNSS overview: GPS, GLONASS, Galileo; Fundamentals of Satellite and Inertial Navigation, Signal Characteristics and Information Extraction; Receiver and Antenna Design. Differential GNSS. Kalman filtering, Inertial Navigation systems.

Mohinder S. Grewal, Lawrence R. Weill, Angus P. Andrews, Global positioning systems, intertial navigation and integration, Second edition, Wiely, 2010

EC354 COMMUNICATION NETWORKS (3-1-0) 4

Switching techniques, Multiplexing and Multiple Access techniques, Packet Switched Networks. OSI and TCP/IP Models, Internet protocols and addressing, networking devices, data links and transmission, LANs and Network of LANS, Wireless Networks and Mobile IP, Routing and internetworking, transport and end to end protocols, congestion control techniques, Application Layer and network management, Network Security. Packet Queues and delays, Little's theorem, Birth and death process, Queuing disciplines, M/M/1 Queues, Burkes and Jackson theorems. Traffic models, ISDN, ATM Networks, Quality of service and resource allocation, VPNs and MPLS, Cellular Telephone and Optical networks, VOIP and Multimedia networking. Mobile Adhoc Networks and Wireless Sensor Networks

Nader F. Mir, Computer and Communication Networks, Pearson Education, 2007
Garcia and Widjaja, Communication Networks, McGraw Hill, 2006
J.F. Hayes, Modelling and analysis of Computer Comm. Networks, Plenum, 1984.
Jean Walrand & Pravin Varaiya, High Performance Communication Networks , Morgan Kaufmann Publishers, 2002

EC355 WIRELESS MOBILE COMMUNICATION (3-1-0) 4

Concepts of cellular communication, Geometry of hexagonal cells; Co-channel interference, cellular system design in worst case, co-channel interference with the use of directional antennas, Cell splitting, Frequency allocation in mobile, Power control, JDC, JDC frame structure, TDMA, TDMA frame, delayed in TDMA, advantages CDMA, Capacity Comparison of FDM /TDM systems and cellular CDMA. Standards for Wireless mobile communication, Micro cells, high way micro cells, spectral efficiency, traffic carried, Signalling and call control; Mobility management, Location tracking. Wireless data networking.

G.L. Sterber, Principles of Mobile Communications, Kluwer Academic, 1996.
T.S .Rappaport, Wireless communications, Principles and Practice, , Pearson Edn, 2002.
William C.Y. Lee, Mobile cellular telecommunication systems: Analog & Digital Systems, McGraw Hill, 1995.

EC356 INFORMATION THEORY AND CODING (3-1-0) 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.

Thomas M Cover & Joy A Thomas, Elements of Information Theory, John Wiley,1991 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.

EC357 ADHOC AND SENSOR NETWORKS (3-1-0) 4

Mobile ad hoc networks and wireless sensor networks concepts and architectures. Routing: proactive routing, Broadcasting and multicasting, TCP over mobile ad hoc networks, Wireless LAN (WiFi) standards, Medium Access Control Protocol issues power control, spatial reusability, and QoS, Bluetooth, Wireless sensor networks architecture: hardware and software components of a sensor node, OS for WSN, WSN MAC layer strategies; naming and addressing; Clock Synchronization; Node Localization; WSN Routing.

C Sivarama Murthy and B S Manoj, Ad-Hoc Wireless Networks, Architectures and Protocols, PH , 2004.
Labiod.H, Wireless Adhoc and sensor networks, Wiley, 2008.
Li,X , Wireless ad hoc and sensor networks: theory and applications, Cambridge University Press,2008

EC358 MULTIMEDIA COMMUNICATION TECHNIQUES (3-1-0) 4

Representation of Multimedia Data, Concept of Non-Temporal and Temporal Media, Multimedia Presentations, Synchronization. Compression of Multimedia Data, Basic concepts of Compression, Audio Compression Introduction to Speech and Audio Compression, Multimedia System Design, General Purpose Architecture for Multimedia Processing, Operating System support for Multimedia, Data, Resource Scheduling with real-time considerations, File System, I/O Device, Management, Delivery of Multimedia data, Network and Transport Protocols, QoS issues, RTP and RSVP, Video-conferencing and video-conferencing standards, Overview of Voice over IP, Multimedia Information Management, Multimedia Data base Design, Content Based Information Retrieval, Image Retrieval, Video Retrieval, Overview of MPEG-7.

Ralt Steinmetz and Klara Nahrstedt, Multimedia : Computing, Communication & Applications, Pearson Education Publications, 2004.

EC359 SOFTWARE DEFINED AND COGNITIVE RADIO (3-1-0) 4

Cognitive radio: goals, benefits, definitions, architectures, Spectrum-Licensed, unlicensed, shared unlicensed, opportunistic unlicensed, Current spectral usage and issues, Regulations, regulation changes, Spectral awareness, Spectrum adaptation, Dynamic frequency selection, Spectrum Sharing priority allocation, Adaptive bandwidth control Policies, Adaptation and optimization- link adaptation, incremental redundancy, jointly adaptive source and channel coding, Digital signal processing role in SDR, Cross- layer optimization (adaptation), Current cellular cognitive features-Hand -off, Channel allocation, cellular network design, Link adaptation, incremental redundancy, Interference avoidance, detection, and cancellation, Power control, Femto cells and relation to cognitive radio. 2.5G/3G/4G cognitive features, Multi-carrier system adaptation (OFDM(A) adaptive features), Collaboration and cooperation in wireless devices, networks, and systems Interference awareness, Multi -dimensional channel variation and dispersion - relation with adaptive radio, Applications of CR into public safety and other applications of CR ,Vertical hand-off and network interoperability - network awareness, multi-tier networks, Biologically inspired cognitive features (like Bats, Ants, human being, etc)

Hoseyin Arslan (Ed.), "Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems," Ser. Signals and Communication Technology, xviii, I. edition, Springer, August 2007
Joseph Mitola, III, "Cognitive Radio Architecture: The Engineering Foundations of Radio XML," John Wiley and Sons Ltd., 2006.

Jeffrey H. Reed, "Software Radio: A Modern Approach to Radio Engineering," Prentice Hall PTR, 2002.
Walter H.W. Tuttlebee, "Software Defined Radio: Enabling Technologies," John Wiley and Sons Ltd., 2002.
Markus Dillinger and Kambiz Madani and Nancy Alonistioti, "Software Defined Radio: Architectures, Systems and Functions," John Wiley and Sons Ltd., 2003.

EC360 MACHINE LEARNING FOR WIRELESS COMMUNICATION SYSTEMS (3-1-0)4

Need for machine learning techniques in wireless communication, Introduction to machine learning, Supervised, unsupervised, and reinforcement learning, Gaussian model, HMM, Clustering, Sequence recognition and analysis, Bayesian networks, Factor graphs, Markov chain Monte Carlo (MCMC) methods, Channel modelling and prediction using machine learning algorithms, Deep learning based channel estimation, Spectrum sensing and signal identification in cognitive radios using machine learning, Machine learning techniques for adaptive modulation and coding techniques, CNN based equalizer design, DNN based channel coding techniques (LDPC and Polar codes), Machine learning algorithms for MIMO communications, Compressive sensing for wireless sensor networks, Reinforcement learning-based channel sharing in wireless vehicular networks.

Ruisi He, and Zhiguo Ding (Editors), "Applications of Machine Learning in Wireless Communications", IET Press, 2019.
Fa-Long Luo (Editor), "Machine Learning for Future Wireless Communications", IEEE Press & Wiley, 2020.
Osvaldo Simeone, "A Brief Introduction to Machine Learning for Engineers", Now Publishers, 2018.
A. C. Faul, "A Concise Introduction to Machine Learning", CRC Press, 2020.

EC361 SPARSE REPRESENTATIONS AND COMPRESSIVE SENSING (3-1-0) 4

Introduction, mathematical preliminaries, Basis and Frames, Low dimensional signal models, Sensing matrices, Signal recovery via l1 minimization, Necessary and sufficient conditions for L0-L1 equivalence. RIP and random matrices. Johnson-Lindenstrauss Lemma, Stable signal recovery and restricted eigen value property. Recovery algorithms and their performance guarantees. Multiple measurement models and Applications.

S. Foucart and H. Rauhut, "A mathematical introduction to compressive sensing," Birkhauser Press, 2013.
M. Elad, "Sparse and Redundant Representations" Springer 2010.
H. Rauhut, "Compressive Sensing and structured random matrices",Radon series, Comp. Applied math. 2011.
Compressive Sensing Resources - http://dsp.rice.edu/cs/

EC362 DEEP REINFORCEMENT LEARNING (3-1-0) 4

Introduction: Course logistics and overview. Origin and history of Reinforcement Learning research. Its connections with other related fields and with different branches of machine learning.

Markov Decision Process: Introduction to RL terminology, Markov property, Markov chains, Markov reward process (MRP). Introduction to and proof of Bellman equations for MRPs along with proof of existence of solution to Bellman equations in MRP. Introduction to Markov decision process (MDP), state and action value functions, Bellman expectation equations, optimality of value functions and policies, Bellman optimality equations.

Prediction and Control by Dynamic Programming: Overview of dynamic programming for MDP, definition and formulation of planning in MDPs, principle of optimality, iterative policy evaluation, policy iteration, value iteration, Banach fixed point theorem, proof of contraction mapping property of Bellman expectation and optimality operators, proof of convergence of policy evaluation and value iteration algorithms, DP extensions.

Monte Carlo Methods for Model Free Prediction and Control: Overview of Monte Carlo methods for model free RL, First visit and every visit Monte Carlo, Monte Carlo control, On policy and off policy learning, Importance sampling.

Temporal difference (TD Methods: Incremental Monte Carlo Methods for Model Free Prediction, Overview TD(0), TD(1) and TD(λ), k-step estimators, unified view of DP, MC and TD evaluation methods, TD Control methods - SARSA, Q-Learning and their variants.

Function Approximation Methods: Getting started with the function approximation methods, Revisiting risk minimization, gradient descent from Machine Learning, Gradient MC and Semi-gradient TD(0) algorithms, Eligibility trace for function approximation, After states, Control with function approximation, Least squares, Experience replay in deep Q-Networks.

Policy Gradients: Getting started with policy gradient methods, Log-derivative trick, Naive REINFORCE algorithm, bias and variance in Reinforcement Learning, Reducing variance in policy gradient estimates, baselines, advantage function, actor-critic methods.

Richard S. Sutton and Andrew G. Barto, "Reinforcement learning: An introduction", Second Edition, MIT Press, 2019.
Wiering, Marco, and Martijn Van Otterlo. "Reinforcement learning." Adaptation, learning, and optimization 12 (2012).
Li, Yuxi. "Deep reinforcement learning." arXiv preprint arXiv:1810.06339 (2018).

Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. "Deep learning." MIT press, 2016.
Reinforcement Learning resource: https://web.stanford.edu/class/cs234/modules.html

EC363 MACHINE LEARNING APPLICATIONS IN RADAR SIGNAL PROCESSING (3-1-0)4

Review of machine learning (ML) algorithms. Applications of ML to Radar System design and analysis, processing range-Doppler using learning algorithms, various techniques applied to radar data acquisition, applications of ML algorithms to radar detection, designing ML algorithms for Radar target tracking and recognition. Principles of deep learning: various approaches of deep learning, Deep Learning Methods for Radar Detection, Classification/Estimation, and Tracking, tracking algorithms of multiple targets in multi-static configurations, Compressive-sensing-based learning technique, Through-the-wall imaging radars, MIMO radar applications, Deep-learning- based adaptive radar detection and tracking, and automotive applications.

Martin T. Hagan, Howard B. Demuth, Mark Hudson Beale, Orlando De Jesús, Neural Network Design, 2nd Edition, eBook. (Available for download from the author: https://hagan.okstate.edu/NNDesign.pdf)
James A., Mark A., Richards, William A., Scheer, Holm, Principles of Modern Radar, Volume I - Basic Principles, SciTech 2010.
J.D. Kelleher, Deep Learning, MIT Press, 2019.
E Charniak, Introduction to Deep Learning, The MIT Press, 2018.
Lee Andrew Harrison, Introduction to Radar Using Python and MATLAB Illustrated Edition, Kindle Edition, Artech house, 2020.
Mark A. Richards - Fundamentals of Radar Signal Processing - McGraw-Hill 2014.

EC440 VLSI CAD (3-1-0) 4

Introduction to VLSI design automation: VLSI design methodologies, use of VLSI EDA tools, Algorithmic Graph Theory, computational Complexity; Partitioning: KL algorithm, FM algorithm, EIG Algorithm, Simulated Annealing. Floorplanning and placement: Sliced and non-sliced planning, Polish expression, Simulated annealing, partition based placement; ILP & mathematical programming, partition based, force directed, Fast-Place, quadratic placement algorithms. Routing: Global routing, detailed routing, graph models, Line Search, Maze Routing, Channel routing; via minimization, clock and power routing. High Level Synthesis: Introduction to HDL, HDL to DFG, operation scheduling: constrained and unconstrained scheduling, ASAP, ALAP, List scheduling, Force directed scheduling, operator binding; Static Timing Analysis: Delay models, setup time, hold time, cycle time, critical paths, 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

EC441 MIXED SIGNAL DESIGN (3-1-0) 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

EC442 ADVANCED COMPUTER ARCHITECTURE (3-1-0) 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.

EC443 VLSI TESTING AND TESTABILITY (3-1-0) 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.

EC444 SYNTHESIS AND OPTIMIZATION OF DIGITAL CIRCUITS (3-1-0) 4

Introduction to Computer aided synthesis and optimization. Hardware Modeling. Advanced Boolean Algebra and Applications – Boolean functions, representations, 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.

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

EC445 TECHNIQUES IN LOW POWER VLSI (3-1-0) 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.
Anantha P.Chandrakasan & Robert W. Brodersen, Low Power Digital CMOS Design, Kluwer, 1995. Gary K. Yeap, Practical Low Power Digital VLSI Design, Kluwer Academic Publications, 1998
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

EC446 SUBMICRON DEVICES (3-1-0) 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/

EC447 ACTIVE FILTERS (3-1-0) 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, Switched Capacitor 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*
M.E. Van Valkenburg, Analog Filter Design, Oxford University Press, 1995.

EC448 HETEROGENEOUS AND PARALLEL COMPUTING (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.

EC449 ALGORITHMS AND ARCHITECTURES FOR SIGNAL PROCESSING (3-1-0) 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", 2006 John Wiley & Sons, Ltd
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*

EC450 ANALOG AND DIGITAL FILTER DESIGN (3-1-0) 4

Introduction to filters and filter specifications. The Butterworth, Chebyshev, Elliptic, and Bessel filters and their realization, Frequency transformations, Analog filter design. Sampling; the Digital filter problem. IIR Filter design using the impulse invariant and bilinear transformation methods. The poles and zeros of the Butterworth and Chebyshev digital filter equivalents. Realization of Digital IIR filters Tradeoffs between aliasing and complexities of Analog filter realizations Direct design of IIR filters. FIR Filter Design: Exactly linear phase filters. Windowing methods. Kaiser window and its properties. Filter design using Kaiser window, Frequency sampling, Optimal FIR Filter design, Real-time implementation of digital filters – coefficient quantisation and finite word length effects.

A.Ambardar, Analog and Digital Signal Processing, Brooks Cole, 1999.
Ifeachor and Jervis, DSP – A practical approach, Pearson, 2002
Sanjit K. Mitra, Digital Signal Processing : A computer based Approach, TMH, 2002
Andreas Antoniou, Digital Filter Design, TMH

EC451 ADVANCED DIGITAL SIGNAL PROCESSING (3-1-0) 4

Power spectral estimation; Parametric and non-parametric methods of spectral estimation, Linear prediction, Higher order spectral estimation; Adaptive filters and applications. Recursive estimation and Kalman filters Multirate Signal Processing: Decimation Interpolation, DFT filter banks, QMF filter banks, Multiresolution Signal analysis wavelets theory of sub band decompositions, Sub band coding and wavelet transforms, Application of wavelet transforms.

P.P. Vaidyanathan, Multirate systems and Filter banks, Prentice Hall,
1993. S.J. Orfanidis, Optimum Signal Processing, McGraw Hill, 1989.
S. Haykin, Adaptive Filter Theory, Pearson, 1996

EC452 REAL TIME SIGNAL PROCESSING (2-0-3) 4

Introduction to DSP systems and architecture; Arithmetic: Fixed point, floating point and residue arithmetic, Cordic architectures; Real time implementation of SP algorithms on Digital Signal Processors: Architecture and programming; Real time implementation of SP algorithms on Reconfigurable architectures: Architecture and design flow; Issues in implementation of convolution, FIR, IIR and adaptive filters, DCT, Image Filtering, Dynamically reconfigurable architectures for SP, Software Configurable processors, Application case studies in multimedia compression and communication.

Behrooz Parhami, "Computer Arithmetic Algorithms and Hardware Design", Oxford, 2000.
Rulph Chassaing, " Digital Signal Processing and Applications with the C6713 and C6416 DSK",
Wiley, 2005
U. Meyer Baesse, "Digital Signal Processing with FPGAs", Springer, 2001
Shehrzad Qureshi, "Embedded Image Processing on the TMS320C6000 DSP" Springer, 2005

EC453 FOURIER AND WAVELET SIGNAL PROCESSING (3-1-0) 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 uncertainty.

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

EC454 MATHEMATICAL ALGORITHMS FOR SIGNAL PROCESSING (3-1-0) 4

Mathematical Foundations–mathematical models, random variables and random processes, Markov and hidden Markov models. Representations and approximations - orthogonality, least squares, MMSE filtering, frequency domain optimal filtering, minimum norm solutions, Iterated reweighted least squares. Linear Operators – Operator norms, adjoint and transposes, geometry of linear equations, least squares and pseudo inverses, applications to linear models.

Subspace methods – Eigen decomposition, KL transform and low rank approximation, Eigen filters, signal subspace techniques – MUSIC, ESPRIT. SVD – matrix structure, pseudo inverse and SVD, system identification using SVD, Total least squares, partial total least squares. Special matrices–Toeplitz matrices, optimal predictors and lattice filters, circulant matrices, properties.

Todd Moon and WC Stirling, Mathematical Methods and Algorithms for Signal Processing, Pearson Education, 2000
Steven, M. Kay, Modern spectral estimation: theory and application, Prentice Hall, 1988

EC455 DIGITAL SIGNAL COMPRESSION (3-1-0) 4

Data Compression. Speech & image waveform characterization. Predictive coding. Transform coding. Subband coding, VQ based compression, Fractal coding of images. High quality video & audio compression for digital broadcasting. Standards for digital signal compression-data, speech, audio, image & video.

D. Salomon, Data Compression – the complete reference, Springer, 2000.
K. Sayood, Introduction to Data Compression, Pearson Education, 2000.
M.Nelson, The data compression book, BPB Publications, 2002.
Jayant & Noll, Digital coding of waveforms-Principles and applications to speech & video, PH, 1984.

EC456 DYNAMICAL SYSTEMS, CHAOS AND FRACTALS (3-1-0) 4

Preliminaries on systems, Eigen values and Eigen vectors, solutions of linear ODEs. Dynamics of linear and nonlinear systems, solutions, attractors, equilibrium point, limit cycles, stability, Linear systems: solutions, stability of autonomous systems, BIBO stability, relation to frequency domain analysis, Nonlinear systems: large-scale notions of stability (Lyapunov functions), linearization. Vector fields of nonlinear systems, limit cycles, Lorenz and Rossler equation, Chua's circuit, Discrete dynamical systems, logistic maps, two dimensional maps, bifurcations, flows, phase plane analysis. Introduction to fractals, Mandlebrot and Julia sets, iterated function systems, strange attractors, fractal dimension, stable and unstable manifolds, analysis of chaotic time series, multifractals.

Applications in control theory, signal processing, digital image modelling, synthesis and compression, chaos communication and Cryptography. Other applications in engineering, natural and social sciences, medicine, economics, ecology, bio and life sciences, and environmental sciences.

S. Stenberg, Dynamical systems, Dover 2010.
MW Hirsch, S. Smale, RL Devaney, Differential equations, dynamical systems, and an introduction to chaos, Academic Press. 2012.
Steven H. Strogatz, Nonlinear dynamics and chaos: with applications to physics, biology, chemistry, and engineering, West-view Press, 2015.
E. Ott, Chaos in dynamical systems, 2nd ed Cambridge University Press, 2002.
S. Wiggins, Introduction to applied nonlinear dynamical systems and chaos, Springer-Verlag, 1990.
Denny Gulick, Encounters with chaos and fractals, 2nd ed CRC Press, 2012.
J.M. Bahi, C. Guyeux, Discrete dynamical systems and chaotic machines: theory and applications, CRC Press, 2013.
M. Barnsley, Fractals everywhere, Academic Press, 1993.

EC457 STATISTICAL ANALYSIS (3-1-0) 4

Preliminaries on matrix theory and probability distributions. Sampling theory: random samples, sampling distribution, statistical inference, estimation of mean and variances, hypothesis testing, statistical tests, goodness of fit. Data analysis: correlation and regression, simple linear regression, multiple linear regressions, logistic regression, nonlinear regression. The Multivariate Normal Distribution, Estimation of the Mean Vector and the Covariance Matrix, The Distributions and Uses of Sample Correlation Coefficients, The Generalized T2-Statistic, Classification of Observations, The Distribution of the Sample Covariance Matrix and the Sample Generalized Variance, Testing the General Linear Hypothesis: Multivariate Analysis of Variance, Testing Independence of Sets of Variates, Testing Hypotheses of Equality of Covariance Matrices and Equality of Mean Vectors and Covariance Matrices, Principal Components, Canonical Correlations and Canonical Variables, The Distributions of Characteristic Roots and Vectors, Factor Analysis, Pattern of Dependence, Graphical Models.

Sam Kash Kachigan, Statistical Analysis: An Interdisciplinary Introduction to Univariate and Multivariate Methods, Radius Press, 1986.
RA Johnson, DW Wichern, Applied multivariate statistical analysis, 6th ed, PHI, 2012.
T. W. Anderson, An Introduction To Multivariate Statistical Analysis, 3rd Edition, Wiley, 2003.
Sam Kash Kachigan, Multivariate Statistical Analysis: A Conceptual Introduction, Radius Press, 1991.
Robert Nisbet, John Elder and Gary Miner, Handbook of Statistical Analysis and Data Mining applications, Elsevier Inc 2009.

EC458 STOCHASTIC PROCESSES (3-1-0) 4

Review of Probability theory and stochastic processes, stochastic processes and linear systems, Gaussian random process, spectral analysis of stationary processes, Power Spectral Densities, Stationarity and Ergodicity, Poisson processes, renewal processes, Brownian motion. Optimal Linear Systems, Wiener Filters, discrete and continuous time Markov chains, discrete time branching processes, birth and death processes, random walks, large deviations and Martingales. Queueing theory Diffusion processes and stochastic differential equations, the Fokker-Planck and Langevin Equations. Applications – Modeling of neural processes, finance, and processes in natural and social sciences.

Richard Durrett, Essentials of Stochastic Processes (Springer Texts in Statistics) May 2001.
R G Gallager, Stochastic processes: theory for applications, 2013.
W. Paul and J. Baschnagel: Stochastic Processes – From Physics to Finance, Springer, 1999.
Frank Beichelt, L. Paul Fatti, Stochastic Processes and Their Applications, CRC Press, 2001.
Petar Todorovic, An Introduction to Stochastic Processes and Their Applications, Springer, 1992.

EC459 OPTIMIZATION AND APPLICATIONS (3-1-0) 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 Bertsimas, 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.

EC460 NEURAL NETWORKS AND DEEP LEARNING (3-1-0) 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.

EC461 SPREAD SPECTRUM COMMUNICATION (3-1-0) 4

Spread spectrum overview, Spreading techniques, Pseudo noise sequences, Direct sequence spread spectrum system, Frequency hop spread spectrum system, Hybrid systems, Synchronization, Jamming considerations, Commercial applications, Cellular systems, Performance of spread spectrum systems.

R.L.Peterson, Introduction to spread spectrum communication, PH,1995.
B.Sklar, Digital Communications, Pearson Education, 2001.
M.K.Simon, Spread spectrum communications Handbook, McGraw-Hill, 2001.
J.S.Lee, CDMA Systems Engineering handbook, Artech House, 1998

EC462 ERROR CONTROL CODING (3-1-0) 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, Decoding beyond the minimum distance parameter, Applications of Reed-Solomon codes, Convolutional codes, Decoding algorithms for Convolutional codes, Viterbi, Stack and Fano algorithms, Application of Convolutional codes. Codes based on the Fourier Transform, Algorithms based on the Fourier Transform, Trellis coded modulation, Combinatorial description of Block and Convolutional codes, Algorithms for the construction of minimal and tail biting trellises, Soft decision decoding algorithms, Iterative decoding algorithms, Turbo-decoding, Two-way algorithm, LDPC codes, Use of LDPC codes in digital video broadcasting, belief propagation (BP) algorithms, Space-Time 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, Theory and Practise of Error Control Codes, Addison Wesley, 1983.

EC463 OPTICAL COMMUNICATION SYSTEMS AND NETWORKS (3-1-0) 4

Introduction to Optical Fibers, Ray Optics-Optical Fiber Modes and Configurations. Signal degradation in Optical Fibers. Optical Sources and Detectors. Optical Communication Systems and Networks. Basic concepts of SONET/SDH Networks.

J.Senior, Optical Communication, Principles and Practice, Prentice Hall of India, 1994/latest edition. Gerd Keiser, Optical Fiber Communication McGraw –Hill International, Singapore, 3rd ed., 2000/latest Edition
J.Gower, Optical Communication System, Prentice Hall of India, 2001.

EC464 RADAR SIGNAL PROCESSING (3-1-0) 4

Introduction to Radar Systems and Signal Processing, Signal Models, Pulsed Radar Data Acquisition Radar Waveforms, Doppler Processing, Detection Fundamentals, Introduction to Synthetic Aperture Imaging, and Introduction to Beamforming and Space-Time Adaptive Processing.

Mark A Richards, Fundamentals of radar signal Processing, McGraw Hill edition, 2nd edition, 2013
Peebles P. Z, Radar Principles, John Wiley and Sons, 1998

EC465 ALGORITHMS FOR PARAMETER AND STATE ESTIMATION (3-1-0) 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, modelling 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.

EC466 DETECTION AND ESTIMATION THEORY (3-1-0) 4

Preliminaries on probability and random processes. Hypothesis testing: Neyman-Pearson theorem, likelihood ratio test and generalized likelihood ratio test, uniformly most powerful test, multiple- decision problem, detection of deterministic and random signals in Gaussian noise, detection in nonGaussian noise, sequential detection. Parameter estimation: unbiasedness, consistency, Cramer-Rao bound, sufficient statistics, Rao-Blackwell theorem, best linear unbiased estimation, maximum likelihood estimation, method of moments. Bayesian estimation: MMSE and MAP estimators, Levinson-Durbin and innovation algorithms, Wiener filter, Kalman filter. Applications in Wireless Communication, Radar Systems, Speech, Image and Video processing and applications relevant to Engineering.

Steven Kay, Fundamentals of Statistical Signal Processing - Detection Theory (Vol. 2), Prentice Hall, 1998. Steven Kay, Fundamentals of Statistical Signal Processing - Estimation Theory (Vol. 1), Prentice Hall, 1993.

H. V. Poor, An Introduction to Signal Detection and Estimation, Springer-Verlag, 2nd edition, 1994.

H. L. Van Trees, Detection, Estimation and Modulation Theory, Parts 1 and 2, John Wiley Inter- Science, 2002

M. D. Srinath, P. K. Rajasekaran and R. Vishwanathan, An Introduction to Statistical Signal Processing with Applications, Prentice-Hall, 1996.

Kailath,T. and Hassibi, Linear Estimation, Pearson, 2000.

EC467 ADVANCED TOPICS IN COMMUNICATION ENGINEERING (3-1-0) 4

Fading Channels, characterizing Mobile radio propagation, Signal time spreading, time variance of channel, mitigating the degradation effects of fading, characterizing fading channels, Fundamentals of Statistical Detection Theory, Baye's Theorem, Decision theory, Neyman Pearson Theorem, Receiver operating characteristics, Bayes's risk. Multiple hypothesis testing, minimum Baye's risk detection for binary hypothesis and multiple hypothesis, Orthogonal Frequency Division Multiplexing, OFDM transmission technique, 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 & M.Salehi, Digital Communication, 5th edition, McGraw Hill 2007.

Stevan M Kay, Fundamentals of Statistical signal processing, Vol. II, Detection Theory, PHI, 1998.

*A.Paulraj, R.Nabar & D.Gore, ,Introduction to Space Time Wireless Communications, Cambridge University, 2003***.**

EC468 SIGNAL INTEGRITY AND EMI/EMC (3-1-0) 4

Fundamentals, Basics of EMI/EMC: coupling mechanisms, why to consider EMC, typical sources and victims, time domain vs. frequency domain, near vs. far field, non-ideal components, controlling signal return currents, differential vs. common mode currents, radiation and pickup from loop and dipoles, the "hidden schematic" idea, etc. High Speed/Frequency Effects In Electronic Circuits, Components In RF/EMI/ EMC /Si, Transmission Lines: Controlling Propagation, Matching, Signal Integrity Parameters, undesired effects, propagation time and delay, reflections and ringing, crosstalk (near and far) and jitter. Delays. Jitter. Signal ground versus safety ground, grounding strategies, ground loops, techniques to minimize ground impedance Grounding, Filtering, Printed Circuit Boards (PCBs), Shielding, Cables, Transients, Diagnostics and Troubleshooting Techniques.

Huray P.G.: The Foundations of Signal Integrity. J. Wiley & Sons, Hoboken, 2010

Hall S.H., Heck H.L.: Advanced Signal Integrity for High-Speed Digital Designs. Wiley-IEEE Press, 2009.

Bogatin E.: Signal Integrity – Simplified. Prentice Hall, 2004.

Johnson H. W.: High Speed Signal Propagation: Advanced Black Magic. Prentice Hall, 2003.

Caniggia S., Maradei F.: Signal Integrity and Radiated Emission of High-Speed Digital Systems. John Wiley & Sons, 2009.

EC469 INTRODUCTION TO PHOTONICS (3-1-0) 4

Photonic Crystals: Electromagnetic wave in periodic medium, Symmetry, 1D photonic crystals: photonic band gap, omnidirectional reflector, 2D photonic crystals: photonic crystal waveguides, micro cavity, negative refraction, self-collimation, photonic crystal fibre, One-way waveguide, 3D photonic crystals: self-assembled photonic crystal,

holographically fabricated photonic crystal. Plasmonics, - Optics in metal, Surface Plasmon polariton, Localized surface plasmon, Phonon polariton, Plasmon waveguides, Transmission through sub-wavelength aperture, Enhancement of fluorescence and nonlinearity, Applications in Biomedical Engineering. Metamaterials, Effective medium theory, Negative refractive index, Super lens, Transformation optics, Invisibility cloak.

Lukas Novotny and Bert Hecht, Principles of Nano-Optics, Cambridge University Press, 2012
Herve Rigneault, Jean-Michel Lourtioz, Claude Delalande, Juan Ariel Levenson, Nanophotonics, Wiley-ISTE, 2006.
Mark L. Brongersma, Pieter G. Kik, Surface Plasmon Nanophotonics, Springer, 2007
P.N. Prasad, Nanophotonics, John Wiley and Sons, 2004
John D. Joannopoulos, Robert D. Meade, Joshua N. Winn, Photonic Crystals, Princeton University Press Princeton, NJ, USA 2008.

EC470 MIMO COMMUNICATION SYSTEMS (3-1-0) 4

Overview of fundamentals of Digital Communications, The Wireless Channel, Detection, Diversity and Channel Uncertainty, Capacity of Wireless channels, Spatial Multiplexing and Channel modelling, Capacity and Multiplexing architectures, Diversity-Multiplexing trade-off and Universal Space Time Codes, Multi-user Communication.

D. Tse, Pramod Viswanath, Fundamentals of Wireless Communications, Cambridge University Press, 2005. E. Biglieri, Coding for Wireless Channels, Springer, 2007
E. Biglieri et al., MIMO Wireless Communications, Cambridge University Press, 2007.

EC471 RF IC DESIGN (3-1-0) 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

EC472 PRINCIPLES OF MODERN RADAR - ADVANCED TECHNIQUES (3-1-0) 4

Advanced Techniques in Modern Radar, Advanced Pulse Compression Waveform Modulations and Techniques, Optimal and Adaptive MIMO Waveform Design, MIMO Radar, Synthetic Aperture Radar, Array Processing and Interference, Mitigation Techniques, Human Detection With Radar: Dismount Detection, Advanced Processing Methods for Passive Bistatic Radar Systems

Mark A Richards, Principles of modern radar(POMR)-Advanced Techniques(Vol-1I), Scitech publishers,

EC473 ELECTRONIC DEFENCE SYSTEMS (3-1-0) 4

Electronic Defence: Introduction, Systems in use in Armed forces; Sensors: Radar Sensors, Infrared sensors; Weapon systems: Artillery systems, missile systems; Electronic Intercept Systems: Introduction The Equation of a Passive System, Radar Warning Receivers; Electronic Countermeasures Systems Introduction, Operational Jamming Modes: SPJ, SOJ, and EJ, Onboard ECM Systems, .Electronic Counter-Countermeasures Systems: Introduction, Search Radar Counter-Countermeasures; New Electronic Defence Techniques and Technologies: Introduction, New Electronic Defence Architectures, ESM Antennas, Wideband Front End and Digital Receiver.

Filippo Neri, Introduction to Electronic Defence Systems, Second Edition, Artech House, London,

EC474 PRINCIPLES OF MODERN SONAR SYSTEMS (3-1-0)4

Sound: wave motion, sound pressure etc. Arrays: Need for projector arrays, Need for hydrophone arrays etc. Propagation of Sound in the Sea : Propagation loss, Losses: Spreading losses, Absorption losses. Target Strength: Definition, Formulae, Measurement, Dependence on pulse type and duration. Noise in Sonar Systems: Sources of nose, Thermal noise, Noise from the sea, Noise from a vessel. Reverberation: Sources of reverberation, Scattering and reflection; The Sonar Equations: What are they? What are their uses? The basic sonar equation, The basic passive equation; Passive Sonar: Radiated noise, Radiated noise: source level, nature of radiated noise. Active sonar: Pulse types, CW processing, FM processing, Active sonar equations.

A. D. Waite, Sonar for practicing Engineers, 3rd edition, Wiley, 2002.
Principles of sonar performance modelling, Michel A Ainslie, Springer,2010.

EC475 ADVANCED ELECTROMAGNETICS (3-1-0) 4

Circuit-field relationship, electrical properties of matter, review of wave propagation, polarization and reflection, EM Theorems, Dielectric waveguides, surface waves, leaky waves, artificial impedance surfaces, Electromagnetic scattering-cylindrical wave radiation by Infinite line source, planar surface wave scattering, circular cylinder and sphere scattering, volume scattering, particle scattering, Introduction to metamaterials-characterization and dispersion relations of left handed materials, EM problems solving Computational EM-differential and integral techniques-FDTD and Method of moments, Green's function technique-Series and closed forms, Identities, scalar Helmholtz equations, dyadic Greens function, Green's function for planar layered media.

C. A. Balanis, Advanced Electromagnetics, Second edition, John Wiley & Sons, Inc., 2012. R.F. Harrington, Time Harmonic Electromagnetic Fields, IEEE Press, 1961(First published) Kong, J. A. Electromagnetic Wave Theory. Cambridge, MA: EMW Publishing, 2000.

EC476 MILLIMETER WAVE COMMUNICATION (3-1-0) 4

Millimeter wave characteristics and implementation challenges, radio wave propagation for mm wave, Millimeter wave generation and amplification, HEMT, transistor configurations, Analog mm wave components, Consumption factor theory, Trends and architectures for mm wave wireless, ADC's and DAC's, Modulation for millimeter wave communications, Millimeter wave link budget, Transceiver architecture, Massive MIMO Communications, Potential benefits for mm wave systems, Spatial, Temporal and Frequency diversity, Dynamic spatial, frequency and modulation allocation, Antenna beam width, polarization, advanced beam steering and beam forming, mm wave design consideration, On-chip and In package mm wave antennas, Techniques to improve gain of on-chip antennas, Implementation for mm wave in adaptive antenna arrays, Device to Device communications over 5G systems, Design techniques of 5G mobile.

K.C. Huang, Z. Wang, "Millimeter Wave Communication Systems", Wiley-IEEE Press, March 2011.
Robert W. Heath, Robert C. Daniel, James N. T.S. Rappaport, Murdock, "Millimeter Wave Wireless Communications", PH, 2014.
Xiang, W.Zheng, K. Shen, X.S, "5G Mobile Communications", Springer, 2016.

EC477 IMAGING, INFORMATICS AND COMPUTATIONAL PHYSICS (3-1-0) 4

Physics of imaging, material structure, Imaging methods and modalities, computational aspects, 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, image informatics; 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.
H. K. Huang, PACS and Imaging Informatics: Basic Principles and Applications 2nd Edition, Wiley-Blackwell, 2010.
E. Russell Ritenour and William Hendee, Medical Imaging Physics, Wiley 2002.
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.

EC478 COMPLEX ANALYSIS AND APPLICATIONS (3-1-0) 4

Complex numbers: algebra, representation, polar forms, complex exponential, powers and roots, topological representation, Riemann sphere and stereographic representation. Analytic functions: limits and continuity, analyticity, CR equations, harmonic functions, elementary functions: polynomials, rational functions, exponential, hyperbolic functions, complex integration: contour integrals, Cauchy's integral theorem, bounds for analytic functions, Series representation for analytic functions: Taylor series, power series, Laurent series, singularities, Residue theory: improper integrals, Conformal mapping, Entire and meromorphic functions, applications of harmonic functions, Fourier series and Laplace transform. Applications in Circuit Simulators, Electromagnetism (time-harmonic fields). Electrostatics (solutions to Laplace's equation), and in various other fields of engineering, natural and applied sciences.

S Ponnusamy, H Silverman, Complex variables with applications, Birkhauser, 2006. JH Mathews, RW Howell, Complex analysisfor mathematics and engineering, Jones and Bartlett, 2001. Edward B. Saff, Arthur David Snider, Fundamentals of Complex Analysis with Applications to Engineering, Science, and Mathematics, Pearson Education 2003
Kozo Sato, Complex Analysis for Practical Engineering, Springer, 2015.
Cohen, Harold Complex Analysis with Applications in Science and Engineering, Springer, 2007.

JW Brown, RV Churchill, Complex variables with applications, 8th ed, McGraw Hill 2009.

EC479 COMPUTATIONAL INVERSE PROBLEMS AND APPLICATIONS (3-1-0) 4

Inverse Problems and Interpretation, Examples of inverse problems, III posed problems and numerical solutions. Classical Regularization Methods, Statistical Inversion Theory, nonstationary Inverse Problems, Regression, regularization, and iterative schemes for smooth optimization, numerical optimization, Bayesian approach to inverse problems, Inverse problems in imaging modalities and radar, applications in remote sensing, geoscience, biomedical.

Heinz Engl, Michael Hanke, and Andreas Neubauer, Regularization of Inverse Problems, Dordrecht, 2nd ed, 1996.
Curtis R.Vogel, Computational Methods for Inverse Problems, SIAM, 2002.
Per Christian Hansen, Discrete Inverse Problems: Insight and Algorithms, SIAM, 2010. Jennifer Mueller and SamuliSiltanen, Linear and Nonlinear Inverse Problems with Practical Applications, SIAM, 2012.
Jorge Nocedal and Stephen J. Wright, NumericalOptimization, Springer-Verlag, 1999.

EC480 REMOTE SENSING: PRINCIPLES, TECHNIQUES AND APPLICATIONS (3-1-0) 4

History and Introduction, electromagnetic radiation, basic laws, Radiometry, Interaction of EMR with matter, RS in visible and IR domain: Radiance to reflectance, atmospheric and topographic correction, Radio remote sensing, RS image acquisition, Different types of sensors, resolution concepts, Resolution concepts, Spectral reflectance curves, Spectral reflectance curves, Spectral indices, Thermal infrared remote sensing, Passive microwave radiometry, Active microwave remote sensing: Imaging radar, Platforms used for RS data acquisition and characteristics, Hyperspectral Remote Sensing, Information Extraction from the Image Data, Lidar, Common remote sensing datasets and data portals, mathematical techniques and algorithms for processing the RS data, acquisition and analysis, estimation, detection, recognition, classification techniques, Applications of RS for land use and land cover monitoring, water resources management, agricultural, environmental, forestry, geology applications, and etc.

Iain H. Woodhouse, Introduction to Microwave Remote Sensing, CRC Press 2005.
W. G. Rees, Physical Principles of Remote Sensing, Cambridge University Press, 2012.
Hamlyn G. Jones and Robin A. Vaughan, Remote Sensing of Vegetation: Principles, Techniques, and Applications, Oxford University Press, 2010.
J. Richards, Remote Sensing with Imaging Radar, Springer 2020.
Pinliang Dong and Qi Chen, LiDAR Remote Sensing and Applications, CRC Press, 2017.
Marcus Borengasser, William S. Hungate, Russell Watkins: Hyperspectral Remote Sensing Principles and Applications, 1 Ed, CRC Press, 2007.

EC481 ADVANCE DEEP LEARNING AND APPLICATIONS (3-1-0) 4

Review of CNNs for classification and segmentation tasks, Advance concepts-depth-wise separable convolution, Atrous convolution, Group Convolution, Gated Atrous Pyramid Pooling, Attention and Self-attentions. Deep CNN Models for Regression, classification and Segmentations task: ResNet Models, Variants of UNet, BiSeNet V2. Advance CNNs for Object Detection and Text Classification, Graph Neural Networks. Vision Transformer and its Applications: object segmentation, detection and classification.

IanGoodfellow, YoshuaBengio, and Aaron Courville Deep Learning, MIT Press, 2016.
MahmoudHassaballah and Ali Ismail Awad, Deep Learning in Computer Vision: Principles and Applications, CRC Press, 2020.
Rowel Atienza, Advance deep learning with Keras, Packt, October 2018.
Wang,X.,Zhao, Y.&Pourpanah, F.Recent advances in deep learning. Int.J.Mach. Learn. & Cyber. 11,747-750 (2020).https://doi.org/10.1007/s13042-020-01096-5
Alexey Dosovitskiy, et al., An Image is Worth 16x16 Words: Transformers for Image Recognition at Scale, https://arxiv.org/abs/2010.11929
Xiangning Chen, Cho-Jui Hsieh, Boqing Gong, "When Vision Transformers Outperform ResNets Without Pre-Training or Strong Data Augmentations",2022

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EC280	**MINI PROJECT IN ELECTRICAL CIRCUITS & SYSTEMS**	**(0-0-3) 2**
EC281	**MINI PROJECT IN DIGITAL SYSTEM DESIGN**	**(0-0-3) 2**
EC380	**MINI PROJECT IN COMMUNICATION SYSTEMS AND NETWORKS**	**(0-0-3) 2**
EC381	**MINI PROJECT IN MICROPROCESSOR & EMBEDDED SYSTEM**	**(0-0-3) 2**
EC382	**MINI PROJECT IN ANALOG SYSTEM DESIGN**	**(0-0-3) 2**
EC383	**MINI PROJECT IN VLSI DESIGN**	**(0-0-3) 2**
EC384	**MINI PROJECT IN RF DESIGN**	**(0-0-3) 2**
EC385	**MINI PROJECT IN DIGITAL SIGNAL PROCESSING**	**(0-0-3) 2**
EC386	**MINI PROJECT IN IMAGE PROCESSING**	**(0-0-3) 2**

EC387 MINI PROJECT IN AI AND MACHINE LEARNING (0-0-3) 2
EC388 MINI PROJECT IN PHOTONICS (0-0-3) 2

The contents of these mini projects will be defined by the course instructor.

COURSES FOR MINOR STREAM

EC391M ANALOG ELECTRONIC CIRCUITS (3-0-0) 3

Introduction to operational amplifiers: The difference amplifier and the ideal operational amplifier models, concept of negative feedback and virtual short, Analysis of simple operational amplifier circuits, Frequency response of amplifiers, Bode plots. Feedback: Feedback topologies and analysis for discrete transistor amplifiers, stabillity of feedback circuits using Barkhausen criteria. Linear applications of operational amplifiers: Instrumentation and Isolation amplifiers, Current and voltage sources, Non-linear applications of operational amplifiers: Comparators, clippers and clampers, Precision rectifiers, Waveform Generation: Sinusoidal feedback oscillators, Relaxation oscillators, square-triangle oscillators. Practical perational amplifiers: Non-idealities and their on circuit performance. Analog and Digital interface circuits: Relays, S/H circuits, Opto-couplers, A/D, D/A Converters.

Ramakant A. Gayakwad, Op-Amps and Linear Integrated Circuits, Pearson, 2015

EC392M DIGITAL ELECTRONICS (3-0-0) 3

Introduction to Boolean Algebra and Switching Functions, Boolean Minimization, Finite State Machines, Design of synchronous FSMs, FSM Minimization, Bipolar Logic Families – TTL, MOS logic families (NMOS and CMOS), and their electrical behaviour. Memory Elements, Timing circuits, Elementary combinational and sequential digital circuits: adders, comparators, shift registers, counters. Logic Implementation using Programmable Devices (ROM, PLA, FPGA).

Morris. M. Mano, Michael D. Ciletti, Digital Design, Fourth Edition, Prentice-Hall India. 2008.
Charles. H. Roth, Jr., Fundamentals of Logic Design, Fifth Edition, Thomson Brooks/Cole, 2005.
J.F.Wakerly, Digital Design Principles and Practices, PH, 1999.
D.D. Givone, Digital Principles and Design, TMH, 2002

EC393M SIGNALS AND SYSTEMS (3-0-0) 3

Sinusoids –complex exponentials and phasor, Spectrum representation – spectrum of sum of sinusoids, Periodic signals, Fourier series representation, synthesis. Sampling and aliasing – sampling of sinusoidal signals, aliasing, sampling theorem, reconstruction. Discrete time FIR systems – moving average filter, general FIR filter, impulse filter, implementation of FIR filters, LTI systems, convolution, frequency response of FIR systems. Z Transform: Definition and properties, ROC, inverse Z transform, transfer function, poles and zeros, application of Z transforms to discrete-time systems. Discrete time IIR systems – Impulse response, step response, representation of LTI systems, frequency response of IIR systems. Applications of DSP – Sinusoidal synthesis, Image denoising,

Mc Chellan, R.W. Schafer & Yoder, Signal Processing First, Pearson 2003.
Sergio Franco, Design with OPAMPS and Linear Integrated circuits, Tata McGraw Hill, 2002.
Ron Mancini, Op Amp for Everyone, Texas Instruments, 2002

EC394M COMMUNICATION SYSTEMS (3-0-0) 3

Amplitude Modulation, Time & Frequency domain description, Modulation techniques, Switching modulator, Demodulation techniques, Envelope detector, Coherent detection, Costas Receiver, The Superheterodyne Receiver, Quadrature Carrier Multiplexing, Single side band and vestigial sideband modulation, Frequency Translation, Frequency Division Multiplexing. Angle Modulation, Basic definitions, Frequency Modulation, Narrow Band FM, Wide Band FM, Transmission bandwidth of FM Signals, Generation of FM Signals, Demodulation of FM Signals, FM Stereo Multiplexing, Phase–Locked Loops and their application in FM demodulation. Theme example: FM stereo broadcast. Noise in Analog Modulation, Introduction, Receiver Model, Noise in DSB-SC receivers, Noise in AM receivers, Threshold effect, Noise in FM receivers, Capture effect, FM threshold effect, FM threshold reduction, Pre-emphasis and Deemphasis in FM. Digital Representation of analog signals, The Sampling process, Pulse Amplitude Modulation, Time Division Multiplexing, Pulse-Position Modulation, Generation of PPM Waves, Detection of PPM Waves, Quantization Process, Quantization Noise, Pulse Code Modulation: Sampling, Quantization, Encoding, Regeneration, Decoding, Filtering, Multiplexing, Application to Vocoders.

M. F. Mesiya, "Contemporary Communication Systems", McGrawHill, 2013.
Steven W. Ellingson, "Radio Systems Engineering", Cambridge University Press, 2016.
Taub and Schilling, "Principles of Communication systems", Second Edition, Tata McGrawHill, 2006 Proakis and Salehi, "Fundamentals of Communication Systems", Second Edition, Pearson International, 2014.

Simon Haykin, "Communication Systems", Fourth Edition, Wiley, 2000.

EC395M DATA COMMUNICATION AND NETWORKS (3-0-0) 3

Data encoding and transmission concepts, Digital data transmission, NRZ encoding, Multilevel binary encoding, Biphase encoding, Scrambling techniques, Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), Performance of digital and analog modulation schemes, Quadrature Amplitude Modulation (QAM), Pulse Code Modulation, Non-linear encoding, Delta modulation, Asynchronous transmission, Synchronous transmission, Ethernet link layer frame example. Switching techniques, Multiplexing and Multiple Access techniques, Packet Switched Networks. OSI and TCP/IP Models, Internet protocols and addressing, networking devices, data links and transmission, LANs and Network of LANS, Wireless Networks and Mobile IP, Routing and internetworking, transport and end to end protocols, congestion control techniques, Application Layer and network management, Network Security. Packet Queues and delays, Little's theorem, Birth and death process, Queuing disciplines, M/M/1 Queues, Burkes and Jackson theorems. Traffic models, ISDN, ATM Networks, Quality of service and resource allocation, VPNs and MPLS, Cellular Telephone and Optical networks, VOIP and Multimedia networking. Mobile Adhoc Networks and Wireless Sensor Networks.

Nader F. Mir, Computer and Communication Networks, Pearson Education, 2007
Garcia and Widjaja, Communication Networks, McGraw Hill, 2006
J.F. Hayes, Modelling and analysis of Computer Comm. Networks, Plenum, 1984.
Jean Walrand & Pravin Varaiya, High Performance Communication Networks, Morgan Kaufmann Publishers, 2002 Taub and Schilling, "Principles of Communication systems", Second Edition, Tata McGrawHill, 2006 Proakis and Salehi, "Fundamentals of Communication Systems", Second Edition, Pearson International, 2014.
Simon Haykin, "Communication Systems", Fourth Edition, Wiley, 2000.

EC390 SEMINAR (0-0-2) 1
EC490 PRACTICAL TRAINING 1
EC498 MAJOR PROJECT 6

EC497 CORNERSTONE/CAPSTONE PROJECT 4

For details refer to clause 3.2 under Regulations specific to Undergraduate Programmes.

UC100 INTRODUCTION TO DESIGN THINKING (2-0-0) 2

Need and Definition of Design Thinking. Framework for Design Thinking. Engineering Design Process. Need Identification, Specification, Concept Generation, Product Architecture and Detailed Design. Prototyping – Virtual and Physical. Testing Methodology

Christian Muller-Roterberg, "Handbook of Design Thinking", 2018
Eli Woolery, "Design Thinking Handbook" Invision Pub, 2019
Nigel Cross, "Design Thinking"
Max Answell "Mastering Design Thinking", 2019
Karl T. Ulrich, Steven D. Eppinger and Maria C Yang, "Product Design and Development", McGraw Hill, 7ed, 2020
George e Dieter, Linda C Schmidt, "Engineering Design", Mc Graw Hill, 4ed, 2009

UC401 LIBERAL ARTS COURSES/CO-CURRICULAR/EXTRACURRICULAR ACTIVITIES 10

CATEGORY A : Maximum 3 credits, CATEGORY B : Maximum 3 credits, CATEGORY C : Minimum 4 Credits and Maximum 7 credits.

10 Credits have to be earned from 1st Semester to 7th Semester by choosing Category (A + B + C) OR Category (A + C) or Category (B + C) courses combination . Registration for 10 Credits has to be done in 7th Semester.

For details of CATEGORY A, CATEGORY B and CATEGORY C refer to clause 3.2 (f) under Regulations specific to Undergraduate Programmes.

IT110 DIGITAL SYSTEM DESIGN (3-0-2) 4

Introduction: Number Systems and Codes; Boolean Algebra and Logic Gates; Karnaugh Maps and Gate-Level Minimization; Combinational Logic Design: Adders, Subtractors, Comparators, Decoders, Encoders, Multiplexers; Sequential Logic Design: latches, Flip-Flops; Registers, Counters and Memory Unit: Shift Registers, Ripple and Synchronous Counters, Random Access Memory; Algorithmic State Machines; Design at the Register Transfer Level; Hardware Descriptive Language.

M. Morris Mano, Digital Logic & Computer Design, 1st Edition, Pearson Education, 2016.
M. Morris Mano and Michael D. Ciletti, Digital Design with VERILOG HDL, 5th Ed., Pearson, 2012.
Mark Zwolinski, Digital System Design with VHDL, 2nd Edition, Pearson, 2004.
B. Holdsworth and R.C. Woods, Digital Logic Design, 4th Edition, Elsevier, 2003.

IT150 OBJECT ORIENTED PROGRAMMING (3-0-2) 4

Concepts of OOP – Introduction to OOP, Procedural Vs. Object Oriented Programming, Principles of OOP, Benefits and applications of OOP; Beginning with C++: Overview and Structure of C++ Program, Classes and Objects, Constructors and Destructors. Programming with JAVA – Overview of Java Language, Classes Objects and Methods, Method Overloading and Inheritance, Overriding Methods, Final Variables and Methods, Interfaces, Packages, Multithreaded programming, Exception Handling; Introduction to Android Programming : Setting up Development Environment, Basic Building blocks – Activities, Services, Broadcast Receivers & Content providers, UI Components –Views & notifications, Components for communication –Intents & Intent Filters; Introduction to Object-Oriented Design and Analysis, UML, Use Case Modeling. Introduction to Design Patterns (Observer, Strategy, Composite, Decorator, Iterator, Adaptor, Command, Factory Method, Proxy, Singleton, and Visitor).

E. *Gamma et al., Design Patterns:Elements of Reusable Object-Oriented Software, 1st Ed., Addison-Wesley, 1994. G. Booch, J. Rumbaugh, and I. Jacobson, The Unified Modeling Language User Guide, Addison-Wesley, 1999. Bruce E. Wampler, The Essence of Object Oriented Programming with Java and UML, Addison-Wesley, 2002. Danny Poo, Derek Kiong and Swarnalatha Ashok, Object-Oriented Programming and Java, 2nd Ed., Springer, 2007.*

IT200 COMPUTER COMMUNICATION AND NETWORKING (4-0-0) 4

Evolution of Data Communication and Networks, Transmission Fundamentals: Signaling Schemes, Encoding and Modulation, Data Transmission over Networks – Switching Techniques, Layered Architecture of Computer Networks, OSI & TCP/IP Architectures and Layers with protocols, Data Link Control and Protocols, Error Detection and Correction, Internetworking & Routing, Transport Layer Protocols, Applications: E-Mail, HTTP, WWW, Multimedia; Implementation of Signaling and Modulation, Bit, Byte & Character Stuffing and Error Detection/Correction Coding Techniques, TCP/IP Level Programming, Routing Algorithms, Exercises comprising simulation of various protocols.

"*Computer Networks", Andrew S. Tanenbaum and David J Wetherall, 5th Edition, Pearson, 2013.*
"Data Communications and Networking", Behrouz A. Forouzan, 4th Edition, McGraw Hill, 2017.
"Data and Computer Communications", William Stallings, 10th Edition, Pearson, 2013.
"Communication Networks", Leon, Garcia and Widjaja, 2nd Edition, McGraw-Hill, 2003.
"Computer Networking: A Top-Down Approach", James Kurose; Keith Ross, 7th Edition, Pearson, 2016.
"Computer Networks: A Systems Approach", Larry Peterson and Bruce Davie, 5th Ed., Morgan Kaufmann, 2011.

IT201 COMPUTER ORGANIZATION AND ARCHITECTURE (3-0-0) 3

Introduction to computer organization and architecture, CPU Organization, Data Representation, Instruction Sets, Data path design, Fixed point and floating point arithmetic operations and hardware design, ALU design, Control unit : Hardwired control unit and Micro programmed control unit. Memory organization, Cache memory, Virtual memory. Input output Unit: Programmed Controlled I/O Transfer, Interrupt controlled I/O transfer, DMA controller. Secondary storage and type of storage devices. Pipelining. Performance evaluation.

Carl Hamacher et al., Computer Organization and Embedded Systems, Sixth Edition, McGraw-Hill, 2014. Vincent P Heuring, Harry F Jordan, T. G. Venkatesh, Computer Systems Design and Architecture, Pearson, 2008. Miles Murdocca and Vincent Heuring, Computer Architecture & Organization An Integrated Approach, Wiley, 2007. J. Hennesy and D. Patterson, Computer Architecture –A Quantitative Approach, 6th Ed., Morgan Kaufmann, 2017.

IT202 DATA STRUCTURES AND ALGORITHMS-I (3-0-0) 3

Elementary Data Types and Abstract Data Types. Computational model and complexity of algorithms (running time and space metrics), Introduction to Asymptotic notation: Big-O, Big-Omega, Big-Theta notations. Worst-case, Best-case, Average-case and amortized analysis. Arrays, Linear search and Binary search on sorted arrays. List ADT, implementing List ADT using arrays. Pointers, implementing List ADT using Linked Lists. Types of Linked Lists:

Single, Double, Circular linked lists and their applications for e.g. in garbage collection. Stack ADT and Queue ADT implementation, applications for parenthesis matching, expression evaluation, implementing recursion, etc. Dynamic set ADT and Dictionary ADT. Hash tables: collisions, open and closed hashing, choosing good hash functions. Trees: Definitions and Representations; Tree traversals and their applications. Binary Search Trees. AVL trees, Red-black trees, Multi-way search trees, B- trees, splay trees; Priority Queue ADT and its implementations using Binary heaps. Applications of Priority Queues. Sorting algorithms: Bubble sort, Selection sort, Insertion sort, Merge sort and Quick sort. Randomized Quick sort and its analysis. Linear-time sorting algorithms like Radix and Counting sort. Lower bound for comparison based sorting.

T H Cormen et al., Introduction to Algorithms, 3rd Edition, PHI Learning Ltd., 2010.
S. Horowitz. Fundamentals of Data Structures in C, Universities Press, 2nd Edition, 2008.
Michael T. Goodrich and Roberto Tamassia. Algorithm Design, Wiley, 1st Edition, 2006.
Knuth D.E., Art of Computer Programming: Fundamental Algorithms, Addison Wesley, 3rd Ed., 1997.

IT203 DISCRETE MATHEMATICS (3-0-0) 3

Mathematical Logic and Proofs: Propositional Logic and Applications, Operations on Propositions, Truth Tables, Tautologies & Logical Equivalence, Predicate Logic, Predicates & Quantifiers, Nested Quantifiers, Inference Rules, Proofs Methods; Set Theory: Sets/Operations, Sequences/Summations, Cardinality of Sets, Functions (Surjections, Injections); Induction and Recursion: Mathematical Induction, Strong Induction and Well-Ordering, Recursive Definitions, Structural Induction; Combinatorics: Counting, Pigeonhole Principle, Permutations/Combinations, Binomial Coefficients, Recurrence Relations, Generating Functions, Inclusion-Exclusion; Relations: *n*-ary Relations and Applications, Representing Relations, Closures of Relations, Equivalence Relations, Partial Orders; Group Theory: Groups, Semigroups, Monoids, Rings, Fields, Vector Spaces and Lattices; Graph Theory: Graphs and Models, Euler and Hamiltonian Paths, Trees, Tree Traversals, Spanning Trees, Graph Matching, Graph Coloring.

C.L.Liu and D.P. Mahapatra, Elements of Discrete Mathematics, 4th Edition, McGraw-Hill, 2012.
K.H.Rosen, Discrete Mathematics and Its Applications, 7th Edition, McGraw-Hill, 2017.
John A. Dossey, Discrete Mathematics, 5th Edition, Pearson, 2011.
Jean-Paul Tremblay and R Manohar, Discrete Mathematical Structures with Apps., 1st Ed., McGraw-Hill, 2017.
J .L.Mott, A.Kandel, T.P .Baker, Discrete Mathematics for Computer Scientists, 2nd Ed., Prentice Hall of India, 1986.

IT204 SIGNALS AND SYSTEMS (3-0-2) 4

Signals in Physical World: Continuous Time Signals & Spectra, Fourier Series, Fourier Transforms; Signals in Digital World: Sampling, Quantization, Interpolation, Discrete Time Signals & Spectra, Discrete Fourier Transforms (DFT): Fast Fourier Transforms (FFT), Discrete Cosine Transforms (DCT), Systems: Continuous Linear Time Invariant (LTI) and Time Variant (LTV) Systems, Discrete LTI & LTV Systems; Z-Transform; Convolution and Correlation; Filters: Feedforward and Feedback; Modulation: AM, FM, PAM, PCM, Multiplexing: FDM and TDM; Compression: Text (Huffman Coding, Run Length Coding); Audio (MP3); Image (JPEG); Video (MPEG4).

