



SRI RAMAKRISHNA ENGINEERING COLLEGE

[Educational Service : SNR Sons Charitable Trust]

[Autonomous Institution, Reaccredited by NAAC with 'A+' Grade]

[Approved by AICTE and Permanently Affiliated to Anna University, Chennai]

[ISO 9001:2015 Certified and all eligible programmes Accredited by NBA]

Vattamalaipalayam, N.G.G.O. Colony Post, Coimbatore-641022



REGULATIONS 2022

(For students admitted from 2022-2023 and onwards)



PG PROGRAMME M.E/M.TECH

www.srec.ac.in

Information on the Number of Credits to be earned for the completion of the PG Programme

† **ME / M.Tech Programme (2 years duration)**

Minimum number of credits for completion : 70

Chairman Academic Council / Principal

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Sri Ramakrishna Engineering College was established in the year 1994 by SNR Sons Charitable Trust. It is an Autonomous Institution since 2007 and accredited by NAAC with 'A' Grade. The Institution offers 10 Undergraduate Programs and 7 Post Graduate Programs in Engineering and Technology along with MBA. All eligible Programs have been accredited and reaccredited by the NBA, New Delhi.

HIGHLIGHTS OF THE CURRICULUM

- Outcome based education with Student centric learning through Choice Based Credit System
- Industry driven learning with multi disciplinary approach
- Project-based learning
- Competency enhancement courses including on-line learning
- Collaborations with Premier Institutions-National and International
- Certification courses in foreign languages
- One credit courses offered by Industries and Research establishments
- Employability enhancement courses focusing on placements
- Industry Internship opportunities
- Inculcates Innovation, startup culture and Entrepreneurship development
- Syllabi development based on emerging technologies
- Active learning methods
- Assessment based on student learning levels
- Periodic programme outcome review within the broad framework of agreed expected graduate attributes

VISION AND MISSION OF THE INSTITUTION



VISION

To develop into a leading world class Technological University consisting of Schools of Excellence in various disciplines; with a co-existent Centre for Engineering Solutions Development for worldwide clientele.



MISSION

To provide all necessary inputs to the students for them to grow into knowledge engineers and scientists attaining.

Excellence in domain knowledge, practice and theory

Excellence in co-curricular and Extra-curricular talents

Excellence in character and personality

SRI RAMAKRISHNA ENGINEERING COLLEGE, COIMBATORE - 641 022
(An Autonomous Institution, Permanently Affiliated to Anna University, Chennai)

REGULATIONS 2022

For Post Graduate Programmes

(For The batch of ME/M.TECH Students admitted in the Academic Year 2022-2023 and Onwards)

Note:

The regulations hereunder are subject to amendments as may be decided by the Academic Council of the Institution from time to time. Any or all such amendments will be effective from such date and to such batches of students (including those already in the middle of the course) as may be decided by the Academic Council.

1. PRELIMINARY DEFINITIONS AND NOMENCLATURE

- **“Programme”** means Post graduate Programmes, like M.E/M.Tech.
- **“Degree”** means specialization or branch of M.E/M.Tech, like Manufacturing Engineering, Power Electronics and Drives, etc.
- **“Course”** means a theory or practical subject that is normally studied in a Semester, like Numerical Methods and Statistics, Adaptive Control Theory, etc.
- **“Head of the Institution”** means the Principal of the Institution.
- **“Head of the Department”** means head of the department concerned.
- **“University”** means Affiliating University.

2. ADMISSION CRITERIA

The Admission Criteria for all Programmes will be as per the norms of the Directorate of Technical Education and the Affiliating University [Refer Table 1].

3. PROGRAMMES OF STUDY

All the Degree Programmes offered by the College are based on modular structure and their academic requirements are spelt out as a number of course credits. Programmes are structured in such a way that a student will be able to complete the programme in a stipulated number of semesters. On the commendation of the Head of Department a student may be granted permission by the Chairman, Academic Council to have a break in the programme of study ; however the programme should be completed within the permitted number of Semesters.

Degree	Stipulated number of Semesters	Permitted number of Semesters
M.E/M.Tech(Full-Time)	4	8
M.E/M.Tech(PartTime)	6	12

Master of Engineering / Technology (Full Time / Part Time)

M.E Power Electronics and Drives

M.E Manufacturing Engineering

M.E VLSI Design

M.E Computer Science and Engineering

M.E Embedded System Technologies

M.E Control & Instrumentation Engineering

M.Tech Nano - Science & Technology

4. DURATION OF THE PROGRAMME

Each Semester consists of 90 working days including examination days. The head of the department shall ensure that every teacher imparts instruction as per the number of periods / hours specified in the syllabus and that the teacher teaches the full content of the specified syllabus for the course being taught.

The Head of the department may arrange to conduct additional classes for improvement, special coaching, model tests etc., over and above the specified periods. But for the purpose of calculation of attendance requirement or writing the End Semester Examinations (as per clause 13) by the students periods conducted within 90 working days as specified in academic schedule alone shall be taken into account and the overall percentage of attendance shall be calculated accordingly.

The End Semester Examinations will follow immediately after the last working day of the semester as per the academic schedule prescribed from time to time.

The total period for completing the Programme is reckoned from the commencement of the first Semester of the Programme to which the candidate is admitted and it shall not exceed the maximum period specified in clause 3 irrespective of the period of break of study (vide clause 26) in order that he/she may be eligible for the award of the Degree (vide clause 21).

5. STRUCTURE OF PROGRAMMES

The Curriculum for each programme includes courses of study and detailed Syllabi as prescribed by the respective board of studies from time to time consisting of:

- **Foundation courses (FC)** may include Mathematics or other basic courses (M.E./M.Tech)
- **Professional Core Courses (PC)** include the core courses relevant to the chosen specialization / branch
- **Professional Elective Courses (PE)** courses include the elective courses relevant to the chosen specialization / branch
- **Employment Enhancement Courses** include Dissertation seminar / Practical Training, Internship if they are specified in the Curriculum.

The Electives from the Curriculum are to be chosen with the approval of the Head of the Department. The following apply to all modes of PG Programmes.

- One credit for each lecture period allotted per week
- One credit for two tutorial period allotted per week
- One credit for each Seminar/Practical session of two periods designed per week

Practical Training / Industrial Attachment / Summer Project if specified in the Curriculum shall not exceed the maximum duration of 4 weeks and should be organized by the Head of the Department for every student.

At the end of Practical Training / Industrial attachment / Summer Project the candidate shall submit a certificate from the organization where he/she has undergone training along with a brief report. The evaluation will be made based on the report and a Viva-Voce Examination.

A candidate who has passed in Course will not be permitted to re-enroll to improve his/her marks in that course.

6. TRANSFER OF CREDITS THROUGH ONLINE COURSES

Within the broad frame work of the SREC learning outcome based curriculum frame work through choice based credit system Regulations 2022, and on the recommendation of the concerned Chair Person of the Board of studies and the Chair person of the Academic Council, students may be permitted to earn part of the credit requirements for professional and open elective courses from other approved Institutes of repute and status in the country /abroad or online learning courses of SWAYAM* platform under UGC during their period of study>(*Credit Frame work for online learning courses through SWAYAM Regulation 2022).

The Credits earned by such credit transferred courses shall be for Professional courses only.