Michael Stiber and Bilin Stiber, "Signal Computing: Digital Signals in the Software Domain", Published by University of Washington Bothell, 2016.
A.V. Oppenheim, A.S. Willsky and S. Hamid Nawab, Signals and Systems, 2nd Edition, Pearson, 2015.
Rodger E. Ziemer, W.H. Tranter and D.R. Fannin, Signals and Systems, 4th Edition, Pearson, 2014.
B.P. Lathi and Roger Green, Linear Systems and Signals, 3rd Edition, Oxford University Press, 2017.
M.J. Roberts, Signals and Systems - Analysis Using Transform Methods & MATLAB, McGraw-Hill, 2017.
Luis F. Chaparro, Signals and Systems Using MATLAB, 2nd Edition, Academic Press, 2014.

IT205 COMPUTER NETWORKING LAB (0-0-3) 2

Implementation of Datalink Layer Protocols, Network Layer Protocols and Application Layer Protocols. Simulate different types of network topology, configure Router and Switches using open source tool such packet tracer. By writing a program/script measure incoming and outgoing network traffic, power consumption and storage status on networking device(s)/server.

IT206 DATA STRUCTURES AND ALGORITHMS-I LAB (0-0-3) 2

Implementation of List ADT operations using arrays and linked lists. Applications of Lists. Stacks, Queues, Circular Queues implementation and application. Implementing Hash Table with chaining and open addressing. AVL tree implementation, B- tree implementation, Application of trees. Array and pointer-based implementation of Binary heaps. Applications of Priority Queues. Searching and sorting. Applications to real world problems.

IT210M DATA STRUCTURES AND ALGORITHMS (3-0-2) 4

Elementary Data Types and Abstract data types. Computational model and complexity of algorithms (running time and space metrics), Introduction to Asymptotic notation; Worst- case, Best -case, Average-case and amortized analysis.

Arrays, Linear search and Binary search on sorted arrays. List ADT and its implementation using arrays and linked lists. Types of linked lists: Single, Double, circular linked lists and their applications. Stack ADT and Queue ADT implementations with applications. Dynamic set ADT and Dictionary ADT. Hash tables – collisions, open and closed hashing, choosing good hash functions. Trees: Definitions and Representations; Tree traversals and their applications. Binary Search Trees. AVL trees, Red-black trees, B-trees; Priority Queue ADT and its implementations using Binary heaps. Applications of Priority Queues. Sorting algorithms: Merge sort and Quick sort. Randomized Quick sort and its analysis. Linear-time sorting algorithms like Radix and Counting sort. Graphs: Definitions and representations. Depth-first and breadth-first search and their applications. Basic Graph algorithms like Dijkstra's shortest path algorithm and Kruskal's MST algorithm.

T H Cormen, C E Leiserson, R L Rivest and C Stein, Introduction to Algorithms, 3rd Edition, PHI Learning, 2010.
S. Horowitz. Fundamentals of Data Structures in C, Universities Press, 2nd Edition, 2008.
Michael T. Goodrich and Roberto Tamassia. Algorithm Design, Wiley, 1st Edition, 2006.
Knuth D.E., The Art of Computer Programming, Vol. I: Fundamental Algorithms, Addison Wesley, 3rd Ed., 1997.

IT250 AUTOMATA AND COMPILER DESIGN (3-0-2) 4

Introduction to Automata and Compiler Design, Regular Expressions, DFA, NFA, Minimization of states, Lexical analysis, usage of Lex, CFG, BNF notation, PDA, Parsing Techniques, Top-down and bottom-up parsing, Error Recovery strategies, Intermediate Code Generation, Runtime environment, Code Generation and introduction to code optimizations. Simple projects to demonstrate the usage of parsers for code generation for a simple C-like language.

John E. Hopcroft et al., Introduction to Automata Theory, Languages and Computation, 3rd Ed., Pearson, 2007.
A.V. Aho et al., "Compilers: Priniciples, Techniques, Tools", 2nd Edition, Pearson, 2006.
Allen I. Holub, "Compiler Design in C", Prentice-Hall, 1990.

IT251 DATA STRUCTURES AND ALGORITHMS-II (3-0-2) 4

Graphs: Definitions and representations. Adjacency List and Adjacency Matrix representations and their relative advantages and disadvantages. Graph Algorithms: Depth-First Search (DFS) and Breadth-First Search (BFS). Applications of BFS and DFS. Topological Sorting and strongly connected components in directed graphs. Dijkstra's shortest path algorithm, and its analysis: runtime and correctness. Data Structure for Disjoint Sets: Union-by-rank and path-compression heuristics; applications to computing connected components and in Minimum Spanning Tree algorithms. Kruskal's and Prim's Minimal Spanning Tree algorithms. Network flows, max-flow min-cut theorem. Applications: network and internet examples. Tries, Suffix trees, Bloom filters and their applications. String Algorithms: Boyer-Moore, Rabin-Karp and Knuth-Morris-Pratt algorithms. Applications to Text Compression, Text similarity testing and Computational Biology. Topics in Computational Geometry: Range-trees, k-d trees, convex hull and other geometric 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 Learning, 2010.
Horowitz and Sahni, Fundamentals of Computer Algorithms, Galgotia Publications, 2nd Ed., 2009.
Michael T. Goodrich and Roberto Tamassia. Algorithm Design, Wiley, 1st Edition, 2006.

IT252/IT252M DATABASE SYSTEMS (3-0-2) 4

Basic Concepts, Data models: ER, EER; Languages: SQL as backend and PHP or equivalent as frontend; Logical Database Design: Normalization; Physical Database Design: Storage organization, Indexing; Query Languages – Procedural , Non-procedural; Logical and Physical Design, Query Processing, Transaction processing: Concurrency Control and Recovery. Current trends in database system, Design and Implementation of Database Systems for applications such as office automation, hotel management, hospital management; Normalization, Query Processing in the above said application projects; Implementation of few important functionalities of relational database management systems.

Raghu Ramakrishnan, Johannes Gehrke, Database Management Systems, McGraw-Hill, 2014 R.
Elmasri and S.B Navathe , Fundamentals of Database Systems,7th Ed., Pearson, 2017
Silberschatz, Korth A.F., Sudarshan S., Database System Concepts, 6th Ed., McGraw-Hill,2010.

IT253 OPERATING SYSTEMS (3-0-2) 4

Operating Systems Overview, Interrupt Sources and Priorities, Interrupt Service Routines; User and Kernel Threads, Synchronization, Critical Section Problem; Process Synchronization and Coordination, Semaphores, Monitors; Inter Process Communication; Deadlock Prevention, Avoidance, Detection, Recovery; CPU Scheduling Algorithms, Memory Management, Paging and Virtual Memory, Storage Hierarchy, File System Organization; Distributed Operating Systems: System Architectures, Design Issues, Communication Models, Clock Synchronization, Mutual Exclusion, Election Algorithms, Distributed Deadlock Detection; Mobile Operating Systems: ARM & Intel

Architectures, Mobile OS Architectures, Runtime Issues, Approaches to Power Management; UNIX/LINUX OS as Case Studies; Configure, Compile, and Install a Linux Kernel/Kernel Module from Sources, Performance Analysis; Device Drivers: Building and Running Modules, Char Drivers, Concurrency and Race Conditions, Interrupt Handling, Data Types in the Kernel, PCI Drivers, USB Drivers, Block Drivers, Network Drivers, TTY Drivers.

Andrew S. Tannenbaum and Herbert Bos, Modern Operating Systems, 4th Edition, Pearson, 2015
Abraham Silberschatz et al., Operating System Concepts, 9th Ed., John Wiley, 2012.
Harvey M. Deitel et al., Operating System, 3rd Edition, Pearson, 2007.
William Stallings, Operating Systems: Internals and Design Principles. 9th Ed., Pearson, 2017.
M. J. Bach. Design of the Unix Operating System, 1st Edition, Pearson, 2015.
Jonathan Corbet et al., Linux Device Drivers, 4th Edition, O'Reilly, 2013.

IT254/IT254M WEB TECHNOLOGIES AND APPLICATIONS (3-0-2) 4

Internet and World Wide Web - Overview, Web System Architecture, Web Clients and Web Servers, Application Servers. Hypertext Transfer Protocol - primitives, methods, content transport, HTTP1.1 and HTTP2, HTTPS, SSL. Client side programming with XHTML, HTML5, CSS3, Event driven programming with JavaScript, Client-side validation; Server side programming, Sessions and Session Tracking techniques, jQuery and AJAX.; XML – Syntax and Semantics, DTD, Namespaces, XML Schemas, XPath and XSLT, Web Frameworks, Search Engines and Search Engine Optimization; The Next Generation Web - Social Web, Semantic Web, Internet/Web of Things, Applications and Research Trends.

Jeffrey C Jackson, "Web Technologies – A Computer Science Perspective", Pearson Education, 2009
Robert W Sebesta, "Programming the World Wide Web", 7th Edition, Pearson Education, 2014 Dietel and Nieto, "Internet and World Wide Web — How to program", Pearson, 2010

IT290 SEMINAR 1

This seminar is a 1 credit mandatory learning course to be completed during 4th semester. Each student will make technical presentation on a topic of academic interest as per recommendations and evaluation criteria of the DUGC of IT department.

IT300 DESIGN AND ANALYSIS OF ALGORITHMS (3-0-2) 4

Models of computation, algorithm analysis and asymptotic notation, time and space complexity, average and worst case analysis, lower bounds. Amortized analysis. Algorithm design techniques: recursion, branch-and-bound, divide and conquer, greedy, dynamic programming, randomization. Applications of the above techniques to a variety of problems: Stable matching, linear- time selection, integer, polynomial and matrix multiplications, Fast Fourier Transforms (FFT): FFT Algorithms, computing shortest paths and minimum spanning trees, etc. Reductions and the theory of NP-Completeness, Approximation 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.

IT301/IT301M PARALLEL COMPUTING (3-0-2) 4

Introduction to Parallel Computer Architectures, Data level and Instruction level parallelism, Shared memory and distributed memory programming techniques, Parallel Programming with OpenMP, MPI, Parallel Programming techniques like Task Parallelism using TBB, TL2, Cilk++ etc. and software transactional memory techniques. Introduction to accelerator programming using CUDA/OpenCL and Xeon-phi. Concepts of Heterogeneous programming techniques. Projects to implement a few of the techniques introduced in this course.

Peter S Pacheco, Matthew Malensek, "An Introduction to Parallel Programming" Morgan Kaufmann, 2022.
Gerassimos Barlas, "Multicore and GPU Programming An Integrated Approach" Second Edition, Morgan Kaufmann, 2023.
Dezso Sima, Terence Fountain, Peter Karsuk, "Advanced Computer Architecture A Design Space Approach", Pearson 2009
J. Dongara, I. Foster, G. Fox, W. Cropp et al, "Sourcebook of Parallel Programming", Morgan Kaufmann, 2002.
Barbara Chapman et.al, "OpenMP: Portable Shared Memory Parallel Programming", Scientific & Engineering Computation, MIT 2008.
B. Wilkinson and M. Allen, "Parallel Programming: Techniques and Applications", 2nd ed., Pearson, 2004.
Benedict R. Gaster et al., Heterogeneous Computing with OpenCL, 2nd Edition, Morgan Kaufmann. 2012.
Rezaur Rahman, Intel Xeon-Phi Coprocessor Architecture/Tools - The Guide for App. Developers, Apress, 2013.

CUDA for Engineers by Duane Storti and Mete Yurgotlu, Addison-Wesley, 2016.

IT302 PROBABILITY AND STATISTICS (3-0-2) 4

Introduction to Statistics and Data Analysis; Probability Theory: Non-deterministic models, Finite Probability Space and related concepts, Conditional Probability, Independent and mutually exclusive events, Bayes' Theorem, Random Variables – One and Two dimensional, Expectation, Variance, Correlation, Statistical Distributions – Uniform, Normal, Binomial, Gamma, Exponential, Poisson, Chi-Square, Log-Normal, Weibull; Stochastic Processes: Markov Chains, Binomial & Poisson; Queuing Systems: M/M/1 and M/M/K; Sampling Theory: Random Sampling and Applications, Mean, Median, Mode, Variance, Standard Deviation; Hypothesis Testing: Formulation of hypotheses – null and alternate hypothesis, Parametric and non -parametric tests and their applicability, Criteria for acceptance of hypothesis, Level of Significance, *t*-test, *z*-test and Chi-Square Tests with applications.

P. L. Meyer, Introductory Probability and Statistical Applications, Oxford & IBH Publishers, 2017.
S. M. Ross, Introduction to Probability & Statistics for Engineers and Scientists, 5th Ed., Academic Press, 2014.
Michael Baron, Probability and Statistics for Computer Scientists, 2nd Edition, CRC Press, 2014.
R. V. Hogg, J. W. McKean and A. T. Craig, Introduction to Mathematical Statistics, 7th Edition, Pearson, 2012.
R. E. Walpole et al., Probability and Statistics for Engineers and Scientists, 9th Edition, Pearson, 2010.
Jane M. Horgan, Probability with R with Computer Science Applications, 1st Edition, John Wiley, 2009.
John Verzani, Using R for Introductory Statistics, 2nd Edition, CRC Press, 2014.
G. Jay Kerns, Introduction to Probability and Statistics Using R, 1st Edition, G. Jay Kerns, 2010.
Maria Dolores Ugarte et al., Probability and Statistics with R, 2nd Edition, CRC Press, 2015.

IT303 SOFTWARE ENGINEERING (3-0-2) 4

Software Requirements Fundamentals: Product and Process Requirements, Functional and Nonfunctional Requirements, Quantifiable Requirements, System Requirements and Software Requirements, Requirements Process Models , Process Actors, Requirements Elicitation, Requirements Classification, Architectural Design and Requirements Allocation , Formal Analysis , Requirements Specification, Software Requirements Specification Requirements Reviews, Prototyping. Key Issues in Software Design: Concurrency , Control and Handling of Events , Data Persistence, Distribution of Components, Error and Exception Handling and Fault Tolerance, Interaction and Presentation , Security , Software Structure and Architecture, , Architectural Structures and Viewpoints , Architectural Styles, Architecture Design Decisions, Families of Programs and Frameworks , User Interface Design, General User Interface Design Principles, Software Design Quality Analysis and Evaluation ,Quality Attributes , Quality Analysis and Evaluation Techniques , Measures. General Strategies: Function-Oriented (Structured) Design, Object-Oriented Design, Data Structure-Centered Design, Component- Based Design; Software Construction : Minimizing Complexity, Anticipating Change, Constructing for Verification, Reuse, Coding, Integration, Construction Technologies, API Design and Use, Object-Oriented Runtime Issues, Parameterization and Generics, Assertions, Design by Contract, and Defensive Programming, Performance Analysis and Tuning , Unit Testing Tools, Profiling, Performance Analysis, and Slicing Tools; Software Testing, Input Domain-Based Techniques, Code-Based Techniques, Fault-Based Techniques, Usage-Based Techniques, Model-Based Testing Techniques, Software Maintenance Fundamentals, Techniques for Maintenance, Program Comprehension, Reengineering, Reverse Engineering, Migration, Retirement; Software Configuration Management, Management of the SCM Process, Organizational Context for SCM, Constraints and Guidance for the SCM Process, Planning for SCM, Surveillance of Software Configuration Management, Software Configuration Identification, Identifying Items to Be Controlled, Requesting, Evaluating, and Approving Software Changes, Implementing Software Changes, Deviations and Waivers, Software Configuration Status Accounting, Software Configuration Auditing , In-Process Audits of a Software Baseline, Software Release Management and Delivery, Software Building Software Release Management, Software Configuration Management Tools.

Axel van Lamsweerde, Requirements Engg: From System Goals to UML Models to Software Specs., Wiley,2009.
Lenny Delligatti, SysML Distilled: A Brief Guide to the Systems Modeling Language, 1st Ed., Addison-Wesley, 2013.
J.H. Allen et al., Software Security Engineering: A Guide for Project Managers, Addison-Wesley, 2008.
R.S. Pressman, Software Engineering: A Practitioner's Approach, 7th ed., McGraw-Hill, 2010.
P. Clements et al., Documenting Software Architectures: Views and Beyond, 2nd ed.,Pearson Education, 2010.
M. Utting and B. Legeard, Practical Model-Based Testing: A Tools Approach, Morgan Kaufmann, 2007.
J.W. Moore, The Road Map to Software Engg: A Standards-Based Guide, Wiley-IEEE Computer Society Press, 2006.
S.P. Berczuk and B. Appleton, Software Configuration Management Patterns:Effective Teamwork, Practical Integration, Addison-Wesley Professional, 2003.

IT350/IT350M DATA ANALYTICS (3-0-2) 4

Introduction to Data analysis: statistical modelling, total information awareness, Bonferroni's Principle; Distributed File systems: MapReduce and Spark; Dimensionality Reduction: PCA, SVD; Finding Similar Items: Distance Measures, Near Neighbour Search; Mining Data Streams; Link Analysis, Mining Social-Network Graphs: graph

centrality concepts, clustering, community detection, partitioning, overlapping community detection, SimRank; Applications of Large-scale Machine Learning, Neural Network Models like Multi-Layer Perceptron (MLP), Recurrent Neural Networks (RNN), Convolutional Neural Network (CNN), Long Short Term Memory (LSTM).

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
Hastie, Trevor, et al. The elements of statistical learning. Vol. 2. No. 1. New York: springer, 2009.
Jure Leskovec et al., "Mining of Massive Datasets" Cambridge University Press, 2014
Tom White " Hadoop: The Definitive Guide" Fourth Edition, O'reily Media, 2015.

IT351 HUMAN COMPUTER INTERACTION (3-0-2) 4

Foundations: The Human, The Computer, The Interaction and Paradigms; User Experience Design; The Process of Developing Interactive Systems: Models, Theories, Design Process and Evaluation; Interacting with Computers: Vision, Graphic Design, and Visual Displays - Touch, Gesture and Marking, Speech, Language and Audition; Human Factors in Design; Effective Interfaces; Application Domain Aspects; Affective User Experiences; Human Centered Evaluations; Assistive Technologies and Accessibility; User Advocacy; Research Trends.

Andrew Sears and Julie A. Jacko, The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications, 3rd Edition, CRC Press, New York 2012.
Philip Kortum, HCI Beyond the GUI: Design for Haptic, Speech, Olfactory and other Nontraditional Interfaces, Morgan Kaufmann Inc., Originally Published by Elsevier, 2008.
Alan Dix et al., Human Computer Interaction, 3rd Edition, Pearson, 2004.
Don Norman, The Design of Everyday Things: Revised and Expanded Edition, Basic Books, 2013.
Ben Shneiderman et al., Designing the User Interface: Strategies for Effective HCI, 6th Edition, Pearson, 2016.
J. Preece et al., Interaction Design: Beyond Human Computer Interaction, 4th Edition, Wiley, 2015.
Joel March, UX for Beginners: A Crash Course in 100 Short Lessons, O'Reilly Media, *2015*
Jesse James Garrett, The Elements of User Experience: UCD for the Web and Beyond, New Riders, 2011.
Jeff Gothelf and Josh Seiden, Lean UX: Designing Great Products with Agile Teams, O'Reilly Media, 2016.
Constantine Stephanidis, User Interfaces for All: Concepts, Methods and Tools, LEA Inc., New Jersey, 2009.
Nicola Millard, Designing Motivational User Interfaces: Balancing Effective and Affective User Interface Design to Motivate Call Centre Advisors, VDM Verlag Dr. Müller, 2009.
Rex Hartson and Pardha S. Pyla, UX Book: Process/Guidelines for Ensuring QUX, Morgan Kaufmann, 2012.

IT352 INFORMATION ASSURANCE AND SECURITY (3-0-2) 4

Cryptography: Private and Public Key Encryption, Uses of Encryption; Network Security: threats, controls – Encryption, Authentication, Network Security tools (Firewalls, Intrusion Detection); Program Security: non-malicious program errors such as buffer overflow, viruses, other malicious code, targeted malicious code, controls against program threats; Protection in Operating Systems: protected objects, methods of protection, access control, authentication; Web Security; Data security and privacy; Forensics and Incident response; Security Policies and Procedures.

"Network Security Essentials", William Stallings, 4th Edition, Pearson Education, 2008.
"Cryptography & Network Security", Atul Kahate, McGraw Hill, 2004.
"Information Assurance–Dependability & Security in Networked Systems", Yi Qian et al, Morgan Kaufmann, 2008.
*"A. Abraham et al,Computational Intelligence in Information assurance and security",*N.Nedjah, Springer

IT360 INFORMATION SYSTEMS (3-0-2) 4

Introduction to Information Systems; Information Systems Development: Life Cycle, Management, Strategies, Construction Approaches; Systems Planning; Systems Analysis: Requirements, Tools for Business Process Modelling, Data Flow Diagram & Its Use, Data Modelling, Analysis Report; Systems Design: Acquisition Development, Construction Development, Systems Design Report; Systems Implementation; Systems Maintenance: Management, Post-Project Evaluation.

Shouhong Wang and Hai Wang, Information Systems Analysis and Design, Universal Publishers, 2012.
V. Rajaraman, Analysis and Design of Information Systems, 3rd Edition, PHI Learning, 2011.
Dennis, Wixom and Roth, Systems Analysis & Design, 5th Edition, John Wiley, 2012.
Langer A.M, Analysis and Design of Information Systems, 3rd Edition, Springer, 2008.
James A. Senn, Analysis & Design of Information Systems, 2nd Edition, McGraw-Hill, 2008.
Jeffrey L. Whitten and Lonnie D. Bentley, System Analysis and Design Methods, 7th Ed., McGraw-Hill, 2007.
Raul Sidnei Wazlawick, Object Oriented Analysis and Design for Information Systems: Modelling with UML, OCL, and

IFML, Elsevier, 2014.

IT361 PARADIGMS OF PROGRAMMING (3-0-2) 4

Programming domains; Language Evaluation; Programming Paradigms – Imperative, Functional, OOP and Logic programming; Formal methods: syntax and semantics - Backus Naur Form, Attribute grammars; Describing semantics - Denotational semantics; Data types, Names, Variables, Bindings, Scope and lifetime, Referencing Environments; Named Constants-Variable Initialization-Subprograms-Parameter Passing – Coroutines; Even Driven Programming: Fundamentals; Case studies from Desktop to Mobile applications, VB.NET, ANDRIOD Applications; Functional programming languages - Lambda calculus - LISP; Application of functional programming languages; Logic programming languages –introduction to predicate calculus - Horn clauses - Logic programming: Prolog, Applications; Asynchronous Programming Model with a Case Study (AJAX, C#...); Run-time Program Management; Virtual Machines: Java Virtual Machine, Common Language Infrastructure, Late Binding of Machine Code, Just-in-Time and Dynamic Compilation, Binary Translation, Binary Rewriting, Mobile Code and Sandboxing, Performance Analysis.

Robert W.Sebesta, "Concepts of Programming Languages", 11th Edition, Pearson, 2016.
Ravi Sethi, "Programming Languages - Concepts and Constructs", 2nd Edition, Pearson, 2002.
Michael L. Scott, "Programming Language Pragmatics", 4th Edition, Morgan Kaufmann, 2015.
Kenneth.C.Louden, "Programming Languages: Principles and Practices", 3rd Edition, Cengage Learning, 2011.

IT362 COMPUTER GRAPHICS (3- 0-2) 4

Computer Graphics Hardware; Scan Conversion: lines, circles, ellipses; Filling Algorithms, Clipping Algorithms, Viewing in 3D: Projections, 2D & 3D transformations, Visible surface determination, Animation of 2D images: Implementation of 2D packages which support graphics editor with classical input techniques and animation.

Hearn and Backer, Computer Graphics Principles and Practice-3rd Edition, Addison Wesley, 2013.
Van Dam, Foley, Feimer, Hugher Computer Graphics Principles and Practice in C, 1st ed., Pearson, 2013.

IT363 MICROPROCESSORS AND INTERFACING (3-0-2) 4

Microprocessor history, Microprocessor architecture, 8086, instruction set, subroutines, Programming examples, software development systems, Interrupts, Polling, Daisy chain, RST instructions, Priority encoder, Programmable peripheral devices, 8255, 8253, 8259, 8257, Intel 80386, 80486 & Pentium Processors, Motorola 68000, 68020, 68030 processors, Mother boards, I/o bus, I/O channel, BIOS, DOS PC bus, Multibus I& II, VME and peripheral controllers.

Douglas V. Hall, Microprocessors and Interfacing, 2nd Edition, Tata McGraw-Hill, 2006.
Babby B.Brey, The Intel Microprocessors – Architecture, Programming & Interfacing, Pearson/Prentice Hall, 2008

IT364 PERFORMANCE MODELING (3-0-2) 4

Performance Evaluation methods. Analytical versus simulation modeling. Performance measurement and benchmarking. Workload modeling. 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 & simulation of computer systems.

Raj Jain, The Art of Computer Systems Performance Analysis, Jon Wisely and Sons, New York, USA, 1991.
KS Trivedi, Probability and Statistics with Reliability, Queuing and computer science, PHI 1982.
Paul & Howard, Computer systems performance Evaluation & Prediction, Elsevier, 2005.

IT365 ADVANCED COMPUTER NETWORKS (3-0-2) 4

Review of TCP/IP Protocol suit with latest developments, Broadband networks, advanced concepts: ATM, Frame Relay, Fiber Optic Networks: SONET, VOIP, MIPv6 etc., Remote Access and Wireless Networking: Virtual Private Networks - L2 and L3 Switches, Tunneling; BGP and Adaptive Routing, MPLS: QoS, Network Recovery/Restoration; Security Issues in TCP/IP and BGP, DoS/DDoS attacks, Mitigation with recent trends, Cryptography, Intrusion Detection; Network Management issues and protocols, Internet Management, Common Management Information services/protocol (CMIS/CMIP), Network Trouble Shooting, QoS (Integrated/Differentiated Services), Port based Network Access control, Availability, Scalability, Load Balancing and Recent Trends.

James F Kurose and Keith W Rose, Computer Networking, Pearson Education, 2003 Andrew. S. Tannenbaum, Computer Networks, Prentice Hall of India, 2nd Edition, 2002. M. Subramanian, Network Management: Principles and Practice, Addison- Wesley, 2000. William Stallings, Data and Computer Communications and Networking, 2nd Edition, TMH, 2002. Behrouz A Forouzan, Data Communications and Networking, 2nd edition, TMH, 2002. Leon,Garcia and Widjaja - Communication Networks, TMH 2002.

IT366 OBJECT ORIENTED ANALYSIS AND DESIGN (3-0-2) 4

Introduction to object technology and applications; object oriented decomposition vs. structured decomposition in software development, concepts and applications of object oriented analysis and design, object oriented databases, application development using programming language JAVA.

Grady Booch, Object Oriented Analysis and Design with Applications, 3rd Edition, Addison Wesley, 2007.
Michael R. Blaha and James Rumbaugh, Object Oriented Modeling/Design with UML, 2nd Ed., Pearson, 2004.
Raul Sidnei Wazlawick, Object Oriented Analysis and Design for Information Systems: Modelling with UML, OCL, and IFML, Elsevier, 2014.

IT372 MOBILE NETWORKS (3-0-2) 4

Global System for Mobile Communications (GSM):Circuit-Switched Data Transmission, Standards, Transmission speeds, The Signaling System Number, The GSM Subsystems, The Network Subsystem, The Base Station Subsystem (BSS) and Voice Processing, Modulation, Voice Activity Detection, Mobility Management and Call Control., Mobile Device, SIM Card, Intelligent Network Subsystem. General Packet Radio Service (GPRS) and EDGE 63..Universal Mobile Telecommunications Systems (UMTS) And High-Speed Packet Access (HSPA) : Overview, History and Future. Important New Concepts of UMTS: Long Term Evolution (LTE) : Introduction and Overview, Network Architecture and Interface, FDD Air Interface and Radio Network, TD-LTE Air Interface, Scheduling, Basic Procedure, Mobility Management and Power Optimization, LTE Security Architecture, Interconnection with UMTS and GSM, Interworking with CDMA2000 Network, Network Planning Aspects, Voice and SMS over LTE, Backhaul Considerations, LTE-advanced. Simulation of GSM Cellular Mobile Networks.

From GSM To LTE An Introduction to Mobile Networks and Broadband, by Martin Scauter, ISBN 978-0-470-66711-8 Wiley Publisher.

IT400 PERCEPTUAL AUDIO PROCESSING (3-0-2) 4

Fundamentals of Audio and Speech Processing; Speech and Audio Analysis: Transforms – STFT, DCT; Audio and Speech Compression Standards: MPEG and AAC; Human Auditory Perception; Perceptual Audio Quality Metrics, Perceptual Processing of Digital Speech; Speech and Audio Rendering; Speech and Audio Storage and Retrieval; Applications and Research Trends.

Jacob Benesty, M. Mohan Sondhi and Yiteng Huang, Handbook of Speech Processing, Springer-Verlag, 2008.
A *Spanias, T Painter and Venkatraman A, "Audio Signal Processing and Coding", Wiley-Interscience, 2007.*
Hugo Fastl and Eberhard Zwicker, "Psychoacoustics: Facts and Models", Springer, 3rd edition, 2006. Marina Bosi and Richard E. Goldberg, "Introduction to Digital Audio Coding Standards", Springer, 2002. Ben G, Nelson M, "Speech & Audio Signal Processing: Processing/Perception of Speech/Music", Wiley, 1999.

IT401 PERCEPTUAL VIDEO PROCESSING (3-0-2) 4

Fundamentals of Image and Video Processing; Image and Video Analysis: Image Transforms - DCT, Hadamard, Haar, KL and Wavelets; Image and Video Compression Standards: JPEG, JPEG2000, MPEG1, MPEG2, MPEG4 & MPEG7; 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; Applications and Research Trends.

Perceptual Based Image Processing, Morgan & Claypool, 2009
Al Bovik, "Handbook of Image and Video Processing", Elsevier Academic Press, 2005
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 William K Pratt, "Digital Image Processing", Wiley, 2001.

IT402 SOFT COMPUTING (3-0-2) 4

Optimization and Some Traditional Methods and issues, Introduction to Genetic Algorithms, Some Specialized Genetic Algorithms, Introduction to Fuzzy Sets, Fuzzy Reasoning and Clustering, Fundamentals of Neural Networks, Fundamentals biologically inspired computing, Hybrid soft computing methods, Swarm optimization techniques: Particle swarm optimization and Global swarm optimization, Applications and Recent Research Trends.

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, Smita Shandilya, Kusum Deep, Atulya K. Nagar, Handbook of Research on Soft Computing and Nature-Inspired Algorithms, IGI Global, 2017.

Evolutionary Algorithm for Solving Multi-objective, Optimization Problems (2nd Edition), Collelo, Lament, Veldhnizer (Springer)
J. Han and M. Kambar, Data Mining: Concepts and Techniques, Morgan Kaufmann Publishers Elsevier), 2008

IT403 GENETIC ALGORITHMS (3-0-2) 4

Robustness of traditional optimization and search techniques, Simple Genetic Algorithms, Similarity templates, goals of optimization, Schema Theorem of John Holland, Computer Implementation and 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.

IT404 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, Learning Mechanisms, Associative Memory Model, Statistical Aspects of Learning, Single-Layer Perceptron, Least Mean Squares Algorithm, Perceptron Convergence Theorem, Bayes Classifier, Back Propagation Algorithm, Multi-Class Classification Using Multi-layered Perceptrons, Radial Basis Function Network, Introduction to Principal Component Analysis and Independent Component Analysis, Introduction to Self Organizing Maps, Applications and Recent Research Trends
Simon Haykin, "Neural Networks - A Comprehensive Foundations", Pearson, 2004
Laurene Fausett: "Fundamentals of Neural Networks: Architectures, Algorithms & Apps.", Pearson, 2004.
James A. Anderson, "An Introduction to Neural Networks", MIT press, 1995.
Yegnanarayana: "Artificial Neural Networks", Prentice Hall of India,2004.

IT405 FUZZY SYSTEM MODELS (3-0-0) 3

Classical /crisp set, fuzzy sets, Fuzzy numbers, Fuzzy arithmetic, Fuzzy measures, Operations on Fuzzy sets, Fuzzy relations, Multi valued logic, Fuzzy logic, Uncertainty and information, Approximate reasoning, Fuzzy decision making, Fuzzy models, case studies.
Klir and Yuan, Fuzzy Sets and Fuzzy Logic, Prentice Hall of India 2001.
Li Xin Wang, A Course in Fuzzy Systems and Control, Prentice Hall, 1996.
J. Yen and R. Langari, Fuzzy logic: Intelligence, Control and Information, Pearson, 1998.

IT406 DISTRIBUTED COMPUTING SYSTEMS (3-0-2) 4

Basic concepts - Computer networks, Distributed systems andComputing, Design goals, Fundamental issues and transparencies in DCS, Ordering of events, Ordering of messages and concerned protocols, Global state detection Process synchronization, Process communications, Load balancing techniques. *Mukesh Singhal and Niranjan G. Shivaratri, Advanced Concepts in Operating System, Tata McGraw Hill, 1994.*
A.S Tanenbaum and M.V. Steen, Distributed Systems – Principles and Paradigms, Prentice-Hall, 2006.
Randy Chow, Distributed Operating Systems and Algorithms, Addison Wesley, 1997.
G.F. Coulouies, J.D. Dollimore and T. Kindberg, Distributed Systems: Concepts & Design, Addison Wesley, 1994.

IT407 TECHNOLOGIES FOR INTERNET OF THINGS (3-0-2) 4

Introduction, IPv6 packet: IPv6 base header, Hop by Hop extension Header, Source Routing, Structure of IPv6 packet: fragmentation, IPv6 packet processing in routers, IPv6 address architecture, Current IPv6 prefix allocation, IPv6 addressing. ICMPv6: functionalities, neighbor discovery, address auto configuration. Communication standards: IEEE 802.15.4, IEEE 802.11, 6LoWPAN. Routing in low power lossy networks: RPL. Introduction to service oriented architecture and Web services, RESTful web services and applications for networked embedded systems. The Constrained Application Protocol (CoAP) and Message Queing telemetry Transport (MQTT): features, interaction model, messages and request and response sub layer
J. Biron and J. Follett, Foundational Elements of an IoT Solution, O'Reilly Media, 2016.
Keysight Technologies, The Internet of Things: Enabling Technologies and Solutions for Design and Test, Application Note, 2016.
Charles Bell, Beginning Sensor Networks with Arduino and Raspberry Pi, Apress, 2013
Arshdeep Bahga and Vijay Madisetti, Internet of Things: A hands on approach, VPT Publications 2014
Olivier Hersent, David Boswarthick, Omar Elloumi, The IoT: Key Applications and Protocols, Wiley, 2015.

IT408 MOBILE COMPUTING (3-0-2) 4

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 and Termination, Handoff, Roaming Support; Threat, Logical Migration, Mobile agents, Security issues. Smartphone-based platform architectures and applications, smart Phone Based Software like android studio, etc, Development of Smart Phone based real time applications, future directions.

Building Mobile Apps at Scale: 39 Engineering Challenges: GergelyOrosz 2021
Fundamentals of Mobile Computing. Prashanth Kumar Patnaik 2016
Mobile Communications (2nd ed.) Jochen Schiller.
Kumkum Garg, Mobile computing- Theory and Practice,2010
Raj Kamal, Mobile Computing, oxford university press 2007.
Joschen Schiller, mobile commns, Pearson, 2003.
Dharma Prakash Agarwal & Qing-An Zeng, Wireless & Mobile Systems, CENGAGE, 2ND Edition, 2006.
William Stallings, Wireless Communication & Networks, Practice Hall of India,2nd Edition, 2004.

IT409 EMBEDDED SYSTEMS (3-0-0) 3

Embedded System Design Process: Embedded Computing Platform, Program Design and Analysis, Real Time Operating Systems, Networks: Distributed Embedded Architeture, System on Chip (SOC) and the current trends. *David E Silmon, An Embedded Software Printer Pearson Edition Asia, 2001 Wayne Wolf, Computer as Components – Harcort India Pvt. Ltd. 2001*

IT410 BIOINFORMATICS (3-0-0) 3

Introduction to Bioinformatics, Biological Databanks, Biological Sequence Analysis: Genome- Microarray, pairwise sequence alignment, Dynamic programming, global and local alignment, Progressive multiple sequence alignment, Iterative multiple sequence alignment. BLAST Scoring matrices, gap penalty, statistical significance of multiple sequence alignment, sum-of-pairs method, CLUSTAL W, searching motifs in sequence alignment. Structure Prediction – Protein Secondary Class prediction, Protein Folding.

Protein-Protein Interaction, Protein Subcellular Localization, Emerging Areas in Bioinformatics.

Durbin, R., Eddy, S., Krough, A. & Mitchison, G. (1998). Biological sequence analysis: probabilistic models of proteins and nucleic acids. Cambridge University Press.
Jones, N.C. & Pevzner, P.A. (2004). An introduction to bioinformatics algorithms. MIT Press.
Bioinformatics: Sequence and Genome Analysis by David W. Mount, Cold Spring Harbor Laboratory Press (2001)
Developing Bioinformatics Computer Skills by C. Gibas and P. Jam beck, 0' Reilly (2001)
Biological Sequence Analysis: Probabilistic models of proteins and nucleic acids by R. Durbin, S.Eddy, A. Krogh and G. Mitchison, Cambridge University Press (1998)

IT411 KNOWLEDGE MANAGEMENT (3-0-0) 3

Introduction to knowledge management, Types of Knowledge within an organization. Intellecutal capital. KM Architecture and Tools. ERP for KM. Knowledge sharing tools. Data ware housing, Knowledge strategy creation. KM practice. KM Process. Integrating knowledge sharing and learing, The chief knowledge Officer (CKO) and his/her job. T4raining programmes for organization. widelearing. 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, Knowledge management: A New Dawn, Institute of Chartered Financial Analysts of India, 2002.*

IT412 TIME SERIES ANALYSIS (3-0-0) 3

Introduction, Stochastic Processes, Stationary Time Series Process (Time Domain), Univariate Analysis: Autoregressive (AR) Process. Moving Average (MA) Process, Autoregressive Moving Average (ARMA) Process, Causality, Multivariate Anbalysis: Autoregressive Distributed Lag (ARDL) Model, Vector Error Correction (VEC) Model, Vector Autoregressive (VAR) Model, Spectral Analysis (Frequency Domain), Non- Stationary Time Series Process, Unit Root Tests: Dickey-Fuller Test Phillips-Peron Test Elliott-Rothenberg-Stock Test, Schmidt-Phillips Test, Kwiatkowski-Phillips-Schmidt -Shin (KPSS) Test, Zivot-Andrews Test, Cointegration introduction and tests, ARCH GARCH Model, Generalized Method of Moments (GMM)

Shumway and D. S. Stoffer (2006), Time Series Analysis and Its Applications (With R Examples), Springer.
kwell, Peter J & Davis, Richard A: Introduction to Time Series and Forecasting. Springer Series, Second Edition.
field, Chris: Analysis of Time Series: an Introduction. Chapman & Hall. Sixth Edition.
epohl, Helmut: Introduction to Multiple Time Series Analysis. Springer-Verlag.
ilton James D: Time Series Analysis. Princeton University Press.

IT413 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, Architecture Overview. Current Integration Architecture Assessment. Technical Integration Architecture, Service Integration Architecture, Information Integration Architecture. Process Integration Architecture, Enterprise Integration Solutions: Application, Information, Composite Application and Process-Driven Integrations; Best Practices for Enterprise Integration.

B. G. Bernstein and W. Ruh. Enterprise Integration: The Essential Guide to Integration Solutions, Addison-Wesley.
C. Britton, P. Bye, IT Architecture, Middleware: Strategies for Building Large Integrated Systems, Addison-Wesley.

IT414 DATA WAREHOUSING AND DATA MINING (3-0-2) 4

Introduction to data mining: Motivation and significance of data mining, data mining functionalities, interestingness measures, classification of data mining system, major issues in data mining; Data pre-processing: Need, data summarization, data cleaning, data integration and transformation, data reduction techniques, data discretization and concept hierarchy generalization; Data warehouse and OLAP technology: multidimensional data model(s), data warehouse architecture, OLAP server types, data warehouse implementation, on-line analytical processing and mining; Data cube computation and data generalization: Efficient methods for data cube computation, discovery driven exploration of data cubes, complex aggregation, attribute oriented induction for data generalization; Mining frequent patterns, associations and correlations: Basic concepts, efficient and scalable frequent itemset mining algorithms, mining various kinds of association rules – multilevel and multidimensional, association rule mining versus correlation analysis, constraint based association mining; Classification and prediction: Definition, decision tree induction, Bayesian classification, rule based classification and support vector machines, associative classification, lazy learners, prediction, accuracy and error measures; Cluster analysis: Definition, clustering algorithms – partitioning, hierarchical, density based, grid based and model based; Clustering high dimensional data, constraint based cluster analysis; Data mining on complex data and applications: Algorithms for mining of spatial data, multimedia data, text data; Data mining applications, social impacts of data mining, trends in data mining.

Han, J. and Kamber, M., "Data Mining - Concepts and Techniques", 3rd Ed., Morgan Kaufmann Series, 2008.
Alex Berson , S. J. Smith, "Data Warehousing, Data Mining & OLAP" , McGraw Hill
Tan, P.N., Steinbach, M. and Kumar, V., "Introduction to Data Mining", Addison Wesley – Pearson,
2006 Pujari, A. K., "Data Mining Techniques", 4th Ed., Sangam Books.
Oded Maimon, Lior Rokach, The Data Mining and Knowledge Discovery Handbook, Springer, 2005.
S. Weiss and N. Indurkhya, Predictive Data-Mining: A Practical Guide, Morgan Kaufmann, 1998.
S. Weiss, N. Indurkhya, T. Zhang and F. Damerau, Text Mining: Predictive Methods for Analyzing Unstructured Information, Springer, 2004.

IT415 MIDDLEWARE TECHNOLOGIES (3-0-2) 4

Introduction to Middleware Technologies, General Middleware, Service Specific Middleware, Client/Server Building blocks: RPC, Messaging – P2P, Java RMI, Computing standards, OMG, Introduction to CORBA, EJB and .NET, XML Technologies - XML, DTD, XSD, XSLT, XQUERY, XPATH, Web Services and SOA.

G. Sudha Sadasivam, Distributed Component Architecture, Wiley India Edition.
Thomas Erl ,Service Oriented Architecture: Concepts , Technology & Design, Prentice Hall
G.Brose, A Vogel and K. Duddy, Java programming with CORBA, 3rd Edition, Wiley India Joha Wiley and Sons
Ed Roman, Mastering Enterprise Java Beans, John Wiley & Sons Inc.

IT416 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.

IT417 PATTERN RECOGNITION (3-0-2) 4

Patterns/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.

IT418 CLOUD COMPUTING (3-0-2) 4

Introduction to Cloud Computing, Cloud Computing Delivery Models, Open Source and Industry Case Studies of Cloud (Apache VCL, Amazon, IBM and Eucalyptus), Map/Reduce and Apache Hadoop Programming models for cloud computing and examples/applications, Virtualizations as an enabler for cloud computing infrastructure, Cloud Application Design & Development, Containers and Dockers.

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.
Arshadeep Bagha and Vijay Madisetti, Cloud Computing: A Hands on Approach, Universities Press, 2014.

IT419 WIRELESS SENSOR NETWORKS (3-0-2) 4

Introduction to wireless communication and wireless sensor networks, Network architecture and design principles, MAC and link layer protocols, Topology control in WSN, Routing protocols, Information Aggregation, Information Storage, Query, Localization, Security issues, Applications and recent trends: Wireless multimedia sensor networks.

F. Zhao and L. Guibas, Wireless sensor networks: An information Processing Approach , Morgan-Kaufmann, 2004.
Carlos de Morais Ciordeiro nad Dharma Prakash Agrawal,Adhoc and Sensor Networks: Theory and Applications,World Scientific Publications, 2006.

IT420 MOBILE ADHOC NETWORKS (3-0-2) 4

Mobile ad hoc 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 Mobile ad hoc networks, Measuring energy consumption, Power save protocols, Maximum life time routing, Secure routing protocols, Intrusion detection, Security considerations in ad hoc sensor networks, Key management, Characterization of IP traffic, QOS classification, Self similar processes, Statistical analysis of both non – real time traffic and real – time services.

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.

IT421 SEMANTIC WEB TECHNOLOGIES (3-0-2) 4

Introduction to the Semantic Web – What is Semantics; Syntax, Structure and Semantics, Layered Cake Architecture; Structured Web Documents and Resource Description Framework – Understanding content, Metadata, metadata standards, XML + metadata specification, RDF and metadata processing; Programming with RDF/XML; Web Ontology Language (OWL)- Domain Modeling, Logic, Inferencing, Context; Logic Reasoning for the Semantic Web- Classification and semantic metadata extraction techniques: statistical, statistical learning/AI, lexical and natural language, knowledge based; Programming with Ontologies; Semantic Applications- semantic technology for services, search, personalization, contextual/custom/ enterprise applications; Linked Open data and next generation semantic content management; Research trends and open issues.

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.

IT422 VIRTUAL REALITY (3-0-2) 4

Introduction to Virtual Reality 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; Overview of Virtual Humans, Face Cloning & Face Motion Capture/Analysis and Research Trends.

Gerard Jounghyun Kim, Designing Virtual Reality Systems – The Structured Approach, Springer-Verlag, 2005.
N Magnenat-Thalmann and D Thalmann, Handbook of Virtual Humans, Wiley, 2004.
L.J. Hettinger, M W. Haas, Virtual & Adaptive Environment: Apps, Human Performance, Lawrence Erlbaum, 2003.
Grigore C Burdea and Phillippe Coiffet, Virtual Reality Technology, John Wiley, 2003.

IT423 RICH INTERNET APPLICATIONS (3-0-2) 4

Web2.0 concepts, SaaS model, Evolution of Web 2.0, Web Programming concepts, HTML, XHTML, CSS,

Javascript. JS Execution Environment, Overview of XML, Web Services, Building Rich Internet Applications, AJAX, XML HTTP Object, ActionScript, Products from Industry like Flex (Adobe), Flash/AIR (Adobe)., Silverlight (MS), JavaFX (SUN), OpenLazzlo technologies, Recent Trends.

Robert Sebesta, Programming the World wide web, Pearson Education, Third Edition
Nicholas C Zakas et al, Professional AJAX, Wrox publications, 2006
Chafic Kazoun, Programming Flex 2, O'Reilly publications, 2007
Colin Moock, Essential Action script 3.0, O'Reilly Publications, 2007
Steven Holzner, Ajax Bible, Wiley India Edition, 2007
Justin Gehtland et al, A Web 2.0 primer Pragmatic Ajax, SPD Publications, 2006.

IT440 PRACTICAL TRAINING 1

The Student has to undergo a practical training programme or carrying out a research/practical oriented project or any equivalent training programme fixed by the DUGC of IT department. This practical training will be done during summer vacation (10-12 weeks) before the evaluation semester. Final evaluation is based on the report/seminar by the student.

IT449 MAJOR PROJECT – I

The student has to select a project based on a topic of interest before starting of VII semester. This project work will be commencing in VII semester and continued in VIII semester, at the end of each semester, the project will be evaluated internally and externally as per the evaluation criteria decided by the DUGC.

IT450 WEB SERVICES (3-0-0) 3

IT Architecture, Distributed Information Systems, Middleware and Enterprise Application Integration, Introduction to Service Oriented Architecture, Web Services origins, standards, basic concepts, Web Service Technologies and Architecture; protocols for Web service Description, Discovery and Access (WSDL, UDDI and SOAP); Web Service Application Management: Co-ordination, Service Orchestration and Compositions; Web Service Application Development: developing Web services, exposing functions as web methods, accessing service endpoints, WCF Framework; RESTful Web Services - basics, concepts, Restful application development and deployment; Services for the Internet of Things - Constrained Application Protocol (CoAP), features, interaction model; Semantic Web Services - background, motivation, advantages, basic concepts; Research Trends and open problems.

Alonso G, Casati F, "Web Services - Concepts, Architectures and Application Series: Data-Centric Systems and Applications", Springer, 2011
Robert Daignea, "Service Design Patterns: Fundamental Design Solutions for SOAP/WSDL and RESTful Web Services" 1st Edition , Addison Wesley Professional, 2011
Sam Newman, "Building Microservices: Designing Fine-Grained Systems", O-Reilly, 2015
Thomas Erl, "Service-Oriented Architecture: Concepts, Technology, and Design", Prentice Hall, 2005.

IT451 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/Evaluating Software Architecture and its reuse, Case studies and Recent Trends.

Mary Shaw, David Garlan, Software Architecture, Prentice Hall ,India, 2000
Bass, Len; Paul Clements, Rick Kazman, Software Architecture In Practice, Second Edition. Addison-Wesley, 2003.
Clements, Paul et al, Documenting Software Architectures: Views and Beyond. Addison-Wesley, 2003.

IT452 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, Arithmetic pipeline, VLIW architecture, Superscalar processors. 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.

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, 2015
Dezso Sima, Peter Karsuk, Advanced Computer Architectures: A Design Space Approach, Addison- Wesley, 2002

IT453 TRANSACTION PROCESSING (3-0-0) 3

Introduction and need of transaction processing, online transaction process (OLTP), OLTP program design, OLTP and system Reliability, OLTP and CICS standards in OLTP, current trends.
Gary McClain, OLTP handbook, McGraw Hill, 1997.

IT454 SOFTWARE QUALITY ASSURANCE (3-0-0) 3

Overview of Software Engineering. Requirement Engineering Analysis, software reliability. Definition and concepts of software reliability, software quality. Introduction to software quality principles, total quality management, Quality Assurance Standards. ISO 9000 Tick-It method. Miscellanious Issues: Software maintenance. Future OF SQA
John J. Marciniak, Encyclopedia of Software Engineering. - Vol. I & II. John Wiley & Sons, 1994. Ince Darrel. ISO 9001 and Software Quality Assurance. McGraw Hill, 1994
Pankaj Jalote, An Integrated Approach to Software Engineering Narosh Publications, 1995
Isabel Evans, Achieving software Quality through team work, Allied publishers, 2004.

IT455 INFORMATION TECHOLOGY FOR HEALTHCARE (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, 5th Edition, Lulu Publishers, 2012
Kevin Beaver, Healthcare Information Systems, Auerbach Publications, 2nd Edition, 2002.

IT456 ENTERPRISE RESOURCE PLANNING AND SYSTEMS (3-0-0) 3

ERP: Needs, Models, Commercial ERP Packages, Client Server and Open Technology Solutions, Supply Chain Management-Issues, Drivers and Obstacles, Coordinating SCM and ERP in E-Business
Vinod Kumar G & N.K. Venkitakrishna, ERP- Concepts and Practice, PHI, 1998
Sunil C & Peter-SCM – Strategy and Planning and Operation, Pearson Education, LPE, 2002
Pete Loshin, Paul A. Murphy, Electronic Commerce, A JAICO Book.

IT457 NATURAL LANGUAGE PROCESSING (3-0-2) 4

Introduction and Overview, Language Modeling, History and Applications, Basic Text Processing - Word stemming, tokenization, normalization, Part of Speech tagging, Text Classification – basics and process, tools, Information Retrieval, TF/IDF, Ranked IR, Vector Space Models, Query analysis and processing, Basics of Information Extraction, Named Entity Recognition, Maximum Entropy models, Relation Extraction; Introduction to Semantics, word sense and word similarity, Basics of Wordnets, tools, 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 Christopher D. Manning and Hinrich Schütze, "Statistical Natural Language Processing" MIT Press, 1999 Tanveer Siddiqui, U. S Tiwary, *"Natural Language Processing/Information Retrieval", Oxford Univ. Press, 2008.*

IT458 INFORMATION RETRIEVAL (3-0-2) 4

Introduction: Basic Concepts, Information need vs. Query, Modern Search Interface requirements, IR System Architecture, Classic IR Models for unstructured text, preprocessing techniques, Tokenizing, Indexing, and Implementation of IR models, Structured IR models, Multimedia IR, Experimental Evaluation of IR Systems, Implicit and Explicit Relevance Feedback techniques, Document/Query Properties and Representations, Web Search and Link analysis algorithms, Recommender Systems, Learning to Rank and Learning the ranking function based techniques, Machine learning in IR, Selected research papers on emerging trends and open problems in IR.
C. D. Manning et al., "Introduction to Information Retrieval",, Cambridge University Press. 2008.
Baeza-Yates & Ribeiro-Neto, "Modern Information Retrieval", Pearson Education, 2010
Donald Metzler et al., "Search Engines: Information Retrieval in Practice", Pearson Education, 2010

IT459 SIMULATION AND MODELING (3-0-2)4

System models and Role of Simulation, Types of Systems, Statistical Tools and Techniques, Discrete Event Simulation Languages, Modeling and Performance Evaluation of Computer Systems, Biological and Sociological System Simulation, Verification and Validation.
A. M. Law and W.D. Kelton, Simulation Modeling and Analysis, McGraw Hill, 2000
A. M. Law, Simulation Modeling and Analysis, McGraw Hill, 4th Edition, 2008

IT460 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-line auctions, Data mining for e-commerce, Web metrics, Recommender systems, Knowledge management, Mobile e-commerce, Legal, ethical and social issues.

Henry Chan et al., 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 and E-Commerce, Allied Publishers, 2004.
Zimmermann, Olaf; Tomlinson, Mark R.; Peuser, Stefan, Perspectives on Web Services, Allied Publishers, 2004.

IT461 ADVANCED DATABASE SYSTEMS (3-0-2)4

Basic concepts, Buffer management, Query optimization, Selectivity estimation, Concurrency control, Recovery, Database tuning, Distributed databases– principles, architecture, design, query processing, transaction management, Replication, Web databases, Current trends in database system.

M. Tamer Özsu, Principles of Distributed Database Systems, Prentice Hall, 1999.
Ceri S and Pelagatti G, Distributed databases: Principles and Systems, McGraw Hill, 2000.
Thomas Connolly and Carolyn Begg, Database Systems: A Practical Approach to Design, Implementation and Management, Pearson Education, 2002.

IT462 NUMBER THEORY AND CRYPTOGRAPHY (3-0-2)4

Introduction to Number Theory: Prime Numbers, Fermat' s Little Theorem and Euler's Theorem, Testing for Primality, Chinese Remainder Theorem, Discrete Logarithms. Euclidean Algorithm, Extended Euclidean Algorithm, Euler' s Phi Function. Finite Fields: Groups, Rings, and Fields, Modular Arithmetic, Euclidean Algorithm, Finite Fields of The Form GF(p), Polynomial Arithmetic, Finite Fields Of the Form GF(2n); Introduction to Cryptography: Symmetric Cryptography, Substitution Cipher, Shift Cipher (or Caesar Cipher), Affine Cipher, Hill cipher. Stream Ciphers: Stream Ciphers vs. Block Ciphers, Encryption and Decryption with Stream Ciphers, Random Numbers and an Unbreakable Stream Cipher, Random Number Generators, One-Time Pad, Towards Practical Stream Ciphers, Shift Register-Based Stream Ciphers, Linear Feedback Shift Registers (LFSR), Known-Plaintext Attack Against
Single LFSRs. The Data Encryption Standard (DES) and Alternatives: Confusion and Diffusion, Double DES (2DES) and Triple DES (3DES). Advanced Encryption Standard (AES). Block Ciphers: Modes of Operation, Electronic Codebook Mode (ECB), Cipher Block Chaining Mode (CBC), Output Feedback Mode (OFB), Cipher Feedback Mode (CFB), Counter Mode (CTR), Galois Counter Mode (GCM). Introduction to Public-Key Cryptography: Practical Aspects of Public-Key Cryptography, RSA Cryptosystem, Elliptic Curve Cryptosystems. Digital Signatures: RSA Signature Scheme, Elgamal Digital Signature Scheme, Digital Signature Algorithm (DSA), Elliptic Curve Digital Signature Algorithm (ECDSA).

"Cryptography and Network Security: Principles and Practices", 4th Edition, W. Stallings, Prentice Hall, 2005.
"Cryptography and Network Security", 6th Edition, William Stallings, Pearson, 2013.
"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.
"Applied Cryptography", 2nd Edition, Bruce Schneier, Wiley, 1996.
"Handbook of Applied Cryptography", A. Menezes, P. Van Oorschot, S. Vanstone, CRC Press, Fifth Printing, 2001.
"Elementary Number Theory with Applications", Thomas Koshy, 2nd Edition, Academic Press, 2007.
"A Computational Intro. to Number Theory and Algebra", Victor Shoup, 2nd Ed., Cambridge Univ. Press, 2005.

IT463 LINUX KERNEL INTERNALS (3-0-2) 4

Introduction to the Kernel: Important data structures, task structure, process table, files and inodes, dynamic memory management, queues and semaphores, system time and timers, main algorithms, signals, interrupts, booting the system, timer interrupt, scheduler, implementing system calls. Memory Management: LINUX, virtual address space for a process, block device caching, paging under LINUX. Inter- Process Communication: Synchronization in the kernel, Communication via files, pipes, debugging using ptrace, IPC with sockets. The LINUX File System: Basic principles, representation of file systems in the kernel, Proc file system, Ext2 file system. Device drivers under LINUX: Character and block devices, Polling and interrupts, Implementing a driver, Multi-processing: Intel multi-processor specification, problems with multi-processor systems, changes to the kernel, kernel initialization, scheduling, message exchange between processors, entering kernel mode, Interrupt handling, compiling LINUX SMP.

"Linux Kernel Internals", Michael Beck et al., Second Edition, Addison-Wesley, 1998.
"Linux Kernel Programming", Michael Beck et al., Third Edition, Addison-Wesley, 2002.

IT464 FOUNDATIONS OF MACHINE LEARNING (3-0-2) 4

Linear algebra and probability theory basics – Machine learning- Types- Classification- Regression- Multi-class classification. dimensionality reduction –Linear and Logistic Regression. Naive Bayes, Parameter Estimation, Sequential Pattern Classification. Neural Network Basics – Backpropagation –Support Vector Machines, Kernel methods – Bias-Variance tradeoff. Regularization and model/feature selection. Ensemble Methods: Boosting, Bagging, Random Forests. Unsupervised learning – K-Means clustering- EM Algorithm – Reinforcement learning – introduction to deep learning. Recent Applications and trends of Machine Learning.

Understanding Machine Learning, Shai Shalev-Shwartz and Shai Ben-David. Cambridge University Press, 2017.
Tom M. Mitchell, -Machine Learning, McGraw-Hill Education (India) Private Limited, 2013.
Stephen Marsland, - Machine Learning: An Algorithmic Perspective, Second Edition, 2014.
Pattern recognition and machine learning by Christopher Bishop, Springer Verlag, 2006.

IT465 CRYPTOCURRENCIES AND BLOCKCHAIN TECHNOLOGIES (3-0-2) 4

Introduction to Crypto currency, peer-to-peer network, Abstract Models for BLOCKCHAIN – GARAY model – RLA Model, Hybrid models cryptographic basics for cryptocurrency – a short overview of Hashing, signature schemes, encryption schemes and elliptic curve cryptography, Bitcoin – Wallet – Blocks – Merkley Tree transaction verifiability – anonymity – forks – double spending, Ethereum, Wallets for Ethereum – Solidity – Smart Contracts – some attacks on smart contracts, Applications of smart contracts, Block chain Application in various areas- Health care, Insurance, IoT etc.

Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder. Bitcoin and cryptocurrency technologies: a comprehensive introduction. Princeton University Press, 2016.
Joseph Bonneau et al, SoK: Research persepectives and challenges for Bitcoin and crptocurrency, IEEE Symposium on security and privacy, 2015 (article available for free download) {curtain raiser kind of generic article, written by seasoned experts and pioneers}. 2. J. A. Garay et al, the bitcoin backbone protocol – analysis and applications EUROCRYPT 2015 LNCS VOl 9057. (VOLII), pp 281-310.. serious beginning of discussions related to formal models for bitcoin protocols. 3. R.Pass et al, Analysis of Blockchain Protocol in Asynchronous networks, EUROCRYPT 2017. A significant progress and consolidation of several principles. 4. R.Pass et al, Fruitchain, a fair blockchain, PODC 2017.

IT466 FUNDAMENTALS OF 5G (3-0-2) 4

LTE An Overview, Different releases of LTE, 5G Introduction, The E- UTRAN protocol Stack, The core network - EPC, PDN Gateway (P-GW), Service Gateway (S-GW), Mobility Management Entity (MME), Cell Architecture - Small Cell, Femto Cell, Pico Cell, 5G radio protocol architecture - User Planes and Control Planes, Duplexing Schemes, Physical Layer Controlling Signals - Uplink and Downlink, Retransmission Protocol - Hybrid ARQ, Scheduling - Dynamic Uplink and Downlink Scheduling, Handover Techniques, 5G and IoT introduction, 5G and IoT Use Cases, Introduction to Machine to Machine (M2M) Communication, Proximity Services (D2D communication), millimeter Wave Communication (mmWave), Massive Multiple Input and Multiple Output (MIMO). 5G Use Cases. Beyond the first release of 5G. 5G Simulation - Implementation of 5G in Network Simulator - 3 (NS-3), patch installation, basic programs on handover and resource allocation.

Erik Dahlman, Stefan Parkvall, Johan Sko ̈ld "5G NR: The Next Generation Wireless Access Technology", Elsevier, Academic Press, 2018
Afif Osseiran, Jose F Monserrat, Patrick Marsch, "5G Mobile and Wireless Communication Technology" Cambridge University Press, 2016
Jonathan Rodriguez "Fundamentals of 5G Mobile Networks" , Wiley, 2015.

IT467 ROBOTIC PROCESS AUTOMATION (3-0-2) 4

RPA Basics – History of Automation – What is RPA – RPA vs Automation – Programming Constructs in RPA – What Processes can be Automated – Types of Bots – Workloads which can be automated; Process Models and Process Discovery, Different Types of Process Models, Process Discovery Techniques and Conformance Checking – RPA Development methodologies-Determining and Designing Automation Process – -Generating RPA Analytics; **Develop bots to accomplish the common business scenarios like :** Capturing user interactions using appropriate Recorders, Running bots from the Workbench and the Control Room, Creating a Meta bot to handle an application login, Integrating with common desktop applications, Writing data from a text file to an Excel spreadsheet, Copying spreadsheet data to a Windows application, Hardening bots against common exceptions, Debugging bots using the debugging feature, Extracting data from web pages, sending and receiving emails, Downloading email attachments, Extracting data from Adobe PDFs, Calling REST web services, Error handling.

Alok Mani Tripathi, Learning Robotic Process Automation, Publisher: Packt Publishing Release Date: March 2018 ISBN: 9781788470940
The Robotic Process Automation Handbook: A Guide to Implementing RPA Systems; Tom Taulli; Apress, 2020 ISBN

1484257286, 9781484257289.

IT468 QUANTUM COMPUTING (3-0-2) 4

History of quantum computation and quantum information, Future directions, Basic Mathematics: Linear operators and matrices, Tensor products, Operator functions. Quantum Logics: QISKIT, Introduction to Qubit, Single qubit operation, Multiple Qubit operation, Single qubit gates, Multiple qubit Gates, Controlled Not gate, Swap gate, Toffoli gate, Universal quantum gates. Quantum Algorithms and Applications: The quantum search algorithm, Quantum search as a quantum simulation, Quantum counting, Speeding up the solution of NP complete problem, Quantum search of an unstructured database, Optimality of the search algorithm.

Michael. A. Nielsen and I. L. Chuang, Quantum Computation and Quantum information, Cambridge University Press 2000.

Bellac Michel Le, "A short introduction to quantum information and quantum computation", Cambridge University Press, 2006

Vishal Sahni, "Quantum Computing", Tata McGrawHill, 2007.

Richard L. Liboff, Introductory Quantum Mechanics, Pearson, Fourth Edition (2003).

QISKIT textbook: https://qiskit.org/textbook/content/ch-ex/.

IT470 CORNERSTONE/CAPSTONE PROJECT 4

For details refer to clause 3.2 (f) under Regulations specific to Undergraduate Programmes.

IT482 SOCIAL NETWORK ANALYSIS (3-0-2) 4

Basics of Information networks, Network structures, Models, Processes; Network analysis-concepts, graph centrality measures, Emergence of the Social Web, Statistical Properties of Social Networks; Complete networks, Ego Networks, Random networks, Homophily Small World and Scale-free phenomena, Structural Holes, Sub-groups, Block models, Empirical Models of Network Formation; Complete detection – node –centric, network-centric, group-centric and hierarchy centric approaches, Clique percolation, Spectral clustering, Modularity maximization, Anomaly detection, Louvain Algorithm, Girvan Newman Algorithm; influence maximization, Social network based recommender systems, Large-scale social network analysis applications and case studies, Emerging trends and issues.

Lab Component: Implementation and evaluation of information network analysis strategies, measuring small world and scale-free characteristics, Analysis of centrality behaviour of nodes in a social network, Community detection algorithms..

J.Goldbeck- Analyzing the Social Web, Morgan Kaufman Publishers, 2015

Yang, Keller and Zherg –Social Network Analysis: Methods and Examples, SAGE Publications, 2016

A.Abraham, A.Hassanien and V.Snasel – Computational Social Network Analysis :Trends, Tools and Research Advances, Springer, 2012

CharuC.Aggarwal,- Social Network Data Analytics, Springer; 2014

Select articles from reputed journals like IEEE Transactions on Computational Social Systems, ACM Transaction on social Computing, Springer Social Network Analysis and Mining, Elsevier Social Networks.

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IT483 NARROWBAND INTERNET OF THINGS (3-0-2) 4

Introduction to Internet of Things. 4G and 5G Systems:LTE History, 5G Narrowband Internet of Things. NB-IoT Applications and Scenarios, Massive Number of Low –Throughput Devices, Longer Battery Lifetime, Low Latency and Data Reporting, LTE NB-IoT Protocol Stack and Architecture, NB-IoT modes of operation, Radio Resource Control Sublayer. Packet Data Convergence Protocol Sublayer. Radio Link Control Sublayer. Medium Access Control Sublayer. Physical Sublayer. Quality of Service Architecture : NB-IoT Quality of Service, Characteristics of QCI, Quality of Service for UE Using CIoT EPS Optimization, QoS Challenges for NB-IoT. Use Cases and Deployment: NB-IoT Devices, Smart Parking, Smart City, Smart Home, Message Queue Telemetry Transport (MQTT), NB-IoT Baseline Deployment, Mobile Operator Deployment. Simulation of Narrowband Internet of Things Networks.

5G LTE Narrowband Internet of Things (NB-IoT)" by Hossam Fattah, CRC Press, Taylor & Francis Group, 6000 Broken Sound Parkw.

IT484 Randomized Algorithms (3-1-0)

Randomness and algorithms. Deterministic vs Randomized algorithms. Monte carlo and Las-Vegas algorithms. Advantages of Randomized algorithms. Basic principles for the construction of randomized algorithm. Motivation: Game Tree Evaluation. Tools and Techniques; Basic probability theory: randomized complexity theory; game-theoretic techniques, etc. Randomized algorithms for the problems in various domains viz., Graph algorithms, Geometric algorithms, parallel and distributing algorithms, online algorithms, Number theory and algebra., etc., coupon collection and occupancy problems; Markov chains and random walks; stable distributions: probability amplification and

derandomization. Applications: Sorting and searching; data structures; combinatorial optimization and graph algorithms; metric embeddings; online and streaming algorithms; algorithms for massive data sets including similarity search, nearest neighbours, and clustering; number-theoretic algorithms.

Motwani and Raghavan. Randomized Algorithms, Cambridge University Press, 1995.

Mitzenmacher and Upfal. Probability and Computing: Randomized Algorithms and Probabilistic Analysis, Cambridge University Press, 1995.

William Feller. An introduction to Probability Theory and Its Applications, Volumes I and II, John Wiley, New York, 1968.

J. Hromkovic, Design and Analysis of Randomized Algorithms, Springer 2005.

IT499 MAJOR PROJECT – II (0-0-6) 4

The student has to select a project based on a topic of interest before starting of VII semester. This project work will be commencing in VII semester and continued in VIII semester, at the end of each semester, the project work will be evaluated internally and externally as per the evaluation criteria decided by the DUGC.

B.Tech. in ARTIFICIAL INTELLIGENCE
PROGRAM CORE

IT111 Fundamentals of Computer Systems (4-0-0) 4

Introduction to computer systems, Program structure and execution: representing and manipulating Information, Machine level representation of Programs, Processor Architecture, Optimizing program performance, The memory hierarchy, Linking, Exceptional Control flow, Virtual Memory, Fundamentals of Operating Systems.

Randal E. Bryant, David R. O'Hallaron, Computer Systems: A Programmer's Perspective, Pearson, 2016

Carl HAmacher, Zvonko Vranesic, SAfeat Zaky, Computer Organization, McGraw Hill, 2011

Abraham Silberschatz, PEter B Galvin, Gerrg Gagne, Operating Systems, Wiley, 2015

IT112 Computer Systems Lab (0-0-2) 1

Basic Linux Commands, Shell programming, Learn to write, test, and debug simple C programs, Learn C programs with conditionals and loops, Pointers, Memory allocation and Memory management using C, Basic System Calls, Introduction to profiling.

IT151 Python Programming (3-0-0) 3

Introduction to Programming Languages, Python Basics, Variables and Data Types, Control Structures, Repetition structures, Functions and Modules, Strings, Lists, File Input and Output, Basic Data Structures, Object-Oriented Programming. Python web frameworks

Martin C. Brown, Python: The Complete Reference, McGraw Hill Education; Fourth edition, 2018

Mark Summerfield, Programming in Python 3: A Complete Introduction to the Python Language, Pearson, 2018

IT152 Python Programming Lab (0-0-2) 1

Learn to write, test, and debug simple Python programs, Loops and Conditionals, Use OOP concepts in Python programs, Read and write data from/to files in Python. String Operations, Basic Data structures and Algorithms. Python web frameworks

IT207 Human Intelligence (3-0-0) 3

Introduction: The Mechanics of Intelligence, Human Intelligence and the Brain; Approaches of Human Intelligence: Biological, Cognitive, Cultural and Psychometric Approaches; Applications of Human Intelligence Research: Extremes of Intelligence, Group and Sex Differences, Environment Effects on Intelligence, Demography of Intelligence.

Robert J. Sternberg, "Human Intelligence - An Introduction", Cambridge University Press, 2020

N. J. Mackintosh, "IQ and Human Intelligence";, Oxford University Press, 2nd Edition, 2011.

Earl0Hunt, "Human Intelligence" Cambridge University Press, 2011.

IT208 Discrete Mathematics (3-0-2) 4

Fundamentals of Discrete Mathematics: Counting, Logic, Set Theory, Proof Techniques, Relations and Functions: Generating functions, Recursive relations; Introduction to Graph Theory: Vertex degrees, paths, Planar graphs, Trees; Basic Algebra: Groups, Monoids, Rings, Lattice Theory, Applications of DM in AI Systems.

R.P. Grimaldi, B.V. Ramana, Discrete and Combinatorial Mathematics: An Applied Introduction, 5th Edition, Pearson, 2008.

B. Kolman, R.C. Busby, S.C. Ross, Discrete Mathematical Structures, Pearson Education India; 6 edition , 2015.
Kenneth Rossen, Discrete Mathematics and its Application, 7th Edition, McGraw-Hill, 2011.
L. Lovasz, Combinatorial Problems and Exercises, 2nd Edition, North Holland, 1993.

IT209/IT209M Data Structures and Algorithms (3-0-2) 4

Elementary Data Types and Abstract data types. Computational model and complexity of algorithms (running time and space metrics), Introduction to Asymptotic notation; Worst- case, Best -case, Average-case and amortized analysis. Arrays, Linear search and Binary search on sorted arrays. List ADT and its implementation using arrays and linked lists. Types of linked lists: Single, Double, circular linked lists and their applications. Stack ADT and Queue ADT implementations with applications. Dynamic set ADT and Dictionary ADT. Hash tables – collisions, open and closed hashing, choosing good hash functions. Trees: Definitions and Representations; Tree traversals and their applications. Binary Search Trees. AVL trees, Red-black trees, B-trees; Priority Queue ADT and its implementations using Binary heaps. Applications of Priority Queues. Sorting algorithms: Merge sort and Quicksort. Randomized Quick sort and its analysis. Linear-time sorting algorithms like Radix and Counting sort. Graphs: Definitions and representations. Depth first and breadth-first search and their applications. Basic Graph algorithms like Dijkstra's shortest path algorithm and Kruskal's MST algorithm.

T H Cormen, C E Leiserson, R L Rivest and C Stein, Introduction to Algorithms, 3rd Edition, PHI Learning, 2010.
S. Horowitz. Fundamentals of Data Structures in C, Universities Press, 2nd Edition, 2008.
Michael T. Goodrich and Roberto Tamassia. Algorithm Design, Wiley, 1st Edition, 2006.
Knuth D.E., The Art of Computer Programming, Vol. I: Fundamental Algorithms, Addison Wesley, 3rd Ed., 1997.

IT211 Probability and Statistics (3-0-2) 4

Probability rules; independence; system reliability (parallel, series); Conditional Probability, Law of Total Probability, Bayes Rule; Definition of Random Variable, Discrete Random Variables Bernoulli, Binomial; probability mass function; Binomial, Hyper geometric, Geometric, Negative Binomial, Poisson and Poisson approximation of Binomial; Expectation and Variance of a Discrete Random Variable; Continuous Distributions (density), including joint distributions and joint density mean and variance of a density; Gaussian density; Exponential and Gamma densities, Central Limit Theorem; Simulation of Random Variables, Statistics and sampling distribution of the sample mean; Statistics and sampling distribution of the sample proportion; Statistical inference; Parameter Estimation (Method of Moments, Maximum Likelihood Method); Confidence Intervals (Pivotal Quantity Method) Hypothesis Testing; type I and type II errors; **Applications and use cases of AI**.

DeGroot & Schervish, Probability and Statistics (4th Edition) Pearson (2011).
Wasserman, All of Statistics: A Concise Course in Statistical Inference Springer (2004).

IT255/IT255M Artificial Intelligence (3-0-2) 4

Introduction to AI-Problem formulation, Problem Definition -Production systems, Control strategies, Search strategies. Problem characteristics, Production system characteristics -Specialized production system- Problem solving methods – Problem graphs, Matching, Indexing and Heuristic functions -Hill Climbing-Depth first and Breath first, Constraints satisfaction – Measure of performance and analysis of search algorithms.- Game playing – Knowledge representation, Knowledge representation using Predicate logic, Introduction to predicate calculus, Resolution, Use of predicate calculus, Knowledge representation using other logic-Structured representation of knowledge- Basic plan generation systems – Strips -Advanced plan generation systems – K strips -Strategic explanations -Why, Why not and how explanations. Learning- Machine learning, adaptive Learning.-Expert systems – Architecture of expert systems, Roles of expert systems – Knowledge Acquisition – Meta knowledge, Heuristics. Typical expert systems – MYCIN, DART, XOON, Expert systems shells.

Kevin Night and Elaine Rich, Nair B., "Artificial Intelligence (SIE)", McGraw Hill- 2008.)
Dan W. Patterson, "Introduction to AI and ES", Pearson Education, 2007
Peter Jackson, "Introduction to Expert Systems", 3rd Edition, Pearson Education, 2007.
Stuart Russel and Peter Norvig "AI – A Modern Approach", 2nd Edition, Pearson Education 2007.

IT256 Applied Linear Algebra (3-0-2) 4

Vectors: definition, scalars, addition, scalar multiplication, inner product(dot product), vector projection, cosine similarity, orthogonal vectors, normal and orthonormal vectors, vector norm, vector space, linear combination, linear span, linear independence, basis vectors; Matrices: definition, addition, transpose, scalar multiplication, matrix multiplication, hadamard product, functions, linear transformation, determinant, identity matrix, invertible matrix and inverse, rank, trace, popular type of matrices- symmetric, diagonal, orthogonal, orthonormal, positive definite matrix; Least Squares: Least Square Problem and Solutions; EigenValues; Eigenvectors: Concept, Significance; Principal Component Analysis: Concept, Properties, Applications; Singular Value Decomposition: Concept, Properties, Applications.

W. Cheney, D. Kincaid, "Linear Algebra Theory and Applications";, Jones & Bartlett, Student Ed.. 2010
Gilbert Strang, "Linear Algebra and Its Applications", Cengage Learning, 4th Edition, 2007
Stephen Boyd, Lieven Vandenberghe, "An Introduction to Applied Linear Algebra: Vectors, Matrices, and Least Squares", Cambridge University Press, 2018.

IT257 Design and Analysis of Algorithms (3-0-2) 4

Models of computation, algorithm analysis and asymptotic notation, time and space complexity, average and worst case analysis, lower bounds. Amortized analysis. Algorithm design techniques: recursion, branch-and-bound, divide and conquer, greedy, dynamic programming, randomization. Applications of the above techniques to a variety of problems: Stable matching, linear- time selection, integer, polynomial and matrix multiplications, Fast Fourier Transforms (FFT): FFT Algorithms, computing shortest paths and minimum spanning trees, etc. Reductions and the theory of NP Completeness, Approximation 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

IT258/IT258M Data Science (3-0-2) 4

Introduction to Data science fundamentals, Nature of Data and its characteristics, Total information awareness, Bonferroni's Principle, Rhine's paradox, Recap of Statistical and Inferential Analysis, Data preprocessing, Data wrangling, Data exploration, Dealing with missing data – single and multiple data imputation, Entropy based techniques, Monte Carlo and MCMC simulations; Correcting inconsistent data – Deduplication, Entity resolution, Pairwise Matching; Fellegi-Sunter Model, Advanced processing- Regression, Correlation, Covariance analysis, Aggregation, Sampling, Dimensionality Reduction; Feature extraction and feature selection; Graph data analysis, Stream processing and online analytics, Dealing with infinite length, concept drift, concept/feature evolution, Visual analytics, Current trends and research.

Jure Leskovec, Anand Rajaraman and Jeffrey Ullman, "Mining of Massive Datasets" Cambridge University Press, 2014
Sinan Ozdemir, "Principles of Data Science - Second Edition" Packt Publishing, 2018
Sam Lau, Joey Gonzalez, and Deb Nolan, "Principles and Techniques of Data Science "
Jeffrey S. Saltz and Jeffrey M. Stanton, "An Introduction to Data Science", Sage Publications, 2017
Davy Cielen, Arno D.B. Meysman, Mohamed Ali Introducing Data Science: Big Data, Machine Learning, and More", 2016
Garrett Grolemund, Hadley Wickham, "R for Data Science"O'Reilly, 2017
Nina Zumel and John Mount, "Practical Data Science with R", 2014

IT304 Optimization Techniques (3-0-2) 4

Introduction to Optimization, Convex Sets, Convex Functions, Lagrange Duality, Convex Optimization Algorithms, Second-order cone models, Semidefinite programming, Semi-infinite programming, Minimax, Sublinear algorithms, Interior Point Methods, Active set, Stochastic gradient, Coordinate descent, Cutting planes method, Applications to Image/Video/Multimedia Processing

Suvrit Sra, Sebastian Nowozin and Stephen J. Wright Optimization for machine learning. MIT Press, 2012.
Roberto Battiti, Mauro Brunato. The LION Way: Machine Learning plus Intelligent Optimization. Createspace Independent Pub, 2014

IT305 Game Theory (3-0-2) 4

Introduction to Game Theory, Quantifying the Inefficiency of Equilibrium: Nash Equilibrium, Routing Games and Congestion Games, Network Formation and Games in Networks, Price of Anarchy and Price of Stability, The Smoothness Framework, Coalitional Stability, Auctions and Mechanism Design: Algorithmic Mechanism Design and Auctions, Second-price and First-price Auctions, Combinatorial Auctions, Truthful Mechanisms, Approximately Efficient Mechanisms, Bayesian Mechanism Design, Maximizing Revenue in Auctions, Ad Auctions, Sponsored-Search Auctions, Quality of Stable Solutions in Simple Auction Mechanisms; Markets and Pricing: Social Welfare and Walrasian Equilibrium, Gross-Substitutes, Single-Minded Valuations, Maximizing Revenue via Pricing, Sequential Buyer Arrival, Combinatorial Walrasian Equilibrium; Algorithmic Aspects of Equilibrium: Existence and Complexity of Finding Equilibrium, Correlated and Coarse-Correlated Equilibrium, No-regret Learning

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.

IT306/IT306M Parallel and Distributed Problem Solving (3-0-2) 4

Introduction to Parallel Computer Architectures, Shared memory and distributed memory programming techniques, Parallel Programming with OpenMP, MPI, Parallel Programming techniques like Task Parallelism using TBB, TL2, Cilk++ etc. Introduction to accelerator and heterogeneous programming using CUDA/OpenCL, Xeon-phi and FLGAs. Optimization of DL training and inference on parallel architectures. Projects in TensorFlow/PyTorch to implement a few of the techniques introduced in this course.

J. Dongara, I. Foster, G. Fox, W. Cropp et al, "Sourcebook of Parallel Programming", Morgan Kaufmann, 2002.
Barbara Chapman et.al, "OpenMP: Portable Shared Memory Parallel Programming", Scientific & Engineering Computation, MIT 2008.
B. Wilkinson and M. Allen, "Parallel Programming: Techniques and Applications", 2nd ed., Pearson, 2004.
Benedict R. Gaster et al., Heterogeneous Computing with OpenCL, 2nd Edition, Morgan Kaufmann. 2012.
Rezaur Rahman, Intel Xeon-Phi Coprocessor Architecture/Tools - The Guide for App. Developers, Apress, 2013.
CUDA for Engineers by Duane Storti and Mete Yurgotlu, Addison-Wesley, 2016.

IT307/IT307M Machine Learning (3-0-2) 4

Introduction: Basic principles, Applications, Challenges. Supervised learning: Linear Regression with one variable and multiple variables, Gradient Descent, Classification, Logistic Regression, Overfitting, Regularization, Support Vector Machines, Artificial Neural Networks, Perceptrons, Multilayer networks, back-propagation, Decision Trees, Ensemble methods, Unsupervised learning: Clustering (K-means, K-mediods, Hierarchical), Dimensionality reduction: Principal Component Analysis, Applications of machine learning methods.

Ethem Alpaydin, ―Introduction to Machine Learning, Third Edition, MIT Press, 2014
Jason Bell,Machine learning Hands on for Developers and Technical Professionals‖, First Edition, Wiley, 2014
Peter Flach, ―Machine Learning: The Art and Science of Algorithms that Make Sense of Data, First Edition, Cambridge University Press, 2012.
Stephen Marsland, ―Machine Learning – An Algorithmic Perspective, Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.
Tom M Mitchell, ―Machine Learning‖, First Edition, McGraw Hill Education, 2013.

IT353 Deep Learning (3-0-2) 4

Deep Networks: Deep FeedForward Networks, Regularization for Deep Learning, Optimization for Training Deep Models, Convolutional Neural Networks, Sequence Modeling - Recurrent and Recursive Nets Autoencoders- Transfer learning-. 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

IT354 Reinforcement Learning (3-0-2) 4

Introduction to Reinforcement Learning, Markov Processes Markov Reward Processes (MRPs) Markov Decision Processes (MDPs), MDP Policies, Policy Evaluation, Policy Improvement, Policy Iteration, Value operators, Model-free learning - Q-learning, SARSA, Scaling up: RL with function approximation, RL with function approximation, Imitation learning in large spaces, Policy search, Exploration/Exploitation, Meta-Learning, Batch Reinforcement Learning, Bandit problems and online learning, Solution methods: dynamic programming, Monte Carlo learning, Temporal difference learning, Eligibility traces, Value function approximation, Models and planning, Case studies: successful examples of RL systems, Frontiers of RL research

Reinforcement Learning: An Introduction, Sutton and Barto, 2nd Edition.
Reinforcement Learning: State-of-the-Art, Marco Wiering and Martijn van Otterlo, Eds
Artificial Intelligence: A Modern Approach, Stuart J. Russell and Peter Norvig.
Deep Learning, Ian Goodfellow, Yoshua Bengio, and Aaron Courville.

MAJOR PROJECT (MP)

IT448 MAJOR PROJECT – I (0-0-3) 2

The student has to select a project based on a topic of interest before starting of VII semester. This project work will be commencing in VII semester and continued in VIII semester, at the end of each semester, the project will be evaluated internally and externally as per the evaluation criteria decided by the DUGC.

IT498 MAJOR PROJECT – II (0-0-6) 4

The student has to select a project based on a topic of interest before starting of VII semester. This project work will be commencing in VII semester and continued in VIII semester, at the end of each semester, the project work will be evaluated internally and externally as per the evaluation criteria decided by the DUGC.

MANDATORY LEARNING COURSES (MLC)

IT289 SEMINAR 1

This seminar is a 1 credit mandatory learning course to be completed during 4th semester. Each student will make technical presentation on a topic of academic interest as per recommendations and evaluation criteria of the DUGC of IT department.

IT447 PRACTICAL TRAINING 1

The Student has to undergo a practical training programme or carrying out a research/practical oriented project or any equivalent training programme fixed by the DUGC of IT department. This practical training will be done during summer vacation (10-12 weeks) before the evaluation semester. Final evaluation is based on the report/seminar by the student

PROGRAMME SPECIFIC ELECTIVES

IT212 Intelligent Data Management (3-0-2) 4

Data Modeling - Designing Logical Data Models - Physical Data Models - Leveraging Data Models-Data relationships - Conceptual Graph - Representing Conceptual Structures - Reasoning with Graphs - Semantic Graph - Relationships between Categorical Variables - Tabular Representation of Associations - Graphical Representation of Associations - Interpretation and Comparison of Results -Datastorage perspectives; Transaction Processing- Basics of Fault Tolerance-Transaction-Oriented Computing - Concurrency and Recovery

John F. Sowa, "Conceptual Graphs Summary," in Conceptual Structures: Current Research and Practice, P. Eklund, T. Nagle, J. Nagle, and L. Gerholz (Eds.), Ellis Horwood, pp. 3-52, 1992.

Jim Gray and Andreas Reuter. 1992. Transaction Processing: Concepts and Techniques *(1st ed.). Morgan Kaufmann Publishers Inc., San Francisco, CA, USA.*

R. Elmasri and S.B Navathe , "Fundamentals of Database Systems", 2000.

IT213 Database Systems (3-0-2) 4

Basic concepts, Data models and languages, Database design (conceptual and physical), System implementation techniques, Current trends in database system, Distributed databases; Design and Implementation of Database systems or packages for applications such as office automation, hotel management, hospital management; deployment of Forms, Reports Normalization, Query Processing Algorithms in the above application projects; Implementation of few important functionalities of relational database management systems

R. Elmasri and S.B Navathe , Fundamentals of Database Systems, The Benjamin/Cummings Publishing Company, 2000

Raghu Ramakrishnan, Database Management Systems, McGraw Hill, 2000

M. Tamer Özsu, Principles of Distributed Database Systems, Prentice Hall, 1999.

Silberschatz, Korth A.F., Sudarshan S., Database System Concepts, McGraw Hill,2005

IT259 Data Visualisation (3-0-2) 4

Overview of visualization, graphics, drawing, photorealism, human perception - Visualization of Numerical Data- Data, mapping, charts, glyphs, parallel coordinates, stacked graphs, Tufte's design rules, using color - Visualization of Non-Numerical Data - Graphs, networks, treemaps, Principle Component Analysis, multidimensional scaling, packing - Visualization systems, Information Visualization, database visualization, visualization system design - - Trends in Data Visualization and Other Tools - Declarative programming, reactive programming.

Visualization Analysis and Design, Tamara Munzner, AK Peters Visualization Series, CRC Press, Nov. 2014

Visualize This: The Flowing Data Guide to Design, Visualization, and Statistics Nathan Yau, Wiley (2011)

Donahue, Rafe. "Fundamental statistical concepts in presenting data: principles for constructing better graphics." (2011).

IT260 Robotics Programming (3-0-2) 4

Introduction to Robotics: Advanced and impressive robots, Robots that look like humans and animals, Robots in the home, Robots in industry, Robot arms, Warehouse robots, Competitive, educational, and hobby robots. Exploring Robot Building Block: Code and Electronics, Types of motors, sensors, and actuators, Status indicators – displays, lights, and sounds, Controllers and IO. Introducing the Raspberry Pi - Starting with Raspbian, Connectivity and networking,

Preparing a Raspberry Pi for a Robot, Building Robot Basics - Wheels, Power, and Wiring Using Python to Control Servo Motors, Programming Distance Sensors with Python, Programming Encoders with Python, Robot Vision - Using a Pi Camera and OpenCV , Voice Communication with a Robot Using Mycroft, Programming a Gamepad on Raspberry Pi with Python

Danny Staple, Learn Robotics Programming, Packt Publishing Ltd., 2018
R Brooks and C Ferrell, Embodied Intelligence, MIT Press
U Nehmzow, Mobile Robotics: A practical introduction, Springer Verlag

IT308 Brain Computer Interfaces (3-0-2) 4

Signal Recording & Stimulation: Recording Signals, Simultaneous Recording & Stimulation; Signal Processing: Frequency Domain Analysis, Fourier Analysis, Discrete Fourier Transforms, Fast Fourier Transforms, Spectral Features, Wavelet Analysis, Time Domain Analysis - Convolution and Correlation, Principal Component Analysis and Independent Component Analysis; Brain Computer Interfaces (BCI): Types, Invasive, Semi-Invasive, Non-Invasive, Stimulating, Bidirectional and Recurrent BCIs, Applications, Medical and Non-Medical, Ethics of BCI.

Rajesh P N Rao, "Brain Computer Interfacing: An Introduction", Cambridge University Press, 2013
Jonathan R Wolpaw, Elizabeth Winter Wolpaw (Eds.), "Brain Computer Interfaces: Principles and Practice", Oxford University Press, 1st edition, 2012.
Desney S Tan, Anton Nijholt (Eds.), "Brain Computer Interfaces: Applying Our Minds to HCI", Springer 2010.

IT355 Autonomous Agents (3-0-2) 4

Agents Overview: Agent definition, agent programming paradigms, Agents Vs objects, mobile agents, Agent frame works, Agent reasoning; Agents Implementation: Processes, threads, Sockets, RPCs – distributed computing, aglets programming – JINI architecture, actors and agents. Multi Agent Systems: Interaction between agents, reactive agents, cognitive agents, interaction protocols, agent coordination, agent negotiation, agent cooperation, agent organization, self –interested agents in electronic commerce applications. Intelligent Software Agents: Interface Agents, Agent Communication Languages, Agent Knowledge Representation, Agent Adaptability, Belief Desire Intension, Mobile Agent, Applications. Agents and Security: Agent Security Issues, Mobile Agents Security, Protecting Agents Malicious Hosts, Untrusted Agents, Black box Security, Authentication for Agents, Security issues for Aglets.

Joseph P. Bigus and Jennifer Bigus, "Constructing Intelligent Agents Using Java: Professional Developer's Guide", Wiley, Second edition, 2001.
Bradshaw, "Software Agents", MIT Press, 2000
Michael Wooldridge, An Introduction to MultiAgent Systems - Second Edition. Wiley, 2009
Roland Siegwart, Illah Reza Nourbakhsh and Davide Scaramuzza, Introduction to Autonomous Mobile Robots - Second Edition. MIT Press, 2011
Rafael H. Bordini, Jomi Fred Hubner and Michael Wooldridge , Programming Multi-agent Systems in AgentSpeak Using Jason. Wiley, 2007

IT356 Natural Language Processing (3-0-2) 4

Introductory concepts of Linguistic systems, Language Modeling and Sequence tagging, Word stemming, tokenization, normalization, Part of Speech tagging, Traditional models of distributional semantics, Unstructured Text Management, Word and Sentence embeddings, n-gram models, Maximum Entropy models, Hidden Markov Models, Viterbi Algorithm, Neural Language Models; Information Extraction, Named Entity Recognition, Relation Extraction; Understanding Semantics, word sense and word similarity, Lesk Algorithm, Wordnets, Topic Modeling, Dialog Systems, 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
Christopher D. Manning and Hinrich Schütze, "Foundations of Statistical Natural Language Processing" MIT Press, 1999
Tanveer Siddiqui, U.S Tiwary, "Natural Language Processing And Information Retrieval", 1st Ed

IT357 Computer Vision (3-0-2) 4

Introduction to Image Processing: Image Formation on Camera, Camera Mechanism, Perspective Transformation, Image Transformations, Concept of convolution, Concept of Masks, Fourier series and Transform. Features and filters: low-level vision, Linear filters, Edges and contours, Binary image analysis, Background subtraction, Texture Motion and optical flow. Grouping and fitting: mid-level vision: Segmentation and clustering algorithms, Hough transform, Fitting lines and curves, Robust fitting, RANSAC, Deformable contours, Interactive segmentation. Multiple views: Local invariant feature detection and description, Image transformations and alignment, Planar homography, Epipolar geometry and stereo, Object instance recognition, Image warphing, Image stitching, Harris corner detection-interest point detection ,SIFT descriptor, Viola Jones Face detector, Cascading Classifiers for detection. Recognition: high-level

vision: Basics of Object detection and recognition, Supervised classification algorithms, Deep learning, Convolutional neural networks.

Rick Szeliski "Computer Vision: Algorithms and Applications".
David A. Forsyth and Jean Ponce " Computer Vision: A Modern Approach"
Linda G. Shapiro and George C. Stockman "Computer Vision"
Emanuele Trucco and Alessandro Verri Introductory Techniques for 3-D Computer Vision,.
Richard Hartley and Andrew Zisserman "Multiple View Geometry in Computer Vision".
Richard O. Duda, Peter E. Hart, and David G. Stork" Pattern classification".
Christopher M. Bishop "Pattern Recognition and Machine Learning".
K. Grauman and B. Leibe "Visual Object Recognition".

IT358 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, Applications and Recent Research Trends

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, Smita Shandilya, Kusum Deep, Atulya K. Nagar, Handbook of Research on Soft Computing and Nature-Inspired Algorithms, IGI Global, 2017.
Evolutionary Algorithm for Solving Multi-objective, Optimization Problems (2nd Edition), Collelo, Lament, Veldhnizer (Springer)
J. Han and M. Kambar, Data Mining: Concepts and Techniques, Morgan Kaufmann Publishers Elsevier), 2008.

IT359 Pattern Recognition (3-0-2) 4

Introduction to Model Selection, Decision Theory, Information Theory; Linear Models for Regression and Classification, Neural Networks: Network Training, Jacobian/Hessian Matrices, Regularization, Mixture Density Networks, Bayesian Networks; Computational Learning Theory, Kernel Methods, Sparse Kernel Machines, Graphical Models, Markov Random Fields, Expectation Maximization, Approximate Inference, Factorized Distributions, Expectation Propagation, Hidden Markov Models, Linear Dynamical Systems, Hybrid Model Construction- Boosting, Tree-based models, Conditional Mixture Models, Q-learning and Policy Gradient, PR Applications.

Pattern Recognition and Machine Learning, Christopher Bishop, Springer, 2006.
Pattern Classification, Duda, Hart, and Strok, Wiley, latest edition.
Pattern recognition, Theodoridis, Sergios, Koutroumbas, Konstantinos, Elsevier.
Introduction to Neural Networks, Heaton, Jeff, Heaton research, 2nd edition, 2008
Pattern Recognition - Narasimha Murthy and Susheela Devi (Univeristies Press, 2011)

IT367 Information Retrieval (3-0-2) 4

Introduction: Basic Concepts, Information need vs. Query, Modern Search Interface requirements, IR System Architecture, Preprocessing techniques, Tokenizing, Indexing, Classic IR Models for unstructured data, Inverted Index, Vector Space Model, Best Match models, Probabilistic models Implementation of IR models, Structured IR models, Multimedia IR, Experimental Evaluation of IR Systems, Implicit and Explicit Relevance Feedback techniques, Document/Query Properties and Representations, Web Search and Link analysis algorithms, Recommender Systems, Learning to Rank and Learning the ranking function based techniques, Selected research papers on emerging trends and open problems in IR.

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
Donald Metzler, Trevor Strohman, and W. Bruce Croft, "Search Engines: Information Retrieval in Practice", Pearson Education, 2010

IT368 Internet of Things (3-0-2) 4

Principles and foundation of IoT: Reference Models, Platforms, Big data and IoT, Relevance of AI in IoT. IPv6 packet. Communication standards for IoT: IEEE 802.15.4, IEEE 802.11, 6LoWPAN. Routing in IoT, Standards for IoT, 5G. Service Oriented architecture, The Constrained Application Protocol (CoAP) and MQTT: features, interaction model, messages and request and response sub layer. Application of AI in IoT.

Amita Kapoor, Hands on Artificial Intelligence for IoT, Packt>, 2019
J. Biron and J. Follett, Foundational Elements of an IoT Solution, O'Reilly Media, 2016. Keysight Technologies, The Internet of Things: Enabling Technologies and Solutions for Design and Test, Application Note, 2016.
Charles Bell, Beginning Sensor Networks with Arduino and Raspberry Pi, Apress, 2013 Arshdeep Bahga and Vijay Madisetti, Internet of Things: A hands on approach, VPT Publications 2014
Olivier Hersent, David Boswarthick, Omar Elloumi, The IoT: Key Applications and Protocols, Wiley, 2015.

IT369 Performance Modeling (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 Theory: open networks, closed networks, time-reversibility, RenewalReward, M/M/1, M/M/k, M/M/k/k, Burke's theorem, Jackson networks, classed networks, load-dependent servers, BCMP result and proof, M/G/1 full analysis, M/G/k, G/G/1, transform analysis (Laplace and z-transforms); Simulations: 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, Matrixanalytic methods; Management of Server Farms: capacity provisioning, dynamic power management, routing policies; Analysis of Scheduling: FCFS, non-preemptive priorities, preemptive 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.
Papoulis and S. U. Pillai, Probability, Random Variables, and Stochastic Processes, McGraw-Hill.
Leon-Garcia, Probability and Random Processes for Electrical Engineering, Prentice Hall.
Michael Pinedo, Scheduling Theory, Algorithms, and Systems, Prentice Hall.

IT370 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.

IT371 Operating Systems (3-0-2) 4

Introduction to operating systems, Process concepts, Scheduling algorithms, CPU scheduling, Multithreading models, Concurrent processes, Deadlocks, Virtual and physical memory management, Disk scheduling, File systems; Device Drivers: Building and Running Modules, Char Drivers, Concurrency and Race Conditions, Interrupt Handling, Data Types in the Kernel, Drivers: PCI, USB, Block, Network, TTY Drivers.

Andrew S. Tannenbaum and Herbert Bos, Modern Operating Systems, 4th Edition, Pearson, 2015
Abraham Silberschatz et al., Operating System Concepts, 9th Ed., John Wiley, 2012.
Harvey M. Deitel et al., Operating System, 3rd Edition, Pearson, 2007.
William Stallings, Operating Systems: Internals and Design Principles. 9th Ed., Pearson, 2017.
M. J. Bach. Design of the Unix Operating System, 1st Edition, Pearson, 2015.
Jonathan Corbet et al., Linux Device Drivers, 4th Edition, O'Reilly, 2013.

IT424 Computational Auditory Perception (3-0-2) 4

Cognitive Neuroscience: Mind and Brain, Structure and Function of the Brain Nervous System, Methods of Cognitive Neuroscience, Hemispheric Specialization, Sensation and Perception, Object Recognition, Attention, Action, Learning and Memory, Emotion, Thinking and Problem Solving, Language, Cognitive Control, Social Cognition, Consciousness.

Michael S. Gazzaniga, Richard B. Ivry, George R. Mangun, "Cognitive Neuroscience: The Biology of the Mind", W. W. Norton & Company; Fifth Edition, December 1, 2018.

Bernard J Baars, Nicole M Gage, "Cognition, Brain and Consciousness: Introduction to Cognitive Neuroscience", Academic Press and Elsevier Ltd., 2nd Edition, 2010.
Michael S. Gazzaniga (Ed.), "The Cognitive Neurosciences", The MIT Press, 4th Edition, 2009.

IT425 Computational Visual Perception (3-0-2) 4

Fundamentals of Image and Video Processing; Image and Video Analysis: Image Transforms - DCT, Hadamard, Haar, KL and Wavelets; Image and Video Compression Standards: JPEG, JPEG2000, MPEG1, MPEG2, MPEG4 & MPEG7; 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; Applications and Research Trends.

Perceptual Based Image Processing, Morgan & Claypool, 2009
Al Bovik, "Handbook of Image and Video Processing", Elsevier Academic Press, 2005
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
William K Pratt, "Digital Image Processing", Wiley, 2001.

IT426 Smart Systems Development (3-0-2) 4

Introduction to Smart Systems, need, Architecture, Infrastructure, Design challenges, Research Challenges. Fundamentals of Smart Infrastructure. Smart Cities, Smart Mobility. Challenges, Architecture, Design of systems in Smart Transportation, Smart Building and Home Devices, Smart health, Smart Government, Smart Energy and Water. Cybersecurity, safety and privacy for smart cities, Applications of IoT, Blockchain, AI and virtual reality in Smart environments.

Carol L. Stimmel, Building Smart Cities: Analytics, ICT, and Design Thinking , CRC press 2015
Lukas Neckermann, Smart Cities, Smart Mobility: Transforming the Way We Live and Work, 2017
Houbing Song, Ravi Srinivasan, Tamim Sookoor, Sabina Jeschke, Smart Cities: Foundations, Principles, and Applications, 2017, Wiley
Amitabh Satyam and Igor Calzada , The Smart City Transformations: The Revolution of The 21st Century, Bloomsbury 2017

IT427 Genetic Algorithms (3-0-2) 4

Introduction, Possible Applications, Pros and Cons, Principles of Evolutionary Processes and Genetics Introduction to Evolutionary Computation: Biological and artificial evolution, evolutionary computation and AI, different historical branches of EC, a simple genetic algorithm. Search Operators: Crossover, mutation, crossover and mutation rates, Crossover for real-valued representations, mutation for real-valued representations, combinatorial GA, Selection Schemes: Fitness proportional selection and fitness scaling, ranking, tournament selection, selection pressure and its impact on evolutionary search. Theoretical Analysis of Evolutionary Algorithms: Schema theorems, convergence of the algorithms, computational time complexity of the algorithms, no free lunch theorem. Search Operators and Representations: Mixing different search operators, adaptive representations. Niching and Speciation: Fitness sharing, crowding and mating restriction. Constraint Handling: Common techniques, penalty methods, repair methods, Deb's penalty parameter method. Multiobjective evolutionary optimization: Pareto optimality, multi-objective evolutionary algorithms: MOGA, NSGA-II, etc. Applications of GA in engineering problems, job-shop scheduling and routing problems. Evolutionary robotics and evolutionary hardware: Evolving control. Evolving morphology. Body-brain co-evolution. Evolution in simulation and in reality. The case for and against simulation.

Goldberg D.E. Genetic Algorithms in Search, Optimization and Machine Learning. Pearson Education Asia 2002
K. Deb, Multi-Objective Optimization Using Evolutionary Algorithms, Wiley and Sons, 2009.
M. Mitchell, An introduction to genetic algorithms, MIT Press, 1996.
L. D. Davis, Evolutionary algorithms, Springer-Verlag, 1999.
Evolutionary Computation: A Unified Approach by Kenneth A. DeJong, MIT Press, 2006, ISBN: 0262041944
Bäck, T, 2000. Evolutionary Computation 1: Basic Algorithms and Operators. Institute of Physics Publishing, Bristol.
Jacob, C., 2001. Illustrating Evolutionary Computation with Mathematica. Morgan Kaufmann.

IT428 Industry 4.0 (3-0-2) 4

Introduction to smart manufacturing, Digitalisation and the Networked Economy; Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0, Driving technologies - Internet of Things (IoT), Industrial Internet of Things (IIoT), Internet of Services, Numerical control (NC), NC programming, Robot programming and PLC, Process plan representation models (for automation), Cyberphysical Systems, Robotic Automation and Collaborative Robots, Cyber Security for smart Industry systems, Autonomous Decision Support Systems for Industry 4.0, Predictive Analytics, Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation, Case studies – Toyota, Autoliv, Tesla Production Systems, Mega Factories, Smart City case studies.

Industry 4.0: The Industrial Internet of Things, Alasdair Gilchrist, Apress Publishers 2017

Enterprise IoT: Strategies and Best Practices for Connected Products and Services - Dirk Slama, Frank Puhlmann , Jim Morrish , Rishi M. Bhatnagar, O-Reilly Media (2015)
Hands-On Industrial Internet of Things Paperback - Giacomo Veneri Antonio Capasso, Packt Books (2018)
Quick Start Guide to Industry 4.0: One-stop reference guide for Industry 4.0, Pabbathi (2018)

IT429 Number Theory and 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 knowledge interactive protocols, Elliptic curve cryptosystems, Formal verification, Hard problems, Randomness and Pseudo randomness & Testing.

Koblitz, N. "Course on Number Theory and Cryptography", Springer Verlag, 1986
Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone. "Handbook of Applied Cryptography", CRC Press, 1996, Fifth Printing (August 2001).
William Stallings "Cryptography and Network Security: Principles and Practice", Sixth Edition, Pearson Publisher.
Behrouz A Forouzan and Debdeep Mukhopadhyay, "Cryptography and Network Security", Mc Graw Hill Education Publisher.

IT430 Quantum Cryptography (3-0-2) 4

Introduction to Quantum Computation: Quantum bits, Bloch sphere representation of a qubit, multiple qubits, XOR of Bit sequence, design of quantum circuits, Introduction to Cryptography, Cryptography with XOR, Shared Secret, Importance of Randomness, Breaking the Code, Comparison between classical and quantum information theory, Bell states, Quantum teleportation, Principles of Quantum Cryptography, Quantum key distribution, Single photons, EPR pairs, no cloning theorem. Quantum Algorithms, BB84 Protocol, Error Correction: Graph states and codes, Quantum error correction, fault- tolerant computation.

Nielsen M. A., Quantum Computation and Quantum Information, Cambridge University Press.
Benenti G., Casati G. and Strini G., Principles of Quantum Computation and Information, Vol. II, Basic Concepts, Vol II: Basic Tools and Special Topics, World Scientific.
Pittenger A. O., An Introduction to Quantum Computing Algorithms
Bellac Michel Le, "A short introduction to quantum information and quantum computation", Cambridge University Press, 2006
N. David Mermin, "Quantum Computer Science" ,Cambridge University Press, 2007.

IT431 Distributed Computing (3-0-2) 4

Basic concepts - Computer networks, Distributed systems and Computing, Design goals, Fundamental Issues in Distributed Systems, Distributed System Models and Architectures; Classification of Failures in Distributed Systems, Basic Techniques for Handling Faults in Distributed Systems; Logical Clocks and Virtual Time; Physical Clocks and Clock Synchronization Algorithms; Security Issues in Clock Synchronization; Transparencies in DCS, Ordering of events, Ordering of messages and concerned protocols, Global state detection Process synchronization, Process communications, Load balancing techniques.

Mukesh Singhal and Niranjan G. Shivaratri, Advanced Concepts in Operating System, Tata McGraw Hill, 1994.
A.S Tanenbaum and M.V. Steen, Distributed Systems – Principles and Paradigms, Prentice-Hall, 2006.
Randy Chow, Distributed Operating Systems and Algorithms, Addison Wesley, 1997.
G.F. Coulouies, J.D. Dollimore and T. Kindberg, Distributed Systems: Concepts & Design, Addison Wesley, 1994.

IT432 Computational Photography (3-0-2) 4

Camera geometry and optics, Focus and depth, Computational apertures and shutters, Exposure and high dynamic range, Flash / no flash photography, Super-resolution and denoising. Photo quality assessment, Image filtering and image pyramids, Image blending and compositing Texture synthesis and inpting, non photorealistic rendering Single / multi view reconstruction, Image based lighting and rendering

Barbara London and John Upton, "Photography".
Richard Szeliski,"Computer Vision: Algorithms and Applications".
Richard Hartley and Andrew Zisserman, "Multiple View Geometry in Computer Vision".
David Forsyth and Jean Ponce, "Computer Vision: A Modern Approach".
Steven Gortler, "Foundations of 3D Computer Graphics".
Rafael Gonzalez and Richard Woods, "Digital Image Processing".

IT433 Blockchain Technology (3-0-2) 4

Blockchain Architecture, P-2-P Networks, Blockchain Networks, Transaction Life Cycle, Role of Miners in Blockchain Technology, Consensus Algorithms, Proof of Work, Proof of Stake, Proof of Elapsed Time, Round Robin-Advantages

and Disadvantages, Candidate Blocks, Blockchain Technology and Artificial Intelligence, IoT and Blockchain: Challenges and Risks, Introduction to Blockchain and IoT, Challenges of Blockchain in IoT, Risks of using Blockchain in IoT, The optimum Secure IoT Model, Blockchain in Intelligent Vehicles, Blockchain Technology for Supply Chain Insight from Enterprise Resource Planning, Next Generation Blockchain Enterprise Artificial Intelligence System, Artificial Intelligence and Deep Learning Chains, Blockchain Technology Use Cases in Health Care, Blockchain Technology Use Case in Smart City Applications. Blockchain Hands on for generating Genesis Block.

"Advanced Applications of Blockchain Technology", Shiho Kim and Ganesh Chandra Deka, Springer , 2019, (Available Online)

Blockchain Technology: Platforms , Tools and Use Cases " Advances in Computers Volume 111, Ali R Hurson and Atif M. Memon, Academic Press, 2019.

"Secure and Smart Internet Of Things (IoT) using Blockchain and Artificial Intelligence" , Ahmed Banafa , 2018

IT434 Digital Forensics (3-0-2) 4

Introduction, The Scope of Computer Forensics, Windows Operating and File Systems, Handling Computer Hardware, Acquiring Evidence in a Computer Forensics Lab, Online Investigations, Documenting the Investigation, Admissibility of Digital Evidence, Network Forensics, Mobile Forensics, Photograph Forensics, Mac 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.

Dr. Darren R. Hayes, "A Practical Guide to Computer Forensics Investigations", Pearson Publisher

Kanellis, Panagiotis, "Digital Crime and Forensic Science in Cyberspace", IGI Publishing", ISBN 1591408733.

Jones, Andrew (2008), "Building a Digital Forensic Laboratory. Butterworth- Heinemann", ISBN 1856175103.

Marshell, Angus M. (2008), "Digital Forensics: Digital Evidence in Criminal Investigation", Wiley-Blackwell, ISBN 0470517751

Philip Craiger, Sujeet Shenoi, "Advances in Digital Forensics in", Springer, 2007.

Paul Crowley Dave Kleiman, "CD and DVD Forensics", Syngress Publishing Inc, 2007.

Chris Prosise, Kevin Mandia, "Incident Response & Computer Forensics", McGraw-Hill, 2 nd Edition, 2003.

IT435 Computational Biology (3-0-2) 4

Introduction to Bioinformatics, Biological Databanks,Biological Sequence Analysis: Genome-Microarray, pairwise sequence alignment, Dynamic programming, global and local alignment, Progressive multiple sequence alignment, Iterative multiple sequence alignment. BLAST Scoring matrices, gap penalty, statistical significance of multiple sequence alignment, sum-of-pairs method, CLUSTAL W, searching motifs in sequence alignment. Phylogentics – distance-based using UPGMA, Neighbour Joining. Protein Structure prediction – Secondary Structure prediction, Protein Secondry Structural Class prediction, Protein Fold recognition, Protein Tertiary Structure prediction. Protein-Protein Interaction, Protein Subcellular Localization, Emerging Areas in Bioinformatics.

Durbin, R., Eddy, S., Krough, A. & Mitchison, G. (1998). Biological sequence analysis: probabilistic models of proteins and nucleic acids. Cambridge University Press.

Jones, N.C. & Pevzner, P.A. (2004). An introduction to bioinformatics algorithms. MIT Press.

Bioinformatics: Sequence and Genome Analysis by David Mount, Cold Spring Harbor Laboratory Press (2001)

Biological Sequence Analysis: Probabilistic models of proteins and nucleic acids by R. Durbin, S.Eddy, A. Krogh and G. Mitchison, Cambridge University Press (1998)

Knowledge Discovery in Bioinformatics: Techniques, Methods, and Applications by Xiaohua Hu and Yi Pan, John Wiley & Sons (2007)

A Metaheuristic Approach to Protein Structure Prediction by Jana, Nanda Dulal, Das, Swagatam, Sil, Jaya, Springer (2018)

IT436 Cloud Computing (3-0-2) 4

Concept of cloud computing and evolution. Define SLAs and SLOs and illustrate their importance in Cloud Computing, Threats in cloud security, Common cloud providers and their associated cloud stacks and popular cloud use case scenarios. Cloud infrastructure: Cloud Reference Architecture. Cloud software deployment considerations such as scaling strategies, Load balancing, Fault tolerance, and Optimizing for cost. Cloud resource management: Virtualizing CPUs, full virtualization, Para-virtualization, and Memory virtualization. Cloud storage: Organization of data and storage. HDFS, Google GFS, Big-Table. Programming models: Fundamental aspects of parallel and distributed programming models. Cloud programming models (Map reduce, Spark, Graph Lab and Spark Streaming). Map-reduce programming model.

Anthony T Velte, Cloud Computing: A Practical Approach, McGraw Hill,2010
J. Lin and C. Dyer, Data Intensive Text Processing with MapReduce, , Morgan and Claypool, 2010
T. Velte, A. Velte, R. Elsenpeter, Cloud Computing, A Practical Approach, McGraw Hill, 2009
Rajkumar Buyya, James Broberg, Andrzej M., Cloud Computing: Principles and Paradigms, Wiley, 2010.
Dan Marinescu, Cloud Computing:Theory and Practice , Morgan Kaufmann, 2013

IT437 Quantum Computing (3-0-2) 4 History of quantum computation and quantum information, Future directions, Basic Mathematics: Linear operators and matrices, Tensor products, Operator functions. Quantum Logics: QISKIT, Introduction to Qubit, Single qubit operation, Multiple Qubit operation, Single qubit gates, Multiple qubit Gates, Controlled Not gate, Swap gate, Toffoli gate, Universal quantum gates. Quantum Algorithms and Applications: The quantum search algorithm, Quantum search as a quantum simulation, Quantum counting, Speeding up the solution of NP complete problem, Quantum search of an unstructured database, Optimality of the search algorithm.

Michael. A. Nielsen and I. L. Chuang, Quantum Computation and Quantum information, Cambridge University Press 2000.
Bellac Michel Le, "A short introduction to quantum information and quantum computation", Cambridge University Press, 2006
Vishal Sahni, "Quantum Computing", Tata McGrawHill, 2007.
Richard L. Liboff, Introductory Quantum Mechanics, Pearson, Fourth Edition (2003).
QISKIT textbook: https://qiskit.org/textbook/content/ch-ex/

IT438 Big Data Analytics (3-0-2) 4
Introduction– distributed file system–Big Data and its importance, Four Vs, Drivers for Big data, Algorithms using map reduce, Apache Hadoop & Hadoop EcoSystem, Data Serialization, HDFS, Hive Architecture, HiveQL Querying Data, Sorting And Aggregating, Map Reduce Scripts, Joins & Sub queries, HBase concepts, Schema Design, Advance Indexing, PIG, Zookeeper , Data Analysis with Spark, Programming with RDDs, Machine Learning with MLlib, NoSQL, NewSQL, Creating and Querying through Indexes, Document-Oriented, principles of schema design, Constructing queries on Databases, collections and Documents, MongoDB Query Language, Big data analytics, Big data applications.

Understanding Big data, Chris Eaton,Dirk derooset al, McGraw Hill, (2017)
Big Data and Analytics, 2ed, Subhashini Chellappan Seema Acharya, Wiley (2019)
Big Data: Principles and Best Practices of Scalable Real-Time Data Systems - Nathan Marz and James Warren, Manning Publishers (2015)

IT439 Sentiment Analysis (3-0-0) 3
Introduction to Sentiment, Subjectivity, and Stance; Overview, From Words to Discourse & Pragmatics, From Text to Tweets to Speech, Joint Models, Recognizing Stances, Arguments, and Viewpoints, Lexicon-based approaches to sentiment analysis, Exploiting dictionaries, Ontologies, Specialized corpora for detecting the sentiment polarity in texts, Machine learning approaches to sentiment analysis, Sentiment and polarity detection as a classification problem. Neural network architectures for sentiment analysis, Neural network for sentiment detection and polarity evaluation, Affect and emotion detection in texts., Methods and techniques for modeling the language of emotions using neural networks and statistical language models., Exploitation of multimodal data in combination with text to detect the language of emotions, Applications and case studies.

Opinion mining and sentiment analysis, Bo Pang and Lillian Lee, Foundations and Trends in Information Retrieval 2(1-2), pp. 1-135, 2008.
Sentiment Analysis and Opinion Mining, Bing Liu, Morgan and Claypool Publishers, 2012.
Sentiment Analysis: Mining Opinions, Sentiments, and Emotions -Bing Liu , Cambridge University Press, 2015
Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition, 2nd edition, by Daniel Jurafsky and James Martin. (J&M)

IT442 Autonomous Cyber Physical Systems (3-0-0) 3
CPS architecture. Overall architecture for CPS. Mobile sensing devices and platforms for CPS. Naming, addressing, and profile services for CPS. Device search and selection for CPS. Energy management for CPS. Enabling technologies for CPS. Networking technologies for CPS. Machine-to-machine communications for CPS. Mobile cloud computing for CPS. CPS applications. Connected healthcare for CPS. Multi-player gaming for public transport crowd. Mobile cloud computing enabled emerging CPS applications.

Chi (Harold) Liu, Yan Zhang, "Cyber Physical Systems: Architectures, Protocols and Applications", 1st Edition, CRC Press, Published September 19, 2019

Rajeev Alur. Principles of Cyber-Physical Systems. The MIT Press, 2015.
K. J. Astrom and R. M. Murray. Feedback Systems: An Introduction for Scientists and Engineers. Prince- ton University Press, 2009. http://www.cds.caltech.edu/~murray/amwiki/index.php/Main_Page.
C. Baier and J.-P. Katoen. Principles of Model Checking. The MIT Press, 2008.
H. Choset, K. M Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, and S. Thrun. Principles of Robot Motion: Theory, Algorithms, and Implementations. MIT Press, 2005.
S. M. LaValle. Planning Algorithms. Cambridge University Press, 2006.
Edward A. Lee and Sanjit A. Seshia, Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, 2015.

IT443 Stochastic Processes (3-0-2) 4

Discrete-time Markov chains: Definition and examples of discrete-time Markov chains, Chapman-Kolmogorov equations, Long run behaviour of Markov chains, Absorption probabilities and expected times to absorption, Statistical aspects of Markov chains, The mover-stayer model, Application of a Markov chain and mover-stayer model to modelling.Continuous-time Markov chains: Definition of a continuous-time Markov chain and examples, Poisson process, The Kolmogorov differential equations, Limiting behaviour of continuous-time Markov chains, birth and death processes, Statistical aspects and applications of continuous-time Markov chains. Discrete-time martingales: Conditional expectation, Definition of a martingale and examples, Optional stopping theorem, Applications to random walks, Martingales in option pricing- a simple example; Brownian Motion and its generalizations: Motivation, definition and properties of Brownian motion, Geometric Brownian motion, Continuous-time martingales, Optional stopping theorem;Stochastic calculus: Stochastic integration, Ito's formula, Black-Scholes option pricing formula

Introduction to Probability and Stochastic Processes with Applications, Castaneda, Arunachalam, Dharmaraja, Wiley, 2012
G.F. Lawler, Introduction to Stochastic Processes (Second Edition), Chapman and Hall, Probability Series, 2006.
An Introduction to Stochastic Modeling, H.M. Taylor and S. Karlin, Academic Press, Third Edition

IT445 User Experience Design (3-0-2) 4

UI/UX Overview: Intro to UI/UX,Finding bad UI/UX design; Design: Introduction,Design Toolkit and UI/UX Notebook;User Research:How to identify stakeholders, Defining stakeholders, How to identify user needs,Creating UX Flows,User Journeys:Mapping the user journey, Finding solutions & constraint cards, User Experience Design techniques such as scenarios, personas, storyboards, wireframing, and information architecture; UX Principles: Present Sketches, UX Principles, Converting Sketches to Grayscales, Psychology of UX; User Testing:Understanding user testing, Prepare grayscales for user testing, think aloud testing; UI Principles:layout and alignment, Finding good UI, color and text,Visual Design Specification;UI Components: buttons, icons, controls, prototyping.

Interaction Design: Beyond Human-Computer Interaction, by Rogers, Sharp, and Preece, ISBN-10 # 0470665769
The Design of Everyday Things, by Norman, ISBN-10 # 0465050654
Sketching User Experiences: Getting the Design Right and the Right Design, by Buxton, ISBN-10 # 0123740371
Designing for Small Screens: Mobile Phones, Smart Phones, PDAs, Pocket PCs, Navigation Systems, MP3 Players, Game Consoles, by Studio 7.5, Zwick, and Schmitz, ISBN-10 # 2940373078

IT469 AI in Healthcare (3-0-2) 4

Introduction to medical informatics, Healthcare data sources and basic analytics, Electronic Health Records, Coding Systems, Modalities - Biomedical image analysis, Genomic data analysis, Natural Language Processing and Data Mining for Clinical Text, mining information from clinical text, dealing with medical terminology, MeSH, SNOMED-CT, Advanced Clinical Data Analytics – Clinical Prediction models, supervised and unsupervised applications, Survival models, evaluations and validation, temporal analytics for clinical data, visual analytics for clinical data, Pervasive health, Clinical Decision Support Systems, Towards explainable-AI in medicine, Applications of Big Data and ML in Medical Diagnostics, Case studies and state-of-the-art systems.