7. THE GUIDELINES FOR THE TRANSFER OF CREDITS ARE AS FOLLOWS :

- The Online Course shall be a credited course which is taught for at least one semester as a part of a subject.
- Students with consistent academic performance (having a CGPA of 8.0 or above and no arrear) can opt for credit transfer courses through online mode of learning with recommendation of the Chairperson of the Board of studies and the approval of the Chair Person of Academic Council.
- The Board of studies of the concerned department shall evaluate the credit transfer course with respect to the course contents, number of contact hours, course evaluation system, and approval or acceptance letter from the other institutions/Online courses and decide the Equivalent Elective Course(s) in their respective department curriculum and the number of Equivalent Credits the student earns for the course
- The Chair person of the Board of studies shall also evolve a method for calculating the Equivalent Grades for the credit transferred courses as per the SREC Autonomous Regulations 2022 by taking into account the course evaluation system followed in the other institution/Online course platform.
- The Chair person of the Board of studies shall issue a Credit Transfer Certificate mentioning in it the details of Equivalent Courses, corresponding Credits and Equivalent Grades for the credit transferred courses. The complete details will then be forwarded to the Chairperson Academic Council for approval.
- Credits and the Grades earned by the student under this Credits Transfer scheme will be reflected in the corresponding Semester Grade Card and Consolidated Grade Card issued by institution by entering the Equivalent Grades for the credit transferred courses. Evaluation of online course as per the absolute grading norms is as given below :

Marks	Letter Grade	Grade Point
90-100	O	10
75-89	A+	9
60-74	A	8
50-59	B+	7
40-49	B	6

Total credits to be earned online is limited to maximum of 6 per semester

8. Audit Courses

- The candidate is allowed to take the additional elective courses as audit course. The candidate shall limit to 4 audit courses during his/her period of study.
- The successful completion of the audit course is mandatory. However, the grade awarded shall not be included in the CGPA calculation.
- Audit course will be internally assessed.

9. Direct Self Study Elective

- The candidates with no standing arrear are permitted to under take a maximum of 3 self study elective courses during his/he rperiod of study.
- The candidate has to register with the office of the Controller of Examinations through the Academic Coordinator and the Head of the Department with in the first 15 working days of the respective semesters.
- The Head of the Department of the programme shall allotment or for the self study course, who will be responsible for the continuous assessment requirements of the student registered for that Course.
- The grade for the Course will be based on the continuous assessment by the ment or and the performance of the candidate in the end semester examinations.

10. Dissertation-I&IIforM.E/M.Tech.Programmes

- Dissertation-I&II will be an individual effort by every candidate.
- The Dissertation for M.E./M.Tech. Programme consists of Dissertation -I and Dissertation–II that are to be undertaken during III and IV Semester respectively.
- Dissertation – I & II should be carried out under the supervision of a “qualified teacher” in the concerned department. In this context “qualified teacher” means the faculty member possessing a Ph.D. Degree or PGDegree with a minimum of 3 year experience in teaching the PG Courses.
- Review committee for the Dissertation–I&II shall be constituted by Head of the Department.
- The Department Project Evaluation Committee (DPEC) will consist of the following members : One Professor -Chairperson
- One Professor/Associate Professor Member Associate Professor/Assistant Professor. -Member
- There will be 3 reviews conducted during each semester
- Internal Assessment marks split up as in clause 10.0
- Preferably, the Dissertation-I should be a research gap analysis in the area of interest/ specialization. Dissertation-I should lead to the problem identification statement of the Dissertation-II.
- A candidate may, be permitted to work on Industry project in an Industry/Research Organization, on there commendations of the Head of the concerned department. In such cases, the Dissertation - II shall be jointly supervised by a Supervisor of the Department and an Expert, as a Joint Supervisor from the Industry/Organization and the student shall be instructed to meet the Supervisor periodically the candidate must attend the Review Committee Meetings for evaluating the progress of the Dissertation.
- If a candidate fails to submit the Dissertation Report on or before the specified deadline, he/she is deemed to have failed in that Dissertation and shall re-register for the same in a subsequent Semester. This applies to both Dissertation-I and Dissertation-II.
- Every student shall communicate a paper for publication of their Dissertation - II in a reputed journal or an international conference. If a paper is published, the copy of the certificate/ reprints/ valid proof shall be

attached to there port of the Dissertation-II. If publication is pending, then an acknowledgment from the supervisor/ guide for having communicated to the journal or international conference shall be attached to there port of the Dissertation-II .In the absence of such acknowledgment, there port shall not be accepted.

- A Copy of the approved Dissertation Report shall be kept in the Library of the Department/Institution after successful completion of the Viva Voce Examination

10.1. Internship

- The candidate can undergo an internship starting from the pre final semester and complete it in the final semester.
- The candidate shall report the progress of the internship to the faculty guide in regular intervals and may seek their advice.
- After completion of the internship, the candidate should submit a report to the department /institution with the approval of the internal/external guides.
- The assessment procedure and marks awarded will be as in the dissertation/Projectwork

11. Reappearance Registration

- If a candidate is unable to secure a pass/Absent in a theory course (except electives), the student shall do reappearance registration for that course in the subsequent semester/ when offered next.
- If a candidate is prevented from writing end semester examination due to lack of attendance, the candidate has to register for the course again in the subsequent semester/when offered next and attend the classes to fulfill the attendance requirements and earn continuous assessment marks.
- If the theory course, in which the student has failed, is a professional elective or an open elective, and the candidate chooses to opt for the same professional elective or open elective course, the student shall do reappearance registration for that course in the subsequent semester/when offered next.[OR] Register for any other professional elective or open elective course in the subsequent semester, attend classes and fulfill the attendance and continuous assessment requirements.
- If a student fails to secure a pass in a laboratory course (including project work), the student shall repeat the course again. When the student repeats the course, the student shall attend the classes, satisfy the attendance requirements, earn Continuous Assessment marks and appear for the End Semester Examinations.
- However the maximum number of credits the candidate can register in a particular semester cannot exceed 36 credits excluding laboratory courses.

12. REQUIREMENTS FOR APPEARING FOR THE END SEMESTER EXAMINATION OF A COURSE

- A candidate who has fulfilled the following conditions shall be deemed to have satisfied the attendance requirements for the completion of a semester:
- Every candidate is expected to attend all classes and secure 100% attendance.
- A candidate must secure not less than 75% of attendance (after rounding off to the nearest integer) course wise taking into account the total number of periods required for that course as specified in the curriculum.
- The maximum limit of duty leave exemption to a candidate during a semester shall be limited to 10% of the required attendance in that course. This duty leave is for representation in University/Inter University/State/National/sport events, Co-Curricular activities, paper and/or project presentation with prior permission from the Head of the Institution based on the recommendation of the Head of the Department, provided the progress and conduct of the candidate is satisfactory.

- If a candidate secures attendance between 65% and 75% in any course in the current semester due to medical reasons (hospitalization/accident/specific illness) he/she may be given exemption (due to medical reasons only) to appear for the current semester examinations in that course. Subject to the condition that the candidate should submit, the medical certificate approved by the Head of the Institution based on the commendation of the Head of the Department on the day of resuming college, after availing leave on medical reasons.
- Candidates who secure, less than 65% of attendance will not be permitted to appear for the End Semester Examinations of that course. The candidate has to re-register and repeat that course in the subsequent semester/when offered.
- A candidate who secures less than 65% of the overall attendance will not be permitted to appear for the end semester examinations. The candidate shall seek re-admission to the same semester in the subsequent academic year.

13. SCHEME OF EXAMINATIONS

- Performance in each course of study shall be evaluated based on:
 - ❖ Continuous Internal Assessment through out the Semester
 - ❖ End Semester Examinations
- Each Course, both Theory and Practical including Dissertation I&II/ Project work & Viva Voce Examinations shall be evaluated for a maximum of 100 marks.
- For all Theory Courses
 - ❖ The Continuous Internal Assessment mark is 40 marks
 - ❖ End Semester examination mark is 60 marks
- For all Practical Course including Dissertation I&II/ Project work
 - ❖ The Continuous Internal Assessment mark is 60 marks
 - ❖ End Semester examination mark is 40 marks For all Theory Cum Laboratory Courses
 - ❖ The Continuous Internal Assessment mark is 50 marks
 - ❖ End Semester examination mark is 50 marks
 - ❖ The End Semester Examinations for theory courses will be of 3 hours duration and shall normally be conducted between October and December during the odd semesters and between April and June during the even semesters.
 - ❖ End Semester Examination is a mandatory requirement for passing the course and every candidate should appear for the examination for theory, laboratory courses and project work.
 - ❖ Every teacher is required to maintain an 'ATTENDANCE AND ASSESSMENT RECORD' for every semester which consists of attendance marked in each Theory / Practical courses, the assessment marks and the record of class work (topics covered), separately for each course handled by the teacher.
 - ❖ This should be submitted to the Head of the Department periodically (at least thrice in a semester) for checking the syllabus coverage and the records of assessment marks and attendance. The Head of the Department will affix his/her signature and date after due verification. At the end of the semester, the record should be verified by the Head of the Department who shall keep this document in safe custody (for 4 semesters).
 - ❖ The records of attendance and assessment of both current and previous semesters should be available for inspection.