Healthcare Data Analytics (Chapman & Hall/CRC Data Mining and Knowledge Discovery Series) Hardcover – Chandan K. Reddy and Charu C. Aggarwal , CRC Press (2015)
Healthcare Information Management Systems: Cases, Strategies, and Solutions - Charlotte A. Weaver, Marion J. Ball, et al. 2015
Medical Informatics, e-Health: Fundamentals and Applications - Alain Venot, Anita Burgun, et al. 2016
Medical Informatics: Computer Applications in Health Care and Biomedicine - Edward H. Shortliffe and Leslie E. Perreault (2001)

IT471 Cyber Security (3-0-2) 4

Digital Securities: Introduction, Types of Attacks, Digital Privacy, Online Tracking, Privacy Laws, Types of Computer Security risks (Malware, Hacking, Pharming, Phishing, Ransomware, Adware and Spyware, Trojan, Virus, Worms,

WIFI Eavesdropping, Scareware, Distributed Denial-Of-Service Attack, Rootkits, Juice Jacking), Antivirus and Other Security solution, Password, Secure online browsing, Email Security, Social Engineering, Secure WIFI settings, Track yourself online, Cloud storage security, IoT security, Physical Security Threads. Online Anonymity: Anonymous Networks, Tor Network, I2P Network, Freenet, Darknet, Anonymous OS – Tails, Secure File Sharing, VPN, Proxy Server, Connection Leak Testing, Secure Search Engine, Web Browser Privacy Configuration, Anonymous Payment: Cryptography and Secure Communication: The Difference Between Encryption and Cryptography, Cryptographic Functions, Cryptographic Types, Digital Signature, The Difference Between Digital Signatures and Electronic Signatures, Cryptographic Systems Trust Models, Create a Cryptographic Key Pair Using Gpg4win/gpg4usb, Disk Encryption Using Windows BitLocker, Disk Encryption Using Open Source Tools, Multitask Encryption Tools, Attacking Cryptographic Systems, Countermeasures Against Cryptography Attacks, Securing Data in Transit, Cloud Storage Encryption, Encrypt DNS Traffic and Email communication, Secure IM and video calls. Cyber Crime Issues and Investigation: Unauthorized Access, Computer Intrusions, White collar Crimes, Viruses and Malicious Code, Internet Hacking and Cracking, Virus Attacks, Pornography, Software Piracy, Intellectual Property, Mail Bombs, Exploitation, Stalking and Obscenity in Internet, Digital laws and legislation, Law Enforcement Roles and Responses, Investigation Tools, eDiscovery, EDRM Model, Digital Evidence Collection, Evidence Preservation, E-Mail Investigation, E-Mail Tracking, IP Tracking, E-Mail Recovery, Hands on Case Studies, Search and Seizure of Computers, Recovering Deleted Evidences, Password Cracking.

Nihad Hassan, Rami Hijazi, "Digital Privacy and Security Using Windows: A Practical Guide" Apress.
"Network Security Essentials", William Stallings, 4th Edition, Pearson Education, 2008.
"Internet and Intranet Security", Rolf Oppliger, 2nd Edition, Artech House, 2007.
"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.
"Cryptography and Network Security", Behrouz A Forouzan/ Mukhopadhyay, 3rd Ed., McGraw-Hill, 2015.

IT472 Computer Networks (3-0-0) 3

Introduction to computer networks and Internet; Understanding of network and Internet, The network edge, The network core, Understanding of Delay, Loss and Throughput in the packet switching network, protocols layers and their service model, History of the computer network. The Link layer and Local area networks: Introduction and link layer services, error-detection and correction techniques, Multiple access protocols, addressing, Ethernet, switches. Network Layer: Introduction, Virtual and Datagram networks, study of router, IP protocol and addressing in the Internet, Routing algorithms, Broadcast and Multicast routing. Transport Layer: Introduction and transport layer services, Multiplexing and Demultiplexing, Connection less transport (UDP), Principles of reliable data transfer, Connection oriented transport (TCP), Congestion control. Application Layer: Principles of computer applications, Web and HTTP, E-mail, DNS, Socket programming with TCP and UDP.

Kurose and Ross, "Computer Networking- A Top-Down Approach", 6th Edition, Pearson
Andrew S Tanenbaum, "Computer Networks", 4th Edition, Prentice Hall
Behrouz A Forouzan, "Data Communications and Networking", 4th Edition, McGraw Hill

IT473 Cognitive Networks (3-0-2) 4

Cooperative and Cognitive Networks Introduction, Adaptive Networks, Dynamic Factors, Network Functions, Representative Adaptive Techniques, , Self Managing Networks, Concepts and Challenges, Theories for designing Self Management Networks, Self Management Intelligence, Machine Learning for Cognitive Networks-Technology Assessment and Research Challenges, Evolution of Adaptive Systems, Biologically Inspired Networking, Principles, Evolutionary and Adaptive Systems, Swarm Intelligence, Cross-Layer Design and Optimization in Wireless Networks, Cognitive Radio Architecture, Cognitive Ad hoc Networks, Distributed Learning and Reasoning in Cognitive Networks – Methods and Design Decisions, applying Evolutionary Approaches for Cooperation in Networks, Intelligence in Router and Switches,

"Cognitive Networks Towards Self Aware Networks" Qusay H Mahmoud, Wiley Publications, 2007
"Cognitive Wireless Networks: Concepts, Methodologies and Vision Inspiring the Age of Enlightenment of Wireless Communications" , Frank H.P. Fitzek and Marcos D. Katz, Springer, 2007
"CISCO Router and switch Forensics Investigating and Analyzing Malicious Network Activity" Dale Liu, Singress Publicatins, 2009.

IT474 Formal Languages & Automata Theory (3-0-0) 3

Formal Languages and Automata Theory: Generative grammar, Chomsky hierarchy, Finite state Automata: Definition, Concept of Non-determinism, Equivalence of deterministic and Non-deterministic Automata, regular languages; Closure properties. Pushdown Automata: Definition, Equivalence between NPDA and context free grammars, Pumping Lemma for C.F.L's, Decision problems, Closure properties. Turing machines: Definition, extension to Turing machines:

Multi-track, Multi-tape, and Non determinism. TM as an acceptor, TM as a computing device; P, NP, NP-Hard & NP-Complete problems

J.E.Hopcroft and J.D.Ullman, Introduction to automata, Languages and computation, Addison Wesley.1969
M. Sipser, Theory of Computation, Cengage, 2013.
H.E.Lewis and C.H. Papadimitiou, Elements of the Theory of Computation, Prentice-Hall of India, 1981.
Derickwood, Theory of Computation, John Wiley & Sons, 1987.

IT475 Computer Organisation and Architecture (3-0-0) 3

Introduction to computer organization and architecture, CPU Organization, Data Representation, Instruction Sets, Data path design, Fixed point and floating point arithmetic operations and hardware design, ALU design, Micro-Operation, Microarchitecture and Instruction Set Architecture, Control unit and Design, Hardwired control unit and Micro programmed control unit, Horizontal micro-programmed and Vertical micro-programmed control unit, Memory organization, Cache memory, Multilevel Cache Organisation, Virtual memory, Input output Unit: Priority Interrupts, Programmed Controlled I/O Transfer, Interrupt controlled I/O transfer, DMA controller, Secondary storage and type of storage devices, Introduction to solid-state drive (SSD), Read and Write operations in memory, Pipelining. Performance evaluation.

Carl Hamacher et al., Computer Organization and Embedded Systems, Sixth Edition, McGraw-Hill, 2014.
Vincent P Heuring, Harry F Jordan, T. G. Venkatesh, Computer Systems Design and Architecture, Pearson, 2008.
Murdocca and Heuring, Computer Architecture & Organization An Integrated Approach, Wiley, 2007.
Hennesy and Patterson, Computer Architecture –A Quantitative Approach, 6th Ed., Morgan Kaufmann, 2017.

IT476 Human Centered Computing (3-0-2) 4

Overview of Human Physiology, Psychology and Usability Factors; Immersive Reality Technologies, Virtual Reality, Augmented Reality and Mixed Realty Systems Design, Prototyping, Framework for Evaluating the Current and Emerging Immersive Reality Technologies and Applications; Design and Technological Foundations for Immersive Experiences; Input Devices – Controllers, Motion Trackers and Motion Capture Technologies for Tracking, Navigation: Touch, Gesture and Marking, Speech, Language and Audition Control; Output Devices – Head Mounted VR Displays, Augmented and Mixed Reality Glasses; 3D Interfaces: Interactive & Procedural Graphics; Immersive Surround Sound; Haptic and Vibrotactile Devices; Systems Architecture and Integrative Immersive Media Platforms; Rapid Prototyping and Physical Computing, VR programming.

Kelly S. Hale, Kay M. Stanney (Eds.), "Handbook of Virtual Environments: Design, Implementation, and Applications", CRC Press, Second Edition, 2015.
Jason Jerald, "The VR Book: Human-Centered Design for Virtual Reality", Association for Computing Machinery and Morgan & Claypool Publishers, 2015.
Bowman, Doug A.; Kruijff, Ernst; LaViola Jr., Joseph J.; Poupyrev, Ivan, "3D User Interfaces: Theory and Practice", Addison-Wesley, 1st Edition, 2005.

IT477 Digital System Design (3-0-2) 4

Introduction: Number Systems and Codes; Boolean Algebra and Logic Gates; Karnaugh Maps and Gate-Level Minimization; Combinational Logic Design: Adders, Subtractors, Comparators, Decoders, Encoders, Multiplexers; Sequential Logic Design: latches, Flip-Flops; Registers, Counters and Memory Unit: Shift Registers, Ripple and Synchronous Counters, Random Access Memory; Algorithmic State Machines; Design at the Register Transfer Level; Hardware Descriptive Language.

M. Morris Mano, Digital Logic & Computer Design, 1st Edition, Pearson Education, 2016.
M. Morris Mano and Michael D. Ciletti, Digital Design with VERILOG HDL, 5th Ed., Pearson, 2012.
Mark Zwolinski, Digital System Design with VHDL, 2nd Edition, Pearson, 2004.
B. Holdsworth and R.C. Woods, Digital Logic Design, 4th Edition, Elsevier, 2003

IT478 Data Mining (3-0-2) 4

Introduction to data mining: Motivation and significance of data mining, Data mining on what kind of data? , data mining functionalities, interestingness measures, classification of data mining system, major issues in data mining; Data pre-processing: Need, data summarization, data cleaning, data integration and transformation, Attribute subset selection methods: filter based and wrapper based methods, Information gain based, correlation based, Minimum redundancy maximum relevance based methods, data discretization and concept hierarchy generalization. Data warehouse and OLAP technology: multidimensional data model(s), data warehouse architecture, OLAP server types, data warehouse implementation, on-line analytical processing and mining; Data cube computation and data generalization. Mining frequent patterns, associations and correlations: Basic concepts, efficient and scalable frequent itemset mining algorithms: A-priori and FP Tree methods, mining various kinds of association rules – multilevel and multidimensional,

association rule mining versus correlation analysis, constraint based association mining; Colossal item set Mining: Enumeration methods, Dynamic switching method, parallel method, sequential pattern mining; Bayesian classification, associative classification, lazy learners, grid based and density based clustering methods, Clustering high dimensional data; Data mining on complex data and applications: Algorithms for mining multimedia data, text data, multimodal data, biological sequence data; Data mining applications and trends in data mining.

Han, J. and Kamber, M., "Data Mining - Concepts and Techniques", 3rd Ed., Morgan Kaufmann Series, (Elsevier), 2008.
Alex Berson , S. J. Smith, "Data Warehousing, Data Mining & OLAP" , McGraw Hill
Tan, P.N., Steinbach, M. and Kumar, V., "Introduction to Data Mining", Addison Wesley Pearson, 2006
Pujari, A. K., "Data Mining Techniques", 4th Ed., Sangam Books.
Oded Maimon, Lior Rokach, The Data Mining and Knowledge Discovery Handbook, Springer, 2005.
S. Weiss and N. Indurkhya, Predictive Data-Mining: A Practical Guide, Morgan Kaufmann, 1998
S. Weiss, N. Indurkhya, T. Zhang and F. Damerau, Text Mining: Predictive Methods for Analyzing Unstructured Information, Springer, 2004.

IT479 Signals and Systems (3-0-2) 4

Signals in Physical World: Continuous Time Signals and Spectra, Fourier Series, Fourier Transforms; Signals in Digital World: Sampling, Quantization, Interpolation, Discrete Time Signals and Spectra, Discrete Fourier Transforms: Fast Fourier Transforms, Discrete Cosine Transforms, Continuous-time Systems: Continuous Linear Time Invariant, Linear Time Variant, Laplace Transforms; Discrete-time Systems: Linear Shift Invariant, Linear Shift Variant, Z-Transforms; Convolution and Correlation; Filters: Feed forward and Feedback; Modulation Techniques: AM, FM, PAM, PCM, Multiplexing Techniques: FDM and TDM; Compression: Text (Huffman Coding, Arithmetic Coding, LZW Coding, Run Length Coding); Audio (MP3); Image (JPEG); Video (MPEG4).

Michael Stiber and Bilin Stiber, "Signal Computing: Digital Signals in the Software Domain", Published by University of Washington Bothell, 2016.
A.V. Oppenheim, A.S. Willsky and S. Hamid Nawab, Signals and Systems, 2nd Edition, Pearson, 2015.
Rodger E. Ziemer, W.H. Tranter and D.R. Fannin, Signals and Systems, 4th Edition, Pearson, 2014.
B.P. Lathi and Roger Green, Linear Systems and Signals, 3rd Edition, Oxford University Press, 2017.
M.J. Roberts, Signals and Systems - Analysis Using Transform Methods & MATLAB, McGraw-Hill, 2017.
Luis F. Chaparro, Signals and Systems Using MATLAB, 2nd Edition, Academic Press, 2014.

IT480 Social Computing (3-0-2) 4

Emergence of the Social Web, Statistical Properties of Social Networks, Network analysis -concepts and graph centrality measures, Complete networks, Ego Networks, Random networks, Homophily, Small World Phenomenon, Structural Holes, Time, Sub-groups, Blockmodels and Strategic Network Formation, Empirical Models of Network Formation, Community detection, Influence maximization, Link mining and prediction, Social network based recommender systems, Anomaly detection in social networks, Mining Discussion networks, Visualizing Online Social Networks, Large-scale social network analysis applications and case studies, Emerging trends and issues.

Computational Social Network Analysis: Trends, Tools and Research Advances, Springer, 2012
Charu C. Aggarwal, —Social Network Data Analytics, Springer; 2014
Evolution in Social Networks. Ajith Abraham, Aboul Ella Hassanien, Václav Snášel
Borko Furht, —Handbook of Social Network Technologies and Applications, Springer, 1st edition, 2011
Giles, Mark Smith, John Yen, —Advances in Social Network Mining and Analysis, Springer, 2010.

IT481 CORNERSTONE/CAPSTONE PROJECT 4

For details refer to clause 3.2 (f) under Regulations specific to Undergraduate Programmes.

IT485 Applied Algorithms (3-1-0)

Sequential algorithms. Preliminaries: Algorithmic design techniques and representative problems. Combinatorial algorithms. Graph algorithms. String matching algorithms, External memory algorithms, online algorithms, algebraic and number theoretic algorithms and Security & Cryptography algorithms. Several other categories of algorithms. Design and analysis of Parallel algorithms, Problem reduction. Basics of randomized algorithms, and randomized algorithms, application of randomness for correctness verification. Hardness and basics of Approximation algorithms.

Alfred V Aho, john E Hopcroft, Jeffery D Ullman, "Data structure and algorithms", Addison Wesley, 1993 (2)
J. Kleinberg, E. Tardos, "Algorithm design". Pearson Education,
Addison Wesley, 2006."
Michael Jay Quinn, "Designing efficient algorithms for parallel computers", McGraw Hill 1997.
Rajeev Motwani, PrabhakarRaghavan, "Randomized algorithms", Cambridge University Press, 1995
R. E. Tarjan, "Data structures and network algorithms", SIAM, 1983.

Vijay V. Vazirani, "Approximation algorithms", Springer, 2001..

UC100 INTRODUCTION TO DESIGN THINKING (2-0-0) 2

Need and Definition of Design Thinking. Framework for Design Thinking. Engineering Design Process. Need Identification, Specification, Concept Generation, Product Architecture and Detailed Design. Prototyping – Virtual and Physical. Testing Methodology

Christian Muller-Roterberg, "Handbook of Design Thinking", 2018
Eli Woolery, "Design Thinking Handbook" Invision Pub, 2019
Nigel Cross, "Design Thinking"
Max Answell "Mastering Design Thinking", 2019
Karl T. Ulrich, Steven D. Eppinger and Maria C Yang, "Product Design and Development", McGraw Hill, 7ed, 2020
George e Dieter, Linda C Schmidt, "Engineering Design", Mc Graw Hill, 4ed, 2009

UC401 LIBERAL ARTS COURSES/CO-CURRICULAR/EXTRACURRICULAR ACTIVITIES 10

CATEGORY A : Maximum 3 credits, CATEGORY B : Maximum 3 credits, CATEGORY C : Minimum 4 Credits and Maximum 7 credits.

10 Credits have to be earned from 1st Semester to 7th Semester by choosing Category (A + B + C) OR Category (A + C) or Category (B + C) courses combination . Registration for 10 Credits has to be done in 7th Semester.

For details of CATEGORY A, CATEGORY B and CATEGORY C refer to clause 3.2 (f) under Regulations specific to Undergraduate Programmes.

MA110 ENGINEERING MATHEMATICS - I (3-0-0) 3

Functions of two or more variables: Definition, Region in a plane, Level curves, Level surfaces, Limits, Continuity, Partial derivatives, Differentiability, Gradients, Directional derivatives, Normals to level curves and tangents, Extreme values and saddle points, Lagrange multipliers.

Integral calculus: Double integral and iterated integrals - Cartesian and polar coordinates, Volume of solids of revolution, Triple integral, Change of variables, Multiple integrals in cylindrical and spherical coordinates.

Vector calculus: Line Integrals, Vector Fields, Work, Circulation and flux, Path independence, Potential functions, and Conservative fields, Green's theorem in the plane, Surface area and surface integrals, Surface area of solid of revolution, Parametrized surfaces, Stokes' theorem, The Divergence theorem.

G.B. Thomas Jr., M.D. Weir and J.R. Hass, Thomas Calculus, Pearson Education, 2009.

N. Piskunov, Differential and Integral Calculus Vol. 1, Mir Publishers, 1974.

E. Kreyszig, Advanced Engineering Mathematics, 10th Ed., John Wiley & Sons, 2010.

J.E. Marsden, A.J. Tromba, A. Weinstein, Basic Multivariable Calculus, Springer Verlag, 1993.

J. Stewart, Calculus (5th Edition), Thomson (2003).

S. R. Ghorpade, B. V. Limaye, A Course in Multivariable Calculus and Analysis.

MA111 ENGINEERING MATHEMATICS - II (3-0-0) 3

Series: Sequences of real numbers and their convergence criteria, Infinite series, Sequence of partial sums, Tests for convergence/divergence - n th term test, Boundedness and monotonicity, Integral, Condensation, Comparison, Ratio and root tests, Alternating series, Absolute and conditional convergence, Rearrangement theorem, Power series, Taylor and Maclaurin series (one and two variables), Fourier series.

Ordinary differential equations: First order ODE - various methods, Initial value problems - Picard's iteration, Conditions for existence and uniqueness of solution to an IVP, Second and higher order linear DEs with constant coefficients - general solution for homogeneous equations (characteristic equations), Super -position principle, Euler-Cauchy equation, Particular integrals, Second order linear ODEs with variable coefficients, Existence and uniqueness

- Wronskian, Method of variation of parameters, Method of reduction of order, Series solutions.

G.B. Thomas Jr., M.D. Weir and J.R. Hass, Thomas Calculus, Pearson Education, 2009.

G.F. Simmons, Differential Equations with Applications and Historical Notes, 2nd Ed., McGraw- Hill, 1991. N. Piskunov, Differential and Integral Calculus Vol. 2, Mir Publishers, 1974.

E. Kreyszig, Advanced Engineering Mathematics, 11th Ed., John Wiley & Sons, 2010. E.A. Coddington, An Introduction to Ordinary Differential Equations, PHI Learning 1999.

MA112 DIGITAL SYSTEM DESIGN (4-0-0) 4

Basics of logic design, Design of combinational functional blocks (decoders, multiplexers, adder, multipliers, etc.), Sequential circuit design basics, Design of sequential functional blocks-registers and counters, Memory - RAM and ROM, Building simple and pipelined datapaths (ALU, register file and their interconnection paths), Concept of register transfers, Sequencing and control-hardwired control and microprogrammed control, Instruction set architecture.

M. M. Mano and C. R. Kime, Logic and Computer Design Fundamentals, 2nd Edition, Prentice Hall, 2002.

MA113 LINEAR ALGEBRA (4-0-0) 4

Vector spaces, subspaces, span, linear dependence, basis, dimension. Linear transformations, rank and nullity, matrix representation, change of bases. Rank-Nullity theorem. Inner products, Orthogonal and orthonormal sets, Gram-Schmidt orthogonalization, Orthogonal Complement, QR factorization. System of linear equations, echelon matrices, LU-factorization, similarity, determinant, inverse of a matrix, eigenvalues and eigenvectors, symmetric matrices, spectral mapping theorem, characteristic polynomial, Cayley-Hamilton Theorem, Diagonalization of matrices.

G. Strang, Linear Algebra and its applications, Thomson Learning, 2003.

S. H. Friedberg, A. J. Insel, L.E. Spence, Linear Algebra, 4th Edition, Pearson, 2015.

S. Lang, Linear Algebra, 3rd Edition, Springer, 2004.

G. Hadley, Linear Algebra, Narosa, 2000.

W. Cheney, D. Kincaid, Linear Algebra Theory and Applications, Jones & Bartlett, Student Edition, 2010.

MA201 CONCRETE MATHEMATICS (3-0-0) 3

Sums and Recurrences, General methods. Finite and infinite calculus. Floors and ceilings, Applications, Number theory, Congruences, Chinese remainder Theorem, Generating functions, Solving recurrences, Special generating functions, Convolutions and Exponential generating functions.

G. Knuth, and Patashnik, Concrete Mathematics: A foundation for Computer Science, Pearson , 2000.

MA202 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: Graph Representations, Directed and Undirected graphs - Introduction and basic properties, Subgraphs, Isomorphism, Trees, Spanning Trees, Eulerian and Hamiltonian graphs, Connectivity, Planar graphs, Euler's formula, Applications of Kuratowski's theorem. Groups: Cosets, Normal Subgroups, Permutation groups, Burnside's Theorem and simple applications. Lattice Theory: Equivalence relations, Partial order relations, Linear order relations, Hasse diagrams, Lattices, Lattices as algebraic systems, Special classes of Lattices, Boolean algebra and its properties, Boolean expressions and their canonical forms.

K. H. Rosen, Discrete Mathematics and its applications with Combinatorics and Graph Theory, 7th Edition, 2012.

D. B. West, Introduction to Graph Theory, Eastern Economy Edition published by PHI Learning Pvt. Ltd, 2nd Edition, 2002.

N. L. Biggs, Discrete Mathematics, 2nd Edition (Indian Edition published by Oxford University Press), 2002.

MA203 GRAPH THEORY (3-0-0) 3

Introduction to Graphs, Digraphs, Multipartite graphs, Connectivity and Flows, Trees, Traversability, Matching, Covering and Independence, Planarity, Coloring, Operations on Graphs, Domination in graphs – Basic concepts, Graphs and Matrices, Enumeration of graphs.

Douglas B. West, Introduction to Graph Theory, Second Edition, Pearson Education, India, 2001.

R. Diestel, Graph Theory, Fifth Edition, Springer-Verlag, Germany, 2017.

T.W. Haynes, S. Hedetiemi and P. Slater, Fundamentals of Domination in Graphs, New York: Marcel Dekker, Inc., 1998.

B. Bollobás, Modern Graph Theory, Springer-Verlag, New York, 1998.

MA204 LINEAR ALGEBRA AND MATRICES (3-0-0) 3

Vector spaces, subspaces, span, linear dependence, basis, dimension. Linear transformations, rank and nullity, matrix Representation, change of bases. Rank-nullity theorem.

Inner products, Orthogonal and orthonormal sets, Gram-Schmidt orthogonalization, Orthogonal Complement, QR-factorization, Best approximation and least squares.

System of linear equations, echelon matrices, LU-factorization, similarity, determinant, inverse of a matrix. eigenvalues and eigenvectors, symmetric matrices, spectral mapping theorem, characteristic polynomial, Cayley-Hamilton Theorem, quadratic forms, orthogonal transformations, singular value decomposition.

G. Strang, Linear Algebra and its applications, Thomson Learning, 2003.

S. H. Friedberg, A. J. Insel, L.E. Spence, Linear Algebra, 4th Edition, Pearson. 2015.

S. Lang, Linear Algebra, 3rd Edition, Springer, 2004

G. Hadley, Linear Algebra, Narosa 2000.

W. Cheney, D. Kincaid, Linear Algebra Theory and Applications, Jones & Bartlett, Student Edition. 2010

MA205 MODERN COMPUTER ALGEBRA (3-0-0) 3

Fundamental algorithms. Extended Euclidean algorithm and applications. Modular inverses, repeated squaring continued fractions and Diophantine approximation. Modular algorithms and interpolation Chinese Remainder Algorithm. Resultant and GCD computation. Applications to decoding BCH codes.

J.V Zur Gathen and Jurgen Gerhard, Modern Computer Algebra, Cambridge University Press, 1999.

MA206 NUMBER THEORY AND CRYPTOGRAPHY (3-0-0) 3

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.

N. Kobltiz, A course in Number Theory and Cryptography, Springer, 1994.

MA207 NUMERICAL METHODS (3-0-0) 3

Root finding of polynomials (zeros of a function) 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.

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.
Jaan Kiusalaas, Numerical Methods in Engineering with MATLAB, 2nd Edition, Cambridge University Press, 2009.

MA208 PROBABILITY THEORY AND APPLICATIONS (3-0-0) 3

Introduction to probability, Sample space, Definitions of probability, Conditional probability, Bayes' theorem, Random variables, pmf, pdf, cdf, Two and Higher dimensional Random variables, Marginal and Conditional Distributions, Mean and Variance, Covariance and Correlation, Standard probability distributions: Bernoulli, Binomial, Geometric, Poisson, Uniform, Exponential, Normal, Gamma, Moment Generating Functions.

S.M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, 5th Edition, Academic Press, 2014.
S.M. Ross, Introduction to Probability Models, 10th Edition, Academic Press, 2010.
P.L. Meyer, Introductory Probability and Statistical Applications, 2nd Edition, Oxford & IBH Publishing Co, 1970.

MA209 THEORY OF COMPLEX VARIABLES (3-0-0) 3

Functions of complex variables. Cauchy Riemann equations. Properties of analytic functions. Conformal mapping. Line integrals in complex plane. Cauchy's theorems. Power series. Residues. Evaluation of standard real integrals using contour integration.

J.B. Conway, Functions of one complex variable, 2nd edition, Springer-Verlag, New York, 1978.
L. V. Ahlfors, Complex analysis, 3rd edition, McGraw-Hill 1979.
E. Stein, R. Shakarchi. Complex Analysis, Princeton Univ. Press 2003.
D. G. Zill, P. D. Shanahan, A First Course in Complex Analysis with Applications, Jones and Bartlett, 2003.

MA210 EXTREMAL COMBINATORICS AND ALGEBRAIC GRAPH THEORY (3-0-0) 3

Basic techniques: Counting, Pigeon hole principle and resolution refutation lower bound, Matching and Hall theorem. The probabilistic method: Basic method, Lovaz local lemma and it's constructive proof, Linearity of expectation, The deletion method, The entropy functions Random walks and randomised algorithm for CNF formulae.

Spectral graph theory: Basic properties of graph spectrum, Cheeger 's inequality and approximation of graph extension, Expander graphs and applications to super concentrators and pseudo randomness, Error correcting codes and expander codes, Small set expansion, Unique games conjecture and hardness of approximation.

Additive Combinatorics: Sum product theorem, Szemeredi-Trotter theorem, Kakeya set problem and applications to randomness extractors.

S. Jukna, Extremal Combinatorics: With Applications in Computer Science, 2nd Edition, Springer.
N. Alon, J. H. Spencer, The probabilistic Method, 4th Edition, Wiley.

MA211 LAPLACE AND Z TRANSFORMS (1–0–0) 1

Laplace Transforms: Solutions of boundary value problem using Laplace transforms, Applications of Laplace Transforms to the solutions of ordinary differential equations. Z-transforms, Solution of difference equations using z-transforms.

I.N. Sneddon; Integral Transforms, Tata McGraw-Hill, 1974.
P.P. Gupta; Integral Transforms, 2nd Edition, Meerut Publishers, 1989.

MA221 DATA STRUCTURES (3-0-0) 3

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 applications, skip lists. Nonlinear data structures: trees, storage representation of binary trees, operations on binary trees: tree traversals, insertion, deletion, searching, trees, applications of trees. Graphs: representation of graphs, breadth first search and depth first search, shortest path problem, minimum cost spanning trees, applications of graphs. Sorting, Searching, 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 Algorithms, Pearson Education, 2003.
J.P. Tremblay and P.G. Sorenson, An Introduction to Data Structures with Application, Tata McGraw-Hill, 1991.

MA222 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 LU and QR factorizations,

positive definite systems, banded systems, symmetric indefinite systems, block systems, vandermonde systems and the FFT, Toeplitz and related systems.

Gene H. Golub and Charles F. Van Loan, Matrix Computations, 3rd Edition, Hindustan book agency, 2007.
A.R. Gourlay and G.A. Watson, Computational methods for matrix eigen problems, 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 Matlab, Prentice-Hall, Upper Saddle River, N.J, 1997.

MA223 COMPUTER ORGANIZATION AND ARCHITECTURE (3-0-0) 3

Introduction to Computers, Register Transfer and Micro-operations, Computer Arithmetic, Programming the Basic Computer, Organization of a Computer, Input-Output Organization, Memory Organization, Parallel Processing and Vector Processing, Multiprocessors.

John. P. Hayes, Computer System Architecture.
Hwang K., Briggs, Computer Architecture and parallel Processing, 1984.
M.Morris Mano, Computer System Architecture, 3rd Edition, 1993.

MA224 DS LAB (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.

MA225 COA LAB (0-0-3) 2

Implementation of Combinational and sequential Boolean circuits using hardware and software.

MA226 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, 6th Edition, John Wiley, 2008.
Mourice J. Bach, The Design of the Unix Operating System, PHI, 2002.

MA227 DATABASE 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.

RamezElmasri, Shamkant B Navathe, Fundamentals of database system, Addison Wesley, McGraw-Hill, 2000.
Silberschatz, Korth and Sudarshan, Database System Concepts, 6th Edition, McGraw Hill, 2011.
Ramakrishnan, R., Gehrke, Database Management Systems, 3rd Edition, McGraw Hill.

MA228 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.

MA229 DATABASE 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.

MA301 ADVANCED GRAPH THEORY (3-0-0) 3 (PREREQ: *Exposure to* MA203)

Representations of Graphs, Trees, Enumeration, Spanning Trees, Planar and Dual Graphs, Detection of planarity, Geometric and Combinatorial Duals, Covering and Independence, Coloring, Structure of k-chromatic graphs, Perfect

graphs, properties.
D.B.West, Introduction to Graph Theory, PHI

MA302 DATA ANALYSIS, TIME SERIES ANALYSIS AND NON-PARAMETRIC METHODS (3-0-0) 3

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. Non – parametric methods, Wald – Wolfowitz test, sign test, Mann – Whitney U test, signed rank test, Kolmogorov – Smirnov tests, Kruskal – Wallis test.
W.W. Hines and D.C. Montgomery, Probability and Statistics in Engineering and Management Science, John Wiley.
J. Medhi, Statistical Methods, Wiley Eastern.

MA303 INTEGRAL TRANSFORMS AND APPLICATIONS (3-0-0) 3

Laplace Transforms: solutions of boundary value problems using Laplace transforms, Applications of Laplace Transforms to the solutions of partial differential equations.
Fourier Transforms: Fourier sine and cosine transforms, Applications of Fourier Transforms to the solutions of ordinary differential equations and partial differential equations.
Hankel and Mellin and z–Transforms: solution of difference equations using z–transforms.
I.N. Sneddon, Integral Transforms, Tata McGraw-Hill, 1974.
P.P. Gupta, Integral Transforms, 2nd Edition, Meerut Publishers, 1989.

MA304 LINEAR PROGRAMMING AND APPLICATIONS (3–0–0) 3 (PREREQ: *Exposure to* MA204)

Linear programming theory of simplex method, Duality, Dual sensitivity analysis. Integer linear programming, Transportation problem, assignment problem, solution by the Hungarian method, transshipment model. Game theory – 2 persons zero sum game. *References:*
G. Hadley, Linear Programming, Narosa Publish, 1987.
H. A. Taha, Operations Research, Fifth edition, Mc Millan Publishing company, 1992.
K. Swarup, Gupta and Manmohan, Operations Research, Sultan Chand Publications, 1995,.

MA305 NETWORK OPTIMIZATION (3–0–0) 3 (PREREQ: *Exposure to* MA203)

Network Models, Minimal Spanning Tree, Shortest Route Problem (viewed as transshipment model), Matching and Covering Problems. Max-Flow Min-Cut Theorem, Capacitated Network Model and Network Simplex Method. PERT and CPM, Resource analysis in Network Scheduling: LP formulation, Precedence Planning Updating, Resource Allocation and Scheduling.
C.H. Papadimitriou and K. Steiglitz, Combinatorial Optimization: Algorithms & Complexity, PHI H. Taha, Operations Research, McMillan

MA306 OPERATIONS RESEARCH (3–0–0) 3 (PREREQ: *Exposure to* MA204)

Introduction, Linear Programming, Duality Theory, Transportation and Assignment problem., Integer Programming: Branch and bound method for IPP, Dynamic Programming: Introduction to Non- linear programming.
G. Hadley, Linear Programming, Narosa Publishers, 1987.
H. A. Taha, Operations Research, Fifth Edition Mc. Millan publishing company, 1992.
F. Hiller and G.J. Leibermann, Operations Research, Holden Day Inc., 1974.

MA307 OPTIMIZATION TECHNIQUES AND STATISTICAL METHODS (3-0-0) 3
(PREREQ: *Exposure to* MA208)

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.
H.A. Taha, Operations Research, Prentice Hall India.
J. Medhi, Statistical Methods, Wiley Eastern.

MA308 STATISTICAL ANALYSIS AND APPLICATIONS (3–0–0) 3
(PREREQ: *Exposure to* MA208)

Sampling theory: random samples, statistic, sampling distribution, x t and F distributions, central limit theorem, statistical inference, point estimation, unbiasedness, MLEs, interval estimation of mean and variances, hypothesis testing, types of errors, one – sided, two – sided tests, tests concerning means and variances, goodness of fit tests, data analysis: correlation and regression of data, simple linear regression.
P. L. Meyer, Introductory Probability and Statistical Applications, Oxford & IBH Publishing Co.

S. M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, John Wiley.

MA321 FUNDAMENTALS OF DATA SCIENCE (3-0-0) 3

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.

Avrim Blum, John Hopcroft, and Ravindran Kannan, Foundations of Data Science, 2018.

MA322 DESIGN AND ANALYSIS OF ALGORITHMS (3-0-0) 3

Models of computation, Algorithm analysis, Time and space complexity, Average and worst case analysis, Lower bounds. Algorithm design techniques: Divide and conquer, Greedy, Dynamic programming, Amortization, Randomization. Problem classes: P, NP, PSPACE; Reducibility, NP-hard and NP-complete problems, Approximation algorithms for some NP-hard problems.

Cormen, Leiserson, Rivest, and Stein, Introduction to Algorithms, MIT Press, 3rd Edition, 2009.
Dasgupta, Papadimitrou and Vazirani, Algorithms, McGraw-Hill Education, 2006.
Horowitz, Sahni, and Rajasekaran, Computer Algorithms, Silicon Press, 2007.
Kleinberg and Tardos, Algorithm Design, Pearson, 2005.
Goodrich and Tamassia, Algorithm Design, Wiley, 2001.

MA323 STATISTICAL METHODS LAB (0-0-3) 2

Introduction to R, Exploratory data analysis: methods of visualization and summary statistics, Sampling from standard discrete and continuous distributions (Bernoulli, Geometric, Poisson, Gaussian, Gamma), Generic methods for sampling from univariate distributions, The use of R to illustrate probabilistic notions such as conditioning, convolutions and the law of large numbers, Examples of modelling real data (but without formal statistical inference) and the use of visualizations to assess fit.

MA324 DAA LAB (0-0-3) 2

Design and Implementation of problem solving techniques like divide and conquer, dynamic programming, greedy and graph algorithms.

MA325 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, 2nd Edition, PHI publication, 2010.
Tom Mitchell, Machine Learning, McGraw Hill, 1997.
Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.

MA326 THEORY OF FINITE AUTOMATA, FORMAL LANGUAGES AND COMPUTATION (3-0-0) 3

Grammars, Production systems, Chomskian Hierarchy, Right linear grammar and Finite state automata, Context free grammars, Normal forms, uvwxy theorem, Parikh mapping, Self-embedding property, Subfamilies of CFL, Derivation trees and ambiguity.

Finite state Automata, Non deterministic and deterministic FSA, NFSA with ε- moves, Regular Expressions, Equivalence of regular expression and FSA.

Pumping lemma, closure properties and decidability, Myhill – Nerode theorem and minimization, Finite automata with output.

Pushdown automata, Acceptance by empty store and final state, Equivalence between pushdown automata and context-free grammars, Closure properties of CFL, Deterministic pushdown automata.

Turing Machines, Techniques for Turing machine construction, Generalized and restricted versions equivalent to the basic model, Godel numbering, Universal Turing Machine, Recursively enumerable sets and recursive sets, Computable functions, time space complexity measures, context sensitive languages and linear bound automata.

Decidability, Post's correspondence problem, Rice's theorem, decidability of membership, emptiness and equivalence problems of languages. Time and tape complexity measures of Turing machines, Random access machines, the classes P and NP, NP-Completeness, satisfiability and Cook's theorem, Polynomial reduction and some NP-complete problems.

John E. Hopcroft, Rajeev Motwani, Jeffrey D. Ullman, Introduction to Automata Theory, languages and Computation, 3rd Edition, Pearson, 2008.
Peter linz, Introduction to formal languages and automata, Narosa publishing, 2006.
Michael Sipser, Introduction to the Theory of Computation, Thomson learning, 2001.

MA327 SCIENTIFIC COMPUTING LAB (0-0-3) 2

Implement a mini project using the concepts studied in preceeding semesters.

MA401 COMPUTATIONL FLUID DYNAMICS (3–0–0) 3 (PREREQ: *Exposure to* MA207)

CFD applications in Engineering, Overview of CFD, Governing equations of fluid dynamics, Introduction to finite differences, Explicit and implicit approaches, Advances in CFD, Upwind schemes, High – resolution schemes. *Hanif Chaudhry, Open – channel Flow.*
J.D. Anderson, *Computational Fluid Dynamics.*

MA402 FINITE ELEMENT METHODS (3–0–0) 3 (PREREQ: *Exposure to* MA207)

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.
M.K. Jain, Numerical Solution of Differential Equations, PHI Ltd.
A.R. Mitchell and R. Wait, Finite Element methods in partial Differential Equations, Edn. John Wiley, 1977.

MA403 MATHEMATICAL MODELING (3–0–0) 3 (PREREQ: *Exposure to* MA110 & MA111)

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.
J. N. Kapoor Mathematical Modeling, 1988, Wiley Eastern.
R. Aris, Mathematical Modeling Techniques 1978, Pitman.

MA404 NON – LINEAR OPTIMIZATION (3–0–0) 3 (PREREQ: *Exposure to* MA304)

Classical optimization techniques: Unconstrained optimization –constrained optimization, Quadratic Programming, Construction of Kuhn- Tucker conditions, Wolfe' s method and Beale's method; separable programming, Geometric Programming: unconstrained and constrained geometric programming problems Dynamic Programming: Deterministic dynamic programming, probabilistic dynamic programming.
H. A.Taha, Operations Research, fifth edition, 1992, Mc Millan.
F. S. Hillier, Gerald J. Libermann, Operations Research, 1974, Holden Day Inc.
K. Swarup, Gupta and Manmohan, Operations Research, 1995, Sultan Chand Publications.

MA405 RELIABILITY THEORY AND APPLICATIONS (3-0-0) 3 (PREREQ: *Exposure to* MA208)

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.
E.E. Lewis, Introduction to Reliability Engineering, John Wiley.
K S. Trivedi, Probability and Statistics with Reliability, Queuing and Computer Science Applications, PHI.

MA406 STATISTICAL DESIGN AND ANALYSIS OF EXPERIMENTS (3-0-0) 3

Sampling theory: random samples, statistics, sampling distributions, central limit theorem, statistical inference: point estimation, unbiasedness, interval estimation of mean and variance, hypothesis testing, types of errors, one – sided, two – sided tests, tests concerning means and variances, goodness of fit tests, Analysis of variance of one – way, two – way classified data, experimental designs: CRD, RBD, LSD, factorial experiments.
D.C. Montgomery, Design and Analysis of Experiments, 9th Edition, John Wiley, 2017.
R.V. Hogg and A.T. Craig, Introduction to Mathematical Statistics, 5th Edition, McMillan, 1995.

MA407 STASTICAL QUALITY CONTROL (3-0-0) 3(PREREQ: *Exposure to* MA208)

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.
E.L. Grant, Statistical Quality Control, Mc Graw Hill.
D C Montgomery, Introduction to Statistical Quality Control, John Wiley.

MA408 STOCHASTIC ANALYSIS AND APPLICATIONS (3-0-0) 3 (PREREQ: Exposure to MA208)

Stochastic processes, basic concepts, classifications, Markov chains, C– K equations, ergodic chains, steady state behaviour, Poisson process, derivations, birth and death process. Queuing systems, basic concepts, M|M|1 and M|M|s queues, Reliability, definitions, concept of hazard, bath- tub curve, system reliability for various configurations.

J. Medhi, Stochastic Processes, New Age International Publishers.

K S. Trivedi, Probability and Statistics with Reliability, Queuing and Computer Science Applications, PHI.

MA 409 ADVANCED LINEAR ALGEBRA (3-0-0) 3 (PREREQ : MA204 / EC224 / EC388 / EE243)

Vector spaces, subspaces, quotient spaces, basis, change of basis, linear functional, dual space, projection, eigenvalues and eigenvectors, Cayley-Hamilton theorem, elementary canonical forms, annihilating polynomials, invariant subspaces, simultaneous diagonalization, direct sum decomposition, invariant direct sum, the primary decomposition theorem, Jordan form, inner product spaces, orthonormal basis, Gram-Schmidt process; adjoint operators, normal and unitary operators, self adjoint operators, spectral theorem for self adjoint operators.

Linear systems; Gaussian elimination, iterative methods - Gauss-Jordan, Gauss-Seidel and successive over relaxation method; LU decomposition, positive definite system, Cholesky decomposition, condition numbers; orthogonal matrices, Householder transformation, Givens rotations, QR factorization, stability of QR factorization, singular value decomposition, sensitivity analysis of singular values and singular vectors, least square problems.

K. Hoffman and R. Kunze, Linear Algebra, 2nd edition, Pearson Education, New Delhi, 2006.

C.D. Meyer, Matrix Analysis and Applied Linear Algebra, SIAM, 2001.

L.N Trefethen and David Bau, Numerical Linear Algebra, SIAM , 1997.

S. Axler, Linear Algebra Done Right, Springer, 1997.

MA421 FINANCIAL MATHEMATICS (3-0-0) 3

Basics of financial markets, market efficiency, stock market anomalies, risk-return tradeoff, Markowitz portfolio model, Sharpe ratio, Treanor ratio; Asset pricing models: Capital Asset Pricing Model (CAPM), Arbitrage pricing theory (APT), single and multifactor models (Fama-French multifactor models, Carhart four-factor models, liquidity augmented models etc.), portfolio optimization.

Basics of financial derivatives, mark to market, margin trading, hedging, arbitraging, types of derivative instruments (futures, options), option pricing theory: single and multiperiod binomial pricing models, Cox-Ross-Rubinstein (CRR) model, Black-Scholes formula for option pricing as a limit of CRR model, Greeks, derivative strategy, term structure of interest rates and interest rate derivatives.

Goodman and Stampfli, The Mathematics of Finance: Modeling and Hedging, Brooks/Cole, 2001.

S. E. Shreve, Stochastic Calculus for Finance I and II, Springer Verlag, 2005.

Ales Cerny, Mathematical Techniques in Finance: Tools for incomplete Market, Princeton University Press, 2009.

MA500 CORNERSTONE/CAPSTONE PROJECT 4

For details refer to clause 3.2 under Regulations specific to Undergraduate Programmes.

MA506 QUADRATIC FORMS AND LINEAR ALGEBRA (3-0-0) 3

Review of basics, Singular Value Decomposition, Generalized Inverses, Triangular and Jordan Canonical forms of matrices, Matrix exponential, Inner Product Spaces, Bilinear and Quadratic Forms, Definite and Indefinite Forms, Sylvester's law of inertia, QR Factorization, Best approximation, method of least squares, Maximum principles, finding the largest Eigen value, Rayleigh quotient.

G. Strang, Linear Algebra and its applications, Thomson Learning, 2003.

Peter D Lax, Linear Algebra, Wiley, 2004.

S. Lipschutz & M Lipson, Linear Algebra, Schaum's Outline series, 2005.

MA507 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.

R.C. Gonzalez, R.E. Woods, Digital image processing using MATLAB, Prentice Hall, 2nd Edition, 2003.

Henri Maitre, Image Processing, 1st Edition, Wiley, 2008.

T.F. Chan, J.H. Shen, Image processing and analysis, SIAM, 1st 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.

MA508 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.

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.

MA509 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.

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, 2nd Edition, 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.
Lex Schrijver, Combinatorial Optimization: Polyhedra and Efficiency, 3-Volume book, Springer-Verlag, 2003.

MA512 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.

R. L. Burden and J. D. Faires, Numerical Analysis, 9th Edition, Brooks/Cole, 2011.
Jain M. K., Numerical Solution of Differential Equations, 2nd Edition, Wiley Eastern, 1984.
Smith G.D., Numerical Solution of Partial Differential Equations, 3rd Edition, Clarendan Press, 2004.
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.

MA513 MODERN 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.

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.

MA514 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.

MA515 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.
Jiawei Han, Micheline Kamber, Data Mining - Concepts and Techniques, 3rd Edition, Morgan Kaufmann Publishers, Elsevier, 2012.
Pang-Ning Tam, Michael Seinbach, Anuj Karpatne and Vipin Kumar, Introduction to Data Mining, 2nd Edition, Pearson.
G. James, D. Witten, T. Hastie and R. Tibshirani, An Introduction to Statistical Learning - with applications in R, Springer, 2017.
T. Hastie, R. Tibshirani and J. Friedman, The Elements of Statistical Learning – Data Mining, Inference and Prediction, 2nd Edition, Springer, 2009.

MA516 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.
Roger S. Pressman, Software Engineering – A practitioner's Approach, 7th Edition, MacGraw-Hill, 2010.
Ian Sommer ville, Software Engineering, 9th Edition, Addison-Wesley.
Rajib Mall, Fundamentals of Software Engineering, 3rd Edition, Prentice-Hall India (PHI) Learning Pvt Ltd.

MA517 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.
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, 2nd Edition, John Wiley, 1984.
R. Graham, D. Knuth, and O. Patashnik, Concrete Mathematics, Addison-Wesley, 1994.
R. Stanley, Enumerative Combinatorics, Volumes I and II, Cambridge University Press, 2001.

MA518 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.
Douglas B. West, Introduction to Graph Theory, 2nd Edition, PHI Learning Pvt. Ltd., 2002.
Haynes, T.W., Hedetniemi, S.T. and Slater, P.J., Fundamentals of Domination in graphs, Marcel Dekker, Inc., New York, 1998.
Gary Chartrand and Ping Zhang, Chromatic Graph Theory, CRC Press, 2009.
Tommy R. Jensen and Bjarne Toft, Graph Coloring problems, John Wiley & sons, 1995.
Michael Stiebitz, Diego Scheide, Bjarne Toft and Lene M. Favrholdt, Graph Edge Coloring, Wiley, 2012.
Béla Bollobás, Random Graphs, 2nd Edition, Cambridge University Press, 2001.
Haynes, T.W., Hedetniemi, S.T. and Slater, P.J., Domination in graphs – Advanced Topics, Marcel Dekker, Inc., New York, 1998.

MA519 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.

G. Gordon, System Simulation, 2nd Edition, PHI, 1989.
A. M. Law and W. D. Kelton, simulation, modeling and analysis, McGraw Hill.
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.

MA520 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 theorem. Linear programming and combinatorial optimization: LPP formulation, simplex method, NP-completeness and Approximation, Polynomial time reduction.

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, 3rd Edition, PHI, 2009.
Jon Kleinberg Eva Tardos, Algorithm Design, Pearson, 2006.

MA521 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 and connectivity, mobile IP and cellular IP in mobile computing, case study of CODA. Wireless LANs: Introduction to IEEE 802.11, Bluetooth and IrDA technologies and standards. Mobile Adhoc Networks: 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.

Hansman, U. and Merck, L., Principles of Mobile Computing, 2nd Edition, Springer.
Jochen Schiller, Mobile Communications, 2nd 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 Java Mobile Agents with Aglets, Addison Wesley, 1998.

MA523 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.

Jim Kurose and Keith Ross, Computer Networking- Top Down approach, 5th Edition, Pearson Education, 2010.
Larry L. Peterson, Bruce S. Davie, Computer Networks: A Systems Approach, 5th Edition, Morgan Kaufmann, 2011.
Behrouz A. Forouzan, Data Communications & Networking, 4th Edition, Tata McGraw-Hill Education, 2006.
Douglas E.Comer, The Internet Book, 4th Edition, Prentice Hall, 2007.

MA525 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.

Song Y. Yan, Number Theory for Computing, 2nd Edition. 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.

MA526 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.

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.

MA527 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

Douglas Stinson, Cryptography Theory and Practice, 2nd Edition, Chapman & Hall/CRC, 2002.
B. A. Forouzan, Cryptography & Network Security, Tata Mc Graw Hill.
W. Stallings, Cryptography and Network Security, 4th Edition, Pearson Education, 2006.

MA528 INTRODUCTION TO PARALLEL PROGRAMMING (3-0-0) 3

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.

David Culler, Jaswant Singh, Parallel Computing Architecture. A Hardware/Software Approach, Morgan Kauffman. ISBN: 981-4033-103, 1999.
Michael J. Quinn, Parallel Computing. Theory and Practice, Tata: McGraw-Hill. ISBN: 0-07-049546-7, 2002.
Bryant and O'Hallaron, Computer Systems – A Programmer's Perspective, Pearson Education. ISBN: 81-297-0026-3, 2003.
Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar, Introduction to Parallel Computing, Addison Wesley. ISBN: 0-201-64865-2, 2003.
Peter S Pacheco, An introduction to Parallel Programming, Morgan Kauffman. ISBN: 978-93-80931-75-3, 2011.
Online references for Open MP, MPI, CUDA.

MA529 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.

Avrim Blum, John Hopcroft, and Ravindran Kannan, Foundations of Data Science, 2018.

MA531 STATISTICAL QUALITY CONTROL (3-0-0) 3

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.

E.L. Grant, Statistical Quality Control, Mc Graw Hill.
D C Montgomery, Introduction to Statistical Quality Control, 4th Edition, John Wiley, 2004.

MA532 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, Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses, Wiley CIO, 2013.

David Loshin, Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph, Morgan Kaufmann, 2013.

Mike Barlow, Real-Time Big Data Analytics: Emerging Architecture, [Kindle Ed.], O'Reilly Media, 2012.

MA533 WAVELETS IN DATA SCIENCE (3-0-0) 3

Introduction: Time - Frequency representation, Fourier and Wavelet bases, what is wavelet and how it is used in Data Science. Theory: From Fourier Transform to Wavelet Transform, How does the Wavelet Transform work?, The different types of Wavelet families, Continuous Wavelet Transform vs Discrete Wavelet Transform, More on Discrete Wavelet Transform: The DWT as a filter-bank. Practical Applications: Visualizing the State-Space using the Continuous Wavelet Transform, Using the Continuous Wavelet Transform and a Convolutional Neural Network to classify signals, Deconstructing a signal using the DWT, Removing (high-frequency) noise using the DWT, Using the Discrete Wavelet Transform to classify signals, Comparison of the classification accuracies between DWT, Fourier Transform and Recurrent Neural Networks. Linear Approximation: Linear Approximation Error, Linear Fourier Approximation, Karhunen - Loeve Approximation

George Bachmann, Lawrence Narici, Edward Beckenstein, Fourier and wavelet analysis, Springer, 2000.

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.

R. Todd Ogden, Essential wavelets for Statistical Applications And Data Analysis, Springer Science, 1997.

Pedro A. Morettin, Aluísio Pinheiro, Brani Vidakovic, Wavelets in Functional Data Sciences, Springer, 2017.

MA534 CLOUD COMPUTING (3-0-0) 3

Introduction: Definition and evolution of Cloud Computing, Enabling Technologies, Service and Deployment Models Popular Cloud Stacks and Use Case Benefits, Risks and Challenges of Cloud Computing, Economic Models and SLAs Topics in Cloud Security; Cloud Infrastructure: 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 (Power Graph)

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.

MA535 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.

Shivarathi & Shingal, Advanced Operating Systems, 1994.

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, 2nd Edition, Cambridge, 2004.

MA536 ADVANCED DATABASE SYSTEMS (3-0-0) 3

Basic concepts, Architecture for data sharing, Federated DBMS, Distributed databases, Client/server architecture, Multimedia databases, Object oriented databases, 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.

MA537 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.

H. A.Taha, Operations Research - An Introduction, 8th Edition, PHI, 2007.

F. S. Hillier and G.J. Lieberman, Introduction to Operations Research, Concepts and Cases, 8th Edition, TMH, 2010.

S. S. Rao, Engineering Optimization: Theory and practice, New Age International publishers.

MA538 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.

MA539 MULTIVARIATE STATISTICAL ANALYSIS (3-0-0) 3

PREREQ: MA208 & MA406

Review of multivariate normal distribution and its properties, distributions of linear and quadratic forms, tests for partial and multiple correlation coefficients and regression coefficients and their associated confidence regions. Wishart distribution. Inference on covariance matrices. Discriminant analysis. Principal component analysis, factor analysis and clustering. Dimension reduction techniques: Principal component and generalized canonical variable analysis - constructions and related inference problems.

T. W. Anderson (1984), An Introduction to Multivariate Statistical Analysis. 2nd Ed. John Wiley.

R. A. Johnson and D. W. Wichern (2013), Applied Multivariate Statistical Analysis. 6th Ed. Pearson.

C. R. Rao (2002), Linear Statistical Inference and its Applications. 2nd Ed. Wiley.

M. S. Srivastava and C. G. Khatri (1979), An Introduction to Multivariate Statistics, Elsevier North Holland, Inc., New York.

UC100 INTRODUCTION TO DESIGN THINKING (2-0-0) 2

Need and Definition of Design Thinking. Framework for Design Thinking. Engineering Design Process. Need Identification, Specification, Concept Generation, Product Architecture and Detailed Design. Prototyping – Virtual and Physical. Testing Methodology

Christian Muller-Roterberg, "Handbook of Design Thinking", 2018

Eli Woolery, "Design Thinking Handbook" Invision Pub, 2019

Nigel Cross, "Design Thinking"

Max Answell "Mastering Design Thinking", 2019

Karl T. Ulrich, Steven D. Eppinger and Maria C Yang, "Product Design and Development", McGraw Hill, 7ed, 2020

George e Dieter, Linda C Schmidt, "Engineering Design", Mc Graw Hill, 4ed, 2009

UC401 LIBERAL ARTS COURSES/CO-CURRICULAR/EXTRACURRICULAR ACTIVITIES 10

CATEGORY A : Maximum 3 credits, CATEGORY B : Maximum 3 credits, CATEGORY C : Minimum 4 Credits and Maximum 7 credits.

10 Credits have to be earned from 1st Semester to 7th Semester by choosing Category (A + B + C) OR Category (A + C) or Category (B + C) courses combination . Registration for 10 Credits has to be done in 7th Semester.

For details of CATEGORY A, CATEGORY B and CATEGORY C refer to clause 3.2 (f) under Regulations specific to Undergraduate Programmes.

<u>Courses for B Tech Minor in Mathematics</u>

MA501M Real Analysis (3-0-0) 3

MA502M Algebra (3-0-0) 3
MA503M Complex Analysis (3-0-0) 3
MA504M Partial Differential Equations (3-0-0) 3
MA505M Topology (3-0-0) 3 PREREQ: MA501

MA501M REAL ANALYSIS (3-0-0) 3

Review of basic concepts of real numbers: Archimedean property, Completeness. Metric spaces, compactness, connectedness. Continuity and uniform continuity. Monotonic functions, Functions of bounded variation; Absolutely continuous functions. Derivatives of functions and Taylor's theorem. Riemann integral and its properties, Characterization of Riemann integrable functions. Improper integrals, Gamma functions. Sequences and series of functions, Uniform convergence and its relation to continuity, differentiation and integration. Fourier series, Pointwise convergence, Fejer's theorem, Weierstrass approximation theorem.

T. Apostol, Mathematical analysis, 2nd Edition, Narosa, 2002.
W. Rudin, Principles of mathematical analysis, 3rd Edition, McGraw-Hill, 1983.
K. Ross, Elementary analysis: The theory of calculus, Springer Int. Edition, 2004.
G. F. Simmons, Topology and modern analysis, Kreiger, 2003.

MA502M ALGEBRA (3-0-0) 3

Group Theory: Definitions, Group Actions, Kernel and Stabilizer of Group actions, Transitive group action, Cayley's theorem, The Class equation, Sylow's theorems, Direct products, Structure theorem for Finite Abelian Groups, Existence and universal Properties of free Groups, Examples of Groups specified by Generators and Relations.

Ring Theory: Definitions, Properties of Ideals, Prime and Maximal Ideals, Two-sided ideals and Quotient Rings, Chinese Reminder Theorem, Euclidean Domain, Euclidean Algorithm, Principal Ideal Domain, Euclidean Domain is a Principal Ideal Domain, UFD, PID implies UFD, Universal Property of a Polynomial Ring, Criteria for Irreducibility. Definition and simple examples of modules over commutative and non-commutative rings.

Field Theory: Finite and Algebraic Extensions, Existence and Cardinality of Algebraic Closure, Finite Fields, Galois Theory of Polynomial in characteristic zero and simple examples.

M. Artin, Algebra, Prentice Hall inc 1994.
I.N. Herstein, Topics in Algebra, John-Wiley, 1995.
D. *S. Dummit and R. M. Foote, Abstract Algebra, 2nd Edition, John-Wiley, 1999. S. Lang, Algebra, 3rd Edition, Addison-Wesley, 1999.*

MA503M COMPLEX ANALYSIS (3-0-0) 3

Topology of the complex plane, Riemann sphere, limits, continuity and differentiability, Analytic functions, harmonic functions and multi-valued functions; Convergence of series of complex numbers, Radius of convergence of power series, and power series as an analytic function, Laurent series; Cauchy's integral theorem, Cauchy integral formula, Morera's theorem, Taylor's theorem, Laurent's theorem, Liouville's theorem, Schwarz lemma; Maximum Modulus Principle, Argument Principle, Rouche's theorem; Conformal mappings, linear fractional transformations, Classification of singularities, Cauchy's residue theory and evaluation of real integrals.

L. Ahlfors, Complex analysis, 2nd ed., McGraw-Hill, New York, 1966.
J.W. Brown and R.V. Churchil, Complex variables and applications, McGraw Hill, 2008.
T.W. Gamelin, Complex analysis, Springer-Verlag, 2001.
J.B. Conway, Functions of one complex variables, 2nd edition, Springer, 1978. S. Ponnusamy: Foundations of complex analysis, Second Edition, Narosa, 2005

MA504M PARTIAL DIFFERENTIAL EQUATIONS (3-0-0) 3

Origins of first order partial differential equations, Cauchy problem, Linear equations of first order, Integral surfaces passing through a given curve, Surfaces orthogonal to a given system of surfaces, Nonlinear equations of first order, Cauchy's method of characteristics, Compatible systems, Charpit's method, Jacobi's method, Linear second order partial differential equations with constant and also with variable coefficients, Characteristic curves of second order equations, Separation of variables, Greens functions for Laplace equation, wave equation and heat equation,

Properties of Laplace equation, wave equation and heat equation.

I. N. Sneddon, Elements of Partial Differential Equations, Dover Pub Inc., 2006.
F. John, Partial Differential Equations, Springer Int Edn, 2009.
G. B. Folland, Introduction to Partial Differential Equations, Princeton Uty Press, 1995.

MA505M TOPOLOGY (3-0-0) 3 PREREQ: MA501M

Topological Spaces, Basis for a topology, Subspace topology, Closed sets and Limit points, Nets and convengence, Continuous Functions and homeomorphisms, Product Topology, Quotient Topology; Connected spaces, Components

and Local Connectedness, Path connectedness, Compact spaces, Local compactness, Compactifications; The Countability and Separation axioms, The Urysohn Lemma, The Urysohn Metrization Theorem, The Tietze Extension Theorem, Tychonoff Theorem.

J.R. Munkres, Topology, 2nd Ed., Pearson Education India, 2001.
K.D. Joshi, Introduction to General Topology, New Age International, 2000.
G. F. Simmons, Introduction to topology and modern analysis, Kreiger, 2003.
M. A. Armstrong, Basic Topology, Springer (India), 2004.

Department of Mechanical Engineering

ME110 ELEMENTS OF MECHANICAL ENGINEERING (2-0-0) 2

Introduction to Mechanical Engineering, Emerging trends & its role, Mechanics in Mechanical Engineering; Materials and Stresses: Mechanical design concept, Types of drives, Friction and wear; Prime movers, Introduction to refrigeration, centrifugal pumps and compressors. Sources of energies: conventional and renewable; Manufacturing Processes: Basic processes like machining, casting, forging etc. welding, brazing and soldering. Manufacturing Systems; Introduction to Mechatronics, electro-mechanical elements, working principles, construction and their applications (Sensors & actuators)

J.wickert, An introduction to Mechanical Engineering, Cengage learning, 2nd edn.
2006 Gopalkrishna K.R., Mechanical Engineering Sciences. Subhas Publications,
Bangalore 1999
K P Roy, S K Hazra Choudhury and Nirjhar Roy, Elements of Mechanical Engineering, Media Promoters and Publishers Pvt Ltd, Mumbai, 2012.
Gupta, P.N., and Poona, M.P., Elements of Mechanical Engineering. 4th Edition, Standard Publications Ltd, 2009

ME111 ENGINEERING GRAPHICS (1-0-3) 3

Orthographic Projections of points, Straight lines, Planes, Solids (Auxiliary Plane Method and Change of position method), Isometric Projections.

Gopalkrishna K. R, Engineering Graphics (I^{st} angle projection), Subhas Publication, Bangalore, 1999.
Bhat N. D., Engineering Drawing, Charotar Publication,1991.

ME112 MATERIALS SCIENCE AND ENGINEERING (3-0-0) 3

Introduction and classification of Materials. Atomic bonding and interatomic forces, Crystal structures, Crystallographic Points, Directions and Planes, Imperfections in Solids, Diffusion, Mechanical Properties of Metals, Failure – Fracture, Fatigue and Creep, Phase Diagrams, The Iron- Carbon System, Solidification, Types of Metal Alloys, Ceramic Structures, Processing and Applications, Polymers – Types and Mechanical Behavior, Composite Materials, Biomaterials, Electronic Materials, Properties of Materials – Electrical, Thermal, Magnetic and Optical.

Callister W.D., Material Science and Engineering, John Wiley & Sons, Inc., 2010
D. R. Askeland, P. P. Fulay W. Wright and K. Balani, The Science and Engineering of Materials, Cengage Learning, India, 2010.
Smith and Hashemi, " Foundations of Materials Science and Engineering", Mcgraw Hill,2009.
Douglass, "Introduction to Materials Science and Engineering: A Guided Inquiry", Pearson 2013.
Raghavan, "Materials Science and Engineering: A First Course", PHI, 6^{th} edition,2015.

ME113 MECHANICS OF DEFORMABLE BODIES (3-0-0) 3

Tension, Compression, and Shear, Mechanical properties of materials, Elasticity, Plasticity and Creep, Hooke's Law. Allowable stresses. Axially loaded members, Statically indeterminate structures, Thermal effects, misfits, and Pre-strains. Torsion of circular bar, Transmission of power by circular shafts. Shear forces and bending moments, Relationships between loads, shear forces and bending moments. Stresses in beams, Pure bending and Nonuniform bending, Design of beams for bending stresses, Shear stresses in beams of rectangular cross section. Plane stress, Principal stresses, Mohr's circle and Hooke's law for plane stresses. Spherical and Cylindrical pressure vessels. Deflection of beams, Column buckling.

Egor P Popov, Mechanics of Materials, Pearson, 2015.
James M. Gere, Mechanics of Materials, Sixth Edition, Thomson Learning, 2004.
Ferdinand Beer, E. Russell Johnston Jr., John Dewolf , David Mazurek, Mechanics of Materials, McGraw Hill Education, 2014.
Russell C Hibbeler, Mechanics of Materials, Pearson, 2013.
William F. Riley, Leroy D. Sturges, Don H. Morris, Mechanics of Materials, John Wiley & Sons, 1998.

ME200 WORKSHOP (0-0-2) 1

Fitting, Carpentry, Demonstration of Welding & Soldering.

Hajara H.K. and Choudhary Workshop Practice vol.I, Media Promoters and Publishers, Bombay, 2007.
Workshop Technology, Choudhary and chapman, Viva publications,1996.

ME201 BASIC ENGINEERING THERMODYNAMICS (3-1-0) 4

Fundamental Concepts, system, temperature, Heat and Work, I law and II law of Thermodynamics, applications, Pure substance, Entropy, Available and unavailable energy , Analysis of cycles, Helmholtz and Gibbs Functions and its applications, Ideal and Real gases, Non reactive mixtures, properties of air and water vapour.

Spalding and Cole, Engineering Thermodynamics, ELBS Edition Longmans,1987.
Arora C.P. Thermodynamics, TMH, 1998.
Gordan J. Van Wylen and Richard E.Sountag, Fundamentals of Classical Thermodynamics, 4th Edition,Wiley, 1994.
P. K. Nag, Basic and Applied Thermodynamics, Tata McGraw Hill. 3rd Edition, 2005.
Yunus A Cengel and Michael A. Boles, Thermodynamics : An Engineering approach , Tata Mcgraw Hill,7th Edition

ME202 FLUID MECHANICS AND MACHINERY (3-1-0) 4

Fundamentals of fluid properties, pressure measurement, hydrostatic forces on surfaces, Buoyancy and floatation, Kinematics of fluid flow, Fluid dynamics, Compressible flow, gas nozzles, Flow of real fluids, Boundary layer theory, Flow around immersed bodies, Flow through pipes, Impact of jets, Hydraulic Machines, pumps, Turbines, Hydraulic systems.

Kumar K.L. Fluid Mechanics, Eurasis Publishing House, New Delhi, 1995.
Yahya S.M., Turbomachines, Satya Prakashan, New Delhi, 1972.
F .M. White, Fluid Mechanics, Springer-Verlag. New York. 1999.

ME203 MECHANICS OF MACHINERY (3-1-0) 4

Basics of Kinematics – Links, Kinematic pair, Kinematic diagram, Mobility, Basic mechanisms and its inversions. Position, Velocity and Acceleration analysis of Planar mechanisms, Inertia forces in machines, Kinematics of Gear, Kinematics of cam-follower mechanisms, Construction of disc-cam profile, Synthesis of Mechanisms: Type, number and dimensional synthesis.

R.L. Norton, Kinematics & Dynamics of Machinery, McGraw Hill
Education, 2017 H.H. Mabe and C.F. Rainbotten, Mechanism and Design,
John Wiley, 1987.
Arthur G. Erdman, George N, Sandor, Mechanism Design –Analysis and Synthesis, Vol. I, Prentice Hall, New
Jersey, 1996 David H Myzska, Machines and Mechanisms, Applied Kinematic Analysis, 4th Edition, Prentice Hall, 2012.
V Ramamurti, Mechanics of Machines, Narosa, 2010

ME204 BASIC MANUFACTURING PROCESSES (3-1-0) 4

Introduction to materials and manufacturing, Manufacturablity-Castablity-Weldability-formability-forgeability-Green Manufacturing, Metal Casting Processes - Introduction to sand moulding, patterns: design and layout, testing of moulding sand. Use of core, other casting processes: shell moulding, precision investment casting, permanent mould casting, Die casting processes and its types - centrifugal casting, Continuous casting, squeeze casting, slush casting, vacuum casting, gating & risering design, Solidification of metal and alloys, directional solidification, Melting practices, cast iron foundry, aluminium foundry, Mechanisation, casting cleaning, casting defects.

Introduction to Metal joining processes - Welding types, Brazing & Soldering, Introduction to metal forming, High Energy Rate forming

Amitabha Ghosh, Manufacturing Science, East-West Press, 2nd edition, 2010
Bhattacharya A, Metal Cutting: Theory and Practices, New Central Book
Agency,2012. Jain P. L., "Principles of Foundry Technology", TMH, 5nd
edition,2014.
Heine, R.W., Loper, C.R., and Rosenthal, P.C., "Principles of Metal Casting", TMH, 2nd edition,2001
Serope Kalpakjian and Steven R Schmid, Manufacturing Engineering and Technology, (Fourth Edition), Pearson Education, Asia,2000.

ME205 WORKSHOP PRACTICE (0-0-3) 2

Fitting, Carpentry, Study and demonstration of hand tools in sheet metal working and foundry, Sheet metal models, Foundry models, Press working equipment

Wood working: Wood working and wood turning tools and models. Use of Power tools, Welding & Plumbing.

Hajara and Choudhary, Workshop technology vol.I &II, Median promotors & publishers, Bombay.
Khanna O. P, Workshop Practice Vol. I, Dhanpat Rai & Co , 2000.

ME211 THERMODYNAMICS AND FLUID MECHANICS (3-0-0) 3

Laws of thermodynamics, Concept of entropy, Air standard efficiencies and MEP representation on P-V and T-S diagrams, Compressor. Reciprocating, Use of compressors in Mining equipment, Fluids: Definition and properties, Ideal and real fluids, Pressure and its measurement for liquids. Dynamics of fluid flow, Flow in pipes, Centrifugal and reciprocating pumps.

Nag, P.K., Engineering Thermodynamics, 5th Edition, Mcgraw Hill Education, 2013.
Kumar, K.L, Engineering fluid mechanics, 8th Edition, Eurasia Publishing House Pvt. Ltd, 2009.

Eastop and McConkey, Applied Engineering Thermodynamics, ELBS, 1995.

ME251 APPLIED THERMODYNAMICS (3-0-0) 3

Compressors, reciprocating and rotary, Steam nozzles and steam turbines, Air standard cycles, Vapour power cycles, Gas turbine cycles, performance testing of IC engines, Refrigeration cycles, vapour absorption system, Psychrometric processes. *Holman J. P., Thermodynamics, McGraw Hill International Student Edition. Newyork, 1969.*
Rajput R.K, Thermal Engineering, Laxmi Publications (Pvt) LTd., NewDelhi. 6th Edition , 2007.
Eastop and McConkey, Applied Engineering Thermodynamics, ELBS, 1995.

ME252 ANALYSIS AND DESIGN OF MACHINE COMPONENTS (3-1-0) 4

Introduction to Design, Engineering Materials, Simple Stresses, Compound Stresses in machine parts, Review of Failure theories Design for static loading, Stress Concentration, Design for dynamic loading, Cotter and Knuckle Joint, Design of shafts, keys and coupling, Variable and Impact loading, Design of springs, Spring nomenclature, Design of helical spring for static and fatigue loads, Collar and Pivot friction, Design of power screws, Design of coupling, lubrication, selection of journal & roller Bearings.
R.L. Norton – Machine Design, An integrated approach, Pearson Education Asia, 2000. J.E. Shigley and Mische, Mech. Engineering Design, Tata Mc Graw Hill -2003.
Jack A.Collins, Henry Busby, George Staab, Mechanical Design of Machine Elements and Machines, 2011.
Richard G Budynas; J Keith Nisbett, Shigley's Mechanical Engineering Design, McGraw Hill Education, 2017. Ansel C. Ugural, Mechanical Design of Machine Components, Second Edition, CRC Press, 2015

ME253 COMPUTER AIDED ENGINEERING (3-0-0) 3

Fundamental of CAD- Hardware and software requirements, methods of modeling- wire frame, surface, solid modeling and feature based modeling, Analytic and synthetic cure entities, Parametric representation of curves and surfaces, NURBS, Computer graphics: display, transformation, visualization, animation, graphics standards, translators. Product Design : Mass property calculations, assembly modeling, Finite element methods. Product Manufacturing: Part programming, CNC machine tool and control system.
Ibrahim Zeid, Mastering CAD/CAM, TMH publishing company ltd, New Delhi, 2007.
P. N. Rao, CAD/CAM Principles and Applications2nd Edition, TMH education, 2007.

ME254 MANUFACTURING TECHNOLOGY (3-0-0) 3

Mechanics of metal removal process, force analysis, friction, economics, Heat Generation in machining, Tool Temperature, Failure of Cutting Tool and Tool Wear , Cutting Tool Materials, Tool Life and Machinability, Cutting Fluids, Machine tools and operations-Turning, Milling, shaping, planing, broaching, drilling, boaring, Grinding and Micro-finishing, CNC & SPM, Principles of Non Traditional Machining, Sheet Metal Forming, Dies, Jigs and Fixtures. GD&T
Serope Kalpakjian and Steven R Schmid, Manufacturing Engineering and Technology, (Fourth Edition), Pearson Education, Asia.
P.N. Rao, Manufacturing technology--Foundry, Forming and Welding, Tata McGraw Hill Education, 2001.
Amitabh Ghosh and Amit Kumar Mallik, Manufacturing Science, Affiliated East West Press (p) Ltd, New Delhi, 2002.
H.F. Taylor, M.C. Flemmings and John Wulff, Foundry Engineering, Wiley Eastern Pvt. Ltd.
Campbell, Principles of Manufacturing Materials and Processes – TMH
Paul Degarmo, J.T. Black and RA.K Kosher, Materials and Process in Manufacturing, PHI.
P .K Mishra, Non-Conventional Machining, 6th Edition Narosa Publishing House, 1997.
A B Chattopadhyay, Machining and Machine Tools (Second Edition), Wiley India Publisher.
Ghosh and Mallick, Manufacturing Science, Prentice Hall PTR, 2001
Paul Degarmo, Materials and Processes in Manufacturing, 9th Edition, John Wiley & sons,

ME255 ENGINEERING DRAWING (1-0-3) 3

Screw Thread forms and Threaded fasteners, Riveted joints, Section of Solids, Development of Surfaces. Othographic views with sections, Intersection of Solids. Machine components done using conventional drawing board and AutoCAD, Assembly drawing from working drawing: Swivel bearing, Machine Swivel vice, Tool head of shaper, Tailstock, Fuel pump, Fuel Injector, Rams bottom safety valve, Stop valve, Blow- off cock, Screw Jack, Centrifugal pump. Part drawing from assembly drawing: Foot step bearing, Eccentric, connecting rod, square tool post, Drill jig, Feed check valve.
Gopalkrishna K. R., Engineering Graphics, Subhas Publications, Bangalore, 1999.
Gopalkrishna K. R, Machine Drawing, Subhas Publications, Bangalore, 1985.
Bhat N. D, Engineering Drawing, Charotar Publishing House, Anand, India, 1991.

Bhat N. D, Machine Drawing, Charotar Publishing House, Anand, India, 1984.

ME301 METROLOGY AND INSTRUMENTATION (4-0-0) 4

Linear, angle measurement, Quality control fundamentals, Standard deviation, normal curve pattern of variations, control charts for variables, Comparators, Limits, Fits and Tolerances, statistical aspect of tolerances and setting tolerances, Surface finish terminology and measurement, Optical measuring instruments, Measurement of screw thread and Gear elements. Instrumentation: Fundamentals of Measurement, Static performance characteristics. Dynamic performance, instrument types, transfer function representation, system response to standard input signals. Treatment of uncertainties: error classification, statistical analysis of data, propagation and expression of uncertainties; Measurement of various physical quantities: Linear and angular displacement, velocity, force, torque, strain, pressure, flow rate and temperature; Transfer functions of standard measuring devices; Data Acquisition and processing, Surface finish and roughness in details

E.O. Doebelin, Measurement systems- Applications and Design, 4th Ed., TataMcGraw-Hill, 1990.
T.G. Beckwith, R.D. Marangoni and J.H. Lienhard, Mechanical Measurements, 5th Ed., Addison Wesley, 1993.
I.C. Gupta, Engineering Metrology, Dhanpat Rai Publications, New Delhi, 1994.
R.K. Jain, Engineering Metrology, Khanna Publishers, New Delhi, 1997

ME302 HEAT TRANSFER (3-0-0) 3

Introduction - conduction, convection, radiation, heat conduction - Fourier law of heat conduction, general heat conduction equation, one dimensional steady state for plane wall, cylinder, sphere, steady state heat conduction with heat generation for plane wall, cylinder, sphere, critical radius thickness, Fin heat transfer, Transient heat conduction - Lumped analysis, one dimensional transient heat conduction - heisler chart, Convection heat transfer - Forced convection - external flow and internal flow, Boiling and condensation heat transfer, Heat exchangers, Radiation heat transfer (Non participating media), Introduction to mass transfer.

Frauk P Incropera, Fundamentals of Heat and Mass transfer, John Wiley and sons, Fifth Edition, 2002.
Nicati M. Ozisik, Heat Transfer a Basic Approach, McGraw Hill Publication,1985.
Holman J. P., Heat Transfer, McGraw Hill Publication, 8th Edition, 1996.
C. P. Arora, Engineering Heat Transfer, Khanna Publishers, India, 1996.

ME303 DESIGN OF MECHANICAL DRIVES (3-0-0) 3

Belt, rope and chain drives, Design of pulleys and sprockets, Design of spur and helical gears, Design of Bevel and worm gears, Design of Gear boxes, Cam design: undercutting, base circle determination, forces and surface stresses. Design of plate clutches, axial, cone, internal expanding rim clutches, Internal and external shoe brakes.

R.L. Norton – Machine Design, An integrated approach, Pearson Education Asia, 2000.
V B Bhandari, Design of Machine Elements, 4th Edition, McGraw Hill India, 2016.
J.E. Shigley and Mische, Mech. Engineering Design, Tata Mc Graw Hill -2003.
Jack A.Collins, Henry Busby, George Staab, Mechanical Design of Machine Elements and Machines, 2011.
Richard G Budynas; J Keith Nisbett, Shigley's Mechanical Engineering Design, McGraw Hill Education, 2017.
Ansel C. Ugural, Mechanical Design of Machine Components, Second Edition, CRC Press, 2015.

ME304 AUTOMOBILE ENGINEERING (3-0-0) 3

Introduction, Automotive Chassis Layout, Frame and body Construction, I.C. Engine Construction and Components. Engine Cooling and Lubrication System, Fuel Supply System for petrol and diesel Engine, Ignition System, Clutches, Transmission System, Drive Line System, Steering System, Suspension and Shock Absorber System, Braking System, Automotive Electrical System, Maintenance, Engine Testing, Servicing and Repair.

K.M. Gupta, Automobile Engineering, Umesh Publications. New Delhi, 2001.
Kirpal Singh, Automobile Engineering, Standard Pub, 8th Edition, 1999.
Heitner Joseph, Automotive Mechanics, East West Press, 2nd Edition, 1974.
Crouse, Automotive Mechanics, Mc Graw Hill, 6th Edition, 1970.
N.K. Giri, Automotive Mechanics, Khanna Pub. New Delhi, 2004.

ME305 MECHATRONIC SYSTEMS (3-0-0) 3

Introduction to Mechatronic system, Sensors and transducers, Signals systems and control, Actuating devices, feedback and intelligent systems, Microcontrollers, PLC, Mechatronic system design, Applications of Mechatronics

Botton W., Mechatronics 3rd Ed, Pearson Education Ltd. Indian print, 2003.
N.P.Mahalik, Mechatronics, TMH publishing Co. Ltd, New Delhi India, 2003
Bradley D. A, Mechatronics, Chapman & hall, London, 1997.
H. M .T Hand Book, Mechatronics, TMH Publication, 1997

ME306 METROLOGY AND CAD LAB (0-0-3) 2

Metrology Lab: Linear and angular measurement, measurement using slip gauges, Calibration, Screw thread and gear tooth parameter measurement, Tool makers microscope, surface measurement, comparators, acceptance test on lathe. CAD Lab: Graphics programming, drafting techniques, solid modeling practices.

I.C. Gupta, Engineering Metrology, Dhanpat Rai Publications, New Delhi, 1994.

Ibrahim Zeid, Mastering CAD/CAM, TMH publishing company ltd, New Delhi, 2007.

ME307 MACHINE SHOP – I (0-0-3) 2

Study and Demonstration of different Lathes for various jobs, different cutting tools and different Lathe operations, Marking, Centre drilling, Facing, Taper turning, Grooving, knurling, Profile turning, Drilling, Boring, Thread cutting, Eccentric turning. *Hajara and Choudhary, Workshop Technology Vol.I(2008) &II(2010), Median Promoters & publishers, Bombay.*

Khanna O. P, Workshop Practice Vol.I, Dhanpat Rai & Co., 2000.

ME308 MECHANICAL LAB – I (0-0-3) 2

Determination of Fuel properties, Calibration of pressure gauge, Performance of IC Engines.

Mathur and Sharma, Internal Combustion Engines, Dhanpath Rai and Sons. New Delhi, 8th Edition,1996.

ME351 ENERGY ENGINEERING (3-0-0) 3

Conventional Energy Sources: Hydel, Steam, Gas turbine, Diesel and Nuclear Power Plant, Layout, function of different components and types, Power plant Economics, Non-conventional or Renewable energy sources: Solar energy, application of solar energy, Wind, Ocean, Geothermal, Biomass Energies, Energy Conversion Principles and types. Carbon footprint. *M.M.El.Wakil, Power Plant Techniques, McGraw Hill, New York, 1985.*

PK Nag, Power Plant Engineering, Tata McGraw Hill, 5th Ed. 2012

Sukathme S.P., Solar Energy Principles of Thermal Collection and Storage, 2nd Ed., TMC New

Delhi,1984 G.D. Rai, Non-Conventional Energy, Dhanpat Rai & Sons, New Delhi, 1998

Houghton E.L., Carruthers, Aerodynamics for Engineering students, Butterworth-Hinemann Ltd., 2006

ME352 MACHINE DYNAMICS AND VIBRATIONS (3-1-0) 4

Introduction to dynamics, Derivation of GDE using Newton's laws of motion, D'Alembert's principle, Virtual work, Lagrangian Dynamics, Hamiltonian principle. Balancing of rotating and reciprocating masses, single plan, multi plane, rotating and reciprocating mass, V engines. Gyroscopic effect on two- wheel vehicle, four wheel vehicle, aero plane, and ship. Whirling of shafts with and without air damping, critical speeds. Dynamic analysis of cams and followers. Governor Mechanisms. Fundamentals of vibration, Free vibration of single degree of freedom systems, Types of damping, Harmonically excited vibration, Response under the Harmonic Motion of the Base. Response under Rotating Unbalance, Vibration Isolation, Transmissibility, Vibration measurement, Undamped Vibration Absorbers.

John J. Dicker, Jr. , Gordon R. Pennock, Joseph E. Shigley, Theory of Machines and Mechanisms, Oxford University Press, 2003

Hamilton H Mabie and Charles F Reinholtz , Mechanisms & Dynamics of Machinery 4th Edition, John Wiley & Sons, 1998 W T Thamson, M D Dahleh, Chandramouli Padmanabhan, Theory of Vibrations with Applications, Pearson, 2008. Singiresu S Rao, Mechanical Vibrations, 6th Edition, Pearson, 2016.

Graham Kelly, Mechanical Vibrations: Theory and Applications, C L Engineering, 2011.

ME353 CONTROL ENGINEERING (3-0-0) 3

Overview of feedback control, mathematical models of dynamical systems, linear time invariant systems, transfer function, time and frequency response of a system, stability analysis, Feedback systems, concept of root locus, dynamic compensation, PID control, state space representation of dynamical systems. Application of MATLAB

Gene F. Franklin et.al., Feedback control of dynamic systems, Pearson Ed.

Asia, 1998. K. Ogata, Modern Control engineering, Pearson Ed, 2002.

Harison and Boilinger, Introduction to Automatic Control System, John Wiley Publication, 1976.

ME354 OPERATIONS RESEARCH (3-0-0) 3

Definition, Formulation of LPP, Graphical Solutions, Simplex Algorithms, Sensitivity Analysis, Maximization Application, Transportation, Travelling Salesman Problems, Dynamic Programming, Game Theory, Solution Methods, Dominance Concept, Approximation Method, Waiting Line Theory, Poisson Arrival Rate, Exponential Service Times, System Characterization and Economy, Simulation, Steps, Applications and Limitations, Monte Carlo Technique, Waiting Line Situations, Networks: CPM and PERT Analysis, Total, Free and Independent Float, Network Crashing, Non-Linear Programming.

S.D. Sharma & H. Sharma, Operations Research- Theory, Methods & Applications- Kedarnath &Ramnath Publishers, 2002.
Taha H.A., Operations Research – An Introduction, 7th Edition, Prentice Hall Pub, 2002.
Shambling and Stevens, Operations Research – Fundamental Approach. McGraw-Hill Inc, US, 1974.

ME311 FINITE ELEMENT METHOD (3-0-0) 3

Introduction, Variational formulation, Weighted-integral and weak formulations, Ritz Method, Weighted Residuals method, One-dimensional finite element formulation for structural problems (static, free vibration), heat transfer and fluid mechanics problems. Two-dimensional element formulation for structural problems,Computer implementation, Numerical integration, Iso-parametric formulations. Case studies.

C Zienkiewics, 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. P Seshu, Textbook of Finite Element Analysis, PHI, 2004
Singiresu S. Rao, The Finite Element method in Engineering, 5th Edition, Elsevier, 2008.

ME312 THEORY OF ELASTICITY (3-0-0) 3

Components of stresses, equations of equilibrium, principle stresses and Mohr 's diagram in three dimensions, boundary conditions, strain components, compatibility equations, stress-strain relation and the general equation of elasticity, formulation of elasticity problems, existence and uniqueness of solution, Saint-Venant's principle, principle of super -position and reciprocal theorem, Airy's stress function to solve two dimensional problem, torsion of prismatic bars, soap film analogy, membrane analogy and elastic stability.

Wang C.T., Applied Elasticity, Mc-Graw Hill Book Company, New York, 1953
Timoshenko and Goodier, Theory of Elasticity, Mc-Graw Hill Book Company, 3rd Edition, 1969.
T.G. Sitharam, Applied Elasticity, Interline publishing, 2008.
L. S. Srinath, Advanced Mechanics of Solids, Tata Mc-Graw Hill Book Company, 3rd Edition, 2009.

ME313 HYDRAULICS AND PNEUMATICS CONTROL (3-0-0) 3

Introduction, Circuit Symbols, Fluid Pumps and Motors, Control Valves, Servo Systems, Single and Multi-Actuator Circuits, Design consideration of Circuits, Pumps and compressors - Working Principles, Hydro-Pneumatics, Fluidics, Principles of Pneumatic circuit design, Maintenance of Circuits, K-V Diagrams and Electrical Controls in Pneumatic Circuits, PLC control of hydraulic and pneumatic systems.

Esposito A.P., Fluid Power with applications, Pearson Education Asia, 6th edition, 2005.
Text Book of Hydraulics, Festo Didactic, 4th Edition, 2001.
Text Book of Pneumatics, Festo Didactic, 4th Edition, 2001
Andrew Parr, Hydraulics and Pneumatics, Jaico Pub, 2000.
S.R. Majumder, Pneumatic Systems – Principles and Maintenance, Tata McGraw Hill Co. 15th Edition, 2006.

ME314 PRODUCT DESIGN AND DEVELOPMENT (3-0-0) 3

Generic process of Product development, Concept Generation, TRIZ, Concept Selection and Testing, Computer applications in Product Development. Product Architecture, Design for Manufacture and Assembly. Prototyping,Virtual and Physical. Rapid Prototyping Technologies, Reverse Engineering. Product Life cycle Management

K T Ulrich and S D Eppinger, Product Design and Development, McGraw Hill, 2000.
K Otto and K Wood, Product Design, Pearson Education, Inc. 2001
K G Cooper, Rapid Prototyping Technology, Marcel Dekker, Inc. 2001
D T Pham and S SDimov, Rapid Manufacturing, Springer-Verlag, 2001

ME315 THEORY OF METAL FORMING (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, friction and lubrication, residual stress. Forging: Classification of forging processes, Hammer or drop forging, Press forging, Open-die forging, Closed- die forging, Calculation of forging loads, Effect of forging on microstructure, Residual stresses in forgings, Typical forging defects.

Extrusion: Introduction/objectives, Classification of extrusion processes, Extrusion equipment ,Presses, dies and tools, Hot extrusion, Deformation, lubrication, and defects in extrusion, Analysis of the extrusion process, Cold extrusion and cold-forming, Hydrostatic extrusion, Extrusion of tubing ,Production of seamless pipe and tubing.

Rolling: Introduction/objectives, Rolling mills, Classification of rolling processes, Hot rolling, Cold rolling, Forces and geometry relationships in rolling, Simplified analysis of rolling load: Rolling variables, Problems and defects in rolled products, Rolling-mill control, Theories of cold rolling, Theories of hot rolling, Torque and power.
Drawing of rods, wires and tubes: Introduction/objectives, Rod and wiredrawing, Analysis of wiredrawing, Tube drawing processes, Analysis of tube drawing, Residual stress in rod, wire and tubes.
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 Betzalel Avitzur, John Wiley and Sons, New York.
Fundamentals of Metal Forming Processes, B.L. Juneja, New Age International,Publishers, New Delhi.

ME316 WELDING TECHNOLOGY (3-0-0) 3

Introduction, Classification, Sample preparation techniques, Gas Welding, Arc Welding, Resistance welding, Submerged Arc welding, Equipment details and working of Gas Metal Arc Welding (TIG & MIG), Carbon Arc Welding, Advanced Welding
processes, Welding defects and inspection. Fiction and friction stir welding, EBW, LBW, Dissimilar metal joining, Welding codes, Welding qualification, Fatigue of welded joints.
IWA reference material
Parmar, R.S, Welding processes and Technology, Khanna Publishers, 1997.
Richard L. Little, Welding & Welding Technology, McGraw Hill, 1973.

ME317 BASICS OF COMPUTATIONAL FLUID DYNAMICS (3-0-0) 3

Introduction to Computational Fluid Dynamics: historical review, applications. Derivation of the fluid flow and heat transfer governing equations based on various fluid flow models. Mathematical aspects of the fluid dynamic equations, classification methods. Implementation of the finite difference and finite volume methods for fundamental advection diffusion, advection-diffusion partial differential equations. Stability, consistency and convergence issues. Numerical schemes for two dimensional Navier– Stokes equations like Lax -Wendroff method, MacCormacks method, SIMPLE. Implementation of boundary conditions. Various meshing methods. Errors and Uncertainty in CFD.
Versteeg, Henk Kaarle, and Weeratung eMalalasekera. An introduction to computational fluid dynamics: the finite volume method. Pearson Education, 2007.
Jiyuan Tu, Guan Heng Yeoh and Chaoqn Liu.Computational fluid dynamics A Practical approach. Butterworth Heinemann An Imprint of Elsevier, 2008.
John D. Anderson Jr . Computational Fluid Dynamics The Basics with Applications. McGraw –Hill International Edtion, 1995. Patankar S V .Numerical Heat Transfer and Fluid Flow.Hemisphere Publishing corporation, Taylor and Francis Group New York, 1980.

ME318 PRINCIPLES OF TURBOMACHINERY (3-0-0) 3

Introduction, Velocity triangles, Different turbomachinery and their operation, Classifications based on flow direction, type of fluid and energy transfer direction. axial, radial, mixed flow machines. Application of the equation of fluid motion: Conservation of mass, momentum and energy, Rothalpy in stators and rotors, Efficiency and reaction, Polytropic efficiency. Dimensional analysis and principle of similitude: Specific speed for turbine and pump. Model Laws. Axial flow machines: Reaction for repeating stage, Loading efficiency with reaction, Stage efficiency, Choice of reaction, Multistage axial compressor and turbines. Hydraulic turbines: Pelton wheel, Francis Turbine, Kaplan Turbine, Loss estimation, Draft tube analysis, Effect of draft tube. Centrifugal pump; Pump geometry and performance, pump diffuser analysis, pump losses, NPSH, application to real pumps.
Maneesh, Prasad and Neema, Turbomachinery, McGraw Hill, 2018.
Yahya S.M, Turbomachines, Tata McGraw Hill, New Delhi, 4th Edition, 2017
H. Cohen and Rogers, Gas Turbines Theory, Longman Green Co., Ltd, 5th Edition, 2001
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., NewYork.

ME319 MINI PROJECT I (0-0-3) 2

Experimental work in the laboratory or design tasks of relatively smaller magnitude comparedto Major Project work and in line with the guidelines formulated by the DUGC (mechanical).

ME320 CRYOGENICS (3-0-0) 3

Introduction to Cryogenics, Properties of fluids and solids at cryogenic temperatures, Thermodynamic relations for isenthalpic and isentropic expansions of fluids, Liquefaction of permanent gases, Methods of air liquefaction, Cryocoolers, Gas separation: Ideal work requirement, McCabe-Thiele Method; Storage and transport, Cryogenic Insulation, Vacuum technology, Applications of cryogenic engineering in various fields, Cryogenic Instrumentations and Safety.

R.B.Scott, Cryogenics Engineering, Van Nostrand& Co, 1962
Randall F.Barron, Cryogenic Systems, McGraw Hill, New York, 1996
Arora C.P., Refrigeration and Air Conditioning, Tata McGraw Hill Company Limited, New Delhi, 1981.
Refrigeration/Thermodynamics/Heat transfer/Air conditioning data hand book.

ME411 THEORY OF FATIGUE AND ANALYSIS (3-0-0) 3

Introduction to linear elastic fracture mechanics, fatigue design methods, application to fatigue crack growth, Stress-life and strain-life approaches, notches and their effects, fatigue from variable amplitude loading, spectrum loading, cumulative damage theories, cycle counting methods, statistical aspects of fatigue.

Ralph I. Stephens, Ali Fatemi, Robert .R. Stephens and Henry O Fuchs, Metal Fatigue in engineering, John Wiley, New York, Second Edition, 2001.
Jack. A. Collins, Failure of Materials in Mechanical Design, Second Edition, John Wiley & Sons, New York, 1981.
Robert L. Norton, Machine Design- An Integrated Approach, Fourth Edition, Prentice Hall, 2010.
David Broek, Elementary Engineering Fracture Mechanics, Sijthoff & Noordhoff International Publishers, Netherlands, 1978

ME412 EXPERIMENTAL STRESS ANALYSIS (3-0-0) 3

Review of Elementary Elasticity and Fracture Mechanics, Strain measurement methods and related instrumentation, Optical methods of stress analysis, Brittle Coat methods, Applications of statistics to experimental data. Introduction to Thermal imaging

J.W. Dally and W.F. Riley, Experimental Stress Analysis, Mc Hill International Editions, New York, 1991.
L.S. Srinath et al., Experimental Stress Analysis, Tata Mc Hill, NewDelhi, 1984.
A.W. Hendry, Elements of Experimental Stress Analysis, Pergamon Press, New York, 1977.
A. J. Durelli, Applied Stress Analysis, Prentice-Hall Inc., New Jersey, 1967.

ME413 SYNTHESIS OF MECHANISMS (3-0-0) 3

Introduction, tasks of Kinematics Synthesis, Type synthesis, Tools of dimensional synthesis, Function Generator: Three prescribed points, Introduction to Analytical synthesis, Standard Dyad form, three prescribed positions for motion, path and function generation, circle, point and center-point circles, Freudenstein's equations for three point function generation, order synthesis, coupler curves for four-link, slider- crank and inverted slider- crank mechanisms, Application of coupler curves in design of six-link mechanism, Coupler cognate mechanisms. Introduction to Compliant mechanism

George N Sandor and Arthur G Erdman, Advanced mechanism design: analysis and synthesis, vol.2, pearson; Facsimile edition (8 March 1984)
A.H Soni, Mechanism Synthesis and Analysis, McGraw Hill, 1984.
Robert L. Norton, Design of Machinery- An Introduction to the Synthesis and Analysis of Mechanisms, WCB Mc Graw Hill, Boston, 1999.
Asok Kumar Mallik, Amitabha Ghosh, Gunter Dittrich- Kinematic Analysis and Synthesis of Mechanisms,CRC Press; 1 edition (1994)

ME414 MICROSYSTEMS TECHNOLOGY (3-0-0) 3

Introduction to electromechanical systems and MEMS, Micro sensors and Micro actuators, Scaling and Material Issues, Micro fabrication techniques, Electro mechanics, Design of MEMS and Design realization tools. Packaging of MEMS, CAD Tools for MEMS

J J Allen, MEMS Design, Taylor and Francis 2005
Tai Ran Hsu, MEMS and Microsystems-Design and Manufacture,
TMH 2002 Nadim Maluf, An Introductionn to MEMS Engg, Artech
House 2004 Stephen D Senturia, Microsystem Design, Springer 2001
Marc J Madou, Fundamentals of Microfabrication, CRC Press 2nd edition,2002

ME415 AUTOMATION SYSTEMS (3-0-0) 3

Introduction to Digital Control Systems, CNC technology, Evolution of Automation, Microcontrollers, Programmable Logic Controllers, Automated Process Planning, Scheduling and Management systems, FMS Elements, Concepts of

Agile Manufacturing, STEP-NC systems.

Mikel P. Grover, Automation Production Systems and Computer Integrated Manufacturing, PHI, 2004. P. Radha Krishna & S. Subramanian, CAD/CAM/CIM, New Age International Publishers, 2009.
Chris Mc Mohan & Browne. J, CAD CAM, Prentice Hall, 1998.
Jerome H. Fuchs, The Prentice Hall Illustrated Handbook of Advanced Manufacturing Methods, PrenticeHall, 1988

ME416 ROBOTICS (3-0-0) 3

Introduction, Classification and applications; manipulator – The industrial robotic arm; Kinematics of a serial-link robotic manipulator, dynamics and control of a serial-link manipulator; sensors and actuators for robotics.

J J Craig : Introduction to robotics: Mechanics and Control, 3rd edition, Pearson Ed, 2004
Asitava Ghosal, Robotics: Fundamental concepts and Analysis, oxford University Press, 2013

ME417 NON DESTRUCTIVE EVALUATION (3-0-0) 3

Liquid penetrate inspection: Post-emulsifiable penetrates, Solvent-soluble penetrates, Radiographic examination: X-Ray apparatus, X-Ray generation, Radiograph, safety hazards and Government control, Ultrasonic's Examination: Ultrasonic triangulation fault location acoustic emission technique, Instrumentation, Signals and processing, Magnetic testing Methods: current flow magnetization, Induction Magnetic Flow method, Induction threading bar method, Induction Magnetizing coli method, Induced current flow method, Magnetic particle Inspection, strippable Magnetic film, Industrial Computed Tomography, Thermal Inspection, Optical Holography, Quantitative Nondestructive Evaluation, Applications of NDE Reliability to Systems, NDE Reliability Data Analysis, Statistical Quality Design and Control, Eddy current testing methods *Non destructive Evaluation and Quality Control, Volume 17, 9th Edition Metals Handbook, ASM Handbook, 1992*

L. F. Pau, Failure Diagnosis and Performance Monitoring. Marcel Dekker Inc,1981.
Charles, J. Hellier, Handbook of Non destructive evaluation, McGraw Hill, New York 2001.
J *Prasad, C G Krishnadas Nair, Non-Destructive Testing and Evaluation of Material, Tata McGraw-Hill Education Paul E Mix, "Introduction to Non-destructive testing: a training guide", Wiley, 2nd Edition New Jersey, 2005*

ME418 PRODUCTION AND OPERATIONS MANAGEMENT (3-0-0) 3

Introduction, Economic Analysis, Process Analysis, Work Study, Productivity, Value Analysis, Break Even Analysis, Layout and Location of Facilities, Line Balancing, Demand Forecasting, Inventory Control, MRP, Aggregate Planning, Scheduling.

R. Panneerselvam, Production and Operations Management, PHI Learning Pvt Ltd, 2006 Samuel Eilson, Elements of Production Planning and Control, Mc Milan Company, 1962.
Joseph G. Monks, Operations Management -Theory & Problems, McGraw- Hill, 1987.
E.S. Buffa, Modern Production / Operations Management, John Wiley, New York, 1983
Seetharama L Narasimhan, Dennis W Mcleavey, Peter J Billington, Production Planning and Inventory Control, PHI, 2nd edition,1997

ME419 COMPOSITES MATERIALS (3-0-0) 3

Basic concepts and characteristics: Definition and characteristics of composite materials, overview of advantages and limitations of composite materials, Significance and objectives, Sciences and technology, Types and classification of typical composite materials, current status and future prospects, Micromechanical and Macro mechanical Behavior of a Lamina, Macro mechanical behavior of a laminate, Processing of Polymer Matrix, Metal Matrix and Ceramic Matrix Composite Materials, Testing of Composite Materials.

F.L.Matthews and R.D.Rawlings, Composite materials: Engineering and science, Wood head publishing limited,1999.
Rober M.Jones, Mechanics of composite Materials, McGraw Hill Kogakusha Ltd, 2nd Edition,1998.
Krishnan K Chawla, Composite material science and Engineering, Springer Publishing,3rd edition, 2012.
P.C.Mallik, Fibre reinforced composites, Marcel Decker,2nd edition,1993.
M M Schwartz, Composite Materials Hand book, McGraw Hill,1983.

ME 420 IC ENGINES (3-0-0) 3

Fuel-air cycles, Actual cycles, Combustion in SI engines, Stages of combustion, Flame propagation, SI combustion chambers, Combustion in CI engines, Delay period, CI engine combustion chambers, Testing and Performance, Adiabatic flame temperature, Enthalpy of product, CRDI, MPFI, CDI, Supercharger, Turbocharger. Alternative fuels for IC engines

M.L Mathur & R.P Sharma, A Course in Internal Combustion Engine, Dhanpat Rai & Sons, New Delhi,2001 John. B. Heywood, Internal combustion engine fundamentals, McGraw Hill, 1st Edition, 1988.
E.F Obert, Internal combustion engines, Addision Wesley, 3rd edition, 1968, V.Ganesan, Internal Combustion Engines,

McGraw-Hill, 1995.

ME421 REFRIGERATION AND AIR CONDITIONING (3-0-0) 3

Refrigerants, Refrigeration Cycles, Air cycle refrigeration, Vapour compression system, multi pressure system, Cascade refrigeration, Vapour absorption system, Dry ice manufacturing, Ejector refrigeration system, Decicant cooling system, Pollution by refrigerants. Use of solar energy, low grade energy to run the refrigeration system. Psychrometry, Air-conditioning processes, use of Psychrometric chart, air conditioning processes, Cooling load calculations. types of air conditioning systems, winter and Summer air conditioning, Applications of air conditioning. (Use of Refrigeration data handbook permitted in examination).

Arora C. P, Refrigeration and Air Conditioning, Tata McGraw Hill Company Limited, New Delhi, 1981. Refrigeration/Thermodynamics/Heat transfer/Air conditioning data hand book
Manohar Prasad, Refrigeration and Air conditioning, Wiley Eastern Limited, New Delhi, 1983.
Parker, Spitler M, Heating, Ventilating and air conditioning, Wiley India, 2011.
Refrigeration/Thermodynamics/Heat transfer/Air conditioning data hand book.

ME422 MECHANICS OF COMPRESSIBLE FLOW (3-0-0) 3

Fundamentals equations of the flow of compressible fluids: multi-dimensional continuity equation, momentum equation, energy equation. Non-dimensional quantities for compressible flow. Pressure equation. Propagation of motion in compressible fluids: Stationary wave, non- stationary wave and formation of shock. Isentropic flow relations in terms of the sonic velocity and the Mach number. Steady one- dimensional flow: Isentropic flow through tubes: without and with heat transfer. Wave phenomenon: Normal shock and Oblique shock. Application of shock expansion theory.

S M Yuan, Foundation of Fluid Mechanics. Prentice Hall of India Pvt. Ltd., 1976.
1.Balachandran P., Fundamentals of Compressible Fluid Dynamics, Eastern Economy Edition, Prentice Hall of India. New Delhi, 2006.
S. M. Yahya, Fundamentals of Compressible Flow, Wiley Eastern Ltd, New Delhi, 1989.
Cambel and Jennings, Gas Dynamics, Mc Graw Hill. New York, 1958.
B.T. Nijaguna, Thermal Science/Engineering data Hand Book, 1st Edition, Allied Publishers Ltd, New Delhi, 1992.
White F.M., Fluid Mechanics, McGraw Hill, Singapore, 1999.

ME423 MULTI BODY DYNAMICS (3-0-0)3

Kinematics of particles and rigid bodies, Euler angles, Generalized displacement, velocity and acceleration, Rigid body dynamics, D'Alembert's Principle, Virtual work application in dynamics and Lagrange's equation, Constraints formulation in Multi Body Systems, Formulation of joint constraints for various joints used in practice, Formulations of Constrained Dynamics

Equations, Lagrange Multipliers,

Multi Body Dynamics Solution, Numerical Integration, Computer simulation of the dynamic behavior of multi-body systems using software tools. Treatment of holonomic and non-holonomic constraints through various elimination and augmentation methods, Application to Vehicle Dynamics, Engine Dynamics, Power Train Dynamics. Tyre models in Vehicle dynamics. Stability Analysis. Deformable Multi Body Dynamic Simulation.

Ahmed A. Shabana, Dynamics of Multibody Systems, 3rd edition, Cambridge University Press, 2010.
Michael Blundell and Damian Harty., The Multibody Systems Approach to Vehicle Dynamics, Elsevier Limited, 2004 Farid Amirouche, Fundamentals of Multibody Dynamics: Theory and Applications, Birkhäuser, 2006 Ahmed A. Shabana, Computational Dynamics", Wiley InterScience, 2nd Edition. 2001

ME424 VEHICLE DYNAMICS (3-0-0) 3

Introduction to Automotive vehicles and Vehicle dynamics, Fundamental approach to modeling, Dynamic axle loads, Automobile - Principle Components, Working Principles and Construction details, Forces and couples on the wheel, Tractive and braking effort, Vehicle drag, power for propulsion, Air resistance, rolling resistance, grade resistance, traction and tractive effort, distribution of effort, Stability of a vehicle on a slope, Front wheel drive, rear wheel drive and four wheel drive. Dynamics of a vehicle running on a banked and curved track, Vehicle Performance, Acceleration Performance, Braking Performance, Road Loads, Aerodynamics, Mechanics of air flow around a vehicle, Pressure distribution on a vehicle, Aerodynamic forces, Ride, Steady State Cornering, Roll Over, Electric Vehicles, Hybrid Electric Vehicles, Rail and off road vehicle dynamics.

T.D. Gillespie, "Fundamentals of vehicle dynamics", Society of Automotive Engineers, Warrendale, PA, 1992. N. K. Giri, "Automotive Mechanics", Khanna Publishers, Eighth edition
Ahmed A. Shabana, "Dynamics of Multibody Systems", Cambridge University Press; 2nd edition,1998.
Michael Blundell and Damian Harty, The Multibody Systems Approach to Vehicle Dynamics, Elsevier,2004.
M.Ehsani, Y.Gao and A.Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles, Second edition, CRC Press,2015.

ME425 CONTEMPORARY CONCEPTS IN PRODUCT DESIGN (3-0-0) 3

Human -Product Interactions – Design for Aesthetics, Input-Output Human interface devices, Design thinking. Design for ease of use. Ergonomics and Human modeling-Definition and aspects in Product Design, Digital Human Modeling and Virtual Humans. Bio-inspired product design and biomechanics- Designs inspired by flora and fauna, fundamentals of biomechanics. Creative Design and Design research methodology- Definition of Novelty and creativity. Abstractize and Synthesize for creative design. Design for sustainability, twelve principles of green engineering.

M S Sanders and E J McCormick, Human Factors in Engineering and Design, McGraw-Hill Education (India)Pvt. Ltd., 7ed, 2013

Don Norman, The Design of Everyday things, Basic Books, 2013

W Lidwell, K Holden and J Butler, Universal Principles of Design, Rockport Publishers,2003.

Duane Knudson Fundamentals of Biomechanics, Springer, 2007 (Second Edition)

ME426 AUTOMOTIVE ELECTRONICS (3-0-0) 3

Automotive Mechanical Systems, Vehicle Systems, Power Train System, Transmission System, Braking System, Steering System, Need for Electronics in Automotive Systems, Overview of Vehicle Electronic Systems, Embedded Systems, Hardware Module, Software Module, Debug Interfaces, BDM and JTAG, Introduction to Embedded RTOS, Embedded System in Automotive Applications, Embedded System Communication Protocols, Vehicle communication protocols.

Lack Erjavec Automotive Technology A systems approach, , 4th edition, Thomson Delmar Learning, 2005, USA; Willliam B., Ribens Understanding Automotive Electronics, , 6 -th Edit., An Inprint of Elsevier Science, USA, 2004; Robert Bosch GmbH Diesel-Engine Management, 3th edition., Bentley Publishers, 2004;

Robert Bosch, GmbH Gasoline-Engine Management, 2nd edition., Bentley Publishers , 2004 Robert Bosch GmbH, Automotive Handbook, 6th edition. Bentley Publishers, 2004;

ME427 INTRODUCTION TO ADDITIVE MANUFACTURING (3-0-0) 3

History, Process Chain, CAD Issues, Classification of Processes – Vat Photopolymerization, Powder Bed Fusion, Material

Extrusion, Directed Energy Deposition, Binder Jetting, Sheet Lamination, Material Jetting Processes, Design for AM, Issues And Qualification of Powders, Process Control and Insitu Monitoring, Applications and Case Studies

Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: 3-D Printing, Rapid Prototyping and Direct Digital Manufacturing", Springer, 2015.

Andreas Gebhardt, Jan-Steffen Hötter, "Additive Manufacturing: 3D Printing for Prototyping and Manufacturing", Hanser

Publications, 2016.

Chua Chee Kai, Leong Kah Fai, "3D Printing and Additive Manufacturing: Principles and Applications, World Scientific, 2014.

Hod Lipson, Melba Kurman, "Fabricated: The New World of 3-D Printing", Wiley 2013.

Patri K. Venuvinod , Weiyin Ma, "Rapid Prototyping - Laser-based and Other Technologies", Kluwer Academic Publishers, 2003

ME428 NON TRADITIONAL MACHINING PROCESSES (3-0-0) 3

Modern Machining Processes: An Overview, Mechanical Processes - Ultrasonic Machining, Abrasive Jet Machining, Water Jet Machining; Electrochemical and Chemical Metal Removal Processes - Electrochemical Machining , Electrochemical Grinding,

Electrochemical Deburring, Electrochemical Honing, Chemical Machining, Thermal Metal Removal Processes - Electric Discharge Machining, plasma Arc Machining, Electron Beam Machining, Neutral Particle Etching , Laser Beam Machining, Introduction to Micromachining

Electrochemical machining, Debarr & Oliver, Elsevier, 1968.

Ghosh & Mallick, Manufacturing science, East-West Press, 2010.

P C Pandey and H S Shan, MODERN MACHINING PROCESSES, Tata McGraw-Hill Education Pvt. Ltd.,1980.

Modern Machining technology, J Pualo Davim, Elsevier,2011.

ME429 ENERGY AUDITING AND MANAGEMENT (3-0-0) 3

Energy sources, energy conservation and its importance, Energy Conservation Act, 2001 Energy management program, Objectives of Energy Management, Energy auditing, Need for energy audit, types of energy audit, instruments used, Energy economics, financial analysis techniques, Payback period, ROI, NPV, IRR, cash flow, sensitivity and risk analysis, Energy conservation in boilers, performance evaluation of boilers, direct and indirect methods, factors affecting boiler performance, types of furnaces, performance evaluation of furnaces, direct and indirect methods, steam

and condensate system, steam distribution system, steam traps, cogeneration concepts, heat exchangers, waste heat recovery, compressed air system, Electrical energy conservation, power factor, electric motors, minimizing motor losses, space heating and cooling, case studies

W R Murphy and G Murrey, Energy management Butterworth-Heinemann, 2007
Larry C Witte, Schmidt and Brown, Industrial energy management and utilization Hemisphere publishing Co. New York 1998 Wayne C Turner, Steve Doty, Energy management handbook, Sixth Edition, CRC Press 2006
D. A Reay , Industrial Energy Conservation, Pergamon press 1980
T L Boten Thermal energy Recovery Wiley 1980
Bureau of Energy Efficiency guide books

ME430 GAS TURBINES AND JET PROPULSION (3-0-0) 3

Design point performance calculations, Intake and propelling nozzle efficiency, Meanline design: Turbofan, turbojet and turboprop engines, Reaction principles, Momentum theory applied to propulsive devices, Augmentation of thrust, Ramjet and Pulse jet engine, The concept of losses and efficiency, Types of combustion system, Combustion process, Compressibility effects, Vortex theory, Selection of blade profile, chord and pitch, Limiting factors in design.

Saravanamuttoo, H. I., Rogers, G. F. C., & Cohen, H. (2001). Gas turbine theory. Pearson Education.
Hall, C., & Dixon, S. L. (2013). Fluid mechanics and thermodynamics of turbomachinery. Butterworth-Heinemann.
Flack, R. D. (2005). Fundamentals of jet propulsion with applications (Vol. 17). Cambridge University Press.
Ganesan, V. (2010). Gas Turbines 3E. Tata McGraw-Hill Education.
Yahya, S. M. (1987). Turbines compressors and fans. Tata McGraw-Hill Education.
Lefebvre, A. H., & Ballal, D. R. (2010). Gas turbine combustion: alternative fuels and emissions. CRC press.

ME431 CONTINUUM MECHANICS (3-0-0) 3

Mathematical Preliminaries – Vector and Tensor calculus
Deformation Kinematics – Deformation gradient, E & L formulations, Time dependent motion, material derivatives
Equilibrium of deformable bodies –Traction and stress, Equilibrium and balance principles. Different Stress Measures
Material models – Material frame indifferences, Thermodynamic considerations, Plasticity Boundary value problems and numerical solutions to BV problems
Structural mechanics of beams – Kinematic hypothesis, Planar beam: Timoshenko & Bernoulli-Euler formulations;

J.E. Marsden and T.J.R. Hughes, Mathematical Foundations of Elasticity. Dover Publications, 1994.
G.A. Holzapfel, Nonlinear Solid Mechanics: A Continuum Approach for Engineering, John Wiley & Sons, 2000.
P. Chadwick, Continuum Mechanics: Concise Theory and Problems, Dover Publications, 1999.
L.E. Malvern, Introduction to the Mechanics of a Continuous Medium, Prentice Hall Series in Engineering of the Physical Sciences, 1969.
Y.C. Fung Foundations of Solid Mechanics, Prentice Hall, 1965.
P.G. Ciarlet, Mathematical Elasticity, Volume III: Theory of Shells, North Holland, 2000.

ME432 ANALYTICAL MECHANICS (3- 0- 0) 3

Review of basic solid mechanics theory, Work, Energy and Variational Calculus, Energy principles in structural mechanics, Variational forms, Energy principles in mechanics, Principle of virtual work, Deformation of Bars and Beams, Plates, Problems in plane elasticity (Plane stress, plane strain, axisymmetric elasticity), Dynamical Systems, Hamilton's principle for particles, rigid bodies, continuum and constrained systems.

Energy Principles and Variational Methods in Applied Mechanics by J. N. Reddy, John Wiley, New York, 2002.
Mechanical Systems, Classical Models, Analytical Mechanics, by P.P. Teodorescu, Springer, 2009
Analytical Dynamics, Theory and Applications, by Mark D Ardema, Kluwer Academic/Plenum Publishers, 2005
Methods of Analytical Dynamics, Leonardo Meirovitch, Dover Publications, 2010

ME433 CONDITION MONITORING (3-0-0)3

Mechanical vibration theory, A review, Theory of vibration measuring instruments, Maintenance methods, Machinery diagnostics and predictive maintenance, Condition monitoring parameters, Machine health prediction using vibration monitoring, Machine signature analysis, Signal processing for fault diagnosis, Vibration standards, Experimental vibration analysis, Predictive maintenance using wear debris analysis, Noise Monitoring, Fault diagnosis using machine learning approach, NDT methods in condition monitoring, Electrical machinery faults and analysis, Diagnostics and condition monitoring of rotors.

R. A. Collacott, Vibration monitoring and diagnosis, George Godwin Ltd London, 1979
Amiya R. Mohanty, Machinery condition monitoring, CRC Press, 2015.
A. Davies, Handbook of Condition Monitoring, Springer ltd. 1998
William T Thomson, Marie Dillon Dahleh and Chandramouli Padmanabhan, Theory of Vibration with Applications, Fifth Edition, Pearson Publications, 2008
C. Sujatha, Vibration And Acoustics, Tata McGraw-Hill Education, 2010.

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

ME434 MICROFLUIDICS (3-0-0)3

Introduction to microfluidics and applications. Scaling laws and effects in microfluidics. Transitional and free molecular regimes, Maxwell first order slip model and accommodation coefficients, Effects of compressibility, Analysis of thermo-fluidic transport in microscale gas flows and its applications. Low Re flows and examples. Liquid and particle handling and transport in microscale. Surface tension driven flows and microcapillary transport, Young Laplace equation and concept of contact angle, Dynamics of Capillary rise. Electrohydrodynamics, Electroosmosis, Electrophoresis, Dielectrophoresis and applications, Analysis of hydro-dynamically and thermally fully developed electro-osmotic flows, ac electro-osmosis, electroosmotic flow of non-Newtonian fluids, Microfabrication techniques, Bio-microfluidics.

Patrik Tabeling, "Introduction to Microfluidics", Oxford University Press, 2011 (Reprint).
H. Bruus, "Theoretical Microfluidics", Oxford University Press Inc., 2008
Suman Chakraborty, "Microfluidics and Microfabrication", First Edition, Springer, 2010
M. J. Madou, "Fundamentals of Microfabrication", CRC press, 2002.
John Happel, Howard Brenner, "Low Reynolds number hydrodynamics", Springer, 1983

ME435 SOLAR ENERGY (3-0-0)3

Introduction, The solar energy option: An overview of thermal applications, Solar Radiation Liquid flate plate collectors, solar air heaters, Thermal energy storage, Solar pond

Duffie and Beckman, Solar Thermal Processes, McGraw- Hill, 2nd Edition, 1991.
Garg H.P & J. Prakash, Solar Energy, TMC, 1997.
Sukhatme S.P, Solar Energy Principles of Thermal Collection and Storage, 2nd Ed., Tata Mc Graw-Hill,New Delhi, 1996.
C. S. Solanki, Renewable Energy Technology, Prentice Hall, New Delhi 2008.

ME436 ENGINEERING TRIBOLOGY (3-0-0)3

Fundamentals of surface contact and interactions: surface topography, asperity contact, interfacial phenomena, Hertzian contact, Sliding and rolling contacts, Stick Slip phenomena, liquid-surface interactions. Friction theories and wear mechanisms. Lubrication and lubricants: Stribeck curve-Hydrodynamic, hydrostatic, elastohydrodynamic and boundary lubrication. Introduction to special topics like Nanotribology, Biotribology, Space tribology. Tribology in metal working processes and machine components, Surface characterization, treatments and testing in Tribology.

Engineering Tribology by John Williams (Publisher: Cambridge Univ. press)
Modern Tribology Handbook Edited by Bharat Bhushan (Publisher: CRC Press)
Fluid Film Lubrication, By B. Hamrock
Friction, Wear, Lubrication: A Textbook in Tribology by Kenneth C. Ludema
Publisher: CRC Press
The Friction and Lubrication of Solids (Oxford Classic Texts in the Physical Sciences) by Frank Philip Bowden, David Tabor Publisher: Oxford University Press;
Friction Science and Technology by Peter J. Blau Publisher: Marcel Dekker;
Tribology, Principles and Design Applications, by Arnell et al.
Fundamentals of Machine Elements, by Hamrock, Jacobson, and Schmid

ME437 THERMAL STRESS ANALYSIS (3-0-0)3

Thermal stresses in bars: free thermal expansion, free thermal strain, action of external forces and temperature change. Thermal stress in clamped bars: constant temperature change, non-uniform temperature change. Thermal stresses in partially restrained bars, thermal stresses in bars under bending. Thermal stresses in clamped beams, rectangular beams, composite beams, thermal deflection in beams, curved beams, thermal shearing stresses in thin-walled beams, thermal stresses in beams on elastic foundation. Heat conduction: one dimension heat conduction problems in Cartesian and cylindrical coordinates. One dimensional thermal stresses in circular cylinder: displacement technique.

Naotake Noda, Richard B Hetnarski, Yoshinobu Tanigawa, Thermal stresses, Taylor and Francis, New York 2003.
Gatewood B.E., Thermal stresses with Applications to Airplanes, Missiles, Turbines and Nuclear Reactor. McGraw Hill Book Company Inc., New York, 1957.
Johns, D. J. Thermal Stress Analyses, Pergamon Press Ltd., Oxford, 1965
Boley B. A., and Wainer J.H., Theory of Thermal Stresses, Dover Publication Inc., Mineola, New York. 1985.

ME438 INJURY BIOMECHAMICS (3-0-0)3

Introduction to injury biomechanics, experimental setup and high speed instrumentation for testing, anthropometric test device (ATD, crash test dummies), post mortem human subjects (PHMS), multibody dynamic and finite element models used for injury biomechanics research, Sled and crash testing, Injury criteria, Abbreviated Injury Scale (AIS), Injury assessment reference value (IARV), Public database National Highway traffic safety Administration (NHTSA) and Crash Injury Research (CIREN), Injury tolerance to head/brain, spine/spinal cord, thorax/abdomen, pelvis/extremity, injury

prevention rollover, head/helmet, seatbelt, airbags/seatbelt, sports..

Kai-Uwe Schmitt, Peter F. Niederer, Duane S. Cronin, Markus H. Muser, Felix Walz (2014) "Trauma biomechanics: An introduction to injury biomechanics", Springer.
Duane Knudson (2007), "Fundamentals of biomechancis", Springer.
Kai-Uwe Schmitt, Peter F. Niederer, Markus H. Muser (2009), "Trauma Biomechanics Accidental injury in traffic and sports", Springer.
Public database for injury www.nhtsa.gov.