14. Method for Calculating of Internal Assessment for M.E/M.Tech Programmes:

14.1 Theory courses

Weightage of marks			Total Marks
Test I/II	Assessment by Course Instructor		
17.5/17.5	5		40

- Internal Tests will be conducted for 50 Marks each.
- The Course instructor shall announce the assessment tools at the commencement of the semester.

14.2 Practical Courses:

Every Practical Experiment shall be evaluated based on conduction and successful completion of the experiment and submission of the related Laboratory Record Work. There shall be at least one Model Examination.

Experiments			Model Examination	Internal Assessment marks
Observation & Preparation	Viva Voce	Record		
15	10	05	30	60

14.3 Evaluation of Dissertation I&II:

- The evaluation for Dissertation I&II shall be done independently in the respective semesters and marks shall be allotted as per the weightage given in Clause 14.
- The Head of the Department shall constitute the Review Committee for each Branch of Study. There shall be three Assessments during the Semester by a Review Committee.
- The student shall make presentation before the Committee.

Dissertation I & Dissertation II	Internal Assessment				End semester Examinations				
	Review I	Review II	Review III	Internal Assessment Marks	Evaluation of Project Reported by External Examiner	Viva-Voce Marks			External Assessment Marks
						Supervisor	External	Internal	
	10	20	30	60	10	10	10	10	40

The evaluation of the Dissertation I & II will be based on the dissertation report submitted and Viva-Voce Examination. The Evaluation Panel will consist of the Supervisor, Internal Examiner and External Examiner of which the Supervisor should be silent.

14.4 Assessment for Theory Cum Laboratory Courses:

Component	Assessment	Internal 50%		External 50%		
		Duration	Weightage	Assessment		Weightage
Lab	Test cycle – I	90 min	10	Lab Exam	Viva	5
	Lab weekly exercise		5		Experiment	10
Theory	Semester in Exam - I	90 min	17.5	End Semester	3 Hrs	35
	Semester in Exam- II	90 min	17.5	Exam Theory		

15. PHOTO COPIES / REVALUATION AND REVIEW OF ANSWER SCRIPT

The students are entitled for the following within fifteen days from the declaration of the results.

- As per the regulations, there is only one valuation. However a student is entitled for obtaining Photo Copies of the Answer Scripts, if they are not satisfied with the Grades allotted. He/She can apply for Revaluation on payment of the prescribed fee. If the student is not satisfied with the Grades allotted after Revaluation, he/she may apply for Review of Answer script.
- Only a student who has applied for the photocopy and Revaluation of the answer script is eligible for applying for Review of Answer Script.
- The prescribed fee for the Review of Answer Script should be paid. The fund of the fee will be made for the students who have failed originally and obtained a pass mark after the Review.

16. PROCEDURE FOR COMPLETING THE COURSE

- The Academic year will be from June to May, in which Odd Semester will be spanning the period from June to November / December and Even Semester from December to May/June respectively.
- The Course Work of the Odd Semester will be conducted during the period of Odd Semester and that of the Even Semester during the period of Even Semester respectively.
- A candidate who has Break of Study for some reason in any one of the Semesters in a Course of Study can rejoin the course in that Semester only at the time of its normal commencement in the Institution for regular students upon satisfying the following conditions:
- He /She should have completed the Course of Study of the previous Semesters. He/She should have registered for all the Examinations of the previous Semesters.
- A candidate will be permitted to proceed from one Semester to the next Semester only if he / she has satisfied the Regulations for eligibility to appear for the End- Semester Examination in the concerned semester, subject to the condition that the candidate should register for all the arrear subjects of previous Semesters along with the current Semester Courses.
- It is mandatory that a candidate has to complete requisite number of Value added Courses during the duration of the Programme.
- It is mandatory to successfully complete the required Audit Course and earn the required xviii
- A candidate who is required to repeat the study of any Semester for want of Attendance / progress / good conduct or who desires to rejoin the course after a period of discontinuance or who upon his/her own request is permitted by the authorities to repeat the study of any Semester, may join the Semester for which he/she is eligible or permitted to rejoin, at the time of its normal commencement of the course along with the regular batch of candidates only after obtaining the approval from the Director of Technical Education and the affiliating University.
- No candidate will however be enrolled in more than one Semester at any time. In the case of repeaters/Readmission, the earlier Internal Assessment in the respective courses will be disregarded.

17. END SEMESTER EXAMINATIONS

- There shall be an End-Semester Examination of 3 hours duration for each Lecture cum Tutorial based course
- The End Semester Examinations shall be conducted between October and December/January during the Odd Semesters and between March and May/June in the Even Semesters.
- For the Practical Examinations (including Dissertation I&II Project work), both internal and external examiners shall be appointed by the Controller of Examinations.
- Supplementary Examinations may also be conducted at such times as may be decided by the Head of the Institution/Principal subject to the approval of the Academic Council.
- Supplementary Examinations will be conducted only for the students passing out in that academic year.
- If a student indulges in malpractice during Examinations, the student shall be liable for punitive action as prescribed by the University from time to time.
- A candidate who is absent for Semester Examination in a Course /Dissertation I & II /Project work after having enrolled for the same shall be considered to have attempted in that Examination for the purpose of classification.

18. AWARD OF LETTER GRADES

- All assessments of a course will be done on absolute marks basis. However, for the purpose of reporting the performance of a candidate, letter grades, each carrying certain number of points, will be awarded as per the range of total marks (out of 100) obtained by the candidate in each subject.
- The letter grade and the grade point are awarded based on the percentage of marks secured by a candidate in individual course; after the results are declared, grade sheets will be issued to each student as detailed below:

Letter Grade	Description	Grade Points
O	Excellent	10
A+	Very Good	9
A	Good	8
B+	Above average	7
B	Average	6
C	Pass	5
U	denotes Re-appearance for not scoring the minimum passing requirement	0
RA SA	denotes Re - appearance for the examination due to Shortage of Attendance	
RA - AB	denotes Re-appearance for being absent for the examination	
WH	denotes withdrawal in the End Semester Examination	

GPA AND CGPA CALCULATION

After the results are declared, grade sheets will be issued to each student, which will contain the following details:

- The list of courses enrolled during the semester and the grades scored.
- The Grade Point Average (GPA) for the semester, which is calculated as follows:

$$\frac{\sum_{i=1}^n (C \times GP_i)}{\sum_{i=1}^n C_i}$$

- The Cumulative Grade Point Average (CGPA), which is calculated as follows:

$$\frac{\sum_{j=1}^n (C_j \times GP_j)}{N}$$

$$\sum_{j=1}^n C_j$$

Where C_i/C_j - is the credits assigned to the course

G_{pi} , G_{pj} - is the grade point corresponding to the letter grade obtained for each course n -is number of all courses successfully cleared during the particular semester in the case of GPA and during all the semesters in the case of CGPA

A candidate who is absent for the final Semester Examination in a Course/Dissertation/Project work after having registered for the same shall be considered as an attempt Grade "RA-AB" in the result column of the mark sheet.

If a candidate fails to submit the report on Dissertation/project work on or before the date specified by the Institution / Department, he/she is deemed to be failed in the Dissertation/Project Phase. Grade "RA - F" is awarded and He/She shall re do the Dissertation/Project Phase as advised by Head of the Department and submit the same in the subsequent Semester.

19. PASSING REQUIREMENTS AND CLASSIFICATION

A candidate who secures not less than 50% (Internal Assessment + End semester examinations marks) of total marks prescribed for the Courses with a minimum of 45% of the marks prescribed for the End-semester Examination in both Theory and Practical Courses (including Project), is declared to have passed in the examination.

If the candidate fails to secure a pass in a particular Course, it is mandatory that candidate shall register and reappear for the Examination in that Course during the subsequent Semester when Examination is conducted in that course; candidate should continue to register and reappear for the Examinations in the failed subjects till candidate secures a pass. The Internal assessment marks obtained by the candidate in the first appearance shall be retained and considered valid for all subsequent attempts till the candidate secures a pass. However, after the completion of the stipulated number of semesters if a candidate fails to obtain pass marks (IA + end semester Examination) as per clause above, then the candidate shall be declared to have passed the examination if the candidate secure 50% and above the maximum marks prescribed for the end semester examinations alone.