ME439 INTRODUCTION TO FLIGHT (3-0-0)3

Basic concepts, Standard Atmosphere, Basics of Aerodynamics: compressibility effects, viscous flow, air speed measurement, laminar and turbulent boundary layer, flow separation, Airfoil nomenclature, Lift, drag and moment coefficient, Infinite and finite wing, Critical Mach number, Swept wings, Flaps, Thrust for level flight, Rate of climb, Gliding flight, Range and endurance, Take off and landing performance, Uninhabited aerial vehicles (UAVs), Micro Air Vehicles, Satbility and control.

Anderson J D Jr., Introduction to Flight, 7th Edition, McGraw Hill, 2008.
Richard Von Mises, Theory of Flight, McGraw Hill
A.C Kermode, Mechanics of Flight, 11th Edition, Pearson Education Limited
Anderson J D Jr., Fundamentals of Aerodynamics, 3rd Edition, McGraw Hill, 2001.

ME440 PRACTICAL TRAINING / INTERNSHIP (0-0-2)1

A student may complete the training before the beginning of 7th semester (or as stipulated by DUGC) and registerfor it in 7th semester. The duration of the internship or practical training will be for a minimum of 4 weeks. Practical training or Internship must be undertaken in physical mode in industry/R&D organisations/Premier educational institutes. Practical training or Internship must focus on mechanical engineering domain.

ME441 POLLTION CONTROL AND ENVIRONMENTAL MANAGEMENT (3-0-0)3

Air pollution, Air quality, Definitions, Characteristics and perspectives, classification of pollutants, Their ill effects, Air quality management concepts, Meteorology and natural purification processes, Air pollution sampling and measurement, Air pollution control methods and equipment, Control of specific gaseous pollutants, Pollutants form automative engines, Legal and necessity of legislation, Sources and classification of water pollutants, Wastewater sampling abd analysis, Wastewater treatment, Solid waste management, Noise and odor pollution.

C.S. Rao, Environmental pollution control Engineering: Wiley Eastern Ltd, 1994.
Hoard S Peavy, Donald R Rowe & George Techobanoglous, Environmental Engineering, McGraw Hill Intnl. Edition, 1986.
S.P. Mahajan, Pollution control in process industries, Tata McGraw Hill, 1985.
W.L. Faith, Air pollution control, John Wiley, 1959.
Henry. C. Perkins, Air Pollution, McGraw Hill, 1974.
K.V.S.G Murali Krishna, Air Pollution and Control, Kaushal & Co, 1995.

ME442 AERODYNAMICS (3-0-0)3

Basic fluid flow equations, Integral and differential formulations of continuity and momentum equations, Potential flow theory, Blasius theorem of force and moment on bodies, Elementary flow patterns and their superposition, Flow past a cylinder, Kutta-Joukowski theorem, Conformal transformations, Thin aerofoil theory, Flow over airfoil, Incompressible flow over finite wings, Vortex filament, Biot- Savart law, Helmholtz theorems, Horseshoe vortex, Prandtl's lifting line theory, Swept and delta wings, Airfoils in compressible flow, Small perturbation theory, Numerical modelling of aerodynamic problems.

J. Anderson, "Fundamentals of Aerodynamics" 5th Ed. McGraw Hill, 2010.
E. L. Houghton, P.W. Carpenter, S. H. Collicot and D. T. Valentine. "Aerodynamics for Engineering Students", 6th Ed. Butterworth-Heinemann, 2013.
A. M. Kuethe and C. Chow, "Foundations of Aerodynamics: Bases of Aerodynamics Design", 5th ed,, John Wiley and Songs, 1998.
L. Katz and A. Plotkin, "Low Speed Aerodynamics", Cambridge University Press, 2001.

ME 443 MECHANICAL VIBRATION AND ACOUSTICS (3-0-0) 3

Vibration: Importance and scope, Review Single DOF systems, Free, damped, forced vibration, Multi DOF systems, Eigen values and vectors. Continuous systems (String, Axial Bar, Torsion of Rod, Beam Bending). Theory of vibration measuring instruments, Vibration reduction methods, Introduction to experimental modal analysis. **Acoustics:** Fundamentals of acoustics, Plane wave propagation, radiation and scattering, Effect of noise on human, Sound measurement, Noise control techniques. Sound absorption and transmission loss calculation using Impedance tube.

S. Graham Kelly, Mechanical Vibrations, Theory and Applications, 1st Edition, Cenage Publication, 2015
W .T .Thomson, M. D. Dahleh and Chandramouli Padmanabhan Theory of Vibration with applications, 5th Edition,

Pearson Education, 2008.
Singiresu S. Rao, Mechanical Vibrations, 6th Edition, Pearson, 2017.
C. Sujatha, Vibration and Acoustics, Measurement and Signal Processing, McGraw Hill Education, 2017.
Dhanesh N Manik, Vibro-Acoustics: Fundamentals and Applications, CRC Press, 2017.

ME444 DATA PROCESSING IN MACHINE LEARNING (3-0-0) 3

Introduction to data processing methods: Machine Learning, statistical description of errors, well posed and ill posed problems. The estimation problem and its solution as an optimization problem: Basic concepts, classification, an overview of various solution techniques. Parameter estimation and function estimation, least square regression, classical methods – Levenberg Marquardt Algorithm, example(s) from sciences/atmospheric science,conjugate gradient method and deterministic methods with adjoint problem for parameter estimation. Bayesian framework, likelihood density, posterior density, priors and calculation of point estimates. Markov chain Monte Carlo methods, Metropolis-Hastings's algorithm and hybrid algorithms. Surrogate models, machine learning – ANN and hybrid approaches combining ML with Bayesian methods. The concepts of hyperpriors and hyperparameters. MAP objective function and the MCMC method of stochastic simulation to engineering problems. State estimation problems using Kalman filter, and recursive procedure. Approximation Error Model and its implementation to engineering problems.

Beck, J. V., and K. J. Arnold. "Parameter estimation in science and engineering." John Wiley, NY 11 (1977): 525-536.
Beck, James V., Ben Blackwell, and Charles R. St Clair Jr. Inverse heat conduction: Ill-posed problems. James Beck, 1985.
Taler, Jan, and Piotr Duda. Solving direct and inverse heat conduction problems. Berlin: Springer, 2006.
Balaji, C. "Design and Optimization of Energy systems." (2014).
Ozisik, M. Necat. Inverse heat transfer: fundamentals and applications. Routledge, 2018.

ME451 MECHANICAL LAB – II (0-0-3) 2

Heat transfer experiments, Performance analysis of Compressors, Blowers, Boilers, Refrigerators and Air Conditioning equipments, Dynamics of Machinery experiments.

C. P. Arora, Engineering Heat Transfer, Khanna Publishers, India, 1996.
J.E. Shigley and John Joseph Vicker, Theory of Machines and Mechanism, 3rd Ed. TMH, 1995.
Manohar Prasad, Refrigeration and Air conditioning, Wiley Eastern Limited, New Delhi, 1983.

ME452 MACHINE SHOP – II (0-0-3) 2

Demonstration of Machine tools and Power tools, Practice on Shaper, Milling Machine, Cylindrical and Surface Grinding, Slotter, Drilling Machines, etc. Programming for CNC Machines,

Hajara and Choudhary, Workshop Technology Vol.I(2008) &II(2010), Median Promoters & publishers, Bombay.
Khanna O. P, Workshop Practice Vol.I, Dhanpat Rai & Co., 2000.

ME490 SEMINAR (0-0-2) 1

This course is an one credit course to be completed during 8th semester. The student will make presentation on topics of academic interest.

ME497 CORNERSTONE/CAPSTONE PROJECT (0-0-4) 3

For details refer to clause 3.2 under Regulations specific to Undergraduate Programmes.

ME498 Major Project - 1 (0-0-4)2

The students jointly or individually will be assigned an experimental or a theoretical problem, to be carried outunder the supervision of a guide. The students shouldcomplete the preliminary literature survey and a part of the work in the VII semester.

ME499 Major Project - 2 (0-0-6)3

Extension and completion of Major project -I started in the previous semester (ME498).

ME501M MANUFACTURING ENGINEERING (3-1-0) 4

Metal casting processes: Introduction to sand moulding, patterns Use f core, other casting processes: shell moulding, precision investment casting, permanent mould casting, die casting, vacuum die casting, Low pressure die casting, centrifugal casting, gating and risering, casting defects.

Machining: Introduction, Mechanism of Chip Formation, Heat Generation and Cutting, Tool Temperature, Failure of Cutting Tool and Tool Wear, Cutting Tool Materials, Tool Life and Machinability, Machining processes: Shaping and Planning, Turning and Boring, Drilling.

Introduction to metal forming processes: Strain rates in metal forming, Development of metallurgical structure during

deformation
Flow curves, Forging, Extrusion, Wire drawing, Deep drawing
Metal joining processes: Gas Welding, Arc Welding, Advanced Welding processes, Brazing
Soldering *Amitabha Ghosh, Manufacturing Science, East-West Press, 2nd edition, 2010*
Serope Kalpakjian and Steven R Schmid, Manufacturing Engineering and Technology, (Fourth Edition), Pearson Education, Asia,2000.
Metal Cutting: Theory and Practices, Bhattacharya A, New Central Book Agency, 2012.
Jain P. L., "Principles of Foundry Technology", TMH, 5nd edition,2014.
Heine, R.W., Loper, C.R., and Rosenthal, P.C., "Principles of Metal Casting", TMH, 2nd edition,2001 Mechanical Metallurgy Si Metric Edition by George E. Dieter, McGraw Hill Book Company (UK),1989.

ME502M THERMAL ENGINEERING (3-1-0) 4

Thermodynamic Laws, Compressors, reciprocating and rotary, Steam nozzles and steam turbines, Air standard cycles, Vapour power cycles, Gas turbine cycles, performance testing of IC engines, Refrigeration cycles, vapour absorption system, Psychrometric processes. Flow of real fluids, Boundary layer theory, Flow around immersed bodies, Flow through pipes, Impact of jets, Hydraulic Machines, pumps, Turbines, Hydraulic systems. Fin heat transfer, Transient heat conduction - Lumped analysis, one dimensional transient heat conduction - Heisler chart, Convection heat transfer - Forced convection - external flow and internal flow, Boiling and condensation heat transfer, Heat exchangers, Radiation heat transfer

Holman J. P., Thermodynamics, McGraw Hill International Student Edition. Newyork, 1969.
Rajput R.K, Thermal Engineering, Laxmi Publications (Pvt) LTd., NewDelhi. 6th Edition, 2007.
Eastop and McConkey, Applied Engineering Thermodynamics, ELBS, 1995.
Frauk P Incropera, Fundamentals of Heat and Mass tranfer, John Wiley and sons, Fifth Edition, 2002.
Nicati M. Ozisik, Heat Transfer a Basic Approach, McGraw Hill Publication,1985.
Holman J. P., Heat Transfer, McGraw Hill Publication, 8th Edition, 1996.
Kumar K.L. Fluid Mechanics, Eurasis Publishing House, New Delhi, 1995.
F .M. White, Fluid Mechanics, Springer-Verlag. New York. 1999.

ME503M MECHANICAL DESIGN (3-1-0) 4

Introduction to elasticity, plane stress and plane strain problems, Shear force and bending moment diagram, Bending equation, Beam deflection, Compound stresses and Mohr's circle, working stresses, modes of mechanical failure, theories of failure, stress concentration, fatigue loading, Soderberg criteria, members subjected to steady and alternating loads. ASME design of transmission shafts and keys. Springs: stresses in coil springs, deflection of coil springs, Design of transmission drives: Flat-and V-belt drives, Gear drives. Kinematics of Machine elements, balancing of rotating and reciprocating systems, gyroscopic effect on two-wheeler, single Degree-of free and forced vibratory systems with and without damper.

RL Norton – Machine Design, An integrated approach, Pearson Education
Asia, 2000 J.E. Shigley and Mische Mech. Engineering Design , Tata
McGraw Hill – 2003 Hall, Holowenko, Laughlin- Machine Design, Schaum's
Outline Series, 1981.
Robert L. Mott- Machine Elements in Mechanical Design, Pearson Prentice Hall 4th Edition, 2003.
V.B. Bhandary - Design of Machine Elements, Tata McGraw Hill, 2010.
K. Mahadevan and K. Balaveera Reddy- Design data Hand Book , (SI Units), 2013

ME504M PRODUCTION MANAGEMENT (3-1-0) 4

Introduction, Economic Analysis, Break Even Analysis, Layout and Location of Facilities, Line Balancing, Demand Forecasting, Inventory Control, MRP and ERP, Supply Chain Management, Aggregate Planning, Scheduling, Project Management, JIT, TPS and Lean operations. Product Life cycle management

Jay Heizer, Barry Render, Operations Management, Pearson, 11th Edition, 2015
R. Panneerselvam, Production and Operations Management, PHI Learning Pvt Ltd, 2006
Joseph G. Monks, Operations Management -Theory & Problems, McGraw- Hill, 1987.
E.S. Buffa, Modern Production / Operations Management, John Wiley, New York, 1983
Seetharama L Narasimhan, Dennis W Mcleavey, Peter J Billington, Production Planning and Inventory Control, PHI, 2nd edition,1997
K Aswathappa, K Shridhar Bhat, Production and Operations Management, Himalaya Publishing, second revised edition,2018

ME505M INDUSTRIAL AUTOMATION (3-1-0) 4

Evolution of Automation, Automation Principles and Strategies, CNC technology, Microcontrollers, Programmable Logic Controllers, Automated Process Planning, Robotics & Flexible Manufacturing Systems. Automation in Production Systems, Industrial Control Systems, Applications of Sensors and Actuators, Material Handling and Transport Systems, Storage Systems, Manufacturing Cells, Group Technology and Cellular Manufacturing, Automated Assembly and Inspection

Mikel P. Grover, Automation Production Systems and Computer Integrated Manufacturing, PHI, 2004.
P. Radha Krishna & S. Subramanian, CAD/CAM/CIM, New Age International Publishers, 2009.
Chris Mc Mohan & Browne. J, CAD CAM, Prentice Hall, 1998.
Jerome H. Fuchs, The Prentice Hall Illustrated Handbook of Advanced Manufacturing Methods, Prentice Hall, 1988.

UC100 INTRODUCTION TO DESIGN THINKING (2-0-0) 2

Need and Definition of Design Thinking. Framework for Design Thinking. Engineering Design Process. Need Identification, Specification, Concept Generation, Product Architecture and Detailed Design. Prototyping – Virtual and Physical. Testing Methodology

Christian Muller-Roterberg, "Handbook of Design Thinking", 2018
Eli Woolery, "Design Thinking Handbook" Invision Pub, 2019
Nigel Cross, "Design Thinking"
Max Answell "Mastering Design Thinking", 2019
Karl T. Ulrich, Steven D. Eppinger and Maria C Yang, "Product Design and Development", McGraw Hill, 7ed, 2020
George e Dieter, Linda C Schmidt, "Engineering Design", Mc Graw Hill, 4ed, 2009

UC401 LIBERAL ARTS COURSES/CO-CURRICULAR/EXTRACURRICULAR ACTIVITIES 10

CATEGORY A : Maximum 3 credits, CATEGORY B : Maximum 3 credits, CATEGORY C : Minimum 4 Credits and Maximum 7 credits.

10 Credits have to be earned from 1st Semester to 7th Semester by choosing Category (A + B + C) OR Category (A + C) or Category (B + C) courses combination . Registration for 10 Credits has to be done in 7th Semester.

For details of CATEGORY A, CATEGORY B and CATEGORY C refer to clause 3.2 (f) under Regulations specific to Undergraduate Programmes.

MT160 INTRODUCTION TO MATERIALS SCIENCE AND TECHNOLOGY (3-1-0) 4

The electronic structure of atoms, Types of atomic and molecular bonds; ionic bonding; covalent bonding; metallic bonding; secondary bonding; mixed bonding; hybridization. Energy bands in metals, insulators and semiconductors. Basic crystallography. Defects and dislocations. Types of Materials: Polymers, metals and alloys, semiconductors, ceramics, composites. Diffusion. Phase rule and phase diagrams. Properties: optical, magnetic, mechanical, electrical, thermal. Corrosion and material degradation. Selected topics and case studies.

W.D. Callister Jr, Materials Science and Engineering, Wiley, 2006.
W.F.Smith et al, Materials Science and Engineering, Tata McGraw Hill, 2008.
D.R. Askeland, W. J. Wright, Essentials of Materials Science and Engineering, Cengage, 2013.
V. Raghavan, Materials Science and Engineering: a First Course, PHI, 2011.

MT200 TESTING OF MATERIALS (2-0-1) 3

Definitions and physical interpretations of various mechanical properties of metals and alloys. Structures & Properties of engineering materials. Comparison of physical, thermal, and mechanical properties of metallic, ceramic, and polymeric materials, and composites. Scientific rationale for mechanical properties; cohesion between atoms, interatomic bonds, different levels of structures: atomic, crystal, micro, macro and mega structures. Methodology, equipment, acquisition-processing-presentation of engineering data of: Tension, Compression, Hardness, Torsion, Impact, Fatigue, and Creep Tests. Introduction to Non-Destructive Testing; DPI, MPI, UTI, Eddy Current Inspection and Radiography.

Lab component: Mechanical Testing: Brinell, Rockwell, Vicker's and Rebound Hardness Tests, Tensile Test using HounsefieldTensometer/UTM,Charpy Impact Test, Creep Test, Spark Test. Non-Destructive Testing: Dye Penetrant and Magnetic Particle Tests.

W.D. CallisterJr, Materials Science and Engineering, Wiley, 2006.
G.E. Dieter, Mechanical Metallurgy, McGraw Hill 1988.
Barry Hull, Vernon John, Non-Destructive Testing, ELBS/Macmillan, 1988.

MT201 METALLURGICAL THERMODYNAMICS & KINETICS (3-1-0) 4

Review of first and second laws of thermodynamics, Maxwell's relations; free energy concept and applications, general strategy of deriving thermodynamic relations; third law of thermodynamics; related problems from Dube&Upadhyaya. Solutions, partial molar properties, Gibbs-Duhem equation, fugacity, activity, equilibrium constant; regular solutions, integration of G-D equation, dilute solutions, interaction parameter; equilibrium in thermodynamic systems, structure of unary phase diagrams in (P,T) space, Clausius -Clapeyron equation, triple point, alternative representation of unary diagrams; Gibbs phase rule, Free energy-composition diagrams, Ellingham diagrams; activation energy, effect of activation energy on reaction rate, chemically controlled reactions (both ideal and non-ideal systems).

Robert T. DeHoff, Thermodynamics in Materials Science, McGraw Hill International, 1993 D.R Gaskell, Introduction to Metallurgical Thermodynamics, McGraw Hill International, 1973 G.S.Upadhyaya and R.S.Dube, Problems in Metallurgical Thermodynamics and Kinetics, Pergamon, 1977 A.Ghosh, Textbook of Materials & Metallurgical Thermodynamics, PHI, 2003. H.S. Roy, Kinetics of Metallurgical Reactions, Oxford, BH, 1993.

MT202/MT202M PHYSICAL METALLURGY (3-1-0) 4

Structure of metals, space lattice, unit cells, crystal systems, metallic crystal structures, packing efficiencies, planes and directions, voids, imperfections in crystalline solids, dislocations and plastic deformation, theoretical shear strength, concept of dislocations, types of dislocations, Burgers vector, strain field associated with dislocations, dissociation of dislocations, climb and cross slip, dislocation interactions, plastic deformation by twin, yield point phenomenon, strain ageing, work hardening in single and polycrystalline materials, effect of temperature, composition and grain size on strain hardening, recovery, recrystallisation and grain growth, high temperature deformation of crystalline materials, diffusion in solids, applications of diffusion concepts, solidification of metals, freezing of alloys, Scheil equation, dendritic freezing in alloys, freezing of ingots, segregation, homogenization, porosity, eutectic freezing, growth of single crystals.

E.Reed-Hill and R. Abbaschian, Physical Metallurgy Principles, PWS Publishing Co., 1994.
G.E. Dieter, Mechanical Metallurgy, McGraw-Hill Book Co., 1988.
W.G.Moffat, G.W.Pearsall&I.Wulff, The Structure & Properties of Materials, Vol. I Structure, Wiley Eastern, 1968. G. W. Hayden, W.G.Moffat and I.Wulff, The Structure & Properties of Materials, Vol.III Mechanical Behaviour,Wiley Eastern Pvt. Ltd, 1968.

MT203/MT203M POLYMER SCIENCE AND TECHNOLOGY (3-0-0) 3

Fundamentals of polymer science: Introduction, different types of polymerization and their mechanism, nomenclature of polymers, polymer molecular architecture, polymerization technology, molecular weight and molecular weight distribution, polymer crystallinity, thermal transitions in polymers. Industrial polymers: property Requirements and polymer utilization, thermoplastics: commodity and engineering plastics, thermosets, elastomers, natural rubber and synthetic rubbers, thermoplastic elastomers, blends & reinforced polymers. Polymer Reactions: polymer modification, polymer degradation. Properties of polymers: viscoelastic behavior, time – temperature superposition, stress-strain behavior, fracture, creep, hardness, impact behaviour, methods to improve mechanical properties, basics of polymer rheology, permeability, electrical, optical and flammability properties. Compounding and processing of polymers: plastics Technology, fiber Technology, elastomer technology.

R. O. Ebewele, Polymer Science and Technology, 1e, CRC Press, Boca Raton, 2000.
V. R. Gowariker, N.V. Viswanathan, J. Sreedhar, Polymer Science, 1e, New Age International, New Delhi, 2011.
C.S. Brazel, S. L. Rosen, Fundamental Principles of Polymeric Materials, 3e, John Wiley, New York, 2012.
F. W. Billmeyer Jr., Textbook of polymer science, John Wiley, New York, 1996.
J. R. Fried, Polymer Science and Technology, 3e, PHI, 2014.
M.P. Stevens, Polymer Chemistry-an Introduction, 3e, Oxford University Press, New York, 1999.

MT 251 TRANSPORT PHENOMENA (3-1-0) 4

Units & Dimensions, applications of transport phenomena in materials processing, properties of fluids, Newton' s law of viscosity, momentum diffusivity, Newtonian and Non-Newtonian Fluids, Laminar flow, simple cases of flow along an inclined plane, flow between parallel plates, flow through a circular pipe, Equation of Continuity and Navier- Stokes Equation, Creeping flow around a sphere, Stokes law, Turbulent and complex flows, Concept of friction factor, dimensional analysis for friction factor, flow over a flat plate, flow past submerged bodies, applications, Packed beds, Darcy's law, Tube Bundle Theory and Ergun's Equation, Fluidized beds, Bernoulli's Equation, friction loss in pipes, concept of friction loss factor and entrance loss coefficient, flow through ladles, Pitot tubes, head meters, pumps, flow of compressible fluids, isentropic flow, convergent-divergent nozzles, vacuum pumps, conductance and throughput, Diffusion Pumps, Ion pumps.

Fourier law of heat conduction, thermal properties of solids, gases and liquids, steady state heat transfer, steady state heat transfer across a composite wall and a cylinder, concept of thermal resistance, critical thickness of insulation, Newtonian heat transfer, Biot Number. Unsteady state heat conduction, Semi-infinite and finite systems, error functions for solving heat conduction problems, Chart solutions, Finite Difference techniques, Modelling of latent heat, Natural and Forced Convection, Dimensional analysis for the heat transfer coefficient, correlations in convective heat transfer, heat exchangers, Significance of LMTD. Solidification heat transfer, Derivation of Chvorinov's rule, Radiation heat transfer, concept of black body, radiation resistance, radiation shields, radiation in gases, Similarity Criteria in heat transfer.

Steady state diffusion, molar diffusivity, Fick's 1stlaw of Diffusion, bulk flow, logarithmic mean of concentration difference, Ordinary and Knudsen Diffusion, Unsteady state diffusion, applications in microelectronic materials processing and homogenization heat treatment. Mass Transfer coefficient, mass transfer correlations, Models of Mass Transfer coefficient, Staged operations, counter current cascade, determination of number of stages .

D. R. Poirier and G. H. Geiger, Transport Phenomena in Materials Processing, TMS Warrendale, 2016, eBook.
N.J. Themelis, Transport and Chemical Rate Phenomena, Gordon Breach, 1995.
R. B. Bird, W.E. Stewart and E.N. Lightfoot, Transport Phenomena, John Wiley, 2007.
R.I.L. Guthrie, Engineering in Process Metallurgy, Clarendon Press, 1992.

MT252/MT252M PHASE DIAGRAMS (3-1-0) 4

Introduction: types of solid solutions, Hume Rothery rules, intermediate phases, binary isomorphous system; phase rule and lever rule, miscibility gaps, eutectic systems, phase diagrams with intermetallic compounds; monotectics, syntetic, eutectoid, peritectic and peritectoid reactions in binary systems and solidification behaviour of typical alloys in these systems; ternary phase diagrams: isothermal sections and isopleths; ternary systems involving binary reactions, ternary reaction, experimental techniques of phase diagram determination: Fe-Fe_3C phase diagram, introduction to steels and cast irons, other commercially important binary systems.

A. Prince, Alloy Phase Equilibria, Elsevier, Amsterdam, 1966.
D.R.F West, Ternay equilibrium diagrams, 3nd Edn.,CRC Press, 2002
Shant P Gupta, Phase equilibria in Materials, Allied Publishers Pvt Ltd, 2003
F.N.Rhines, Phase Diagrams in Metallurgy, McGraw Hill, N.Y.1956. S.H.Avner,
Introduction to Physical Metallurgy, 2nd Ed (Indian edition) 1997.

MT253/MT253M PRINCIPLES OF EXTRACTIVE METALLURGY (3-1-0) 4

Sources of metals, unit processes, pyrometallurgical processes, halides in extractive metallurgy, refining processes,

stoichiometric calculations, hydrometallurgical processes, recovery of metal values from leach solution, electrometallurgical processes, electrorefining and electrowinning, nickel: sources, extraction from sulphide ores, carboxyl and electrolytic refining of nickel, extraction of nickel from oxide ores; copper: sources of copper, extraction from sulphide ores, refining, newer processes for copper extraction, hydrometallurgy of copper; zinc: sources, pyrometallurgical extraction, hydrometallurgical extraction, recovery of byproducts (cadmium); Imperial Smelting Process (ISP); lead: sources, extraction of lead, lead blast furnace, refining, modern developments in lead smelting, aluminium and magnesium extraction.

Ray, Sridhar and Abraham - Extraction of nonferrous metals, EWP., New Delhi 1985.
R.D.Pehlke - Unit Processes of extractive metallurgy,1975, American Elsevier, New York.
Sevmkov N. - Nonferrous Metallurgy, 1975, Mir, Moscow.

MT254 X-RAY DIFFRACTION AND ELECTRON MICROSCOPY (3-1-0) 4

Stereographic projections, generation, absorption and detection of X-rays; intensity of diffracted beam, Scherrer formula; Laue, rotating, powder methods, Debye-Scherrer technique, focusing technique, pin hole technique, diffractometer, crystal structure, indexing cubic and non-cubic patterns, precise lattice parameter, single crystal orientation; order-disorder transformation, grain size, texture, solvus line, chemical analysis: qualitative, quantitative; TEM Vs optical microscope, electron - matter interaction, image formation, specimen preparation, reciprocal lattice, indexing SAD patterns; SEM: modes, magnification, contrast, EPMA, FIM, STM, EDAX.

B *D.Cullity, Elements of X-Ray Diffraction, Addison Wesley, 1977. R. E. Smallman& K. M.B. Ashbee, Modern Metallography, 1966.*

MT255 INSTRUMENTAL METHODS OF ANALYSIS (3-0-1) 4

Spectroanalytical methods:Introduction, Beers law, selction rules, IR spectroscopy, UV-visible spectroscopy, atomic absorption spectrometry. Thermal Analysis: Thermogravimetry, differential thermal analysis, differential scanning calorimetry, temperature modulated DSC, dynamic mechanical thermal analysis,hyphenated techniques.Surface Characterization: X-ray photoelectron spectroscopy,scanning tunnelling microscopy, atomic force microscopy, comparison between electron microscopy and scanning probe microscopy, sample preparation techniques for electron microscopy.

Lab component: Experiments on FTIR spectroscopy, DSC, SEM, and TEM of materials.

J.W.Robinson, E.M.S Frame, and G.M Frame II, Undergraduate Instrumental Analysis, 6e, Marcel Dekker, 2005.
D.A.Skoog, F.J.Holler and T.A Nieman, Principles of Instrumental Analysis, 4e.Harcourt, 2001.
J.D Menczel, R.B Prime, Thermal Analysis of Polymers, Wiley, 2009.
G.H Michler, Electron Microscopy of Polymers, 1e, Springer – Verlag, 2008.

MT256 MEASUREMENTS AND CONTROL (3-0-0)3

Measurement and Instrumentation: Introduction, Measurement, Instrument, Measurement methods, Generalized measurement system and its functional elements, Classification of instruments, Basic standards and units

Instrument Characteristics: Introduction, Static terms and characteristics, Dynamic terms and characteristics, standard test-inputs, Zero, first and second order instruments, First order system responses, Second order system responses.

Measurement Errors and Statistical Analysis: Introduction, Classification of errors, Statistical analysis of test data, Curve fitting by least squares, selecting an instrument.

Pressure Measurement: Introduction, Terminology, Pressure units and measuring instruments

Flow Measurement: Introduction, Nature of flow, Classification of fluid flow measurement techniques, Variable head-meters, Pitot tubes, Variable area flow meters, Quantity meters.

Temperature Measurement: Introduction, Temperature scales, Temperature measuring instruments, Liquid-in-glass thermometers, Bimetallic thermometers, Filled-system thermometers, Thermocouples, Resistance thermometers and thermistors, Radiation and optical pyrometers, Pyrometric cones, crayons, paints and pellets.

Strain Gauges and Strain Measurement: Introduction, Strain measuring techniques, Requirements of a strain gauge, Resistance strain gauge, Stain gauge alloys and materials, Metal resistance strain gauges, Unbonded versus bonded gauges.

Force and Torque Measurements: Introduction, Force measurement, Torque measurement.

Miscellaneous Measurements: Density and specific gravity, Liquid level, Viscosity.

Control Systems and their Classification: Introduction, Examples of control systems, Classification of control systems, Control systems terminology, Servomechanism, process control and regulators, Manual and automatic control systems.

Kumar, D.S., Mechanical Measurements and Control, Metropolitan, New Delhi, 2015.
Instrumentation for engineering measurements: J W Dally, W.F. Riley, K.G. McConnel, John Wiley, 1995.
Industrial Instrumentation-Al Sutko, J.D. Faulk, Cengage Learning, 1996.

Principles of Industrial Instrumentation- D. Patranabis, McGraw Hill, 1996.
Industrial Instrumentation, D.P. Eckman, John Wiley, 1951.

MT300 PRODUCTION OF IRON AND FERRO ALLOYS (3-0-0)-3

History of Iron Making, Traditional Iron Making, Evolution of Blast Furnace, Iron Making in India. Iron ores of the world: Distribution; Indian iron ores, limestones and coking coal deposits, problems associated with Indian raw materials. Iron ore beneficiation and agglomeration, theory and practice of sintering and pelletising, Testing of burden materials, Blast Furnace Reactions, Thermodynamics and Kinetics, Fundamental studies, Blast furnace design, other auxiliary units, plant layout, recent developments in the design & operation of blast furnace, irregularities in operation and their remedies, Blast furnace refractories and instrumentation; Blast furnace slag & gas: importance, formation and use. Direct reduction methods, Details of some commercial processes like Rotary Kiln, Electric Pig Iron Furnace, HYL, Midrex, Fluilised Bed, Corex Process, Pyrophoricity of DRI, Ferroalloy Furnaces, Production of FeSi, FeMn and FeCr, Nitrided Ferroalloys.

Making, Shopping and Treating of Steel, 10 th Edition, Edited by United States Steel, 1985; or 11th Edition Edited by the Association of Iron and Steel Engineers, 1999.
Ghosh and A. Chatterjee, Ironmaking 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.
Kurt Meyer, Pelletizing of Iron Ores Springer Verlag, Berlin, Heidelberg, Newyork, 1980.
Strasburger, Brown, Stephenson & Dancy, B.F. Theory and Practice, Vol.I & II, 1969, Gordon & Reach, New York.
K.K.Prasad& H.S. Ray, Advances in Rotary Kiln Sponge Iron Plant.
Robert L. Stephenson, Direct reduced iron – Technology & Economics of production and use, 1980, Iron & Steel Society of AMIE.
C.K.Gupta and A.K.Suri, Ferroalloys Technology in India, C.K. 1982, Milind Pub., New Delhi.

MT301 HEAT TREATMENT (3-1-0) 4

Nucleation and growth of austenite, pearlitic transformation, TTT diagrams, formation of martensite, annealing, normalizing, hardening and tempering, hardenability, heat treatment furnaces, austempering, martempering, ausforming; thermomechanical treatments; surface hardening of steels; effect of alloying elements on Fe-C diagram, structure and properties of steels; carbon and alloy tool steels, stainless steels, HSLA steels, maraging steels, dual phase steels; cast irons and their heat treatment, alloy cast irons, aluminium and its alloys.

R.E. Reed Hill, Physical Metallurgy Principles, Van Nostrand, East West Press, Newyork, New Delhi, 1973.
S.H.Avner, Introduction to Physical Metallurgy, McGraw Hill, 1974.
D.S.Clark& W.R Varney, Physical Metallurgy for engineers, East West Press, New Delhi, 1962.
T.V.Rajan and G.P.Sharma, Heat treatment (Principles & Techniques), Prentice Hall of India, 1995.

MT302 MACHINE DESIGN (3-1-0) 4

Fundamentals of machine design, Engineering materials and their properties, Manufacturing Considerations in Machine Design, modes of mechanical failure, Shear force and bending moment diagram, Bending equation, Beam deflection, Simple and compound stresses in machine parts, variable stresses in machine parts, stress concentration, welded joints, strength and efficiency of the joint, Springs: stresses in coil springs of round and square, deflection of coil springs, design of compression and tension springs. Flexible machine elements: Flat belt, V belt drives rope drives, Gears: spur, helical, bevel, worm gear, nomenclature, Lewis equation, Lewis form factor, design based on strength dynamic and wear loads, design of flywheels, pressure vessels and pipe joints.

K. Mahadevan and K. Balaveera Reddy, Design and data book (SI Units) 2e, CBS publishers & distributors, 1984.
V. B. Bhandary, Design of Machine Elements, Tata Mc Graw Hill, New Delhi, 2e, 2007.
Robert. L. Norton, Design of Machinery, Mc Graw- Hill International, 1992.

MT303 ELECTRONIC PROPERTIES OF MATERIALS (3-0-0) 3

Free electron theory, Fermi-Dirac statistics; density of energy states, Fermi energy, electrons in a periodic field of a crystal, Kronig Penny model, Brilluoin zone theory, classical theory of specific heat, thermal conductivity, photon conductivity, phonon conductivity, thermal expansion of metals, polymers and ceramics, resistivity variation, intrinsic & extrinsic semiconductors, semiconducting compounds, production of transistors, integrated circuits, zone refining and single crystal growth, dielectric materials, ferroelectric materials, superconductors, magnetic materials, applications, ferrites, zone theory, opacity, luminescence, translucency, laser modulation and amplification, LED, optical storage and optical computer, optical fibres; Lasers.

W. H. Rothery and B R Coles, Atomic Theory for Students of Metallurgy, Institute of Materials, London, 1988.
G.V. Raynor, An Introduction to Electron Theory of Metals, Institute of Materials,London, 1988.

Rolf E Hummel, Electronic Properties of Materials, 2nd Edition, Narosha Publishing House, 1995.
Manas Chanda, Science of Engineering Materials, Vol. 3, Engineering Properties, McMillan, 1980.
S. O. Pillai, Solid State Physics, New Age International Pvt. Ltd., India 2002.
B. M. Srivatsava and C. Srinivasan, Science of Engineering Materials New Age International Pvt. Ltd.1999.
John Wulff et al. Electronic Properties, Vol. IV John Wiley and Sons, 1964.

MT304 PHYSICAL METALLURGY LAB (0-0-3) 2

Temperature measurement: calibration of thermocouples, use of optical and radiation pyrometer, metallography, study of metallurgical microscope, specimen preparation for metallography, etching technique, image analyzer, quantitative metallography, phase diagram by cooling curve, phase transformation study by dilatometer, diffusion studies of solidification structure.

MT305 EXTRACTIVE METALLURGY LAB (0-0-3) 2

Study of temperature distribution in a tubular furnace, oxidation and reduction roasting, pelletisation and sintering of iron ore fines, leaching studies, flotation of sulphide ores, oxidation of metals and alloys, cementation of copper, reducibility of ores, proximate analysis of coal, calorific value of solid fuels and gaseous fuels, flash and fire point determination using Cleveland's open cup and Pensky Marten's closed cup testers, determination of viscosity of liquids using Redwood viscometer and Brookfield viscometer, Orsat apparatus for gas analysis.

MT306 FATIGUE, FRACTURE AND CREEP (3-0-0) 3

Fatigue test: S-N curve, statistical nature, effect of mean stress, Goodman diagram, effect of surface finish, size, residual stress and temperature; effect of metallurgical variables, suppression of fatigue, fracture mechanics: type of fracture in metals, theoretical cohesion strength, Griffith theory, dislocation theory of fracture, plane strain fracture toughness and its evaluation, instrumented impact testing, comparison of fracture toughness of various materials, embrittlement of steels, creep and stress rupture, creep curve, stress rupture test, determination of fracture at higher temperature, presentation of engineering creep data, prediction of long time practices, theories of creep, effect of metallurgical variables.

Dieter G.E., Mechanical Metallurgy, McGraw Hill, 1988.
T. H. Courtney, Mech. Behaviour of Metals, McGraw Hill 1990.

MT307 FUELS AND FURNACES (2-1-0) 3

Classification of fuels, properties and tests, coal origins, carbonization and gasification. Other solid fuels; Liquid fuels -Types, testing, properties; Gaseous fuels, Hydrates. Introduction to nuclear fuels; Indian fuel deposits. Heat balance, principles of theory of combustion, Combustion calculations, evolution of heat, flame temperature, waste heat utilization. Basic concept of temperature measurement and control. Thermocouples: Principal, calibration, types and advantages Classification of furnaces; Construction and working principles of furnaces like Cupola, Induction furnace, Microwave furnace, Spark Plasma Sintering furnaces, Arc furnace, Resistance furnace, Pit furnace, Rotary furnace, Muffle furnace etc. Designing of laboratory furnaces.

O.P.Gupta, Elements of fuels, furnaces and refractories, 2011.
J. D. Gilchrist, Fuels, Furnaces and Refractories, 1977.
V. A. Krivandin, B. L. Markov, Metallurgical Furnaces, 1980.
W Trinks, Industrial Furnaces, W. Trinks, John Wiley & Sons Inc, 2003.

MT350 PRODUCTION OF STEEL (3-0-0) 3

History of steel making, major steel making processes, principles of steel making, physical chemistry of steel making, deoxidation, tapping and teeming, slags in steel making. Basic oxygen steelmaking processes, top and bottom blown processes, combined blowing/Hybrid processes, LD/BOF, Q-BOP/ OBM, LD-AC/OLP, Kaldo Rotor; Requirement of Metallic Coolant, Energy Optimizing furnace (EOF), Inputs required in oxygen steel making, yields from metallic inputs. Alloy and stainless steel making, continuous steel making, steelmaking in electric arc furnace, steel making in induction furnace, conarc process. Secondary steel making processes, steel degassing processes, casting pit practice, continuous casting of steel, moulds used for continuous casting; use of casting powder, Electromagnetic stirring, defects in continuous cast product.

Making, Shaping and Treating of Steel, 11e, Edited by the Association of Iron and Steel Engineers, 1999.
A. Ghosh and A. Chatterjee, Ironmaking and Steelmaking: Theory and Practice, PHI, 2008.
A.K. Chakravarty, Steelmaking, PHI (P) Ltd., New Delhi, 2007.
R. H. Tupkary, Modern Steel Making, Khanna Pub, 2008.
C. Bodsworth, Physical Chemistry of Iron and Steelmaking
T. Rosenqvist, Principles of Extractive Metallurgy.

R.G. Ward, An Introduction to the Physical Chemistry of Iron and Steel making, ELBS, London.

MT351/MT351M CERAMICS AND REFRACTORIES (3-0-0) 3

Structure of ceramics: bonding, Pauling's rules, oxide structures, silicate structures, structure of glasses; Defects in ceramics, Kroger-Vink notation; Processing of ceramics: powder processing, forming, calcination, sintering; Sintering – solid state and liquid phase sintering, grain growth; Microstructure of ceramics; Properties and testing of ceramics: physical, mechanical, thermal; Brittle Fracture, Toughening mechanisms; Formation and properties of glasses; Cement; Advanced ceramics; Definition of refractory, Classification, Properties and testing of refractories; General Production method of refractories, Selection of refractories for metallurgical applications, Special types of refractories.

Michel Baersoum, Fundamentals of ceramics, McGraw Hill, 1997.
W.D.Kingery, Introduction to Ceramics, Wiley Interscience, 1976.
D.W.Richerson,Modern Ceramic Engg., Marcel Decker Inc. New York and Basel, 1984.
F. H. Norton, Refractories, Mcgraw-Hill; 4 Reprint edition,1992.
A. R. Chesti, Refractories, Manufacture, properties& applications refractories.
A.O Surendranthan, An introduction to ceramics and refractories, CRC Press NY 2015.

MT352 METALLOGRAPHY LAB (0-0-3) 2

Microstructure of cast iron, plain carbon steel, brasses, bronze and babbits, aluminum silicon alloys, aluminum copper alloys, image analysis, inclusion studies, macro-microstructure of forged, rolled, cast and welded structures.

MT353 CERAMICS AND POLYMERS LAB (0-0-3) 2

Molecular weight determination of polymer by viscometry, Melt flow Index of thermoplastics, Apparent density and specific gravity of a ceramics, physically bound water in a ceramic material, interfacial polycondensation, wet spinning, synthesis of conducting polymer, molding and measuring hardness of a thermoplastics material, synthesis of nanoceramics, identification of polymers, FTIR spectroscopy and scanning electron microscopy of polymer and ceramics, characterization of rubber latex.

MT354 HEAT TREATMENT LAB (0-0-3)2

Full annealing, normalizing, hardening and tempering of plain carbon steels, Jominy end quench test, pack carburizing, precipitation hardening, diffusion studies, recrystallisation and grain growth, heat treatment of high speed steel and stainless steels.

MT355 POWDER METALLURGY (3-0-0)3

Historical Development of Powder Metallurgy, Reasons for Using Powder Metallurgy, Advantages of Powder Metallurgy (P/M), Limitations, Applications, Metal Powder Production Methods, Production of Ceramic Powders, Microstructure Control In Powders, Powder Treatments And Handling, Pyrophoricity and Toxicity of Metal Powders, Powder Characteristics, Consolidation of Metal and Ceramic Powders, Classification of P/M Parts, Compaction Characterization, Sintering, Types of Sintering, Sintering Theory, Sintering Mechanisms, Solid State Sintering, Sintering of Multicomponent Systems, Sintering Variables, Effects of Sintering, Sintering Atmospheres and Equipment, Metallography of P/M Parts, Postsintering Operations, Testing, P/M Products: Porous P/M Parts, Sintered Carbides, Cermets, Sintered Friction Materials, Refractory Metals, Cemented Carbides or Hard Metals, Dispersion Strengthened Materials, Electrical Applications of P/M, Magnetic Materials, Structural P/M Parts; Mechanical Alloying, Metal Injection Molding (MIM) Testing, Standards and Quality Controls

Powder Metallurgy- Science, Technology and Applications, 3rd Edition, P. C. Angelo and R. Subramanian, PHI Learning Private Limited, Delhi, 2012.
Powder Metallurgy- Advanced technique of processing engineering materials, 2nd Edition, B. K. Dutta, PHI Learning Private Limited, Delhi, 2014.
Powder Metallurgy Science, 2nd edition, Randall M. German, Metal Powder Industries Federation, USA, 1994.
An Introduction to Powder Metallurgy, F. Thummler and R. Oberacker, The Institute of Materials, 1993.
ASM Handbook, Powder Metallurgy Technologies and Applications, Vol. 7, ASM International, 1998.
Powder Metallurgy, Anil Kumar Sinha.

MT356 JOINING OF METALS (3-0-0) 3

Classification of Welding Methods; Types of Welded Joints, Electrodes, Electrode Codes and Their Critical Evaluation, Welding Fluxes and Coatings - Type and Classification; Coated Electrodes, Hardfacing Electrodes,

Stainless Steel and Cast Iron Electrodes, Inconel Electrode, Fluxes, Filler Materials, Solid State Welding Processes: Forge Welding, Friction Welding, Explosive Welding, Ultrasonic Welding, Cold Pressure Welding, Hot Pressure Welding, Thermo-Compression Bonding, Diffusion Bonding; Induction Welding, Resistance Welding Processes: Resistance Spot Welding, Resistance Seam Welding, Projection Welding, Resistance Butt Welding, Flash Butt Welding, Percussion Welding, High Frequency Resistance Welding, High Frequency Induction Welding; Production of Tubes; Essential Parameters and Principles in Fusion Welding, Heat Sources for Fusion Welding, Introduction to Weld Metal and Solidification, Gas-Metal Reaction, Liquid-Metal Reaction, Solid State Reactions; Gas Welding, Arc Welding: Gas Tungsten Arc Welding Torch, Materials and Shielding Gas, GTAW Circuit and Set-Up, GTAW Operation, Joint Design, Variants of GTAW; Shielded Metal Arc Welding (SMAW/MMAW): Equipment & Material, Operation, Metal Fusion And Weld Penetration, Electrode Motions, Welding Positions, Variants Of SMAW Process; Submerged Arc Welding (SAW): Equipment, Process Variables, Variants off SAW; Gas Metal Arc Welding (GMAW): Equipment and Material, Operations and Technique, GMAW Variables Variants of GMAW; Electroslag Welding (ESW): Equipment and Material, Electrical Set-Up , Operations and Technique, Process Variables, Variant of ESW; Plasma Arc Welding [PAW]; Plasma-MIG Welding, Radiant Energy Welding Processes: Electron Beam Welding [EBW], Laser Beam Welding [LBW]; Thermit Welding; Underwater Welding; Welding In Vacuum, Welding at Low Temperature (Cryogenic Welding), Welding in Space, Robotic Welding, Welding of Wrought Iron, Copper, Aluminium, Magnesium, Titanium and Super Alloys, Welding of Dissimilar Metals, Heat Treatment of Welds, Micro and Macrostructure, Residual Stresses, Shrinkage and Distortion in Welds, Inspection and Testing of Welds, Weldability, Weld Quality and Strength, Checking and controlling weld quality, Design of Weldments, Allied Processes: Brazing & Soldering, Braze Welding, Adhesive Bonding, Surfacing, Thermal Spraying; Flame Cutting, Powder Cutting, Plasma Cutting, Laser Cutting, Electron Beam Cutting,

Principles of welding technology, 1st Edition, L. M. Gourd, Viva Books Private Limited, India,
2004 Welding Science and Technology, Ibrahim Khan, New Age International Publishers, India,
2009 Welding Processes and Technology, 3rd Edition, R. S. Parmer, Khanna Publishers, 2015
Welding Technology, 4th Edition, N. K. Srinivasan, Khanna Publishers, 2016
Metallurgy of welding, 6th Edition, J.F.Lancaster, Woodhead Publishing Limited,, Cambridge, London, 1999.
Welding & Welding Technology, Richard Little, Tata McGraw Hill, 1998.
Welding, A. C. Davies, Cambridge University Press 1996.
ASM Handbook, Volume 6.

MT357 AEROSPACE MATERIALS (3-0-0) 3

Carbon-carbon composites, production, properties and applications, intermetallic matrix composites, ablative composites based on polymers, ceramic matrix, metal matrix composites based on aluminium, magnesium, titanium and nickel based composites for engines, superalloys, aluminum alloys, magnesium alloys and titanium alloys, materials for plasma engines, intermetallic aluminides, ceramics and polymeric materials.

H. Buhl, Advanced Aerospace Materials, Springer Verlag, Berlin 1992.
Balram Gupta et.al Aerospace Materials Vol 1, 2, 3, ARDB, S. Chand& Co. 1996.

MT 400 CORROSION ENGINEERING (3-0-1) 4

Definition of corrosion, Classification of corrosion, role of microstructures on corrosion, thermodynamic and electrochemical kinetics aspects, details of Mixed Potential Theory. Effect of Galvanic Coupling Using Mixed Potential Theory. Polarization, Details of metallic Passivity, role of passivity on corrosion, role of allying elements, Types of corrosion, Tribo-corrosion, Environmental Effects, Effect of oxygen and oxidizers, Effect of Temperature, Effects of Corrosive Concentration.

High Temperature Corrosion: Oxidation of metal and alloy, hot corrosion and Mechanisms and Kinetics, High-Temperature Materials, Corrosion problems in selected industry.

Corrosion Protections: Materials Selection, Alteration of Environment and Design, Cathodic and Anodic Protection, Coatings (paints and electro-deposition) and inhibitors.

Corrosion Testing:Corrosion Rate measurement, Galvanic corrosion, Intergranular Corrosion, Pitting, Stress Corrosion, Erosion Corrosion, Tafel and Linear Polarization, AC Impedance, Mott-Schottky test, Paint Tests, Interpretation of Results, ASTMandNACE standard for corrosion testing.

Laboratory:examination ofcorrosion rate using weight loss and Tafel plot. Pitting corrosion test, Intergranular corrosion test (electrochemical etching techniques). Surface preparation method and Electro-deposition of metals.

Mars G. Fontana, Corrosion Engineering, 3rd edition, McGraw-Hill Book Company, 1986
David Talbot and James Talbot, Corrosion Science and Technology, CRC Press, New York,
1998 H. H. Uhlig and R. W. Revie, Corrosion and Corrosion Control, Wiley (NY) (1985)
K.E. Perumal and V.S. Raja, Corrosion Failures: Theory, Case Studies, and Solutions" 1st edition, John Wiley & Sons, USA
ASM Handbook Vol-13 (A, B & C)

R. G. Kelly, John R. Scully, D. W. Shoesmith, and R. G. Buchheit "Electrochemical Techniques in Corrosion Science and Engineering" 1st edition, CRC Press
Nasser Kanani "Electroplating: Basic Principles, Processes and Practice" Elsevier publications(2004)
YD. Gamburg, G Zangari "Theory and Practice of Metal Electro deposition" Springer publications (2011).

MT401 METAL FORMING **(2-0-1) 3**

Elasticity and plasticity, yield criterion theories of metal forming, hot, warm and cold working, ring compression test, temperature rise in deformation zone, superplasticity and explosive forming, force-stroke diagrams in forming, friction and lubrication in metal working processes, forging, CAD & CAM in forging, extrusion, Mannesmann mill, rolling, drawing of rods, wire and tubes, dies, optimum die angle, bulk forming and sheet metal forming, deep drawing, redrawing, limiting draw ratio, forming limit diagram, role of texture defects in sheet metal working, bending, shearing, rubber pad forming, stretch forming, electro hydraulic forming, electromagnetic forming and high energy rate forming, numerical problems and design aspects in forming.

G. E. Dieter and David Bacon, Mechanical Metallurgy, McGraw-Hill, 1988,3e.
Kurt Lange, Handbook of Metal Forming McGraw-Hill, 1985.
W. F. Harsford& R M Caddell, Metal Forming Mechanics & Metallurgy, Prentice Hall, USA, 1993, Second Edition. B. Avitzur, Handbook of Metal Forming Processes, John Wiley, New York, 1983 Metals Handbook Vol. 14, Forming and Forging, ASM Metals Park, Ohio, 1988.
T Altan, Metal Forming-Fundamentals and Applications, ASM Metals Park, Ohio, 1983.

MT402 FOUNDRY TECHNOLOGY **(2-0-1) 3**

Patterns, sand moulding, cores and core materials, sand compaction, sand reclamation, moulding equipment, foundry layouts, furnaces and mechanization of foundries. Melting and pouring practices. Gating Systems; design of sprue, risers, and runners. Metallurgy of cast irons; White, Grey, Malleable, Ductile irons, ADI.
Demonstration of sand testing; moisture content, clay content, permeability, sieve analysis, compressive and shear strengths of moulding sand, shatter index, mould hardness.
Demonstration of green sand moulding process, Melting and pouring of aluminium alloy, Study of casting defects.

J. Campbell, Castings, Butterworth, 1991
Heine and Rosenthal, Principles of Metal Casting, McGraw Hill, 1955
H.W. Taylor, M.C. Flemings, J. Wulff, Foundry Engineering, Wiley, 1959

MT403 PHASE TRANSFORMATIONS **(3-0-0) 3**

Thermodynamic concepts, homogeneous and heterogeneous transformation, nucleation and growth, growth kinetics, Johnson-Mehl and Avrami models, precipitation hardening, modern theories of precipitation hardening, crystallography and morphology of precipitates, typical age hardening alloys, martensitic transformation, morphological features, crystallographic features, kinetic features, phenomenological theories of martensitic transformation, martensitic transformation in-Tl, Fe-Ni and Fe- C alloys, pearlitic transformation, order-disorder transformation, short range order, long range order, degree of order, experimental methods to study ordering, dependence of order parameter on temperature, change of property with ordering, recovery, recrystallisation and grain growth, secondary recrystallisation, anelasticity and internal friction, thermo-elastic effect, interstitial diffusion, Snoek effect, Kahn's torsion pendulum, relaxation time, measurement of damping capacity.

R.E.Reed-Hill and R. Abbaschian, L Abbaschian, Physical Metallurgy Principles, 4th Ed., PWS Publishing Co., 2008.
V. Raghavan, Solid State Phase Transformations, Prentice Hall of India Pvt. Ltd, 1987. D.A.Porter and KE.Easterling,Phase Transformation in Metals and Alloys, Chapman & Hall, 1992. Anil Sinha, Physical Metallurgy Handbook, McGraw Hill, 2002
D E Laughlin & K Hono, Physical metallurgy, 5thed, Kindle Ed, 2014.
H Bhadeshia& R Honeykombe, Steels: Microstructure and Properties, 4th ed., Kindleed, 2016.

MT404 EXTRACTION OF NON-FERROUS METALS **(3-0-0) 3**

Silver: sources, extraction by cyanidation, refining; gold: sources, concentration methods, gold recovery, refining; chromium: occurrence, production; cadmium: sources, extraction, recovery from secondary sources; mercury: sources, extraction from cinnabar; uranium: ores, processing of uranium ores, solvent extraction, reduction, production in India; thorium - sources, extraction and its purification; beryllium: types of ore, production, zirconium: sources, extraction and its refining, separation of Zr and Hf, fabrication of zirconium, production of zirconium in India; titanium: sources, beneficiation methods of illmenite, production of titanium tetrachloride, the Kroll process;

molybdenum: production of powder and ductile Mo; tungsten: ores, concentration methods, production of tungsten trioxide; production of tungsten powder and ductile tungsten; tin: types, smelting of tin concentrates, refining of tin.

H.S.Ray A.SridharandK.P.Abraham, Extraction ofNonferrousMetals,1985,EWP,NewDelhi.
Sevryukov N., Nonferrous Metallurgy, 1975, Mir, Moscow.
W.H.Dennis - Metallurgy of the Non-Ferrous Metals, Ed.2, 1966, Pitman, London.

MT405 SECONDARY REFINING OF STEELS (3-0-0) 3

Introduction, unit processes in secondary steelmaking viz stirring, slag control, refractories and atmosphere control: ladle furnace method; ladle injection metallurgy, vacuum treatment of liquid steel: priniciples, processes viz ladle, stream and circulation degassing methods, stainless steel making technology - VOD, AOD and CLII processes, remelting, refining processes - ESR and VAR processes.

R.H.Tupkary, Modern Steelmaking, Khanna Publishers, New Delhi, 1996
R.G.Ward, An Introduction to the Physical Chemistry of Iron and Steel making, ELBS, London, 1962 V.Kudrin, Steel Making, Mir Publication, Moscow, 1985

MT406 PROCESS PLANT MATERIALS (3-0-0) 3

Selection of process materials, fabrication, mechanical properties and strength of materials, effect oftemperature on mechanical properties, testing and inspection of materials, properties and uses of ferrousmetals, cast iron, plain carbon steels, thermal and electrical insulating materials, non- ferrous metals and alloys, general properties and fields of application of non-ferrous metals, plastics as materials of construction for chemical plant, corrosion resistance, uniform corrosion, galvanic corrosion, pitting, intergranular corrosion, effect of stress, erosion corrosion, high temperature oxidation, hydrogenembrittlement, selection for corrosion resistance, corrosion charts, design for corrosion resistance.

William F. Smith, Principles of Material Science and Engineering, McGraw Hill Book Co,1990.
Vernon John, Engg Materials, 3rd Edition, Macmillan, 1992.
William D. Callister, Materials Science &Engg., 4th Edition, John Wiley, 1997.

MT407 ADVANCED ENGINEERING MATERIALS (3-0-0) 3

Metals for high temperature service, Ti and Zr alloys, Ni and Co based super alloys, rapid solidification, metallic glasses, production, properties and applications, liquid crystals: production, properties and applications, composite materials, mechanics of composite materials, dispersion strengthening, metal matrix composites, special steels, maraging steels, trip steels, patenting, interstitial free steels, smart materials, shape memory effect, principles, pseudoelasticity, applications, nano technology, nano materials.

R. E. Reed Hill & Reza Abbaschian, Physical Metallurgy Principles, 3rd Edition, 1994 PWS Publishers USA.
W. E. Smith Structure & Properties of Engineering Alloys McGraw Hill, 1993 F.L. Matthews & R. D. Rawlings, Composite Materials Engg. & Science, 1994 K. K. Chawla, Composite Materials, 2nd Edition, Springer - Verlag 2001

MT408 THIN FILMS, COATINGS AND APPLICATIONS (3-0-0) 3

Need for miniaturization, Basics of thin film, Brief review of kinetic theory of adsorption, desorption, film growth: nucleation and growth kinetics. Vacuum science and technology, vacuum pumps, surface: role of substrate surface, substrate cleaning. Epitaxy, thin film growth control, physical vapor deposition (PVD) processes, evaporation: thermal and e-beam. Principles of glow discharge and various sputtering processes. Fundamentals of Chemical Vapor Deposition (CVD) processes. Pulsed laser deposition (PLD), other techniques: electro-deposition, spin coating, sol-gel, Langmuir Blodgett (LB) techniques, SILAR technique, Doctor blade technique, printing. Hard coating: physical, mechanical and protective properties, basic thin film thickness measurement, microstructural characterization of films/coating. Thin film devices: optoelectronic devices, photo-detectors, solar cells. Applications: high hardness, corrosion resistance, biocompatibility and high temperature stability.

Milton Ohring, Materials Science of Thin Films, 2nd Edition, Academic Press, 2001 Hartmut Frey and Hamid R Khan, Handbook of Thin Film Technology, Springer,2016
K. L. Chopra & L. K. Malhotra, Thin film Technology and Application, Tata McGraw-Hill, 1985 Peter M. Martin, Handbook of Deposition Technologies for Films and Coatings, Elsevier, 1994 Sam Zhang, Nanostructured Thin Films and Coating, CRC Press, 2010
Narendra B. Dahotre and T.S. Sudarshan, Intermetallic and Ceramics Coatings, Mercel Dekker Inc.,
1999 L. Tushinsky, I. Kovensky, A. Plokhov, V. Sindeyev, P. Reshedko, Coated Metal, Springer, 2002.

MT409 NUCLEAR MATERIALS (3-0-0) 3

Structure of a nuclear power plant, requirements of reactor materials, fuel materials, plutonium uranium and thorium and their alloys & compounds, core materials: beryllium, graphite, control and shielding materials, magnesium & its

alloys, aluminium & its alloys, zirconium & its alloys, austenitic stainless steel; materials for reactor vessel and other components, pearlitic steels, ferritic, chromium stainless steels, copper alloys, titanium and its alloys, coolants used in reactors: radiation embrittlement, corrosion of reactor materials, mechanical properties of materials.

V.Gerasimov& A. Monakhov, Nuclear Engineering Materials, Mir Publishers, Moskow, 1983.
D.S.Clark& W.R Varney, Physical Metallurgy for engineers, East West Press, New Delhi,
1987 C.M.Srivatsava&C.Srinivasan, Science of engineering Materials, 1997, New Age
International.

MT410 FRACTURE OF ENGINEERING MATERIALS (3-0-0) 3

Failure and their causes - techniques of failure analysis, conventional design concepts, inadequacies of conventional design, mechanics of fracture, theoretical cohesive strength, Griffith theory of fracture, Irwin-Orowan modification, concepts of G and R, relation between G and rate of change of compliance, crack tip stress fields, stress intensity factors, relation between G and K, fracture toughness: determination of fracture toughness, ASTM standards; crack tip plasticity, plastic enclaves and their effect on energy release rate, concept of plastic zone criterion, R curve concept, J Integral, COD criterion, brittle and ductile fractures, fatigue crack growth and fracture mechanics, stress corrosion cracking, liquid metal embrittlement, hydrogen embrittlement, microscopic aspects of cleavage crack propagation, plastic relaxation at crack tip, nucleation of cleavage cracks by plastic deformation, crystallographic mechanism, initial growth and propagation, ductile - brittle transition; designing and testing for fracture resistance, principles of fracture safe design, testing procedure, designing steels for fracture resistance, improved toughness in ceramics, composites, case studies in failure analysis.