19.1 First Class with Distinction

The candidates satisfying the following conditions shall be declared to have passed the examinations in First Class with Distinction.

- A candidate who qualifies for the award of the Degree having passed the Examination in all the Courses within the Stipulated number of Semesters of study in First Appearance.
- The candidate should have secured a CGPA of not less than 8.50 in all the courses prescribed for the programme of study.

However, for the purpose of classification, the authorized withdrawal from appearing for The Examination in any one Semester in any course or courses in that semester (vide clause 23) will not be construed as an appearance.

19.2 First Class

The candidates satisfying the following conditions shall be declared to have passed the examinations in First Class:

- (i) A candidate who qualifies for the award of the Degree having passed the examination in all the Courses within the Stipulated number of Semesters plus One Year (Two Semesters) reckoned from the commencement of study in the first Semester including authorized Break of Study.
- (ii) The candidate should have secured a CGPA of not less than 6.50 in all the Courses prescribed for the Programme of Study.

19.3 Second Class

All other candidates (not covered in clauses 19.1 and 19.2) who qualify for the award of the Degree shall be declared to have passed the Examination in Second Class.

20. ELIGIBILITY FOR THE AWARD OF THE DEGREE

A student shall be declared to be eligible for the award of the Degree if he/she has Successfully gained the required number of total credits as specified in the Curriculum corresponding to his/her Programme with in the stipulated time.

- Successfully completed the prescribed number of Valued Added Course*, as prescribed in the Curriculum.
- Successfully completed any additional Courses prescribed by the Head of Institution, whenever any candidate is re admitted under this Regulations.
- No disciplinary action is pending against him/her.

* Value added courses are offered to facilitate the students to keep pace with the latest technologies pertaining to their chosen field of study. The students have the option to choose the course according to their interest and these courses will improve the employability of the students and assist the min exploring new opportunities.

21. PROVISION FOR WITHDRAWAL FROM EXAMINATION

A candidate, may for valid reasons and on prior application, be granted permission to withdraw from appearing for the Examination of any one Course or Courses of only one Semester Examinations during the entire duration of the Degree Programme.

Withdrawal application shall be valid only if the candidate is eligible to appear for the Examination if it is made prior to the commencement of the Examination in that Course(s) duly recommended by the Head of Department and approved by the Head of the Institution.

Withdrawal shall not be construed as an appearance for the eligibility of a candidate for First Class with Distinction.

The candidate shall reappear for the withdrawn Course / Courses during the Examination conducted in the immediate subsequent Semester.

22. FACULTY ADVISOR AND CLASS COMMITTEE

To help the students in planning their Courses of Study and for general advice on the Academic Programme, the Head of the Department will attach a certain number of students to a teacher of the Department who shall function as Faculty Advisor for those students throughout their period of Study. Such Faculty Advisor shall advise the students and monitor the courses taken by the students, check the attendance and progress of the students attached to him / her and counsel them periodically. If necessary, the Faculty Advisor may also discuss with or inform the parents about the progress of their wards. An Academic coordinator will monitor the Faculty Advisors.

The Class Committee consists of teachers who handle the class, student representatives and a chair person who is not handling the subject for that class. It is like the 'Quality Circle' with the overall goal of improving the teaching-learning process. The functions of the Class Committee include:

- Solving problems faced by students in the classroom and in the laboratories.
- Clarifying the regulations of the Degree Programme and the details of rules therein.
- Informing the student representatives about the academic schedule dates and the syllabus coverage.

Informing the student representatives about the regulations regarding weight age used for each assessment. In case of Practical Courses (Laboratory/Drawing/Project Phase-II/Seminar etc.) the breakup of marks for each Experiment/ exercise/ module of works, should be clearly interacted with the representatives in the Class Committee Meeting and in form to the students.

- Analyzing the performance of the students of the class after each Test and finding the ways and means of solving problems, if any, and
- Identifying the weak students, if any and requesting the teachers concerned to provide some additional help or guidance or coaching for such weak students.

The Class Committee for a class under a particular Branch is constituted by the Head of the department. The Class Committee shall be constituted in the first week of the Semester. Two or three subsequent Meetings may be held at suitable intervals. During these Meetings, the student members representing the entire class, shall meaningfully interact and express their opinions and suggestions of the class students to improve the effectiveness of the teaching-learning process. At least 4 student representatives (usually 2 boys and 2 girls) shall be included in the Class Committee.

The Chairperson of the Class Committee may invite the Academic Coordinator Faculty advisor(s) and the Head of the Department to the meeting of the Class Committee.

The Principal may participate in any Class Committee Meeting of the Institution.

The Chair person has to prepare the minutes of every meeting, submit the same through the Head of the Department to the Head of the Institution within two days of the Class Committee Meeting and arrange to circulate among the students and teachers concerned. If there are some points in the minutes, requiring action by the authorities concerned, the same shall be brought to the notice of the authority by the Head of the Institution.

23. ISSUE OF STATEMENT OF GRADES AND DEGREE CERTIFICATE

After the publication of the results in each Semester, the Institution will issue the Statement of Grades. After the successful completion of the Degree Programme, the Academic Council of the Institution will recommend the list of candidates to the University which in turn shall award the Degree Certificates.

24. TEMPORARY BREAK OF STUDY FROM A PROGRAMME

The candidates permitted to rejoin the programme after break of study / prevention due to lack of attendance, shall be governed by the Curriculum and Regulations in force at the time of rejoining.

The students rejoined in any of the Semesters have to gain the stipulated number of credits in order to become eligible for the award of Degree, under the Regulations in vogue at the time of his/her rejoining.

The total period for completion of the Programme reckoned from, the commencement of the course for the first Semester to which the candidate was admitted shall not exceed the maximum period specified in clause 3 irrespective of the period of break of study in order that he/she may be eligible for the award of the Degree.

If any student is detained for want of required attendance, progress and good conduct, the period spent in that Semester shall not be considered as permitted 'Break of Study'.

25. PERSONALITY AND CHARACTER DEVELOPMENT

All candidates shall enroll, on admission, in any one of the personality and character development programmes (the NSS /YRC /RRC/ Yoga/Sports and Games) and undergo training for 40 hours during the first two years. The training shall include classes on hygiene and health awareness and also training in first-aid.

- National Service Scheme (NSS) have social service activities in and around the College /Institution, through camps(the camps will be conducted during vacation period).
- Sports and Games activities include preparation for inter-collegiate and intra-mural sports and games events.
- Yoga for mental relaxation,
- Youth Red Cross(YRC) society activities include health & hygiene, international friendship, awareness camp etc.

26. DISCIPLINE

Every student has to maintain discipline both inside and outside the Institution and not to indulge in any activity that may spoil the name of the Institution. The Head of the Institution shall constitute a Disciplinary Committee which will enquire into act so fine discipline and report to the Head of the Institution.

27. REVISION OF REGULATIONS AND CURRICULUM

The Institution may from time to time revise, amend or change the Regulations, scheme of Examinations and Syllabi if found necessary subject to the approval of the Academic Council.



M.E. COMPUTER SCIENCE AND ENGINEERING



M.E. COMPUTER SCIENCE AND ENGINEERING

VISION AND MISSION OF THE INSTITUTION

VISION

- To develop into a leading world class Technological University consisting of Schools of Excellence in various disciplines; with a co-existent Centre for Engineering Solutions Development for worldwide clientele.

MISSION

- To provide all necessary inputs to the students for them to grow into knowledge engineers and scientists attaining.
- Excellence in domain knowledge, practice and theory
- Excellence in co-curricular and Extra-curricular talents
- Excellence in character and personality

VISION AND MISSION OF THE DEPARTMENT

VISION

The Department of Computer Science Engineering (PG) will aim at

- Providing high quality education and promoting research and development in the frontier areas of Computer Science Engineering.

MISSION

The Department of Computer Science Engineering (PG) is committed to

- Develop Successful Professionals in Computer Science Engineering by preparing graduates with the knowledge, ability and skill to become innovators and leaders who are able to contribute to the aspirations of the country
- Benefit humanity through research, creativity, problem solving and application development
- Share knowledge and expertise to benefit the country while inspiring people to engage in computing fields

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

The graduates shall demonstrate the following after few years of graduation

PEO I: The graduates of the program will be prepared to become a successful professional in their career in industry, government or academia; and continue to develop their research knowledge.

PEO II: The graduates of the program will have skills to function as members of multi-disciplinary teams and to communicate effectively using modern tools.

PEO III: The graduates of the program will be prepared to engage themselves in life-long learning to adapt with the continuously evolving technology

S. No.	Course Code	Course Title	L	T	P	C	Category	CA	ES	Total
SEMESTER I										
THEORY										
1	22MA1002	Discrete Mathematics and Statistics	4	0	0	4	FC	40	60	100
2	22CS1001	Data Structures & Advanced Algorithms	3	0	0	3	PC	40	60	100
3	22CS1002	Embedded System using Internet of Things	3	0	2	4	PC	40	60	100
4	22CS1003	Industrial Software Development Process	3	0	2	4	PC	40	60	100
5	22CS1004	Data Sciences and Analytics	3	0	0	3	PC	40	60	100
6	22ME1A004	Research Methodology and IPR	3	0	0	3	EEC			
PRACTICAL										
7	22CS1051	Data Structures & Advance Algorithms Laboratory	0	0	2	1	PC	60	40	100
Total Credits						22				
SEMESTER II										
THEORY										
S. No.	Course Code	Course Title	L	T	P	C	Category	CA	ES	Total
1	22CS1005	Neural Network and Deep Neural Networks	3	0	2	4	PC	40	60	100
2	22CS1006	Cloud Computing Systems, Services & Security	3	0	2	4	PC	40	60	100
3	22CS1007	Security in Engineering	3	0	0	3	PC	40	60	100
4	22CS1008	Distributed Operating Systems	3	0	0	3	PC	40	60	100
5	22CSE0XX	Professional Elective – 1	3	0	0	3	PE	40	60	100
6	22CSE0XX	Professional Elective – 2	3	0	0	3	PE	40	60	100
PRACTICAL										
7	22CS1052	System and Network Security Laboratory	0	0	2	1	PC	60	40	100
Total Credits						21				
AUDIT COURSE										
8	22EN1001	English for Research Paper Writing	AC - GRADE ONLY							
SEMESTER III										
THEORY										
S. No.	Course Code	Course Title	L	T	P	C	Category	CA	ES	Total
1	22CSE0XX	Professional Elective – 3	3	0	0	3	PE	40	60	100
2	22CSE0XX	Professional Elective - 4	3	0	0	3	PE	40	60	100
3	22CSE0XX	Professional Elective - 5	3	0	0	3	PE	40	60	100

S. No.	Course Code	Course Title	L	T	P	C	Category	CA	ES	Total
4	22CS1008	Distributed Operating Systems	3	0	0	3	PC	40	60	100
5	22CSE0XX	Professional Elective – 1	3	0	0	3	PE	40	60	100
6	22CSE0XX	Professional Elective – 2	3	0	0	3	PE	40	60	100
PRACTICAL										
7	22CS1052	System and Network Security Laboratory	0	0	2	1	PC	60	40	100
Total Credits						21				
AUDIT COURSE										
8	22EN1001	English for Research Paper Writing	AC - GRADE ONLY							
SEMESTER III										
THEORY										
S. No.	Course Code	Course Title	L	T	P	C	Category	CA	ES	Total
1	22CSE0XX	Professional Elective – 3	3	0	0	3	PE	40	60	100
2	22CSE0XX	Professional Elective - 4	3	0	0	3	PE	40	60	100
3	22CSE0XX	Professional Elective - 5	3	0	0	3	PE	40	60	100
PROJECT WORK										
4	22CS1010	Dissertation - I / Industrial Project - I	0	0	0	6	EEC	60	40	100
Total Credits						15				
SEMESTER IV										
PROJECT WORK										
1	22CS1011	Dissertation - II / Industrial Project - II	0	0	0	12	EEC	60	40	100
Total Credits						12				

Total Credits to be earned for the Award of Degree: 70

- * Audit Course not considered for CGPA Calculation
- * Audit Course -Mandatory

PROFESSIONAL ELECTIVES										
S. No.	Course Code	Course Title	L	T	P	C	Category	CA	ES	Total
1	22CSE001	Data Mining Techniques	3	0	0	3	PE	40	60	100
2	22CSE002	Internet Technologies	3	0	0	3	PE	40	60	100
3	22CSE003	Data Base Engineering	3	0	0	3	PE	40	60	100
4	22CSE004	Open Source Software	3	0	0	3	PE	40	60	100
5	22CSE005	Agile Software Development Process	3	0	0	3	PE	40	60	100
6	22CSE006	Software Automation in Industries	3	0	0	3	PE	40	60	100
7	22CSE007	UX / UI	3	0	0	3	PE	40	60	100
8	22CSE008	Soft Computing Concepts	3	0	0	3	PE	40	60	100
9	22CSE009	Cryptography & Digital Forensics	3	0	0	3	PE	40	60	100
10	22CSE010	Multimedia & Virtual Reality	3	0	0	3	PE	40	60	100
11	22CSE011	Multicore Architecture	3	0	0	3	PE	40	60	100
12	22CSE012	Computer Vision	3	0	0	3	PE	40	60	100
13	22CSE013	Compilers and Language Design	3	0	0	3	PE	40	60	100

Total Credits to be earned for the award of degree: 70

FC – Foundational Course

PC – Professional Core

PE – Professional Elective

AC – Audit Course – Grade only

EEC - Employment Enhancement Course

Note : The Audit course will be awarded Grades which will not be included in the CGPA calculation. However it is mandatory to complete the course successfully.

S.NO.	SUBJECT AREA	CREDITS AS PER SEMESTER				CREDITS TOTAL
		I	II	III	IV	
1.	Foundation Course	4				4
2.	Professional Core	15	15			30
3.	Professional Elective		6	9		15
4.	Employability Enhancement (Research Methodology & IPR, Dissertation / Industrial Project I & II)	3		6	12	21
Total		22	21	15	12	70

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SEMESTER – I

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COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Identify and work on functions required in discrete structures.
CO2:	Apply logic proof and logical reasoning to real problems, such as predicting the behavior of software.
CO3:	Use the concepts of combinatorics to solve counting problems.
CO4:	Find the statistical measures that describe the distribution.
CO5:	Interpret the attributes of the population by studying the sample drawn from it.

RELATIONS AND FUNCTIONS**12**

Binary relations – Matrices of Relations - Partial orderings – Equivalence relations – Functions - Bijective functions – Composition of functions – Inverse functions – Characteristic functions – Recursive functions.

MATHEMATICAL LOGIC**12**

Propositional logic – Logical connectives – Truth tables – Normal forms – Direct and Indirect Proofs in Propositional Calculus – Predicate logic – Universal and existential quantifiers – Proof techniques.

COMBINATORICS**12**

Basics of counting – Counting arguments – Pigeonhole principle – Principle of Inclusion and Exclusion - Permutations and Combinations-Permutation with repetition – Recursion and Recurrence relations.

STATISTICS AND TESTING OF HYPOTHESIS**24**

Measures of Central Tendency: Arithmetic Mean, Median, Mode and Standard deviation – Testing of hypothesis – Large sample tests – Test of significance for single proportion, Difference of proportions, Single mean and Difference of means – Small sample tests – t-test for single mean and difference of means, F- test for variances, Chi square test for goodness of fit and independence of attributes.

Total Periods : 45+15 = 60

TEXT BOOKS

1. Veerarajan T, "Discrete Mathematics", TMH, 2017.
2. Gupta S.C. and Kapur J.N., "Fundamentals of Mathematical Statistics", 10th Edition, Sultan Chand, 2011.