D. Broek,Elementary Engineering Fracture Mechanics, Springer, 2012.
J.F.Knott, Fundamentals of Fracture Mechanics, Butterworths, 1973.
S.Teteleman&A.J.McEvily, Fracture of Structural Materials, John Wiley and Sons, 1967.

MT440 PRACTICAL TRAINING 1

This course is a 2 credit course. A student may complete the training before the beginning of 7^{th} semester (or as stipulated by DUGC) and register for it in 7^{th} Semester. The duration and the details shall be decided by the faculty advisor, with approval from DUGC.

MT441 SEMINAR 1

This course is a 1 credit course to be completed during 7^{th} / 8^{th} semester. The student will make presentations on topics of academic interest.

MT442 MAJOR PROJECT – I (0-0-2) 1

MT451 COMPOSITE MATERIALS (3-0-0) 3

Reinforcements, whiskers, matrix materials, polymers, metals, ceramics, interfaces: wettability, crystallographic nature, interactions, types of bonding: processing, thermoset matrix composites, thermoplastic matrix composites, structure and properties, structural defects, mechanical properties applications, processing: liquid-state processes, solid state processes, properties, thermal characteristics, aging, fatigue and creep applications, electronic-grade MMCs, ceramic matrix composites: processing, infiltration, directed oxidation properties, toughness, thermal shock resistance, applications- cutting tool inserts, ceramic composite filters.

K. K. Chawla, Composite Materials, Springer, New York, 1998
Mallick, P.K, Composite Materials Technology: Process and Properties, Hanser, New York, 1990
D. Hull and T.W.Clyne, An Introduction to Composite Materials, Cambridge University Press,
1996.

MT452 ADVANCED WELDING TECHNOLOGY (3-0-0) 3

Arc Characteristics: Cathode Spot, Cathode Drop Zone, Arc Column; Arc Efficiency; Arc Blow; Types of Welding Arcs, Arc Initiation; Arc Maintenance, Electrode Polarity, Arc Stability, Arc Temperature, Metal Transfer, Welding Machine Characteristics - Conventional and Pulsed Power Sources, Inverter Type, Power Sources for Resistance Welding, Fusion Welding Process Variables, Gases in Weld Metal, Weld Thermal Cycle, Heat flow in welding - Significance, Theory of Heat Flow, Cooling Rate Determination, Selection of Welding Parameters Based on Heat Flow Analysis, Heat Flow Equations, Characteristics of Weld Solidification, Thermal Gradients and Turbulence in the Melt, Geometry of Weld Melt, Epitaxial Solidification, Crystal Growth and Segregation, Cellular and Dendritic Solidification in Welds, Refining of Weld Structure, Phase Transformation During Weld Metal Cooling, Role of Alloying and Slag Inclusions, Weld Metal Toughness, Heat Affected Zone: The Base Material, Carbon Equivalent, Heating Cycle, Recrystallization, Phase Transformation, Precipitate Stability, Coarsening, Dissolution During Weld Thermal Cycle, Grain Growth; Reactions at The Fusion Line, Hardness Measurements, Multi Run Welds, Cracking

and Fracture in Welds, Special Welding Techniques: Electron Beam Welding, Laser Welding, Ultrasonic Welding, Numerical Problems in Welding, Residual Stresses in Welds and Their Measurements, Weld Defects, Fracture and Failure of Welds, Welding codes, Fracture Toughness Testing and Its Application to Welded joints, Determination of Preheat temperature, Use of Schaefflers Diagram, Weldability Tests, Weldability of Plain Carbon Steels, Low Alloy Steels, Stainless Steels, Tool Steels, Cast Iron.

Welding Processes and Technology, 3rd Edition, R. S. Parmer, Khanna Publishers, 2015
Metallurgy of welding, 6th Edition, J.F.Lancaster, Woodhead Publishing Limited,, Cambridge, London, 1999
Introduction to the Physical Metallurgy of Welding, 2nd Edition, Kenneth Easterling, Butterworth Heinemann, 1992
Principles of welding technology, 1st Edition, L. M. Gourd, Viva Books Private Limited, India, 2004
Welding Science and Technology, Ibrahim Khan, New Age International Publishers, India,
2009 Welding and Welding Technology, Richard L. Little, Tata McGraw Hill, 2004.

MT453 SURFACE ENGINEERING (3-0-0) 3

Current status of surface engineering, fundamentals of electrode position, electroless plating, metalliding, hard anodizing, carburizing, nitriding, carbonitriding, flame hardening, induction hardening, thermal evaporation, sputter coating, ion plating electron-beam surface treatments, electron- beam hardening, laser hardening, ion implantation, hardfacing processes: shielded metal arc welding, gas tungsten arc welding, gas metal arc welding, flux cored arc welding, submerged arc welding, plasma arc welding, oxyacetylene welding, furnace fusing, thermal spray processes.

Kenneth G.Budinsk, Surface.Engineering for Wear Resistance, Prentice Hall, New Jersey, 1988 P.K.Datta&lS.Gray, Surface Engineering, Vol. I, II, & III, Royal Society of Chemistry; 1993 J.S.Burnell -Grayand, P.K.Datta, Surface Engineering Casebook- Solutions to Corrosion and Wear- related Failures, Woodhead Pub., 1996.

MT454 MODELLING AND SIMULATION IN MATERIALS PROCESSES (3-0-0) 3

Introduction to modelling, simulation models, Casting process: modelling of heat transfer, direct heat conduction modelling, one- dimensional and multidimensional inverse modelling, fluid flow and heat transfer model, thermodynamics of solidification, metal/mold interfacial heat transfer, deformation and stresses in castings, thermo-mechanical modelling in casting, determination of heat transfer coefficient and air gap width in permanent mould castings, continuous casting and DC casting process, Welding process: weld heat -source models, thermal analysis with-microstructure, transient fluid flow, residual stresses in welds, Heat treatment: metal quenchant, interfacial heat transfer, diffusion model, microstructure model, carburization model, quench crack simulation, creep simulation, Modeling of rolling, forming and extrusion processes, Artificial Neural Networks in materials processing, Phase-field modeling and Monte-Carlo simulations, introduction to commercially available softwares - Solid Cast, FIowCast, OptiCast,.Deform HT, ProCast, MagmaSoft, Design of experiments and factorial designs.

Modeling in Welding, Hot Powder Forming and Casting (Eds. L. Koarlsson), ASM, MaterialsPark,OH, 1997. Szekely,J.,Evans, J.E.and Brimacombe, J.K., The Mathematical and Physical Modelling of Primary Metal processing Operations, Wiley, 1988.
Numerical Recipes: The Art of Scientific Computing, Cambridge Univ. Press, N.Y., 1988.
D.R. Poirier and G.H. Geiger: Transport Phenomena in Materials Processing, TMS, warrendale 1994.
R.I. L. Guthrie: Engineering in Process Metallurgy, Oxford Science Publications (1989).

MT455 SCIENCE & TECHNOLOGY OF NANOMATERIALS (3-0-0) 3

Introduction: Definitions, Classification, Fundamental principles, Fullerences, nanoparticles, nanoclusters, nanowires, nanotubes, nanolayers, nanopores, supramolecules.

Synthesis: Top-down and bottom-up approaches, Plasma arcing , Chemical vapor deposition, Electro-deposition, Sol-gel synthesis, High energy ball milling, Nanolithography , Self-assembly , Langmuir-Blodgett films, Electrospinning.

Characterization: Particle size and surface area determination, IR and Raman Spectroscopy, X-ray photoelectron spectroscopy, scanningtunnelling Microscopy, Atomic force microscopy.

Properties : Size dependence of properties, such as Electrical, Physical, Optical, Chemical.

Applications:Nanomachines and nanodevices, nanocomposites, 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.
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.

MT456 ADVANCED MICROSCOPIC TECHNIQUES (3-0-0) 3

SEM-Review of electron optics, Electron specimen interactions, image formation and interpretation, High resolution

imaging, WDS and EDS, Quantitative x-ray analysis, compositional mapping, Sample preparation for inorganic, organic, hydrated and biological materials.
TEM-Review of electron optics, reciprocal space and electron diffraction, sample preparation, diffraction from crystals and small volumes, diffraction patterns and their indexing, Kikuchi diffraction, CBED, Amplitude contrast and phase contrast, Thickness and bending effects, defects and their visualisation, High resolution TEM, Quantitative analysis using TEM. Concept of EELS, STEM, XPS, Auger microscopy, SIMS, etc.
Scanning electron microscopy and X-ray analysis: J.I Goldstein et al. Plenum press, (Second or higher ed), 1992
Transmission electron microscopy: D.B. Williams & C B Carter, Springer,
2009 Electron microscopy- S. Amelincky et al. VCH publ., 1997.

MT457 SMART MATERIALS AND SENSORS (3-0-0) 3

Inorganic: solid electrolyte sensor, oxygen sensors, hydrogen sensors, sulfur and sulfur containing gas sensors, humidity sensors, gas sensitive resistors, surface acoustic wave sensors, catalytic gas detectors, semiconductor junction devices, organic: semiconductor gas sensors, surface Plasmon resonance sensors, mass-sensitive sensors optical chemical sensors, electro chemical sensors, future prospects, automotive sensors: ceramic sensors, silicon sensors, chemical sensors for hostile environments, Piezoelectric sensors, actuator materials, micromechanics, chiral materials, conducting and chiral polymers, electrochromic materials, liquid crystals, molecular level smart materials, bio materials, composites, ceramics processing and fabrication, interface science, optical fibers, optical mirrors, smart skins for drag and turbulence control, other applications in aerospace/hydrospace structures, transportation vehicles, manufacturing equipment.
J. of Smart, Materials and Structures, Back volumes, Institute of Physics, Polishing Bristol, U.K.
L.Dai, Intelligent Macromolecules for Smart Devices, Springer, 2002.

MT492 MAJOR PROJECT – II (0-0-6) 3

MT493 CORNERSTONE/CAPSTONE PROJECT (0-0-6) 4

For details refer to clause 3.2 under Regulations specific to Undergraduate Programmes.

UC100 INTRODUCTION TO DESIGN THINKING (2-0-0) 2

Need and Definition of Design Thinking. Framework for Design Thinking. Engineering Design Process. Need Identification, Specification, Concept Generation, Product Architecture and Detailed Design. Prototyping – Virtual and Physical. Testing Methodology
Christian Muller-Roterberg, "Handbook of Design Thinking", 2018
Eli Woolery, "Design Thinking Handbook" Invision Pub, 2019
Nigel Cross, "Design Thinking"
Max Answell "Mastering Design Thinking", 2019
Karl T. Ulrich, Steven D. Eppinger and Maria C Yang, "Product Design and Development", McGraw Hill, 7ed, 2020
George e Dieter, Linda C Schmidt, "Engineering Design", Mc Graw Hill, 4ed, 2009

UC401 LIBERAL ARTS COURSES/CO-CURRICULAR/EXTRACURRICULAR ACTIVITIES 10

CATEGORY A : Maximum 3 credits, CATEGORY B : Maximum 3 credits, CATEGORY C : Minimum 4 Credits and Maximum 7 credits.
10 Credits have to be earned from 1st Semester to 7th Semester by choosing Category (A + B + C) OR Category (A + C) or Category (B + C) courses combination . Registration for 10 Credits has to be done in 7th Semester.
For details of CATEGORY A, CATEGORY B and CATEGORY C refer to clause 3.2 (f) under Regulations specific to Undergraduate Programmes.

Department of Mining Engineering

MI101 INTRODUCTION TO MINING ENGINEERING (3-0-0)3

Introduction to Indian Mining Industry, National and International Scenario, Unit Opeartions-Drilling, Blasting, Excavation , Transportation , Size reduction.Introdction to Mining Methods Environmental Impacts.Safety.

Deshmukh D.J Elements of Mining Engineering Vol.I Central Techno Publications Naqgpur, 1998

Hartman H.L –Intoductory Mining Engineering , Wiely Interscience, New York, 1987

Mishra , G.B, Surface Mining Dhanad Publishers, Dhanbad , 1994

MI201 DEVELOPMENT OF MINERAL DEPOSITS (3-0-0)3

Methods of shaft construction, Widening and deepening of shafts. Special methods of shaft sinking under difficult conditions. Methods of raising. Drivage of horizontal openings: Conventional and mechanized systems. Tunneling under difficult conditions. Supports: supporting roadways and mine faces using timber, steel (friction and hydraulic); Roof bolting and roof stiching. Over view of mining industries and relevant mining laws.

Tatiya R.R., Surface and underground excavation: methods, techniques and equipment, A. A. Balkema publishers, 2005.

Deshmukh, D. J., Elements of Mining Engineering, Vol. I, Central Techno Publications, Nagpur, 1998.

Onika D., Design of Mine Excavations, Mir Publishers, Moscow, 1973.

Pokrovskiy., Driving of Horizontal Workings, Mir Publishers, Moscow, 1992.

MI202 MINE SURVEYING (3-1-0)4

Principles of mine surveying and its scope. Plane and geodetic surveying. Compass surveying. Leveling. Theodolites: Construction and operation. Tests and adjustments. Angle measurement. Errors in measurement. Traversing. Balancing of traverse. Calculation of coordinates and plotting. Contouring, Interpolation of contours. Calculation of areas and volumes. Dip, fault and borehole problems.

Punmia, B. C., Surveying Vol- I & II, Laxmi Publishers, New Delhi, 2008.

Kanetkar, T.P., Suveying, Vol- I & II, Tata McGraw Hill, New Delhi, 2007.

Ghatak, S., Mine Surveying and Levelling – Vol I, II & III, Coal Field Publishers, Asansol, 2005.

MI203 MINE SURVEYING LAB (0-0-3)2

A total of 10 to 12 experiments shall be carried out pertaining to the subject.

MI210 DRILLING & BLASTING ENGINEERING (3-0-0)3

Applications of drilling in mining industry. Classification and mechanism of rock drilling methods. Different types of drill machines. Alignment and deviation of bore holes. Factors influencing drilling in percussive and rotary methods. Developments in explosives and initiating devices. Properties of explosives. Safety aspects. Exploders & Circuit testers.

Das, S. K., Explosives and Blasting Practices in Mines, Lovely Prakashan, Dhanbad, 2001.

Pradhan, G. K. & Sandhu, M. S., Blasting Safety Manual, 2002

Deshmukh D.J. Elements of Mining Technology Vol. I; Vidyasewa Prakashan, Nagpur, 1994

Chug, C. P. Manual of drilling Technology, Oxonian Press Pvt. Ltd., Delhi, 1985.

MI211 SEABED MINING (3-0-0)3

Resources from the seabed. Exploring and extraction of minerals from seabed. Comparison of seabed mining with traditional in-land mining. Mining systems - hydraulic mining, continuous line bucket (CLB) mining, modular or shuttle mining systems. Alternative systems for deep sea mining, transport and processing. Ore transfer technology. Environmental impact of seabed mining. Economics. Indian scenario - phase wise development of seabed mining. Vessels for conducting survey, research and extraction of ore reserves.

Hartman, H.L., Introductory Mining Engineering; Wiley Interscience, New York, 1987.

Manjula, R. Shyam, Metals from the seabed: Prospects for Mining Polymetallic Nodules of India. Oxford & IBH Publishing Co., New Delhi, 1982.

MI251 MINE ENVIRONMENT & VENTILATION ENGINEERING (3-1-0)4

Mine gases. Mine illumination. Heat and humidity. Cooling power of mine air. Air conditioning. Airflow in mines. Natural and mechanical ventilation. Ventilation networks. Computer aided design of ventilation systems.

Mishra, G.B. – Mine Environment and Ventilation; Oxford University Press, Delhi, 1986.

Vutukuri, V.S. & Lama, R.D. – Environmental Engineering in Mines; Cambridge University Press, Cambridge, 1986.

Harsha Vardhan –An Introduction to Underground Mine Environment and Ventilation available online atNPTEL website

Hartman, H. L. –Mine Ventilation & Air Conditioning; John Wiley & Sons; New York, 1982.

MI252 MINE ENVIRONMENT& VENTILATION ENGINEERING LAB (0-0-3)2

A total of 10 to 12 experiments shall be carried out pertaining to the subject.

MI253 APPLIED MINE SURVEYING LAB (0-0-3)2

A total of 10 to 12 experiments shall be carried out pertaining to the subject.

MI254 MINING MACHINERY (3-1-0)4

Basic principles of transport of men, materials and mineral in underground mines. Techno- economic indices of transportation systems. Pit top and pit bottom lay outs. Motive power used in mines. Types of compressors used in mines. Wire ropes: construction, classification, application, inspection, maintenance and calculations. Capping and slicing of ropes. Suspension gear for drum and Koepe winding. Rope haulages: Types, principle of operation, suitability, safety appliances, calculations. Winding: Drum winding and Koepe winding, Braking systems – mechanical and electrical. Man riding systems. Drainage and Pumping. Sumps.

Ramlu M.A. Mine Hoisting. Oxford & IBH. New Delhi 1996.
Walker S.C. Mine Winding and Transport. Elsevier, Amsterdam 1988.
Deshmukh D.J. Elements of Mining Technology Vol. III; Vidyasewa Prakashan, Nagpur, 1994
Reese, C., Material Handling Systems: Designing for Safety and Health, CRC Press, 2000.

MI255 INDUSTRIAL TRAINING IN MINES-1 (0-0-0)1

Industrial training should be taken up at the end of III semester, preferably in surface mines. Relevant information pertaining to the development and extraction of mineral deposits by surface mining methods, details of different equipments, layouts and other techno-economic data should be collected. Information regarding safety aspects, man-power, production and productivity, management practices and environmental protection measures should also be included in the report.

MI260 APPLIED MINE SURVEYING (3-0-0)3

Triangulation: Station marks, signals and towers. Satellite station and reduction to center. Tacheometry: Tangential method and movable bar method. Curve ranging: Different methods of curve ranging. Laying of curves in underground. Aerial photogrammetry, Field astronomy, Correlation survey: Connection of underground and surface survey. Total station. GPS. DGPS. Introduction to Terrestrial Laser Scanner and Drone Surveying.

Punmia, B. C. Surveying Vol- I, II& III, Laxmi Publishers, New Delhi, 2008.
Kanetkar, T.P. Suveying, Vol- I, II& III, Tata McGraw Hill, New Delhi, 2007.
Ghatak, S., Mine Surveying and Levelling – Vol I, II & III, Coal Field Publishers, Asansol, 2005.
Operational Manuals of Lawrence & Mayo, Bangalore.

MI261 ELECTRICAL MACHINERY IN MINES (3-0-0)3

Three-phase circuit analysis, magnetic circuits, transformers, transformer losses, tests on transformers, electromechanical energy conversion, direct current motors and generators, induction motors, synchronous motors, control of speed and torque of DC and AC motors, intrinsically safe and flame-proof equipment, design of substations, switchhouses and power centers, power distribution systems in surface and underground mines, legislative and safety aspects.

Morley, L.A., Mine Power Systems, US Bureau of Mines Information Circular 9258, 1990.
Gross, C. A., Electric Machines, 1st Edition, CRC Press, 2006.
Kothari, D.P. and Nagrath, I.J., Electric Machines, 5th Edition, McGraw Hill, 2017.

MI301 SURFACE MINING TECHNOLOGY (3-1-0)4

Status and scope of surface mining. Elements of surface mining. Unit operations – Drilling, Blasting, Excavation and Transporting. Details of principal production equipment. Layout of workings and waste dumps. Environmental management and reclamation in mines. Operational details of major surface mines with special reference to coal, lignite, iron, limestone etc. Techno-economic evaluation of surface mining projects. Problems in deep mining.

S.K. Das, Surface Mining Technology, Lovely Prakashan, Dhanbad, 1984.
Misra, G.B., Surface Mining, Dhanbad Publishers, Dhanbad, 1994.
Deshmukh, D. J. Elements of Mining Technology, Vol. I, II & III, Central Techno Publishers, Dhanbad, 1988.

MI302 MINE HAZARDS, RESCUE AND RECOVERY (3-1-0)4

Spontaneous combustion. Surface and underground fires. Fire extinguishers. Isolation/Explosion proof stopping. Reopening of sealed off areas. Mine explosions. Inundation. Approaching water logged areas and old workings.

Water dams and design. Rescue & recovery equipment's for use in mines. Rescue organization. Examples of major mine disasters in India & abroad.

Ramlu, M.A. Mine Fires, Explosions, Rescue, Recovery & Inundations; Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 1991.

Rakesh &Lele, M.G. Inundation in Mines; Mrs. Asha Lata, Varanasi, 1970.

MI303 UNDERGROUND COAL MINING TECHNOLOGY (3-1-0)4

Status and scope of underground coal mining. Classification of coal reserves. Opening up of deposit. Horizon mining. Basic coal mining methods. Bord and pillar mining: development & depillaring with semi-mechanised and mechanized board and pillar mining. Longwall mining. Thick-seam mining: Classification of thick seam mining methods, inclined slicing with caving; sub-level caving. Hydraulic Mining. Underground gassification of coal.

Singh, R.D. Principles and Practices of Modern Coal Mining, 1997.ISBN 81-224-0974-1

Singh, T.N. Underground Mining of Coal, Oxford & IBH, 1992.

MI304 INDUSTRIAL TRAINING IN MINES - II (0-0-0)1

Industrial Training – II should be taken up at the end of IV semester, preferably in underground coal mines. Relevant information pertaining to the development and extraction of coal by underground mining methods, details of different equipments working in the mines and their operational information, layouts and other techno- economic data, information regarding safety aspects, man-power, production and productivity, management practices and environmental protection measures should be included.

MI310 NOISE POLLUTION AND CONTROL ENGINEERING (3-0-0)3

Basics of sound. Frequency analysis. Equipment's used for noise measurement. Various standards in India & abroad on noise exposure. Effects of noise exposure. Community noise. Industrial noise control & hearing testing. Environmental noise measurement. Noise measurement & control of HEMM, Coal handling & preparation plants, Jackhammer drills. Noise control measures for DG sets. Human vibration:measurement, control and standards. Health effect of vibration-Handarm and Whole-body vibration. Parameters influencing human response to vibration.

Harris, C.M : Handbook of Noise Control, McGraw- Hill Book Company, 1979.

Albert Thumann & Richard K. Miller : Secrets of Noise Control, The Fairmont Press, Georgia, 1976.

ISO 2631-1: Mechanical vibration and shock-Evaluation of human exposure to whole-body vibration-second edition 1997-05-01.

MI311 ROCK REINFORCEMENT ENGINEERING (3-0-0)3

Roof bolting. Cable bolting. Shotcreting. Cavability of rocks – effect on supports design. Longwall supports. Lining of tunnels and shafts. Yieldable arches and ring sets. Reinforcement of pillars. Stabilization of slopes. Roof convergence. Stope closure. Back filling, Mechanical behavior and monitoring of various supports. Capital investment for supports, cost control process.

Biron, C and Ariglu, E., Design of Supports in Mines, John Wiley & Sons, 1983.

Britton, S.G., Construction Engineering in Underground Coal Mines, SME, 1983.

MI312 MINE POWER SYSTEMS (3-0-0)3

Electric power in mining, three-phase circuit analysis, mine power system components, distribution of electrical power in surface and underground mines, grounding systems, ground wire monitoring, distribution cable construction and selection, power flow calculations, power factor correction, design of substations, switchhouses and power centers, method of symmetrical components, mine power system fault analysis, transients and overvoltages, protective equipment and relaying, legislative and safety aspects.

Morley, L.A., Mine Power Systems, US Bureau of Mines Information Circular 9258, 1990.

Stevenson, W.D., Elements of Power System Analysis, 4th Edition, McGraw Hill, 1982.

Kothari, D.P. and Nagrath, I.J., Modern Power System Analysis, 4th Edition, McGraw Hill, 2011.

MI351 UNDERGROUND METAL MINING TECHNOLOGY (3-1-0)4

Development and opening up of underground deposits. Choice and suitability of entries. Draw points and ore passes. Different methods of stoping. Problems encountered in deep mines and measures to tackle them. Introduction to solution mining and in-situ leaching. Case studies from Indian Mines.

Hartman, H.L. Introductory Mining Engineering. John Wiley & Sons, 1987.

Hustrulid, W.A., SME Handbook on Metalliferous Mining, 1985.

Niosh Snowden, Geological and Mining Reports of Underground Metal Mining: VolumeII, Wide Publishing, India, 2016.

Ratan Raj Tatiya , Surface and Underground Excavations, 2nd Edition : Methods, Techniques and Equipment, Taylor & Francis Ltd , *London, United Kingdom, 2013.*

MI352 ROCK MECHANICS (3-1-0)4

Physical properties, Physico-mechanical properties of rocks, Elastic constants under static and dynamic loading. Determination of in-situ strength properties of rocks and Nondestructive testing, Analysis of stresses and strains. Mohr's representation of stress and strain. Stress – strain relations. Behaviour of rocks under stress.Engineering classification of rock mass, Rock fracture mechanics. Stress distribution around different mine openings.

Obert, L. & Duvall, W.I.- Rock Mechanics and design of structures in rock; John Wiley & Sons, New York, 1967.
Wittke, W., Rock Mechanics, Springer-Verlag, Berlin, 1990.

MI353 ROCK MECHANICS LAB (0-0-3)2

A total of 10 to 12 experiments shall be carried out pertaining to the subject.

MI354 MINE SYSTEMS OPTIMIZATION (3-1-0)4

Introduction to systems concept, analysis and systems engineering; models in system analysis; linear programming; integer programming; network techniques for mining projects; CPM and PERT techniques; dynamic programming; transportation and assignment models; decision theory; inventory control; queuing theory; simulation techniques for equipment selection and production scheduling; significance of management information systems in controlling and managing the mining activities.

Sharma, J.K., Mathematical Models in Operations Research, Tata Mcgraw-Hill, New Delhi, 1989.
Cummins, A.B., Mining Engineers Handbook, Vol. II, SME, AIME, New York, 1973.
Taha, H.A., Operations Research: An Introduction, 8th Edition, Pearson, 2006.

MI355 INDUSTRIAL AND PROFESSIONAL PRACTICE (0-0-0)1

Mine camp to be held at the end of V semester. Relevant information pertaining to the development and extraction by mining methods, details of different equipments working in the mines and their operational information, layouts and other techno-economic data, information regarding safety aspects, man-power, production and productivity, management practices and environmental protection measures should be included in the report.

MI356 INDUSTRIAL TRAINING IN MINES – III 1

A detailed report of the industrial training undergone at the end of VI semester, preferably in underground metal mines, should be submitted. The report should consist of all details about opening up of the deposit, development and stoping techniques, specifications and operational details of equipment working in the mine, ventilation scheme, power distribution, safety aspects, management practices and environment protection measures and the relevant lay outs. Current techno-economic indices should be a part of the report.

MI360 MINE HEALTH AND SAFETY ENGINEERING (3-0-0)3

Mine accidents, Accident analysis and prevention, Accident report, Risk assessment & preparation of safety management Plan. Safety audits. Occupational hazards in mines, Hazard analysis. Hazard control by engineering approach, Hazard control by system approach. Economics of safety and cost-effectiveness. Occupational health and safety, Occupational diseases, Problems of safety and health in contractual work, Behavior based safety, Ergonomics and its application in mining.

Ridley, J & Channing, J.; Safety at Work; Butterworth-Heinemaan, Oxford, 2001.
L.C. Kaku: A Study of Mine management, Legislation & General Safety
S. Ghatak: A Study of Mine management, Legislation & General Safety
C.P. Singh: Occupational safety and health in Industries and mines

MI361 ADVANCED SURFACE MINING TECHNOLOGY (3-0-0)3

Analysis of elements of surface mining operations. Classification of surface mining equipment systems vis-à-vis unit operations. Equipment selection criteria and procedures, application and selection. Types, basic operations, maintenance and capacity utilization, applicability and selection considerations. Computations for the capacity and number of machines vis-à-vis mine production. Dump planning. Minimization of adverse impacts and maximization of use of mineral resources. Cost Estimation. Conversion of old underground workings into surface mines.

Amithosh Dey, Latest Development of Heavy Earth Moving Machinery, Annapurna Publishers, Dhanbad, 1995. Martin, J. W., Martin T. J., Bennett, T. P. &Martin,K. M. Surface Mining Equipment, Martin Consultants Inc., USA, 1982.

(3-0-0)3

MI362 PRODUCTION DRILLING FOR OIL WELLS

Geography of petroleum and natural gas. Characterization of crude and natural gas deposits. Well logging. Interpretation and use of information in petroleum and natural gas engineering. Drilling technology for mining of crude and gas. Well completion and stimulation.

Chugh, C.P., Drilling Technology Handbook, Oxford & IBH Pub. Co, 1988.
Hartman, H.L., Introductory Mining Engineering; Wiley Interscience, New York, 1987.
S.Mcalecse, Operational Aspects of Oil and Gas Well Testing: Volume1, Elsevier Science &Technology, Elsevier Science Ltd, Oxford, United Kingdom,2000.

MI363 MECHANIZATION AND MATERIALS HANDLING (3-0-0)3

Locomotive haulage, rolling stocks, conveyors, belt conveyor calculations, safety devices for conveyors, face machinery, calculation of productivity of loading machines, material handling systems, elements of material handling systems in large opencast projects, high-angle conveyors, pipeline transportation, aerial ropeways, aerial ropeway calculations, equipment for hydraulic and pneumatic stowing, roof bolting machines, variable and thyristor drives, remote control, monitoring and automation of mining processes.

Ramlu, M.A., Mine Hoisting, Oxford & IBH, New Delhi, 1996.
Walker, S.C., Mine Winding and Transport, Elsevier, Amsterdam, 1988.
Deshmukh, D.J., Elements of Mining Technology Vol. III; Vidyasewa Prakashan, Nagpur, 1994.
Reese, C., Material Handling Systems: Designing for Safety and Health, CRC Press, 2000.

MI401 MINERAL PROCESSING TECHNOLOGY (3-1-0)4

Scope and objective of mineral processing. Ore handling and storage. Ore sorting, Sampling techniques and devices. Liberation and comminution, Laboratory and industrial sizing. Concentration methods. Magnetic and high tension separation. Forth flotation. Classifiers. Coal quality. Coal preparation for coarse and fine coal. Washability curves and washability number. Dewatering devices. Drying and tailings disposal.

Wills, B.A., Mineral Processing Technology ; Pergamon Press – 4th Edition , 1989.
Weiss, N.L. , Mineral processing Handbook – Vol. I & II, S.M.E., 1985.
Maurice C. Fuerstenau , Edited by Kenneth N. Han , Principles of Mineral Processing, Society for Mining, Metallurgy, and Exploration , United States, 2003.
Ashok Gupta , Denis S. Yan ., Mineral Processing Design and Operations : An Introduction, Elsevier Science & Technology, Oxford, United Kingdom, 2016.
G S Ramakrishna Rao , Mineral Processing Techniques Basics and Related Issues, Zorba Publishers , India, 2014.

MI402 MINERAL PROCESSING TECHNOLOGY LAB (0-0-3)2

A total of 10 to 12 experiments shall be carried out pertaining to the subject.

MI403 ROCK FRAGMENTATION ENGINEERING (3-1-0)4

Bulk explosive systems. Substitutes for explosives. Mechanisms of rock fragmentation due to blasting. Fragmentation prediction and assessment. Blast design. Theory of shaped charges. Recent advances in blasting techniques in both underground and surface mines. Blasting in construction projects. Special techniques of blasting. Underwater blasting. Environmental effects and their control. Controlled blasting techniques. Economic evaluation of blasting operations.

Konya, C.G. Blast design, CRC Press, London, 1989.
Persson, Rock fragmentation. International development Corporation, Sweden, 1986.
Sastry, V.R., Advances in Drilling & Blasting, Allied Publishers, 1993.

MI404 MINE DESIGN LABORATORY (0-0-3)2

A total of 10 to 12 experiments shall be carried out pertaining to the subject.

MI405 STRATA MECHANICS (3-0-0)3

Definition and concepts of ground control in mines; State of stress in underground openings- premining and induced stresses, influence of water, time, temperature on stress behaviour. Design of structure in rock, Design of pillars, Cavability characteristics &cavability index, design of supports. Subsidence- Concept, prediction and determination, measurement techniques, subsidence damage and its prevention. Rock bursts and bumps – mechanisms, prediction and estimation of damage.

Obert L. and Duvall W.I. – Rock Mechanics and The Design of Structures In Rocks; John Wiley & Sons, New York, 1967.
Peng, S.S. Coal Mine Ground Control ; John Wiley & Sons, New York, 1978.
Biron C. and Arioglue E- Design of Supports in Mines; John Wiley & Sons, New York, 1983.

MI410 ADVANCED U/G COAL MINING TECHNOLOGY (3-0-0)3

Planning considerations for inclines and shafts, considerations for their location and construction. Location of shaft using sieve analysis; Design of shaft pillar. Bord & pillar mining- design of pillar, design of panel, barrier pillar. Planning inputs for development and depillaring by continuous miners. Longwall face support and machinery, Extraction of pillars in thick and steep seams with caving and stowing. Planning inputs for longwall panel. Selection design and development of most suitable mining method based on Physico - mechanical properties. Production planning. Production cost estimation. Punch entries. High wall mining. Caving characteristics of roof rocks. Shield Mining.

Singh, R.D. Principles and Practices of Modern Coal Mining, 1997, ISBN 81-224-0974-1
Singh, T.N., Thick seam Mining, Oxford & IBH, 1992.
Vorbjev & Deshmukh, Advanced Coal Mining, Tata McGill, 1988.
Mathur, S.P., Advanced Coal Mining, M.S. Enterprises Bilaspur, 1999.

MI411 GEOSTATISTICS (3-0-0)3

Sampling Methods – Theory and Concepts. Classical Statistical methods: Univariate and Bivariate; Exploratory data analysis. Probability distributions: application in ore reserve estimation. Concepts of Geostatistics; Semi-variogram: Kriging: Geostatistical conditional simulation. Practical applications of Geostatistics in geotechnical investigation.

S.M Gandhi and B.C Sarkar Essentials of mineral exploration and evaluation, Elsevier publications 2016
Chilès, J.-P., and P. Delfiner (1999), Geostatistics - Modeling Spatial Uncertainty, John Wiley & Sons, Inc., New York, USA.
Lantuéjoul, C. (2002), Geostatistical simulation: Models and algorithms, 232 pp., Springer, Berlin.
Kitanidis, P.K. (1997) Introduction to Geostatistics: Applications in Hydrogeology, Cambridge University Press.

MI412 APPLICATION OF IT IN MINING PROJECTS (3-0-0)3

Development of algorithms and flow charts related to mining projects. Overview of mine planning software's. IT applications in:pit limits determination, reliability of equipment&preventive maintenance, blast design, ventilation planning, safety data base management system and mine safety automation,Computer aided production planning and scheduling in mines. Selected topics to be cover on IT applications in mining.

Ram, R. V. et. al. ITs in Mineral Industry, Oxford & IBH, 1994
Husterilid, Open Pit Mine Planning and Design, Bulkema, 1995.
SURPAC Software manual: www. gemcomsurpac.com Isograph
Reliability Workbench Version 13.0 User Guide
GIAN Course on IT application and data analysis in mining and other core industries.

MI413 CORNER STONE/CAPSTONE PROJECTS 4

For details refer to clause 3.2 (f) under Regulations specific to Undergraduate Programmes.

MI449 MINE DESIGN PROJECT- I (0-0-3)2

A small project of relevance to mining will be taken up by the student

MI451 MINE LEGISLATION & SAFETY (4-0-0)4

Important statuary provisions related to Payment of Wages Act, History and development of mine Legislation in India (In brief) and NCWA, provident Fund Act, Mines Act- 1952, Mines Rules- 1955, Coal Mines Regulations-2017, Metalliferrous Mines Regulations-1961, Mines and Minerals (Regulation and Development) Act 1958, Mineral Conservation and Development Rules 2016. Mines Rescue Rules-1985. Vocational Training Rules-1966, Indian Electricity Rules-1956. Accident- causes and preventive measures for various accidents in mines; Accident analysis statistics; Accident cost, Accident enquiry report, safety management and audit.

Rakesh and Prasad, Legislation in Indian Mines – A critical appraisal, Ashalata Pub., Varanasi, 1986.
Singh, C.P. Occupational Safety and Health in Industries and Mines, Tata McGill, 2004.

MI452 ORE RESERVE ESTIMATION AND MINE VALUATION (3-0-0)3

National mineral resources; national mineral policy and strategies for development of mining industry; resource conservation; technology import, taxation, royalty and subsidies; mineral trade; concept of derivatives in mineral trade; pricing mechanism of minerals; sampling; estimation of reserves; economic block model concept; valuation of mines and mineral properties, life of a mining project; project evaluation; determination of optimum size of mine; risk analysis in mineral investment decisions.

Annels, A.E., Mineral Deposit Evaluation: A Practical Approach, Chapman Hall, 1991.
Deshmukh, R.T., Mine and Mineral Economics, Emdee Publishers, 1986.
Edwards, A. C., Mineral Resource and Ore Reserve Estimation, Australasian Institute of Mining and Metallurgy, 2001.

MI453 MINE PROJECTS EXPOSURE **1**

Comprehensive report about the short visits made to different mines and other industries will be submitted at the end of VIII Semester

MI490 SEMINAR **1**

A topic of relevance to the mining industry to be chosen and the seminar be delivered with audio – visual aids. A write up of the same should also be submitted.

MI499 MINE DESIGN PROJECT- II **(0-0-6)4**

A major project of relevance to mining will be taken up by the student

MI460 COAL WASHING AND HANDLING **(3-0-0)3**

Coking and non-coking coal. Coal washeries, sink and float tests on coal, washability index, optimum degree of washability and washability number, application of jigs, heavy media cyclone, Coal cleaning techniques for fine coal and coarse coal, coal flotation, beneficiation of non-coking coal, automation and quality control in preparation plants. Environmental management in coal preparation. Coal gasification, liquefaction and new products from coal. homogenization and blending systems.

Weiss, N.L., Mineral Processing Handbook- Volume-II, Published by SME, 1985.

Muthui Richard K, Rop Bernard K, Kabugu M, Coal Handling and Equipment Selection, LAP Lambert Academic Publishing, United States, 2014.

MI461 SURFACE MINE DESIGN **(3-0-0)3**

Preliminary investigations. Stages of planning. Feasibility Report. Planning inputs. MMDR and MCDR. Project scheduling and monitoring. Estimation of mine life. Determination of ultimate pit limits. Interrelation and planning of unit operations. Equipment selection. Transport and dumping subsystems. Design of haul roads. Extraction methods for beach sand deposits. Mining of developed coal seams. Selective mining. Estimation of productivity & profitability. Quality control. Introduction to mine design softwares.

Rzhevsky, V.V. Opencast Mining Unit Operations, Mir Publisher, 1983.

Rshensky V.V. Opencast Mining Technology and Integrated Mechanisations, Mir Publishers, 1985.

W.Hustrulid and M.Kuchta, Open Pit Mine Planning & Design, Vol. 1 & 2, Taylor & Francis, 2006.

MI462 UNDERGROUND COAL MINE DESIGN **(3-0-0)3**

Objectives and Stages of Planning. Feasibility report. Detail project report (DPR); Determination of mine design parameters. Planning input for selection of mining method. Estimation of mine life. Design and production planning. Introduction to mine design software. Production cost analysis.Selection criteria for face and underground transport equipment. Planning and design layouts for ventilation, drainage and power supply. Ventilation management. Productivity and quality control; planning of deep underground coal mines; Automation in underground coal mines.

Peng, S.S. Longwall Mining , Department of Mining Engineering, West Virginia University, 2006

Mathr, S.P. Coal Mining, M.S. Enterprises Bilaspur, 1999.

MI463 UNDERGROUND METAL MINE DESIGN **(3-0-0)3**

Planning and scheduling of insets, shaft bottoms, winding and transportation systems. Surface lay outs including mill and concentrator plants. Determination of number and dimensions of stopes. Planning and scheduling of a cycle of operations. Concept of ore blending. Overall planning and scheduling of activities in metal mining and processing. Case studies of planning of mining operations.

Agoshkov M., et. Al., Mining of Ores and Non- Metallic Minerals, Mir Publishers, Moscow, 1983.

Hartman, H.L. Introductory Mining Engineering, John Willey & Sons, 2007.

Niosh Snowden, Geological and Mining Reports of Underground Metal Mining: VolumeII, Wide Publishing, India, 2016.

Ratan Raj Tatiya , Surface and Underground Excavations, 2nd Edition : Methods, Techniques and Equipment, Taylor & Francis Ltd *, London, United Kingdom, 2013.*

MI464 ENVIRONMENTAL MANAGEMENT AND SUSTAINABLE DEVELOPMENT **(3-0-0)3**

Environmental problems due to mines and quarries. Land degradation. Pollution due to mining in terms of air and water. Acid Mine Drainage, Socio- economic impacts. Control measures. Pollution due to noise and vibrations. Effluents discharge. Reclamation of mined out and subsided areas. Mine closure. Environmental legislation and policies. Environmental Management Plan. Environmental Impact Assessment. Risk Analysis. Disaster management

plan. Preparation of EMP for various mineral industries. Cost of environmental management. Environmental audit.
Dhar, B.B., Environmental Management of Mining Operations, Ashish Publication House, New Delhi, 1991.
Chadwick et al., Environmental Impacts of Coal Mmining and Utilization, Pergamon Press,1992.

MI471 RELIABILITY ANALYSIS OF ENGG. SYSTEMS (3-0-0)3

Reliability definition. Failure data analysis of mining equipment's. System of reliability. Reliability improvement. Maintenance of mining machinery, MIS for maintenance function. Maintenance planning and scheduling. Statistical analysis and data distributions of failure data. Availability and maintainability. Reliability and availability of repairable and non-repairable system. Systems with preventive and corrective maintenance. Reliability evaluation. Reliability prediction and modelling. Application of reliability in engineering systems and case studies. Applications of reliability software's in engineering.
Patrick D. T. O' Connor. "Practical Reliability Engineering". Wiley India Pvt. Ltd., 4th Edition, 2012.
L. S. Srinath. "Reliablity Engineering". East –West Press, 4th Edition, 2005.
John Davidson (Ed). The Reliability of Mechanical Systems. I Mech E. London 1994.
John P. Bentley. An Introduction to reliability & Quality Engineering. Longman Scientific & Technical, England, 1993.

MI472 ROCK EXCAVATION IN MINES & INFRASTRUCTURE PROJECTS (3-0-0)3

Rock excavation by different methods in mining and infrastructure projects. Excavation and material handling equipment. Selection of equipment. Excavation in sensitive areas. Project Planning and Management. Practical examples in mining projects, ports, tunneling projects, pipeline excavations, canal excavation projects, hydel projects, Caveens/ large excavations etc. Environmental planning, environmental impact assessment and Management. Project economics.
Stack, B., Mining and Tunneling Machine, 1978.
Martin, J. W., Martin T. J., Bennett, T. P. &Martin,K. M. Surface Mining Equipment, Martin Consultants Inc., USA, 1982.

MI473 STABILITY OF ROCK SLOPES (3-0-0)3

Mechanisms of slope failures. Field investigations and data collection. Design of slopes - physical, empirical, probabilistic methods, analytical (limit equilibrium analysis) and numerical (continuum models, discontinuum and crack propagation models) modeling. Stabilization and reinforcement of slopes. Slope failure monitoring-modern techniques (SSR).Softwares for slope stability analysis. Case studies.
Hoek, E. and Bray, J.W; Rock Slope Engineering; John Wiley & Sons; New York; 1984
Brawner, C.O; Stability in surface mining, SME of USA; New York, 1982. Giani, F; Rock
Slope Stability Analysis; Balkema; Rotterdam; 1992.

MI474 TUNNELLING ENGINEERING (3-0-0)3

Design principles of underground openings, single and multiple openings with different orientation. Dimensions, shape, structural behavior and sequence of excavations intunnels.Rock conditions and initial state of stresses. Computer aided tunnel design. Tunnel driving techniques. Tunnel supports, automation of supports, Shield tunneling system with road headers. Field instrumentation, Tunnel stability analysis, Case studies.
Bieniawski, Z.T., Rock Mechanics and Design in Mining and Tunnelling, Rotterdam : A.A. Balkema, 1984.
Pokorovski, Driving Horizontal Workings and Tunnel, Mir Publishers, 1980

MI475 NUMERICAL MODELLING TECHNIQUES (3-0-0)3

Development and use of numerical modeling in rock excavations. Finite element (2D and 3D). Boundary element (2D and 3D). Displacement and continuity. Basic equations for mathematical modeling of rock mass. Static and dynamic behavior of rock mass. Elastic-linear and non-linear, elastoplastic and time dependent models. Case studies.
Kidybinski A. & Kwasniewski M. (Eds); Modelling of Mine Structures, A.A. Balkema, Rotterdam, 1988.
Kidybinski A. &Dubinski J. (Eds); Strata Control in Deep Mines, A.A. Balkema, Rotterdam, 1990.

MI476 INDUSTRIAL ENGINEERING & MANAGEMENT (3-0-0)3

Concepts of Management and Organisation, Functions of Management, Organisational Structures, Basic concepts related to Organisation Departmentation, Motivation, Leadership, Group dynamics, Conflict management, Work study, Time study, Job Evaluation, Project management, Network techniques, Human Resource Management.
Khanna, O.P., Rai, D. Industrial Engineering and Management, 2005.
Stoner, Freeman, Gilbert, Management, 6th Ed, Pearson Education, New Delhi, 2005.
Ralph M Barnes, Motion and Time Studies, John Wiley and Sons, 2004.
Chase, Jacobs, Aquilano, Operations Management, TMH 10th Edition, 2003.

MI477 REMOTE SENSING AND GEOINFORMATICS (3-0-0)3

Concept of GPS. Application of remote sensing to mining projects. Satellite signals. GPS instruments. Sensors and platforms. Image Processing and interpretation. Data processing. Concepts of GIS. Components, data acquisition, topology and spatial relationships, data storage verification and editing, network systems, data manipulation and analysis. Spatial and mathematical operations in GIS. Various GIS packages and their salient features.

Basudev Bhatta, Remote sensing and GIS, II Edition, Oxford Publishing House, 2016.
George Jeoseph, Fundamentals of Remote Sensing, II Edition, Universal Press, 2017.
Lillisand, Keifer and Chipman, Remote Sensing and Image Interpretation, VI Edition, Wiley Publishers.
Hassan A. Karimi, Handbook of Research in Geoinformatics, Information Science Reference, 2017.

MI478 SAFETY ENGINEERING (3-0-0)3

Basic concept of risk; Difference between hazards and risks; Risk components and types, Risk management objectives, Risk management process; Hazards Identification and Risk Assessment (HIRA).Type of injury. Causes of injury, statistical analysis of injury data. Accident and preventive measures for various accidents in mines; Accident analysis and accident statistics; Economic evaluation of accident, Accident investigation report. Safety management and audit.Ergonomics and its application in safety engineering. Behavior base safety.

Ridley, J & Channing, J.; Safety at Work; Butterworth-Heinemaan, Oxford, 2001.
L.C. Kaku: A Study of Mine management, Legislation & General Safety.
S. Ghatak: A Study of Mine management, Legislation & General Safety.
C.P. Singh: Occupational safety and health in Industries and mines
Seppo Väyrynen · Kari HäkkinenToivo Niskanen: Integrated occupational safety and health management by springer publications. SBN 978-3-319-13179-5 ISBN 978-3-319-13180-1 (eBook) DOI 10.1007/978-3-319-13180-1

MI479 ENERGY RESOURCES UTILIZATION AND CLIMATE CHANGE (3-0-0)3

Trends in Energy Supply & Quality of Life; Energy Demand & Supply Options; Energy Resources - their distribution & Utilisation ; Non-Conventional Hydrocarbons; Concepts of Energy & Exergy flows; Sustainability and Climate Change; Environmental Economics. Carbon Emissions; Potential Impacts; Climate Change Prediction Models - Basics; Global Climate Change negotiations – Problems and Issues; Carbon sequestration – Capture & Storage.

David Coley, Energy & Climate Change — Creating Sustainable Future, John Wiley & Sons Ltd, 2008
Chris Goodall, Ten Technologies to Fix Energy and Climate, Second edition Profile Books, 2009 Anilla Cherian, Energy and Global Climate Change: Bridging the Sustainable Development Divide, John Wiley & Sons, 2015

Courses for Minor in Mining Engineering

MI480M MINING TECHNOLOGY (3-1-0) 4

Introduction to mining projects. Roll of mining industry in development of nation. Mine development. Basics of underground coal mining technologies. Basics of underground metal mining technologies. Basics of surface mining technologies. Application of mechanical, civil, electrical, electronics and IT in mining projects.

Tatiya R.R., Surface and underground excavation: methods, techniques and equipment, A. A. Balkema publishers, 2005.
Walker S.C. Mine Winding and Transport. Elsevier, Amsterdam 1988.
Gross, C. A., Electric Machines, 1st Edition, CRC Press, 2006. Isograph
Reliability Workbench Version 13.0 User Guide
GIAN Course on IT application and data analysis in mining and other core industries.

MI481M ROCK EXCAVATION ENGINEERING (3-1-0)4

Rock excavation in mining and infrastructure projects. Methodologies. Mines. CNG Pipeline projects. Hydel projects, Tunnels. U/G Caverns. Ports. Material handling equipment. Selection of equipment. Excavation in sensitive areas. Project Planning and Management. Environmental impact assessment and Management. Project economics.

Stack, B., Mining and Tunneling Machine, 1978.
Martin, J. W., Martin T. J., Bennett, T. P. &Martin,K. M. Surface Mining Equipment, Martin Consultants Inc., USA, 1982.

MI482M MINE SAFETY ENGINEERING (3-1-0)4

Accident- causes and preventive measures for various accidents in mines; Accident analysis statistics. Accident cost. Accident report, Risk assessment & preparation of safety management Plan. Safety audits. Occupational hazards in mines, Hazard analysis. Hazard control by engineering approach, Hazard control by system approach. Economics of safety and cost-effectiveness. Occupational health and safety, Occupational diseases, Problems of safety and health in

contractual work, Behavior based safety, Ergonomics and its application in mining.

Ridley, J & Channing, J.; Safety at Work; Butterworth-Heinemaan, Oxford, 2001.
L.C. Kaku: A Study of Mine management, Legislation & General Safety
S. Ghatak: A Study of Mine management, Legislation & General Safety
C.P. Singh: Occupational safety and health in Industries and mines
Rakesh and Prasad, Legislation in Indian Mines – A critical appraisal, Ashalata Pub., Varanasi, 1986.
Singh, C.P. Occupational Safety and Health in Industries and Mines, Tata McGill, 2004.

MI483M MINE MECHANISATION (3-1-0)4

Equipment for excavation, transportation, processing. Selection of equipment. Tendering and processing. Maintenance. Inventory. Automation. New developments. Productivity of machines. Economics.

Amithosh Dey, Latest Development of Heavy Earth Moving Machinery, Annapurna Publishers, Dhanbad, 1995.
Reese, C., Material Handling Systems: Designing for Safety and Health, CRC Press, 2000.
Martin, J. W., Martin T. J., Bennett, T. P. &Martin,K. M. Surface Mining Equipment, Martin Consultants Inc., USA, 1982.

MI484M ENVIRONMENTAL MANAGEMNET (3-1-0)4

Environmental issues. Pollution due to mining in terms of land degradation, air and water, noise and vibrations. Socio-economic impacts. Waste management. Reclamation and rehabilitation. Environmental Impact Assessment. Risk Analysis. Disaster management. Environmental audit. Environmental economics.

Dhar, B.B., Environmental Management of Mining Operations, Ashish Publication House, New Delhi, 1991.
Chadwick et al., Environmental Impacts of Coal Mining and Utilization, Pergamon Press,1992.

Courses for Honors in Mining Engineering (Refer PG and PhD curriculum for details)

MI705	**Project Management**	**(3-1-0)4**
MI804	**Underground Space Technology**	**(3-1-0)4**
MI855	**Reclamation Rehabilitation and Risk Management**	**(3-1-0)4**
MI901	**Applied Rock Mechanics**	**(3-1-0)4**
MI916	**Risk and Safety Management in Mines**	**(3-1-0)4**

UC100 INTRODUCTION TO DESIGN THINKING (2-0-0) 2

Need and Definition of Design Thinking. Framework for Design Thinking. Engineering Design Process. Need Identification, Specification, Concept Generation, Product Architecture and Detailed Design. Prototyping – Virtual and Physical. Testing Methodology

Christian Muller-Roterberg, "Handbook of Design Thinking", 2018
Eli Woolery, "Design Thinking Handbook" Invision Pub, 2019
Nigel Cross, "Design Thinking"
Max Answell "Mastering Design Thinking", 2019
Karl T. Ulrich, Steven D. Eppinger and Maria C Yang, "Product Design and Development", McGraw Hill, 7ed, 2020
George e Dieter, Linda C Schmidt, "Engineering Design", Mc Graw Hill, 4ed, 2009

UC401 LIBERAL ARTS COURSES/CO-CURRICULAR/EXTRACURRICULAR ACTIVITIES 10

CATEGORY A : Maximum 3 credits, CATEGORY B : Maximum 3 credits, CATEGORY C : Minimum 4 Credits and Maximum 7 credits.

10 Credits have to be earned from 1st Semester to 7th Semester by choosing Category (A + B + C) OR Category (A + C) or Category (B + C) courses combination . Registration for 10 Credits has to be done in 7th Semester.

For details of CATEGORY A, CATEGORY B and CATEGORY C refer to clause 3.2 (f) under Regulations specific to Undergraduate Programmes.

Department of Physics

PH110 PHYSICS (3-1-0) 4

Brief review of Newton's laws and vector notation, Conservation laws: energy, momentum, angular momentum, torque, moment of inertia as a matrix, diagonalization to obtain principle moments of inertia, Non-inertial frames of reference. Coriolis force. Pseudo-forces, Solution of damped and forced harmonic oscillator. Resonance, q-factor. Electric flux, Gauss' Law, divergence operator and divergence theorem, Dielectrics, bound and free charges, electric susceptibility, relative permittivity, dielectric constant, Curl, Stokes' theorem, Faraday's law, displacement current, Maxwell's equations in differential (point) and integral (volume) form, Electromagnetic wave propagation in free space, speed of light, Swimmers in a river, Michelson-Morley experiment, Lack of invariance of Maxwell's wave equation under Galilean transformation, Einstein's postulates, Consequences of Einstein's postulates - length contraction, time dilation, velocity addition, Relativistic energy, momentum, Mass-energy relationship, relativistic system of units, Photoelectric effect, Compton effect, de Broglie hypothesis, Davisson-Germer experiment, uncertainty relationship for classical waves, Heisenberg uncertainty principle, wave packets, phase and group velocity, properties of waves at boundaries, Schrodinger's equations, particle in infinite and finite potential wells, tunneling.

Kleppner & Kolenkow, An Introduction to Mechanics, 2nd edition, 2010
Hayt & Buck, Engineering Electromagnetics, 8th (intl) edition, 2012
Kenneth Krane, Modern Physics, 3rd edition, 2012
Arthur Beiser, Concepts of Modern Physics,
MIT OpenCourseWare, freely available online

PH111 PHYSICS LABORATORY (0-0-2) 1

Error analysis and graph drawing, photoelectric effect, laser diffraction, slinky spring experiments, Newton's rings, Pendulum experiment, Helmholtz resonator, Hall Effect.

Kenneth Krane, Modern Physics, 3rd edition, 2012
Arthur Beiser, Concepts of Modern Physics.

PH201 QUANTUM MECHANICS FOR ENGINEERS (3-0-0) 3

Basic principles of quantum mechanics. Probabilities and probability amplitudes. Linear vector spaces. Bra and ket vectors. Completeness, orthonormality, basis sets. Change of basis. Eigenstates and eigenvalues. Position and momentum representations. Wavefunctions, probability densities, probability current. Schrodinger equation. Expectation values. Generalized uncertainty relation. One dimensional potential problems Particle in a box. Potential barriers. Tunnelling. Linear harmonic oscillator: wavefunction approach and operator approach. Motion in three dimensions. Central potential problem. Orbital angular momentum operators. Spherical harmonics. Eigenvalues of orbital angular momentum operators. The hydrogen atom and its energy eigenvalues. Charged particle in a uniform constant magnetic field, energy eigenvalues and eigenfunctions. Schrodinger and Heisenberg pictures Heisenberg equation of motion. Interaction picture.

V.K. Thankappan, Quantum Mechanics. Wiley Eastern (1985)
A.K Ghatak, S.Lokanathan Quantum Mechanics Theory and applications, Macmillan India Ltd (1984)

PH202 CLASSICAL MECHANICS (3-0-0) 3

Review of Newton's Laws of motion; Conservation principles; Harmonic oscillator; Two particle systems; Time dependent forces; Variational Principle; Lagrange's equation of motion; Charged particles in EM fields; Planetry motion; Rutherford scattering; Small Oscillations; CO_2 Molecule; Beads on a stretched string; Euler's equation for rotating bodies; Hamilton's equations of motion; Charged particle dynamics; Virial theorem; Hamilton – Jacobi equations; Action angle variables; Poisson Brackets; Integral invariants; Stretched elastic string; Energy momentum relations.

PH251 ELECTRICAL PROPERTIES OF MATERIALS (3-0-0) 3

Conductivity of metals-classical free electron theory and quantum free electron theory, Semiconductors -pure and impure semiconductors, band model, conductivity and its temperature dependence, Hall effect, Direct and indirect bandgap semiconductors, p-n junction and diode equation, Dielectric properties of insulators-dielectric behaviour in static and alternating fields, dipolar relaxation and dielectric loss, ferroelectric and piezoelectric materials.

Electrical Engineering Materials – A.J.Dekkar, Prentice Hall India Publ.
Solid state Electronic Devices – B.G. Streetman, Prentice Hall India Publ.

PH252 ELECTROMAGNETIC THEORY (3-0-0) 3

Electrostatics: electrostatic field, Divergence and Curl of electric field, Electric potential. Laplace's equation in three

dimetians. Separation of variables. Electrosatic field in Matter Electric displacement. Magnetostatic , Lorentz force law, Biot-Savarts law, Divergence and Curl of Magnetic field, Ampere's law. Electromotive force Faraday's law, Maxwell's Equations plane wave solutions of Maxwell's equations, Poynting vector, wave propagation through a boundary, reflection, refraction, absorption and skin depth.

D. Griffiths, Introduction to Electrodynamics, 2nd ed., Prentice Hall, 1989.

William H. Hayt . Engineering Electromagnetics, 5th ed. Tata Mc Graw Hill Publishing Company Ltd.

PH351 PHYSICS OF SEMICONDUCTOR DEVICES (3-0-0) 3

The PN Junction Diode, basic device technology, current-voltage characteristics, Transient behaviour and noise. Heterojunction. Bipolar transistor- static characteristics. Microwave and power transistor and related devices. Metal-semiconductor contacts. Energy band relation, transport processes, barrier height JFET and MESFET basic device characteristics. Microwave performance. MOSFET-Device structure and characteristics, Nonvolatile memory devices Tunnel Diode, IMPATT and related transit-time diodes. Transferred-electron devices- Gunn effect. Principles of photonic devices: LEDs, semiconductor lasers; photodetectors – photodiodes and APDs. Solar Cells.

S.M. Sze, Physics of Semiconductor Devices.

Donald A Neamen, Semiconductor Physics and Devices-Basic Principles

M.S. Thyagi, Semiconductor Materials and Devices. David H Ferray,

Electronic materials and Devices

Jasprit Singh, Semiconductor Optoelectronics and Technology.

PH352 VACUUM TECHNOLOGY AND THIN FILMS (3-0-0) 3

Production of vacuum – mechanical pumps, sorption pumps and cryogenic pumps. Measurement of vacuum – thermal conductivity gauges and ionization gauges. Behaviour of gases at low pressure. Thin films – methods of preparation – vacuum evaporation, sputtering, electro-deposition, chemical deposition. Properties of thin films. Measurement of film thickness, Applications of thin films.

Handbook of thin film technology – L. I. Maissel and R. Glang, McGraw Hill publ.

PH401 OPTOELECTRONICS (3-0-0) 3

Light Propagation in material media. Maxwell's equations, Wave equations for dielectrics, Polarization., reflection and refraction of light from dielectric interfaces, total internal reflection, light propagation in uniaxial crystals. Nonlinear polarizability of material media, second harmonic generation of light, optical rectification, frequency conversion by 3- wave mixing, parametric oscillators. Optical wave guides- Types of optical wave guides, guided modes in planar wave guides, guided modes in step-index optical fibers. Attenuation and dispersion. Directional couplers, prism couplers. Mach -Zehnder interferometer, Optical sources and detectors - light absorption and emission in semiconductors, structure, working and operating characteristics of heterojunction LED's laser diodes, photodiodse and APDs. Noise in photodiodse, Electro-optic effect, longitudinal and transeverse electro-optic modulators. Acousto-optic effect, Bragg diffraction. Photonic switching and optical bistability.

B E Saleh & M.C. Teich, Fundamentals of Photonics.