REFERENCE BOOKS

1. Kenneth.H.Roshan, "Discrete Mathematics and its Applications", Seventh edition, TMH, 2012
2. Trembly J.P. and Manohar R, "Discrete Mathematical Structures with Applications to Computer Science", Tata McGraw-Hill Pub. Co. Ltd, New Delhi, 30th Re-print (2008)
3. Neil A.Weiss Introductory Statistics, Seventh Edition, Pearson Education, 2007.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand how the choice of data structures and algorithm design methods impact the performance of programs
CO2:	Employ various algorithms analysis and design techniques for specific applications
CO3:	Analyze the efficiency of various computing algorithms

INTRODUCTION TO ALGORITHMS AND ANALYSIS 10

Role of Algorithms in Computing – Analyzing Algorithms – Designing Algorithms – Growth of Functions – Probabilistic Analysis and Randomized Algorithms.

ADVANCED ANALYSIS AND DESIGN TECHNIQUES 10

Dynamic Programming – Greedy Algorithms – Amortized Analysis

ADVANCED DATA STRUCTURES 15

Red Black Trees – Augmenting Data Structures - B-Trees – Fibonacci Heaps – Van Emde Boas Trees – Data structures for Disjoint Sets.

ANALYSIS PROOF METHODS 10

NP-completeness – NP Hard- Approximation Algorithms

Total Periods: 45

TEXT BOOKS:

1. Thomas H.Cormen, Charles E.Leiserson, Ronald L.Rivest, Clifford Stein, Introduction to Algorithms, Third Edition, Prentice–Hall India, MIT Press, 2009.
2. Robert Sedgewick, Philippe Flajolet, An Introduction to the Analysis of Algorithms, Second Edition, Addison-Wesley Professional, 2013

REFERENCE BOOKS:

1. A. Levitin, “Introduction to the Design and Analysis of Algorithms”, Second Edition, Pearson Education, 2012.
2. Horowitz, Sahni, Rajasekaran, Fundamentals of Computer Algorithms, Orient Black Swan; 2nd edition, 2008.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Describe the fundamental concepts of IoT and Embedded Systems.
CO2:	Illustrate the ARM Processor Architecture
CO3:	Analyze the concepts of ARM memory management.
CO4:	Design embedded programs using open source tools.
CO5:	Develop embedded programs for interfacing sensors with embedded micro controller

INTRODUCTION TO IoT**12**

Define IoT, Characteristics of IoT, Physical design of IoT, Logical design of IoT, Functional blocks of IoT, Communication models & APIs. IoT & M2M Machine to Machine, Difference between IoT and M2M, Software Define Network. Design challenges, Development challenges, Security challenges. Domain specific applications of IoT: Home automation, Industry applications, Surveillance applications - IoT Physical Servers and Cloud Offerings: Web server for IoT, Cloud for IoT.

INTRODUCTION TO EMBEDDED SYSTEMS**10**

Embedded systems, processor embedded into a system, embedded hardware units and devices in a system, embedded software in a system, examples of embedded systems - Embedded System Hardware- Embedded System Software, Case study: digital camera hardware and software architecture, embedded systems in automobile, embedded system for a smart card, mobile phone software for key inputs.

ARM PROCESSOR FUNDAMENTALS**13**

The RISC Design Philosophy -The ARM Design- Registers - Current Program Status Register -Pipeline - Exceptions, Interrupts, and the Vector Table - Core Extensions - Architecture Revisions - ARM Processor Families- Introduction to the ARM Instruction Set - Data Processing Instructions - Branch Instructions - Load-Store Instructions -Software Interrupt Instruction -Program Status Register Instructions - Loading Constants - ARMv5E Extensions - Conditional Execution

MEMORY PROTECTION AND MANAGEMENT UNITS**10**

Protected Regions -Initializing the MPU, Caches, and Write Buffer- xDemonstration of an MPU system- Moving from an MPU to an MMU - How Virtual Memory Works- Details of the ARM MMU - Page Tables- The Translation Look aside Buffer - Domains and Memory Access Permission - The Caches and Write Buffer -Coprocessor 15 and MMU Configuration - The Fast Context Switch Extension -Demonstration: A Small Virtual Memory System - The Demonstration as mmuSLOS

Total Periods : 45

LIST OF EXPERIMENTS

1. Analysis of various Embedded coding standards and adapting the Standard in practice of Programming.
2. Linux Kernel Compilation.
3. Utilization of GNU Tool Chains for effective System Programming.
4. Debugging the projects using Tools CScope.
5. Design of simple Character/Block oriented Device Drivers in Linux.
6. Implementation of Application Porting using Linux.
7. Implementation of the following on ATMEL AVR Microcontroller:
 - (i) I/O Port programming
 - (ii) Interfacing with Sensors.
8. Testing the embedded devices using JTAG and ICE.
9. Implementation of Real-Time Operating Systems (RTOS) in ATMEL AVR Microcontroller for: (i) Scheduling
10. Design of Simple embedded applications which effectively utilize the concept of multi tasking using Free RTOS.

TOOLS REQUIRED

1. ATMEL AVR Microcontroller kit
2. Sensors

Total Periods: 15

TEXT BOOKS :

1. Embedded Systems Architecture Programming and Design by Raj Kamal, II edition, Tata Mc Graw-Hill, 2013
2. Designing Embedded Systems with PIC Microcontrollers: principles and applications by Tim Wilmshurst, Elsevier.
3. ARM System Developer's Guide: Designing and Optimizing System Software, Andrew N.Sloss, Dominic.Symes, Chris Wright., Elsevier Publications
4. Internet of Things - A Hands-on Approach, Arshdeep Bahga and Vijay Madiseti, Universities Press, 2015, ISBN: 9788173719547
5. Walteneus Dargie, Christian Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice"
6. https://doc.lagout.org/electronics/Game%20boy%20advance/ARM_BOOKS/ARM_System_Developers_Guide-Designing_and_Optimizing_System_Software.pdf

REFERENCE BOOKS:

1. Peter Waher, 'Learning Internet of Things', Packt Publishing, 2015
2. Embedded Systems Design by Steve Heath, II edition, Newnes publications
3. Embedded Systems Architecture: A Comprehensive Guide for Engineers and Programmers by Tammy Noergaard, Elsevier.
4. Shibu. K.V, "Introduction to Embedded Systems", Tata Mcgraw Hill, 2009.
5. Elicia White, "Making Embedded Systems", O' Reilly Series, SPD, 2011.
6. Tammy Noergaard, "Embedded Systems Architecture", Elsevier, 2006.
7. Han-Way Huang, "Embedded system Design Using C8051", Cengage Learning, 2009.
8. Rajib Mall "Real-Time systems Theory and Practice" Pearson Education, 2007.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Perform formal analysis on specifications and Use UML diagrams for analysis and design
CO2:	Understand Architect, design and Testing approaches
CO3:	Know Agile methodology of Software development
CO4:	Know the various Agile Processes
CO5:	Understand the advantages of DevOps practices.

SOFTWARE REQUIREMENTS SPECIFICATION**9**

Software Engineering concepts – various software models - Requirement analysis and specification – Requirements gathering and analysis – Software Requirement Specification – Formal system specification – Finite State Machines – Petrinets – Object modelling using UML – Use case Model – Class diagrams – Interaction diagrams – Activity diagrams – State chart diagrams – Functional modelling – Data Flow Diagram.

ARCHITECTURE, DESIGN & TESTING**12**

Software design – Design process – Design concepts – Coupling – Cohesion – Functional independence – Design patterns – Model-view-controller – Publish-subscribe – Adapter – Command – Strategy – Observer – Proxy – Facade – Architectural styles – Layered - Client-server - Tiered - Pipe and filter.- User interface design - Testing – Unit testing – Black box testing– White box testing – Integration and System testing– Regression testing – Debugging - Program analysis – Symbolic execution – Model Checking

AGILE METHODOLOGY & PROCESSES**7**

Theories for Agile management – agile software development – traditional model vs. agile model - classification of agile methods – agile manifesto and principles – agile project management – agile team interactions – ethics in agile teams - agility in design, testing – agile documentations – agile drivers, capabilities and values

AGILE PROCESSES**7**

Lean production - SCRUM, Crystal, Feature Driven Development, Adaptive Software Development, and Extreme Programming: Method overview – lifecycle – work products, roles and practices

DEVOPS**10**

DevOps : Motivation - Cloud as a platform - Operations - Deployment Pipeline : OverallArchitecture Building and Testing – Deployment - Case study: Migrating to Micro services.

Total Periods: 45**Text Book :**

1. Bernd Bruegge, Alan H Dutoit, Object-Oriented Software Engineering, 2nd edition, Pearson Education, 2004.
2. Craig Larman, Applying UML and Patterns, 3rd ed, Pearson Education, 2005

3. Len Bass, Ingo Weber and Liming Zhu, —DevOps: A Software Architect's Perspective, Pearson Education, 2016.
4. Craig Larman, —Agile and Iterative Development: A manager's Guidel, Addison-Wesley, 2004

Reference Books:

1. Carlo Ghezzi, Mehdi Jazayeri, Dino Mandrioli, Fundamentals of Software Engineering, 2nd edition, PHI Learning Pvt. Ltd., 2010.
2. David J. Anderson; Eli Schragenheim, —Agile Management for Software Engineering : Applying the Theory of Constraints for Business Results, Prentice Hall, 2003
3. Rajib Mall, Fundamentals of Software Engineering, 3rd edition, PHI Learning Pvt. Ltd., 2009. Stephen Schach, Software Engineering 7th ed, McGraw-Hill, 2007.

LIST OF EXPERIMENTS

- Explore the following in a Project Development using JIRATool
- Backlog items in Jira
- Create a project in Jira
- Dashboards in Jira
- Configure gadgets in Jira
- Users and groups in Jira
- Permissions in Jira
- User management in Jira
- Project roles in Jira
- Create project roles in Jira
- Test permissions in Jira
- Smart queries and filters in Jira
- Boards in Jira
- Rich text in Jira
- Sprint planning in Jira
- Dashboards for sprints in Jira
- Automation tools in Jira
- Create automation rule in Jira
- Test automation rule in Jira
- Subscriptions in Jira
- Visual dashboard alerts in Jira
- Product roadmaps in Jira
- Information radiators in Jira
- Close a sprint in Jira
- Reports in Jira
- Sprint retrospective items in Jira
- Planning poker in Jira, part 1
- Planning poker in Jira, part 2

Total Periods: 15

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Illustrate about the Introductions of Data Analytics.
CO2:	Analyze with working models of Data Analytics with different tools
CO3:	Summarize with Machine Learning Systems and Data Analysis

Introduction to Big Data Analytics **9**

Big Data Overview - Practice in Analytics - Roles for the New Big Data Ecosystem - Examples - Data Analytics Lifecycle - Data Analytics Lifecycle Overview – Various Phases - Case Studies

Data Analytic Methods Using R **9**

Introduction to R - Exploratory Data Analysis - Statistical Methods for Evaluation - Advanced Analytical Theory and Methods: Clustering - K-means - Association Rules - A priori Algorithm - Evaluation of Candidate Rules - Applications of Association Rules – Examples

Regression Analysis **9**

Linear Regression - Logistic Regression - Regression Models - Classification - Decision Trees - Naive Bayes - Diagnostics of Classifiers - Classification Methods - Time Series Analysis - ARIMA Model - Additional Methods - Advanced Analytics -Technology and Tools: In-Database Analytics - SOL Essentials - Database Text Analysis - Advanced SOL

Turning Data into Business Value **9**

Predictive Modeling - Methodology for Building Models – Classifications and Predictive Modeling - Neural Networks - Support Vector Machines - Ensemble Methods - Segmentation - Distance Measures (Metrics) - Incremental Response Modeling - Building the Response Model - Measuring the Incremental Response

Text Analytics **9**

Information Retrieval - Content Categorization - Text Mining - Case Study: Financial Services Company - Traditional Marketing Campaign Process - High Performance Marketing Solution - Value Proposition for Change - Major Health Care Provider: CAHPS, HEDIS, HOS, IRE, Finding Defective Devices

Total Periods: 45

TEXT BOOKS

1. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, EMC Education Services, Wiley Publications
2. Big Data, Data Mining and Machine Learning, 'Jared Dean', Wiley Publications.

REFERENCE BOOKS

1. Cathy O'Neil and Rachel Schutt, "Doing Data Science, Straight Talk from the Frontline", O'Reilly, 2014.
2. Joel Grus, "Data Science from Scratch", Copyright c 2015

WEB REFERENCES

1. https://onlinecourses.nptel.ac.in/noc19_mg26/preview
2. https://onlinecourses.nptel.ac.in/noc19_cs33/preview

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Identify the research problem and state its scope and objectives
CO2:	Prepare a report and research proposal after conducting literature survey considering plagiarism and research ethics.
CO3:	Outline the types of intellectual property rights
CO4:	Administer patent systems and new developments in IPR.

APPROACHES IN RESEARCH**15**

Meaning of research problem, Sources of research problem, criteria characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations. Effective literature studies approaches, analysis. Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

NATURE OF INTELLECTUAL PROPERTY**15**

Patents, Designs, Trade and Copyright. Process of Patenting and development Technical research, innovation, patenting, development. International scenario: International cooperation on intellectual property. Procedure for grants of patents, Patenting under PCT.

PATENT RIGHTS AND DEVELOPMENTS IN IPR**15**

Scope of patent rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. Administration of patent System. New developments in IPR; IPR of biological Systems, Computer software etc., Traditional knowledge case studies, IPR and IITs.

Total Periods: 45**TEXT BOOKS**

1. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016
2. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.
3. Halbert, "Resisting Intellectual Property," Taylor and Francis Ltd, 2007.

REFERENCE BOOKS

1. Stuart Melville and Wayne Goddaed, “ Research methodology : An introduction for science and engineering students “
2. Wayne Goddard and Stuart Melville, “ Research methodology : An introduction”
3. Ranjit Kumar, 2nd edition,” Research Methodology : A Step by Step Guide for beginners “
4. Halbert, “Resisting Intellectual Property,” Taylor and Francis Ltd, 2007.
5. Mayall, “Industrial Design “, McGraw Hill, 1992.
6. Niebel, “Product Design”, McGraw Hill, 1974.
7. Asimov, “Introduction to Design “, Prentice Hall, 1962.

22CS1051 DATA STRUCTURES & ADVANCED ALGORITHMS 0 0 2 1 LABORATORY

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Analyze the performance of fundamental data structures.
CO2:	Simulate various advanced data structures with its applications.

LIST OF EXPERIMENTS:

1. Analyze the performance of Elementary Data Structures like Stack, Queue, List and Trees using Open source tools.
2. Prepare an Analysis Chart of all Sorting, Searching and Hashing Algorithms.
3. Simulate real time File Systems organization using Red Black Tree and B-Tree.
4. Simulate the performance of Fibonacci Heap for implementing scheduling of jobs.
5. Simulate an application for implementing Dis Joint Sets.
6. Case Study: Analyzing the performance of social networking environments in terms of Data Structures.
7. Case Study: Identify the set of applications lies under NP-Complete and NP-Hard level



SEMESTER – II



COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Explain the basic working of a neural network model
CO2:	Analyse the problems faced in training of a neural network System.
CO3:	Analyse how Convolutional Neural Network are used in Machine Vision.
CO4:	Design Recurrent Neural Network model for a simple NLP application.
CO5:	Illustrate adversarial networks with its application.
CO6:	Explain the recent trends and applications of Deep Learning.

Basics of Neural Network and Feedforward Neural Network 10

Biological Neuron, Idea of computational units, McCulloch–Pitts unit and Thresholding logic, Linear Perceptron, Perceptron Learning Algorithm, Linear separability. Convergence theorem for Perceptron Learning Algorithm. Multilayer Perceptron, Gradient Descent, Backpropagation, Empirical Risk Minimization, regularization, autoencoders.

Training of Deep Neural Networks 9

Difficulty of training deep neural networks, Greedy layerwise training. Newer optimization methods for neural networks -Adagrad, adadelta, rmsprop, adam, NAG, second order methods for training, Saddle point problem in neural networks, Regularization methods -dropout, drop connect, batch normalization.

Convolutional Neural Networks and Recurrent Neural Networks 10

LeNet, AlexNet, Back propagation through time, Long Short Term Memory, Gated Recurrent Units, Bidirectional LSTMs, Bidirectional RNNs

Deep Generative models 10

Auto-encoders, variational auto-encoders, generative adversarial networks, auto regressive models, generative image models, unsupervised and self-supervised representation learning

Recent trends and Applications 6

Case Study on Machine Vision, NLP and Speech based applications.