J Wilson & J F B Hawkes, Optoelectronics - an Introduction

Jasprit Singh, Optoelectronics: An introduction to Materials & Devices

P. Bhattacharya, Semiconductor Optoelectronics.

Courses for B.Tech. with Physics Minor (Refer M.Sc Physics curriculum for details): Student may select any five courses from the following:

PH701M MATHEMATICAL METHODS-1 (3-1-0)4
PH702M CLASSICAL MECHANICS (3-1-0)4
PH703M QUANTUMMECHANICS-1 (3-1-0)4
PH751M MATHEMATICAL METHODS-2 (3-1-0)4
PH752M QUANTUM MECHANICS-2 (3-1-0)4
PH754M ELECTROMAGNETIC THEORY (3-1-0)4

School of Humanities, Social Sciences and Management

SM110 PROFESSIONAL COMMUNICATION (3-0-0) 3

Organization Communication : Attempts to acquaint students with the process and requirements of Communication in organization. It includes the Objectives of Communcation, Channels of Communication, Barriers in Communication, Cross Cultural Communication.

Written Communication : Focuses on improving the Writing Skills. A Review of Grammar, Tranformation of Sentences; Reading Comprehension; Precis Writing; Skills to Express ideas through various kinds of Essays; Business Letters, Application Letters, Email and Internet; Report Writing, CVs/Resumes.

Oral Communication : Aims at improving the Oral Communication Skills, Public Speaking Skills, Features of Effctive Speech-Verbal and Non-Verbal, Presentation Skills, Audio and Visual Aids; Group Discussion, Mock Interviews and Meetings.

Meenakshi Raman and Sangeeta Sharma, Technical Communication; Principles and Practice, Oxford University Press, 2011.

Mattukutty M. Monippally, Business Comunication Strategies, Tata Mcgraw-Hill Publishing Co. Ltd, 2001.

Shirley Taylor, Model Businees Letters, E-Mails and other Business Docuements (VI Edition), Pearson Education /Prentice Hall, 2012.

Michael Swan, Practical English Usage, Oxford University Press, 2005.

SM111 PROFESSIONAL ETHICS AND HUMAN VALUES (1-0-0) 1 Professional Ethics:Engineering as a Profession, Aim of Engineering, Responsibilities of Engineers, Rights of Engineers, Impediments to Responsibilties , Honesty, Integrity, Reliablity, Risk, Safety and Liability, Global Issues. Personal Ethics: Value of Self, others and Society, Compliance with Law, Social Norms, Service to Community, Engineer's Responsibilities to Economically Deprived Peoples and Environment, Corruption, Indian and Western Culture, Simple Living and High Thinking, Science and Spirituality.

Charles E. Harris et al., Engineering Ethics,Cengage Learning,
2009 Govindarajan M, Engineering Ethics:PHI 2004.
Fleddermann, Charles D. Engineering Ethics:Pearson Education
2004 Baura Gail D. Engineering Ethics:Academic Press 2006

SM300 ENGINEERING ECONOMICS (3-0-0) 3

Basic economic concepts and problems – Theories of demand, supply and Market equilibrium. Elasticity, demand forecasting, cost terminology. Methods of economic analysis in Engineering– Bases for Comparison of alternatives. Selection among alternatives, replacement analysis - Evaluating public activities - depreciation accounting - Estimating economic elements.

Samuelson P.A. and Nordhans W.D., Economics, 15th ed., McGraw Hill, New York, 1995.

Thuesen G.J. and Fabrycky W.J.Engineering Economy, 9th ed., Prentice Hall of India, New Delhi 2002.

Sullivan W.G., Bontadelli J.A. and Wicks E.M., Engineering Economy, 11th ed., Pearson Education Asia, New Delhi 2001

Leland Blank P.E and Anthony Tarquin P.E.,Engineering Economy, 4th ed., McGraw Hill, Singapore, 1998.

SM302 PRINCIPLES OF MANAGEMENT (3-0-0) 3

Unit – 1: I***ntroduction to Management*** – Functions of Management – planning, organising, leading and controlling - case studies

Unit – 2***: Staffing***– recruitment- selection- perfromance appraisal– leadership styles –– case studies

Unit – 3: O***rganisation culture*** – diversity and inclusion – business environment – corporate social responsibility (CSR) - international management - market entry approaches - case studies

Unit – 4: O***rganizational behaviors*** – theories of motivation – communication – power- conflict - negotiation – case studies

Unit – 5: ***Quality Management*** - total quality management applications (TQM) – six sigma – balanced score card — 5s – poka yoka - kaizen – 7QC tools – case studies

Essentials of Management - An International, Innovation and Leadership Perspective | 11th Edition Paperback – 15 July 2020 - Harold Koontz (Author), Heinz Weihrich (Author), Mark V. Cannice (Author)

Stoner, James A.F., Freeman, Edward R., Gilbert, Daniel R., Management, Prentice Hall,

Robbins, Stephan B., Organisational Behaviour, Prentice Hall

SM400 MANAGERIAL ECONOMICS (3-0-0) 3

Introduction, Business Objectives and business decisions, Entrepreneurship Demand Analysis and forecasting,

Market Structure, Perfect and imperfect competition, Production Theory, Pricing and Profit Management, Decision techniques and capital budgeting, National Income, Money System, Case Studies.

Mote V.L. Paul Samuel and Gupta G.S., Managerial Economics, McGraw-Hill,
Craig Petersen H. and Cris Lewis W., Managerial Economics Prentice-Hall of India, 2000.
Dwivedy D. N., Managerial economics, Vikas Publishing House, 1995.

SM401 MARKETING MANAGEMENT (3-0-0) 3

Concept of Market, Marketing Management Process, Marketing Environment, Organisational Market and Buyer behaviour, Market Segmentation, targeting and positioning, Planning marketing tactics, Product, price distribution and promotion decisions, Concepts of Market Research, Product Development and Re-Engineering- E-commerce, Marketing Information System and Research, Customer Relations Management (CRM), Business Process Outsourcing (BPO), 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.

SM402 MANAGEMENT INFORMATION SYSTEM (3-0-0) 3

Functions of Management, Organization Environment, Organization Structure, System Concepts, Stakeholders Analysis, Framework for Information Systems (IS), Decision making process, Problem solving Process, Definition of Management Information System (MIS), EIS, DSS, Artificial Intelligence, Expert Systems, Computer hardware, Hardware standards, Computer Software File and Database Management, Communication Systems, Common Network components, Distributed systems, Design of MIS, Applications of MIS to business, Case studies.

Kenneth C. Laudon and Jane Price Laudon, Management Information Systems, Managing the Digital firm, Pearson Education, Asia, 2002.
GordonB.Davis, Management Information System:Conceptual Foundations, Structure &Development, McGrawHill, 1974.
Joyce J Elam, Case series for Management Information Systems', Simon and Schuster Custom Publishing, 1996.

SM403 HUMAN RESOURCE MANAGEMENT (3-0-0) 3

HRM functions, role each plays in the overall HRM process. HRM integration into strategic planning of the organizations - Key issues facing global HRM today and their impact on its successful practice in the 21st Century, including the critical issues of technology, workplace stability, workforce diversity or pluralism, globalization and ethics - Job analysis, job design, and job description in relation to job evaluation, job enrichment, and job enlargement. Effective recruiting plan and selection process for hiring qualified employees. Design of training program focused on needs assessment and evaluation of the effectiveness of training in relation to job performance – Development of practical system for evaluating employee performance and managing performance on a continuous basis - Analysis and evaluation of various approaches to compensation and benefit programs designed to meet the needs of the organizations and its employees - Integrating the human resource and organizations development aspects of the overall HRM responsibility. Evaluation of relationship between labour unions and management in relation to collective bargaining and contract negotiation. Approaches to respecting employees rights and protecting the health and safety of workers. Concept of planned, managed organizational change through proven organization development techniques.

Drucker, Peter F. (1992). Managing for the Future: The 1990s and Beyond. Truman Talley Books/Dutton. New York.Gary Dessler, Human Resource Management.

SM450 FINANCIAL MANAGEMENT (3-0-0) 3

Financial Management, Accounting concepts. Financial statement analysis. Financial Investment Analysis. Financial Decisions.Managing Components of Working Capital. Capital Investment & Financing Decisions .

Pandey I.M., Financial Management, Vikas Publishing House, 1999.
Prasanna Chandra, Financial Management, Tata McGraw Hill Publication, 1998.
Kuchhal S.C., Financial Management an Analytical & Conceptual Approach, Chaitanya Publ. house, Allahabad 15th Ed, 2001.

SM451 FOUNDATION COURSE ON ENTREPRENEURSHIP (3-0-0) 3

Self Discovery; Opportunity discovery, Customer and Solution – understanding who is the customer, identify job, pains, gains and early adopters, Establish your venture's unique value proposition and competitive advantage; Basics of business models and lean canvas; Validation – refine value proposition with blue ocean strategy, build

solution demo, prototype development; Understanding cost structures, bootstrapping and initial financing; Positioning and branding, Sales plan using funnel approach; Support – Project management, operating a business.

Mariotti, Steve. The Young Entrepreneur's Guide to Starting and Running a Business., New York NY: Random House, Inc.2000.
Osterwalder Alexander, Business Model Generation, Wiley India Pvt. Ltd., 2017
Entrepreneurship Development and Management – EDI Ahmedabad.
Vasant Desai, Dynamics of Entrepreneurial Development and Management, Himalaya Publishing House. 2000.

SM452 INTELLECTUAL PROPERTY RIGHTS (3-0-0) 3

Introduction to intellectual property. Copyright. Related Rights. Trademarks. Geographical indications(GI). Industrial Design. Patents. International Registration Systems. Unfair Competition. Protecting New Varieties Plants. Overall Summary. Glossary

WIPO handbook/ notes
Wadehra B.L, Law Relating to Patents, Trademarks,Copyright Designs & Geographical Indications, Universal Law Pub., 2000.
Sullivan & Patrick H.,Profiting from Intellectual Capital: extracting value from Innovation, John Wily, 1998.
Correa, Carlos M., Intellectual Property Rights, the WTO and Developing Countries: the TRIPS Agreement and Policy Options, Zed books, New York, 2000.

SM453 YOGA SUTRAS OF PATANJALI (3-0-0) 3

Bases and relevance of yoga. Elements of Sankhya philosophy. Some ancient texts on yoga. Sri Krishna and Gita. Patanjali and his Yoga Darshana. Commentaries (Bhashyas) and notes (Teekas) to Yoga aphorisms. The nature of asthanga yoga or raja yoga. A brief introduction to Patanjala Yoga Sutras on contemplation, yogic practices, attainments and the nature of freedom and realization.

Maharsi Patanjali,Yoga Sutram (shattikopetham) Edited with notes by Nyayacharya, Kavyathirtha Pandit Dhundhiraj Sastri, Chaukhamba Sanskrit Sansthan, Varanasi.
Bangali Baba, The Yogasutra of Patanjali with the commentary of Vyasa.
Swami Vivekananda, Raja Yoga.

SM454 INTRODUCTION TO INDIAN CLASSICAL MUSIC (3-0-0) 3

A brief history of Indian classical music and musical culture – Specificities of Indian classical music- Hindustani and Carnatic traditions of music – Musical notes in Indian classical music – Raga and Tala – Difference between Indian and Western musical traditions – vocal and instrumental music – Classification of Indian musical instruments – Some doyens of Indian music and their music – Classical and non- classical music – folk and film music – Dialectical relation between the classical and the non-
classical music – Music criticism – certain key terms – Indian classical music in print media – Indian classical music I (India) English literature – Some novels

Raghava R Menon, Indian Classical Music: An Initiation, New Delhi: Vision Books, 1996
Ram Avtar Vir, Theory of Indian Music, New Delhi: Pankaj Publications, 1999
Sumati Mutatkar, Aspects of Indian Music, New Delhi: Sangit Natak Academy, 2006

SM 455 PHILOSOPHY (3-0-0)3

The difference between knowledge (Vidya) and Ignorance (Avidya): Upanishads; Six systems orthodox and Heterodox Schools of Indian Philosophy. Greek Philosophy; Origin of the Universe: Nasidiya Sukta: "Who really knows?" Brhadaranyaka Upanishad; Chandogya Upanishad; Non-self, Self, real and unreal. Taittiriya, Upanishd; Siksha Valli. Plato's Symposium: Lack as the source of desire and knowledge. Socratic method of knowledge as discovery. Language: Word as root of knowledge (Bhartrahari's Vakyapadiyam) Fourteen Knowledge basis as a sources of Vidya; Four Vedas; Six auxihary sciences (Vedangas); Purana, Nyaya, Mimamsa and Dharama Sastras. Knowledge as Power: Francis Bacon. Knowledge as both power and self –realization in Bagavad Gita. Knowledge as oppression: M. Foucault. Discrimination between *Rtam* and *Satyam* in Indian Philosophy. Knowledge as invention: Modern definition of creativity, scientific activity in the claim that science invents new things at least through technology. Knowledge about the self, transcendental self; knowledge about society, polity and nature. Knowledge
about moral and ethics codes. Tools of acquiring knowledge: Tantrayuktis, as system of inquiry (charaka, Sushruta, Kautilya, Vyasa)

Copleston, Frederick, History of Philosophy, Vol. 1. Great Britain : Continuum.
Hiriyanna, M Outlines of Indian Philosophy, Motilal Banarsidass Publishers; Fifth Reprint edition(2009) Sathaye, Avinash, Translation of Nasadiya Sukta

Ralph T. H. Griffith. The Hymns of the gveda. Motilal Banarsidass ; Delhi:1973.
Raju, P.T. Structural Depths of Indian Thought, Albany; State University of New York Press.
Plato, Symposium, Hamilton Press.
Kautilya Artha Sastra, Penguin Books, New Delhi.

SM456 FINANCIAL MARKETS AND INSTITUTIONS (3-0-0)3

Financial System: Significance and Structure of the Financial System, Banks and Other Financial Institutions - Financial Innovation - Function of Financial Markets. Banking Institutions: Institutional structure in India- Implication for the economy - Asset and Liability Management by Banks. Non-Bank Financial Intermediaries: Institutional structure in India - Types and comparison of asset liability structures of various NBFCs. Money Market: Money and Call Money Market - Institutions constituents. The money markets - The discount market - The 'parallel' markets - The interbank market. Capital Market: The importance of capital markets - Characteristics of bonds and equities. The trading of bonds and equities. Foreign Exchange Markets: The nature of foreign exchange markets - Interest rate parity - Other foreign exchange market rules. The determinants of spot exchange rates - Purchasing power parity. International Capital Markets: The world capital market - Eurocurrencies. Central Banking and the Conduct of Monetary Policy: Reserve Bank - Assets liabilities and implications for the financial sector - Conduct of Monetary Policy: Tools, Goals, Strategy, and Tactics - Autonomy of the central bank.

Fabozzi, Frank, *Modigliani, Franco, Jones, Frank (Feb 2009),* Foundations of Financial Markets and Institutions, *International Edition, 4th Edition, Pearson.*
Mishkin, Frederic S. and Eakins, Stanley *G. (2005), Financial Markets and Institutions (6th Edition), Pearson. Howells, Peter, Bain, Keith (2007), Financial Markets and Institutions, 5th Edition. Madura, Jeff (2008), Financial Markets and Institutions, 8th edition, Thomson Publications.*
Kidwell, David, Blackwell, David W., Whidbee, David A. et.al. (2008) Financial Institutions, Markets, and Money, 10th Ed., John Wiley & sons. Bhole, L. M., and Jitendra Mahakud (2010), Financial Institutions And Markets: Structure, Growth And Innovations, 5th Edition, Tata Mgraw Hill.

SM457 CREATIVE WRITING (3-0-0)3

Introduction to creative writing, challenges involved in writing, process of writing, modes of writing, introducing fiction, non-fiction, poetry, and academic writing, important literary terms, defining literary terms, basics of story writing, characteristics of stories, structure, variations in the style of writing stories, writing fiction, types of fiction, form and structure, character sketch, writing non-fiction, features of writing non-fiction, structure, choice of topic, relevance of non-fiction, writing poems, procedure involved in writing poems, variations in style, rhythm, travel writing, essentials and relevance of travel writing, writing in community and academy, cross-over discipline, academy as open space, analysis of various forms of writings, discussions on style.

Morley, David. The Cambridge Introduction to Creative Writing. New Delhi: Cambridge University Press, 2010.
Rao, N. Meera Raghavendra. Feature Writing. New Delhi: PHI Learning Private Limited, 2009.
Bulman, Colin. Creative Writing: A Guide & Glossary to Fiction Writing. London: Polity Press. 2007.
Mills, Paul. Creative Writing Course Book. London: Routledge, 2006.
Rao, Cheryl, Gita Iyengar and Meena Murdeshwar. Ed. Anyone Can Write. New Delhi: Cambridge University Press, 2009.

SM458 INTRODUCTION TO INDUSTRIAL ECONOMICS AND ORGANIZATION (3-0-0)3

Introduction to economics of industry- review of relevant microeconomic concepts; Theory of the Firm; Structure-Conduct -Performance paradigm; Market structure concepts including concentration and vertical integration; Market conduct concepts including pricing behaviour; Performance aspects including growth and profitability; Transaction cost analysis; Economics of information technology; Introduction to Game Theory- Basic elements, Prisoner's Dilemma, Nash equilibrium; Overview of latest industrial and competition policies in India.

Belleflamme, P. and Peitz M., Industrial Organization: Markets and Strategies, Second Edition, Cambridge University Press, 2015.
Carlton D.W. and Perloff, J. M., Modern Industrial Organization, Fourth Edition, Pearson, 2005.
Hay, D.A. and Morris, D.J., Industrial Economics and Organization: Theory and Evidence, Oxford University Press, Revised Edition, 1991.
Varian, H.R., Farrell, J. and Shapiro, C., The Economics of Information Technology: An Introduction, Cambridge University Press, 2004.
Osborne, M.J. and Rubinstein, A., A Course in Game Theory, Cambridge, MIT Press, 1994.

SM459 ADVANCED COURSE ON ENTREPRENEURSHIP (3-0-0)3

Pivoting – evaluating different business models, analyze competitors, product management.
Business palnning – yearly sales, people and financial paln; Growth strategy – scaling customers, revenue and

sources of funding; Team building; Brading and channel strategy – Understand and examine different channels; Leveraging technology – Identifying technology needs and choosing key technologies, technology as a competitive advantage; Measuring progress establishing key merics and measuring; Lega – Incorporating, regulations.

John R. Bessant, Joe Tidd, Entrepreneurship, Wiley, 2018

Beverly Rudkin IngleDesign Thinking for Enterpreneurs and Small Businesses: Putting the Power of Design to Work 1st ed. Edition, Wiley, 2018

Value Proposition Design, Osterwalder Alex, Wiley India Pvt. Ltd.

SM460 CONTEMPORARY ENTREPRENEURSHIP (3-0-0)3

Self Discovery; Opportunity discovery, Customer and Solution – understanding who is the customer, identify job, pains, gains and early adopters, Establish your venture's unique value proposition and competitive advantage; Basics of business models and lean canvas; Validation – refine value proposition with blue ocean strategy, build solution demo, prototype development; Understanding cost structures, bootstrapping and initial financing Positioning and branding, Sales plan using funnel approach; Support – Project management, operating a business.
Pivoting – evaluating different business models, analyze competitors, product management. Business planning – yearly sales, people and financial paln; Growth strategy – scaling customers, revenue and sources of funding; Team building; Brading and channel strategy – Understand and examine different channels; Leveraging technology – Identifying technology needs and choosing key technologies, technology as a competitive advantage; Measuring progress establishing key metrics and measuring; Lega – Incorporating, regulations.

Jonathan Allen, Digital Entrepreneurship, Routledge, 2019

John R. Bessant, Joe Tidd, Entrepreneurship, Wiley, 2018

Beverly RudkinIngleDesign Thinking for Enterpreneurs and Small Businesses: Putting the Power of Design to Work 1st ed. Edition, Wiley, 2018

Value Proposition Design, Osterwalder Alex, Wiley India Pvt. Lt

B.Tech. Minor Courses

1. **Minor in Management**
   i. SM200M- Financial Management(3-0-0) 3
   ii. SM250M- Human Resource Management(3-0-0) 3
   iii. SM305M- Business Analytics and Decision Making(3-0-0) 3
   iv. SM350M- Entrepreneurship(3-0-0) 3
   v. SM405M- Marketing Management(3-0-0) 3
2. **Minor in Economics**
   i. SM205M Microeconomics (3-0-0) 3
   ii. SM255M Macroeconomics (3-0-0) 3
   iii. SM310M Introduction to Industrial Economics and Organization (3-0-0) 3
   iv. SM355M Financial Economics (3-0-0) 3
   v. SM410M Development Economics (3-0-0) 3

Detailed Course Content- Minor in Management

SM200M 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 – FinancialAnalysis, 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 – EvaluationTechniques, Evaluation Of Lease Contracts - Corporate Restructuring, Mergers And Acquisitions – FinancialRestructuring, - Working Capital Management

Van Horne James C., Financial Management Policy, Prentice of India, (9th Edition)

Pandey I.M., FinancialManagement, Vikas Publications House, (7th Edition) Chandra, P., Fundamentals of Financial Management, TMH

SM250M Human Resource Management (3-0-0) 3

Overview Of HRM, Strategic HRM, HR Planning, Job Analysis, Recruitment And Selection, Human ResourceDevelopment, Performance Assessment And Management, Compensation System, Incentives And Benefits, SafetyAnd 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.

SM305M- Business Analytics and Decision Making(3-0-0) 3

Analytical decision making: emerging business environment- analytical competition-embedding analytic in businessprocess- reporting / descriptive analytics, modeling or predictive analytics, data-driven strategies- analytics andbusiness performance- building analytical culture- industry trends in analytics-review techniques and tools. Businesscontexts-stages of enhanced analytics capabilities-defining metrics- categories and levels of metrics-defining KPIslinkingstrategic outcomes and KPIs- KPI directories for different industry segments- aligning technologies inanalytics 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 analysissuggestingstrategic and tactical programs. Project development: industry inputs- validation of models- frameworksdataanalytics.

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)

SM350M- Entrepreneurship

Nature and importance of entrepreneurship, entrepreneurial decision-making process, role of entrepreneurship ineconomic development, National knowledge commission report, entrepreneurship- characteristics, motivation, rolemodels 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 modelsof family business, challenges facing entrepreneurs-individuals,family,groups, society, provisions for nursing sickunits.

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

SM405M- Marketing Management (3-0-0) 3

Introduction to Marketing - Marketing Process - Marketing Environment - Marketing Research – DemandForecasting - Competition - Marketing Strategy - Consumer Behaviour- Industrial Marketing -Customer Satisfaction- Segmentation - Targeting, Positioning Developing New Market Offerings - Product Life Cycle - Designing GlobalMarket 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 Keller Marketing Management, Pearson, 12th Edition, 2006.
Philip Kotler and Gary 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

Detailed Course Content- Minor in Economics

SM205M Microeconomics (3-0-0) 3

Exploring the Subject Matter of Economics, Markets and Welfare. The Ten Principles of Economics; Working of the economy as a whole; Thinking like an Economist: The Market Forces; Markets and Competition; The Demand and Supply; Market Equilibrium; Elasticity of Demand and Supply; Consumer and Producer Surplus. Theory of

Consumer Choice; The budget constraint; Optimisation-Equilibrium. The Firm and Market Structures; Theory of Production and Cost: Production Function; Isoquants and Laws of Production; Firms in Competitive Markets; Profit maximisation and the competitive firm's supply curve. The firm's supply decision; Firm's short-run decision to shut down; Firm's long-run decision to exit or enter a market. The Input Markets. The marginal product of labour; demand for labour; The supply of labour- the trade-off between work and leisure; Equilibrium in the labour market.

Varian, Hal R. (1992), Microeconomic Analysis, 3rd Edition, International Student Edition, W. W. Norton and Company
Gregory N Mankiw, "Principles of Economics" 6e Cengage Learning India Private Limited, New Delhi
Pindyck, Rubinfeld and Mehta: (2018): Microeconomics, 9e, Pearson Education Inc

SM255M Macroeconomics (3-0-0) 3

The Economic Problem: Scarcity and Choice; Introduction to Macroeconomics, Measuring National Output and National Income; Classical Theory - Unemployment, Inflation, and Long-Run Growth; Aggregate Demand and Equilibrium Output - The Keynesian Theory of Consumption, The Government and Fiscal Policy - Government in the Economy, Fiscal Policy at Work: Multiplier Effects; Aggregate Supply – Phillips curve; Government Policy Debates

Mankiw, G. and Taylor, M.P. Macroeconomics, 7th Edition, Cengage, 2017.
Case, K.E., Fair, R.C., Oster, S.M., Principles of Macroeconomics, 13th Edition, Pearson, 2017.
Dornbusch, R., Fischer, S., and Startz, R., Macroeconomics, 12th Edition, Mc Graw Hills 2018
McDonnell, C., Brue, S., and Flynn, S., Macroeconomics: Principles, Problems, and Policies, Irwin Professional Pub; Student, Student edition, 2014.
Several research articles.

SM310M Introduction to Industrial Economics and Organization (3-0-0) 3

Introduction to economics of industry- review of relevant microeconomic concepts; Theory of the Firm; Structure-Conduct -Performance paradigm; Market structure concepts including concentration and vertical integration;Market conduct concepts including pricing behaviour; Performance aspects including growth and profitability;Transaction cost analysis; Economics of information technology; Introduction to Game Theory- Basic elements,Prisoner's Dilemma, Nash equilibrium; Overview of latest industrial and competition policies in India.

Belleflamme, P. and Peitz M., Industrial Organization: Markets and Strategies, Second Edition, CambridgeUniversity Press, 2015.
Carlton D.W. and Perloff, J. M., Modern Industrial Organization, Fourth Edition, Pearson, 2005.
Hay, D.A. and Morris, D.J., Industrial Economics and Organization: Theory and Evidence, Oxford UniversityPress, Revised Edition, 1991.
Varian, H.R., Farrell, J. and Shapiro, C., The Economics of Information Technology: An Introduction, CambridgeUniversity Press, 2004.
Osborne, M.J. and Rubinstein, A., A Course in Game Theory, Cambridge, MIT Press, 1994.

SM355M Financial Economics (3-0-0) 3

Financial Markets- Bonds, Equities and Derived Instruments. The time dimension – Present value and duration – The term structure of interest rates– Measurement of risk. Stock market operations – Money market funds. Stock exchanges – The over-the-counter stock market – Operational efficiency and the Efficient Market Hypothesis (EMH) – The weak, semi-strong and the strong form of EMH. The Capital Asset Pricing Model (CAPM) – Estimating betas- Implications for portfolio management – Validity of CAPM – Arbitrage Pricing theory- Fama-French model. Stock indices- Price Indices and Total Return Indices. Uses of Derivatives – Forwards- Futures - Options – The origins of Futures trading. Relation among spot and futures prices – financial futures – commodity futures – Derivative Market Participants – Futures and portfolio management. The pay offs from buying and selling options – Boundary conditions on option prices – The put-call parity– The Black-Scholes formula.

Houthakkar H.S. and Williamson P.J. (1996), The Economics of Financial Markets, Oxford University Press
Jurgen Echberger and Ian R. Harper (1997), Financial Economics, Oxford University Press
Fabozzi (2009), Bond Markets, 7th revised edition, Pearson Publications.
Select research papers.

SM410M Development Economics (3-0-0) 3

Introduction, distinction between Growth and Development Studies, Concept of Development, Evolution of Measures of Economic Development, Physical Quality of Life Index (PQLI), Various Dimensions of Human Development, Gender Development Index, Gender Inequality Index and Multi-dimensional Poverty Index. Adam Smith's Theory, Ricardian Theory, Malthusian Theory, Mill's Theory, Marxian Theory, Schumpeterian Theory, Keynesian Theory, Rostow's Stages of Growth, Harrod-Domar Model, the Solow model and its variants,

endogenous growth models. East Asian Miracle, East Asian Crisis, Latin American Economic Development, Indian Economic Performance and Reforms, China's Economic Development and Reforms and Africa's Development Experience. The Concept and Measurement of Poverty, Nature and levels of Poverty in Developing countries, Economic Inequality, Criteria of Inequality Measurement, The Lorenze Curve, Functional Distribution, Economic Growth and Income Distribution: The Kuznets Hypothesis. Human Capital Formation and Economic Development: Composition of Human Investment, problems of Human Capital Formation. Entrepreneurship and Economic Development: Qualities of Entrepreneurs, Role of Entrepreneur, Obstacles in the Growth of Entrepreneurship, Measures to Encourage Entrepreneurship. Technology and Economic Development: Role of Technology in Economic Development, Process of Technological Change, Suitability of Foreign Techniques.

Meier, G, (2001), 'The Old Generation of Development Economics and the New', Meier and J. Stiglitz (eds), Frontiers of Development Economics, World Bank.

Meier, G and J. Rauch (2009), 10 edition, Leading Issue in Economic Development, Oxford University Press, USA.

Debraj Ray, (2009) Development Economics, Oxford University Press.

WO110 ENGINEERING MECHANICS (3-0-0) 3

Fundamentals of force system, Concept of Rigid body and deformable bodies, Free body diagrams. Support Reactions-Determinate and Indeterminate structures. Analysis of Trusses, Frames and Machines. Centroid and Moment of Inertia of plane areas. Shear Force and Bending Moment Diagrams. Simple stress and strain, Hooke's Law, Mechanical properties of materials, Elastic Constants.

Merian, J.L, Kraige, L.G. Engineering Mechanics – Statics, 5th Edition, Wiley Publishers, New-Delhi, 2007.
Beer & Johnston, Mechanics for Engineers, 4th Edition, McGraw – Hill, New Delhi, 1987.
Timoshenko, S.P., Young, D.H., Rao, J.V. Engineering Machines,4th Edition, McGraw-Hill, Singapore, 1956.
Singer, F.L. Strength of Materials, Third Edition, Harper and Row Publishers, New York, 1980.
Hearn, E.J., Mechanics of Materials, Pergaman Press, England, 1972.
Beer and Johnston E. R. Mechanics of Materials, 3rd Edition, Tata McGraw Hill, New Delhi, 2007.

WO200 MECHANICS OF MATERIALS (3-0-0) 3 PREREQ: WO110

Simple flexure theory, Bending stress and shearing stress distribution across sections. Deflection of beams, Macaulay's method for deflection of statically determinate beams. Compound stresses - analytical method, graphical method - Mohr's circle of stresses. Torsion, Transmission of power through hollow and solid shafts. Beams of uniform strength, springs, Combined bending and torsion, Strain energy, Theories of failure, Columns & struts, Thick and thin pressure vessels.

Singer, F.L. Strength of Materials, 3rd Edition, Harper and Row Publishers, New York, 1980.
Hearn, E.J., Mechanics of Materials, Pergaman Press, England, 1972.
Beer and Johnston E. R. Mechanics of Materials, 3rd Edition, Tata McGraw Hill, New-Delhi, 2007.

WO216 STRENGTH OF MATERIALS LAB (0-0-3) 2

Tension test on mild steel and cast iron, Compression test on mild steel and cast iron, Torsion test on mild steel rod, Rockwell and Brinell hardness tests, Impact test (Charpy and Izod) on mild steel, Bending test on mild steel rod and wood, Shear test on mild steel plate and rod, tests on leaf and helical spring. Demonstration on fatigue test.

Hearn, E.J., Mechanics of Materials, Pergaman Press, England, 1972.
Beer and Johnston E. R. Mechanics of Materials, 3rd Edition, Tata McGraw Hill, New-Delhi, 2007.

WO217 MECHANICS OF SOLIDS LAB (0-0-2) 1

Tension tests on mild steel and cast iron, Compression tests on mild steel and cast iron, Shear tests, Bending test on mild steel, Torsion test, Hardness test and Impact test. Demonstration on fatigue test and springs

Hearn, E.J., Mechanics of Materials, Pergaman Press, England, 1972.
Beer and Johnston E. R. Mechanics of Materials, 3rd Edition, Tata McGraw Hill, New-Delhi, 2007.

WO218 MECHANICS OF FLUIDS (3-0-0) 3

Properties and classification of fluids. Basic equation of fluid statics. Manometers. Buoyant force. Kinematics of fluid flow. Continuity equation. Bernoulli's equation. Momentum equation. Flow measurements: Brief introduction. Dimensional analysis. Model law. Basics of pipe flow. Hagen-Poiseuille equation. Darcy-Weisbach equation. Moody's diagram. Uniform flow in open channels.

Modi, P.N and Seth, S.M., Hydraulics and Fluid Mechanics, Standard Book House, Delhi, 2010.
Streeter. V.L and Wylie. E.B., Fluid Mechanics, McGraw Hill Book Company, New York,1997.
Ven Te Chow, Open Channel Hydraulics, McGraw Hill, New York 1959.

WO219 HYDRAULICS LAB (0-0-3) 2 PREREQ: WO218

Calibration of V notch, Rectangular Notch; Venturimeter, Orifice meter, Water meter. Friction factor of pipes. Impact of jet on vanes. Tests on centrifugal pump, reciprocating pump, Pelton wheel turbine, Francis turbine. Hydraulics jump, Syphons, Demonstration experiments (pressure gauge, Pitot tube, Kaplan turbine)

Modi, P.N and Seth, S.M., Hydraulics and Fluid Mechanics, Standard Book House, Delhi, 2010

WO260 WATER RESOURCES ENGINEERING (3-0-0) 3 PREREQ: WO218

Hydrology: Hydrologic cycle, Water budget, Catchment. Precipitation: types, measurement, intensity, duration, temporal and spatial analysis. Infiltration, soil moisture, evaporation, transpiration, Groundwater. Runoff: components, factors, hydrographs, unit hydrograph, flood estimation. Irrigation: objectives, methods, irrigation water requirements. Components of irrigation system and design principles. Water Power Engineering: Basic principles, types of schemes

Subramanya K, Engineering Hydrology, Tata McGraw Hill, 3rd Edition, 2008.
Garg S. K, Irrigation Engineering and Hydraulic Structures, Khanna Publishers, 2008.
Ven Te Chow, LW Mays and DR Maidment., Applied Hydrology, McGraw Hill, 1988.

WO317 FLUID MECHANICS AND MACHINERY LAB (0-0-2) 1 PREREQ: ME202

Calibration of V notch, Venturimeter, Orifice meter, Water meter. Friction factor of pipes. Impact of jet on vanes. Tests on centrifugal pump, reciprocating pump, Pelton wheel turbine. Demonstration experiments (pressure gauge, Pitot tube, Kaplan turbine)

Modi, P.N and Seth, S.M., Hydraulics and Fluid Mechanics, Standard Book House,

WO371 OPEN CHANNEL FLOW AND SEDIMENT TRANSPORT (3-0-0) 3 PREREQ: WO218

Steady GVF, SVF, RVF. Unsteady flow: basic equations, velocity of flood wave discharge, flood routing. Bulk properties of sediments, various related theories such as competent velocity concepts, lift concept, critical tractive force concept, Shield's analysis, regimes of flow, bed forms, resistance to flow, bed and suspended load transport, reservoir sedimentation, agredation and degradation of rivers, local scour, sediment samplers.

Subramanya. K, Open channel flow, Tata McGraw Hill,3rd Edition, 2010. Graf,W. H.
Hydraulics of sediment transport, McGraw Hill, 1984.
Garde and Rangaraju, Sediment transport, Wiley Eastern, 2nd Edition,1985 Chow, V.T. open channel flow

WO372 CIVIL ENGINEERING SYSTEMS (3-0-0) 3

Introduction to systems approach, simple and complex system, unique features of complex system. Unconstrained optimization, concave & convex functions, constrained optimization - KT conditions, Lagrangian multiplier method. Introduction to LP, Simplex method, Two phase method, Duality in LP, Introduction to DP, Network model, Allocation model. Some typical case studies.

Rao. S.S., Engineering Optimization, Wiley-IEEE, 3rd Edition, 1996.
Taha, H..A,Operation Research, Prentice Hall, 6th Edition, 1997.
Panik M. .J., Classical optimization foundation, North Holland Pub. Co., 1976.

WO380 MINI PROJECT – I (0-0-3) 2

Experimental work either in the field or in the laboratory or design tasks of relatively smaller magnitude compared to Major Project work and in line with the guidelines formulated by the DUGC (WROE).

WO381 MINI PROJECT – II (0-0-3) 2

Experimental work either in the field or in the laboratory or design tasks of relatively smaller magnitude compared to Major Project work and in line with the guidelines formulated by the DUGC (WROE).

WO400 GEOGRAPHIC INFORMATION SYSTEMS (3-0-0) 3

Components of GIS, functions , Coordinate Systems, Raster and vector-based GIS and data structures, Spatial data sources Geo-relational Vector data model, Object based vector data model, raster data model, data input, geometric Transformation, Spatial data editing, Attribute data input and management, vector data analysis, Raster data analysis., Applications of GIS in several domains

Kang-tsung Chang, Introduction to Geographic Information Systems, 4 th edition Tata McGraw Hill Burrough & McDonnell, Principles of Geographical Information Systems, Oxford University Press
Yang, Snyder & Tobler, Map projection Transformation principles and applications, Taylor and Francis

WO401 SATELLITE DIGITAL IMAGE ANALYSIS (3-0-0) 3

Introduction to Remote sensing and Digital image Processing, Remote sensing data collection Alternatives, Hardware and software issues, Image Quality assessment , Electromagnetic Energy Radiation Principles and radiometric correction, Geometric correction, Image Enhancement , Pattern Recognition, Information extraction from MSS and Hyperspectral data, Change detection studies.

Jensen J.R Remote Sensing of the Environment An Earth Resource Perspective Second Edition , Dorling Kindersley India Pvt Ltd.
Jensen J.R Introduction to Digital Image Processing: A remote sensing Perspective. Prentice- Hall,2005. Lillesand, T.M., R.W. Kiefer, and J.W. Chipman. Remote Sensing and Image Interpretation. 5th Edition. John Wiley and Sons. 2004.

(3-0-0)3

WO402 INTRODUCTION TO GEOSPATIAL TECHNOLOGIES AND APPLICATIONS

Introduction to Geographic Information Systems, spatial data sources and models, spatial data analysis and applications, GPS principles and applications, introduction to satellite remote sensing, sensors and resolution, image processing methods classification, accuracy assessment in GIS and GPS, change detection; applications of GIS, remote sensing and GPS in resources management, environmental monitoring, optimal site selection, rural and urban development.

Chang K., Introduction to Geographic Information Systems, 8th Edition, McGraw-Hill, New York, 2006.
Hofman-Wellenhof. B., Wein. Global Positioning System: theory and practice, Springer 2001
Lillesand, T. and Kiefer, R.W., Remote Sensing and Image Interpretation, 5th edn., 2004
Richards, J.A. and Jia, X., Remote Sensing Digital Image Analysis, 4th ed., Springer, 2006.

WO403 GLOBAL POSITIONING SYSTEMS (3-0-0) 3

Introduction to GPS, GPS details, GPS Errors and Biases , Datum, Coordinate Systems and Map Projections , GPS Positioning Modes, Ambiguity-Resolution Techniques, GPS Data and Correction Services,GPS standard Formats, GPS integration, GPS applications, Other Satellite Navigation Systems

Ahmed El- Rabbany " Introduction to GPS" Artech House Rao,
K.N. R Fundamentals of Satellite Communications PHI, 2004

WO421 DESIGN & DRAWING OF HYDRAULIC STRUCTURES (1-0-3) 3 PREREQ: WO260

Introduction to Lacey's regime theory, Khosla's theory, Bligh's creep theory, Hydraulic design and drawing of following structures: i. Earthen dam; ii. Gravity dam (OS); iii. Gravity dam (NOS); iv. Surplus weir; v. Canal drop; vi. Canal regulator; vii. Tank sluice with tower head; viii. Direct sluice; ix. Aquaduct.

Punmia,BC and Lal,PBB. Irrigation& Water Power Engineering, Standard Book House, 2ndEdition,1990.
Michel, WH. Manual of Irrigation Engineering, Hubbard Press,1997.
C.S. Murthy, Water Resources Engineering:Principles and Practices, New Age International,1997.

WO422 FUNDAMENTALS OF COASTAL ENGINEERING (3-0-0) 3 PREREQ : WO218

Basic Wave Hydrodynamics, Linear Wave Theory, Wave Phenomena,Generation of Wind Waves, Wave Spectrum, Wave Forecasting, Basics of Wave Structure Interaction, Coastal Processes - Littoral Drift, Coastal Erosion and Protection (Hard and Soft Options), Design Principles of Breakwaters.

Shore Protection Manual, U.S.Army Corps of Engineers, Coastal Engineering Research Center,1984. US Army Corps of Engineers, 'Shore protection manual(SPM)", Vol. 1 &2, Coastal Engg Res. Centre, US Govt. Printing Office , Washington D.C. USA, 1984.
US Army Corps of Engineers, 'Coastal Engg. Manual (CEM)", Parts 1 to 6, Coastal Engg Res. Centre, Washington D.C. USA., 2006.
Ippen A.T., Estuary & Coastline Hydrodynamics, McGraw Hill, New York, USA, 1996.

WO423 BASICS OF OFFSHORE ENGINEERING (3-0-0) 3 PREREQ: WO218

Ocean Waves, Currents, Winds, Ice and Mud loading, Basics of Offshore Structures - Jacket, Tower, Gravity platforms, Hybrid Structures and factors governing their selection, Linear wave theory, Morison equation. Linear dynamic analysis, Pile foundations, Bearings capacity of footings, Corrosion and under water Welding.

US Army Corps of Engineers, 'Shore protection manual(SPM)", Vol. 1& 2, Coastal Engg Res. Centre, US Govt Printing Office , Washington D.C. USA., 1984.
US Army Corps of Engineers, 'Coastal Engg. Manual (CEM)", Parts 1 to 6, Coastal Engg Res. Centre, Washington D.C.,USA, 2006.
Weigel R.L.,Recommended practice for Planning, Designing, & Construction of Fixed Offshore Structures - Oceonographical Engg., Prentice Hall, 1969.
Pilarckzyk K. W. and Zeidler R. B., "Offshore breakwaters and Shoreline Evolution Control", A. A. Balkema Publishers, Rotterdam, The Netherlands,1996.

WO424 COASTAL EROSION & ITS MITIGATION (3-0-0) 3 PREREQ : WO218

Origin of Coasts, Sediment Transport and Budgeting, Coastal Erosion and Mitigation: A Global Scenario and Indian Perspective, Coastal Processes, Planning and Design of Coastal Protection Works, Soft and Hard Options, Innovative Technologies, Remote Sensing, Geographical Information System and Artificial Neural Network in Coastal Engineering, 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

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

WO445 FUNDAMENTALS OF FINITE ELEMENT METHOD (3-0-0) 3

Direct approach. Basic structural elements. Finite difference method, Galerkin weighted residual approach, Rayleigh Ritz method, Element properties. Linear and quadratic elements, shape functions. Isoparametric elements. Numerical integration using Gauss-Legender quadratures, 1-D problems. Shape function for 4, 8 and 9 nodal quadrilateral elements, Stiffness matrix and consistent load vector, Evaluation of element matrices using numerical integration.

Robert D Cook, David S Malkus, Michael E Plesha, 'Concepts and Applications of Finite Element Analysis', 4th edition, John Wiley and Sons, Inc., 2003.
Reddy J.N., An Introduction to Finite Element Method , McGraw Hill – 2000.
Rao. S.S., Finite Element Methods in Engineering, Butterworth and Heinemann, 2001.
L.T. Segerlind, Applied Finite Element Analysis, John-Wiley, 2nd edition,1984.

WO455 ENGINEERING OPTIMIZATION (3-0-0) 3

Optimization, Formulation of linear Optimization problems, Linear Programming model,Graphical method, Simplex method, Finding a feasible basis - Big M and two phase Simplex method, Duality in Linear Programme. Primal-dual relationship. Sensitivity analysis. Network analysis: Transportation problem. Dynamic Programming (DP); Non-linear Programming-unconstrained and constrained optimization, Lagrange multipliers and Kuhn - Tucker conditions.

F.S.Hiller and G.J.Liberman, Introduction to Operations Research.
Ravindran ,D. T.Philips and J.J.Solberg , Operations Research - Principles and Practice.
Hadly.G, Linear Programming(LP)
S.S.Rao, Engineering Optimisation

WO473 WATER RESOURCES EXCESS MANAGEMENT (3-0-0) 3 PREREQ : WO260

Excess rainfall, Direct runoff, Peak flow estimation, Frequency and Return Period, Risk, Design storm, Design Storm Hydrograph. Flow routing. Drainage of urban areas, System components and Design principles, Storm water management.

Ven Te Chow, LW Mays and DR Maidment., Applied Hydrology, McGraw Hill, 1988.
American Society of Civil Engineers Task Committee on Hydrology Handbook, Hydrology Handbook, 2nd edition, ASCE Manuals & Reports on Engg. Practice No.28, 1996
Mays. L.W. Water Resources Handbook,McGraw Hill, 2007.

WO474 COMPUTATIONAL METHODS IN HYDROLOGY (3-0-0) 3 PREREQ : WO260

Introduction**,** Hydrometeorological measurements, Hydrological models, catchment simulation. Continuity, momentum and energy equations, differential equations in hydrology. Finite difference technique, Finite element method, Galerkin method, steady and transient problems. Model application, flow routing, wave motion, unsaturated /saturated ground water flow.

Maidment, D. Hand Book of Hydrology, McGraw Hill, 1st edition, 1993.
Huyakorn and Pinder, Computational methods in subsurface flow, Academic Press, New York, 1983. Zienkiewiz O.C. and Morgan, K., Finite elements and approximation, John Wiley,2006.

WO475 GROUNDWATER ENGINEERING (3-0-0) 3 PREREQ : WO260

Fundamentals of ground water flow, Mechanics of well flow, Image well theory, Well design, Well characteristics, Production tests and maintenance. Pollution of aquifers: salt water intrusion, Aquifer remediation and management, Groundwater recharge, Rainwater harvesting, Ground water rights.

Todd D.K, Ground water hydrology, 3rd edition, Wiley,2008.
Walton, W.C., Ground water resource evaluation. McGraw Hill, 1970. Raghunath, H.M., Ground Water, New Age International, 3rd edition, 1998. Karanth, K. Groundwater Assessment and Management, Tata McGraw Hill, 2007.

WO477 OPEN SOURCE VIRTUAL INSTRUMENTATION (2-0-2) 3

Introduction to Open Source Virtual Instrumentation, Basics of Open Source Programming and data acquisition, Basics of Open source Sensors, actuators and its characteristics, Design and development of Smart Management Systems using Virtual Instrumentation. Lab component : Open source technique for identification of natural frequency of simplified real world system. Experimental methods of system parameter identification. Experiment on smart monitoring of Agricultural related sensors, pumps, energy meter, Experiment on development of Smart

Management Systems.

D Patranabis Sensors and Transducers, Phl 2nd Edition, 2003.
J.P Holman Experimental Methods for Engineers, McGrawHill 6th Edition, 2000.
Matt Richardson, Shawn Wallace, Getting Started with Raspberry Pi Maker Media Inc., 2012.

WO478 THEORY OF ISOTROPIC ELASTICITY (3-0-0) 3 PREREQ.: WO200 or WO201

Definition of Stress and Strain: Stress - Strain relationships - Equations of Equilibrium, Compatibility equations, Boundary Conditions, 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, semi - inverse method and applications to shafts of circular, elliptical, equilateral triangular and rectangular sections.

Wang, C. T., Applied Elasticity, McGraw – Hill Co., New York, 1993.
Sokolnikoff, I. S., Mathematical Theory of Elasticity, McGraw – Hill, New York, 1978.
Volterra & J.H. Caines, Advanced Strength of Materials, Prentice Hall, New Jersey,
1991 Barber, J. R., Elasiticity, Kluwer Academic Publishers, 2004
Timoshenko, S., and Goodier, T.N., Theory of Elasticity, McGraw – Hill Ltd., Tokyo, 1990.
Ansel C Ugural and Saul K Fenster, 'Advanced Strength and Applied Elasticity', 4th Edition, Prentice Hall, New Jersey, 2003.
Bhaskar, K., and Varadan, T. K., Theory of Isotropic/Orthotropic Elasticity, CRC Press USA, 2009.

Interdisciplinary Minor

Minor in Machine Learning

CH459M MACHINE LEARNING APPLICATIONS IN CHEMICAL ENGINEERING (0-0-6)4

In this course, the machine learning (ML) minor program's chemical engineering students will learn how to incorporate ML-based analysis combined with first-principles-based models of chemical equipment, chemical processes, and other systems by project-based learning. Various problems in chemical engineering (such as process monitoring, diagnosis, and control, equipment/process/material design, process optimization, and process hazards analysis, etc.) that can be analysed using various ML approaches such as regression, clustering, neural networks, random forests, Bayesian networks, directed evolution, etc. will be given as project work to students. The course (project work) will be evaluated by all the faculty members who offer the ML projects in the particular semester.

CV448M MACHINE LEARNING APPLICATIONS IN CIVIL ENGINEERING (0-0-6)4

The student has to select a project to apply basic principles of different machine learning algorithms namely Agent Based Modelling (ABM), Artificial Neural Network (ANN), Bayesian Networks, Fuzzy Logic (FL), Genetic Algorithm (GA), or Support Vector Machine (SVM) to various Civil Engineering applications in construction management, environmental assessment, geological investigations, structural engineering, transportation engineering, geotechnical engineering, water resources management and wastewater treatment.

CS367M FOUNDATIONS OF CYBER-PHYSICAL SYSTEMS (3-1-0)4

CPS concepts and requirements, CPS architectures, Key Features of CPSs, Applications, etc. Models of physical systems, Reactive Components, Properties of Components, Composing Components, Synchronous Designs, and Safety Requirements. Asynchronous Processes, Asynchronous Design Primitives, Asynchronous Coordination Protocols. Continuous and Timed Models, Hybrid Dynamical Models, Designing Hybrid Systems. Linear Hybrid Automata, Analysis of Elementary Cyber-Physical Systems. Resource scheduling, temperature and power management, real-time communication. Operating systems and hardware architecture support for CPS,CPS software synthesis.

Cyber-Physical Systems: Foundations, Principles and Applications, Houbing Song Danda Rawat Sabina Jeschke Christian Brecher, 1 st Ed., Elsevier, 2016.
Principles of Cyber-Physical Systems, Rajeev Alur, 1 st Ed., MIT Press, 2015.
Cyber-Physical Systems- From Theory to Practice, Danda B. Rawat, Joel J.P.C. Rodrigues, Ivan Stojmenovic 1 st Edn., CRC Press, 2016.

CS422M DEEP LEARNING (3-1-0)4

Machine learning basics, Basic neural network models [McCulloch-Pitts Model of Neuron, Perceptron], Adaline, linear and non linear activation functions, loss functions, gradient descent method, back propagation algorithm, Deep feed forward networks, Regularization for deep learning, Convolutional neural networks, Optimization for training deep models, RNN, Autoencoders, Popular deep learning architectures published in the last 10 years, Limitations of CNN, Semi-supervised deep learning, Applications (image classification and segmentation).

Goodfellow, I., Bengio, Y., Courville, A. Deep learning (Vol. 1). Cambridge: MIT press.
Martin T hagan etc, Neural network design (2nd edition), 2014
Taqiq Rashid, Make your own Neural Network, 2016
Tom Mitchell, Machine Learning, McGraw-Hill, 1997
Y. S. Abu-Mostafa et .al , Learning from Data, AMLbook.com

CS426M REINFORCEMENT LEARNING (3-1-0)4

Introduction and Basics of RL, Defining RL Framework and Markov Decision Process Polices, Value Functions and Bellman Equations, Exploration vs. Exploitation,Tabular methods and Q-networks,Deep Q-networks,Policy optimization, Vanilla Policy Gradient Reinforce algorithm and stochastic policy search, Actor-critic methods, Advanced policy gradient, Model-based RL approach, Meta-learning, Multi-Agent Reinforcement Learning, Partially Observable Markov Decision Process, Ethics in RL, Applying RL for real-world problems.

Reinforcement Learning: An Introduction, Sutton and Barto, 2nd Edition.
Reinforcement Learning: State-of-the-Art, Marco Wiering and Martijn van Otterlo, Eds.
Artificial Intelligence: A Modern Approach, Stuart J. Russell and Peter Norvig
Deep Learning, Ian Goodfellow, Yoshua Bengio, and Aaron Courville.

CS473M PROJECT FOR ML MINORS (0-0-6) 4

The student has to select a project in application or computational models of machine learning. The project work

will be evaluated internally and externally as per the evaluation criteria decided by the DUGC.

EC500M MACHINE LEARNING FOR ELECTRONICS AND COMMUNICATION ENGINEERING
(3-1-0) 4

Machine learning for 5G and 6G Wireless Networks, Medical Signal and Image Processing, Satellite Image Processing and Remote Sensing, Radar Signal Processing, Tactical and Surveillance Applications, Speech and Audio Processing, VLSI, Device modelling, electronic manufacturing, Computer vision and other applications.

Josh Patterson and Adam Gibson, "Deep Learning: A Practitioner's Approach", O'Reilly, 2017
Ian Goodfellow, Y. Bengio and A. Courvelle, "Deep Learning", MIT Press, 2016
Li Deng and Dong Yu, "Deep Learning: Methods and Applications", 2013
Machine Learning for Audio, Image and Video Analysis", F. Camastra, Vinciarelli, Springer, 2007
Jeremy Watt and Reza Borhani, Machine Learning Foundation, Algorithms and Applications
Fa-long Luo, MAchine learning for future Wireless Communications, 2020 edition, Wiley

EE450M APPLICATIONS OF MACHINE LEARNING TECHNIQUES TO PROBLEMS IN ELECTRICAL ENGINEERING (3-0-2) 4

Identification of Problems that require machine learning approach. Study of Electrical Engineering Problems and selection of problems that are amenable to be tackled through machine learning techniques; Understanding the physical phenomenon of different problems in Electrical Engineering; Developing different models – Dynamic and/or steady-state; Data necessary for training and testing and validation – Data from models and fields. Hybrid Models. Representative examples could be – Classification problems: Non Intrusive Load monitoring/Energy disaggregation, detection of nature of Faults in machines and Transmission and Distribution lines; Estimation Problems: Estimation of location of Faults on overhead lines and Underground cables, Battery State-of-Charge Estimation; Control problems: Applications of ANN and Reinforcement learning to improve control performance of some selected problems in Electrical Engineering; Prediction Problems: Dynamic Ampacity Estimation of Cables and Overhead lines, Solar PV panel output prediction; Forecasting: Load Forecasting, solar PV panel output; Online Identification and Data Recovery for PMU Data Manipulation Attack.

D. Niebur and T. S. Dillon, Neural Network Applications in Power Systems, CRL Publishing Ltd. U. K., 1996.
Rafael E. Bourguet and Panos J Antsaklis, Artificial Neural Networks in Electric Power Industry – A report, Univ. of Notre Dame, April 1994.
S. O. King, How Electrical Engineering and Computer Engineering Departments are Preparing Undergraduate Students for the New Big Data, Machine Learning, and AI Paradigm: A Three-Model Overview, IEEE Global Engineering Education Conference (EDUCON), 2019.
Richard J. Povinelli, Cristinel Ababei, Henry Medeiros, Application of Machine Learning and Data Mining in Electrical Engineering – A Special issue of Energies, 2019.
Selected Publications from journals, conferences, and lecture notes developed for the purpose of this course.

IT340M MACHINE LEARNING **(3-0-2) 4**

Introduction, linear classification, perception update rule, Perception convergence, generalization, Maximum margin classification, Classification errors, regularization, logistic regression, Linear regression, estimator bias and variance, Active learning, non-linear predictions, kernels, kernel regression, support vector machine (SVM) and kernels, kernel optimization. Model selection ,description length, feature selection, Combining classifier, Boosting, margin and complexity, Margin and generalization, mixture models, Mixtures and the expectation maximization(EM) algorithm, EM, regularization, Clustering, Spectral clustering, Markov models, Hidden Markov models (HMMs), Bayesian networks, Learning Bayesian networks, Probabilistic inference, collaborative filtering.

Ethem Alpaydin, -Introduction to Macine Learning, Revised and Updated Edition, MIT Press, 2021
Joson Bell, Machine Learning: Hands-On for Developers and Technical Professionals 2nd Edition, 2020
Peter Flach, -MAchine LEarning: The Art and Science of Algorithms that Make Sense of Data, Indian Edition, Cambridge University Press, 2015
Stephen MArsland - MAchine Learning - An Algorithmic Perspective, Second Edition, Chapman and Hall/CRC, Edition:2, 2018

IT479M MACHINE LEARNING MINOR PROJECT **(0-0-6) 4**

The student has to select a project in applications or computational models of Machine Learning. The project work will be evaluated internally aa per the evaluation criteria decided by the DUGC.

MA212M MATHEMATICS FOR MACHINE LEARNING **(4-0-0) 4**

Linear Algebra: MAtrices, Systems of Linear Equations, Echelon form and Rank, LU and Cholesky decompositions, Vector Spaces, Linear Independence, Basis and dimension, Linear Mappings, Inner Products and

Orthogonality, Orthogonalisation, QR decomposition, Determinant and Trace, Eigenvalues and Eigenvectors, Eigen decomposition, Singular Value Decomposition.
Probability and Distributons: Construction of a Probability Space, Introduction to Discrete and Continuous Probabilities, Sum Rule, PRoduct Rule, and BAyes' Theorem , Summary Statistics and Independence, Gaussian Distribution, Conjugacy and the Exponential Family, Change of Variables.
Linear Regression: Least Squares estimators of the regression parameters, Distribution of the Estimators, Analysis of Residuals, Transforming to Lilearity, weighted Lest Squares, Introduction to multiple linear regression. **Dimensionality Reduction with Principal Component Analysis**: Eigenvector Computation and Low-Rank Approximations, PCA in High Dimension.
Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong,"Mathematics for Machine Learning", Cambridge University Press (2020).
Gilbert Strang, "Linear Algebra and Its Applications", Cengage (2006).
Sheldon M Ross, "INTRODUCTION TO PROBABILITY AND STATISTICS FOR ENGINEERS AND SCIENTISTS", Academic Press (2014).

MA309M MATHEMATICAL FOUNDATIONS OF DATA SCIENCE (3-1-0)4
High-Dimensional Space: The law of large numbers, Geometry of high dimension, Unit ball and its properties, Gaussians in high Dimension, Random projection, Separating Gaussians, Fitting a spherical Gaussians to data. **Best-Fit Subspace and Singular Value Decomposition**: Singular vector, Singular value decomposition (SVD), Best rank-K approximations, Left singular vectors, Power method for SVD, Applications of SVD. **Algorithms for Massive Data Problems**: Frequency moments of data streams, Matrix algorithms using sampling, Sketches of documents. **Clustering**: Introduction, k-Means and k-center clustering, Low-error clustering – Spectral Clustering, High-density clusters, Kernel methods, Recursive clustering based on sparse cuts, Dense submatrices and communities, Community finding and Graph partitioning.
Avrim Blum, John Hopcroft, and Ravindran Kannan, "Foundations of Data Science", Cambridge University Press (2020)

ME496M APPLICATION PROJECT IN MECHANIACL ENGINEERING (0-0-6) 4
The student has to select any project from the mechanical engineering domain and apply the knowledge of Machine learning to develop the prediction, classification and optimization model. The project work will be evaluated internally and externally as per the evaluation criteria decided by the DUGC.

MT494M PROJECT FOR MACHINE LEARNIG MINOR (0-0-6) 4
The student has to select a project in applications or computational models of Machine Learning related to Materials processing/Materials Engineering/Nanotechnology. The project work will be evaluated as per the evaluation criteria approved by the DUGC.

MI485M PROJECT FOR MACHINE LEARNING MINOR (0-0-6) 4
The student has to select a project in mining applications of Machine Learning. The project work will evaluated internally and externally as per the evaluation criteria decided by the DUGC.

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

STUDENT DECLARATION ON THE *NITK HONOUR CODE*

I do hereby undertake that as a student at NITK-Surathkal, I shall be bound by the NITK Academic Regulations & Curriculum, and all the applicable Rules governing the academic programmes; and also specifically that :

(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:

- Copying in examination, from another's paper or from any other source;
- 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;

I understand and accept that any act of mine that can be considered to be a violation of the NITK *Honour Code* will invite disciplinary action as decided by the Institute Authorities.

Student's Full Signature : _____

FULL NAME IN BLOCK LETTERS : _____

_____

Semester Fee Payment Receipt Number & Date : _____

Student Register Number :

Admission Number (if assigned)	Roll Number (if assigned)

Date : _____

Declaration to be duly filled-in by the student, and signed in presence of the Faculty-Advisor or the HOD.

NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL

STUDENT DECLARATION ON THE *NITK HONOUR CODE*

I do hereby undertake that as a student at NITK-Surathkal, I shall be bound by the NITK Academic Regulations & Curriculum, and all the applicable Rules governing the academic programmes; and also specifically that :

(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:

- Copying in examination, from another's paper or from any other source;
- 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;

I understand and accept that any act of mine that can be considered to be a violation of the NITK *Honour Code* will invite disciplinary action as decided by the Institute Authorities.

Student's Full Signature : _____

FULL NAME IN BLOCK LETTERS : _____

_____

Semester Fee Payment Receipt Number & Date : _____

Student Register Number :

Admission Number (if assigned)	Roll Number (if assigned)

Date : _____

- copy to be retained by the student, as a *Reference* -

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