Total Periods: 45

Text Books

1. Ian Goodfellow, YoshuaBengio, Aaron Courville. Deep Learning, MIT Press, 2016.
2. Christopher Bishop, Pattern Recognition and Machine Learning, Springer 2006.

References

1. Theodoridis, S. and Koutroumbas, K. Pattern Recognition. Edition 4. Academic Press, 2008.
2. Satish Kumar, Neural Networks: A Classroom Approach, Tata McGraw-Hill Education, 2004

Web References

https://onlinecourses.nptel.ac.in/noc22_cs41/course

https://onlinecourses.nptel.ac.in/noc19_cs22/course

LIST OF EXPERIMENTS

1. Implementation of Word Embedding using Neural Network.
2. Implementation of Digit Recognizer using Neural Network
3. Implementation of Sentiment Analysis using Recursive Neural Network.
4. Implementation of Object Detection using Convolution Neural Network.
5. Implementation of Natural Language Processing using Auto encoders.
6. Implementation of Game Playing using Adversarial networks

Total Periods: 15

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the fundamentals of cloud computing and cloud services
CO2:	Illustrate cloud virtualization, storage and network management
CO3:	Relate Cloud, SOA and benchmarks

INTRODUCTION 9

Introduction - Essentials - Cloud and Virtualization -Cloud Services Requirements - Cloud and Dynamic Infrastructure - Business and IT Perspective -Cloud Computing Characteristics-Types of clouds-Public/Private/Hybrid Clouds - Cloud Adoption. Security in a Public Cloud –The cloud as the next OS, Need and Importance of Cloud as OS.

CLOUD SERVICES AND SOLUTIONS 9

Gamut of Cloud Solutions - Principal Technologies - Cloud Strategy - Cloud Design and Implementation using SOA - Conceptual Cloud Model - Cloud Service Defined. Cloud Solutions - Introduction - Cloud Ecosystem - Cloud Business Process Management - Cloud Service Management - Cloud Stack - Computing on Demand (CoD) – Cloud sourcing.

CLOUD VIRTUALIZATION TECHNOLOGY 9

Overview & Terminology -, Introduction to virtualization - Xen , Hyper-V , KVM, Hardware support for virtualization - Logical Partitioning (LPAR) - VIO Server - Virtual Infrastructure Requirements - Storage virtualization - Storage Area Networks - Network-Attached storage - Cloud Server Virtualization - Virtualized Data Center-,OpenStack /Amazon /Google /Microsoft Cloud Protocols

CLOUD, SOA AND INFRASTRUCTURE BENCHMARKING 7

SOA and Cloud - SOA Defined - SOA and IaaS - SOA-based Cloud Infrastructure Steps - SOA Business and IT Services. OLTP Benchmark - Business Intelligence Benchmark - e-Business Benchmark - ISV Benchmarks Cloud Performance Data Collection and Performance Monitoring Commands Benchmark Tools.

CLOUD STORAGE AND SECURITY 11

CAP theory - Replication Vs. Erasure coding – Consistent hashing - Software Defined Networking (SDN) Security-Confidentiality, privacy, integrity, authentication, non-repudiation, availability, access control, defence in depth in PaaS, IaaS and SaaS. Cryptographic Systems- Symmetric cryptography, stream ciphers, block ciphers, modes of operation, public-key cryptography, hashing, digital signatures, public-key infrastructures, key management, X.509 certificates, OpenSSL.

Total Period: 45

REFERENCES

1. Kumar Saurabh, “Cloud Computing: Insights into New-Era Infrastructure”, Wiley India, 2011.
2. John Rhoton, “Cloud Computing Explained: Implementation Handbook for Enterprises”, Recursive Press, 2013.
3. George Reese, “Cloud Application Architectures: Building Applications and Infrastructure in the Cloud (Theory in Practice)”, O'Reilly, 2009.
4. Adnan Ahmed Siddiqui - OpenStack Orchestration, PACKT Publishing 2015
5. Tim Mather, Subra Kumaraswamy, ShahedLatif, “Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance” O'Reilly Media; 1 edition [ISBN: 0596802765], 2009.

List of Experiments:

1. Creating and running virtual machines on open source OS. Using Technology: KVM, VMware.
2. Install a C compiler in the virtual machine created using virtual box and execute Simple Programs
3. Installing OpenStack and use it as Infrastructure as a Service
4. Install Google App Engine. Create simple web applications using python/java.
5. Use GAE launcher to launch the web applications.
6. Explore Amazon EC2, and Microsoft azure.

Total Hours: 15

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the concepts and foundations of computer security
CO2:	Identify vulnerabilities of IT systems.
CO3:	Develop basic security enhancements in stand-alone applications.

Computer Security Concepts :**5**

Introduction to Information Security, Introduction to Data and Network Security, Integrity, and Availability, NIST FIPS 199 Standard, Assets and Threat Models, Examples.

Security in System and Network :**20**

Control Hijacking– Attacks and defenses, Buffer overflow and control hijacking attacks Exploitation techniques and fuzzing- Finding vulnerabilities and exploits. Dealing with bad (legacy) application code: Sandboxing and Isolation. Least privilege, access control, operating system security- The principle of least privilege, Access control concepts, Operating system mechanisms, Unix, Windows, Qmail, Chromium, and Android examples.

Web Application Security- SQL injection, Cross-site request forgery, Cross-site scripting, Attacks and Defenses, Generating and storing session tokens, Authenticating users, The SSL protocol, The lock icon, User interface attacks, Pretty Good Privacy.

Network Vulnerabilities and Defensive measures:**20**

Network Protocols and Vulnerabilities- Overview of basic networking infrastructure and network protocols, IP, TCP, Routing protocols, DNS. Network Defenses- Network defense tools, Secure protocols, Firewalls, VPNs, Tor, I2P, Intrusion Detection and filters, Host-Based IDS vs Network-Based IDS, Dealing with unwanted traffic: Denial of service attacks.

Malicious Software and Software Security- Malicious Web, Internet Security Issues, Types of Internet Security Issues, Computer viruses, Spyware, Key-Loggers, Secure Coding, Electronic and Information Warfare.

Mobile platform security models- Android, iOS Mobile platform security models, Detecting Android malware in Android markets.

Total Hours: 45**Text books:**

1. William Stallings, Network Security Essentials: Applications and Standards, Pearson, 6th edition, 2017.
2. Michael T. Goodrich and Roberto Tamassia, Introduction to Computer Security: Pearson New International Edition, 2013.

Reference Book:

1. Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone, Handbook of Applied Cryptography, CRC Press, 2001

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Apply the concepts in analyzing and designing Advance Operating System.
CO2:	Demonstrate the Mutual exclusion, Deadlock detection and agreement protocols of Distributed operating system.
CO3:	Analyze the performance and reliability of different Advanced Operating Systems.

DISTRIBUTED OPERATING SYSTEM**9**

Introduction - Functions of Operating Systems - Design Approaches - Motivation - Types of Advanced OS. Architecture: Motivations – Issues – Communication Networks – Communication primitives. Theoretical Foundations : Inherent Limitations of a Distributed System – Lamport's Logical Clocks – Vector Clocks – Causal Ordering of Messages – Global State - Cuts

DISTRIBUTED MUTUAL EXCLUSION**9**

Distributed Mutual Exclusion: Classification of Mutual Exclusion Algorithm – Non-Token Based Algorithms – Lamport's Algorithm – The Ricart-Agarawala Algorithm - Maekawa's algorithms - Token Based Algorithm - Suzuki-kasami broadcast algorithm and Raymond's tree based algorithm.

DISTRIBUTED DEADLOCK DETECTION**9**

Resource vs Communication Deadlocks- Communication deadlock - Strategies to handle deadlock, Ho-Ramamoorthy Algorithms - Path-Pushing - Edge-Chasing – Diffusion - Computation-based algorithms. Agreement Protocols: System model - Classification of agreement problems – Solutions to Byzantine agreement problems.

MULTIPROCESSOR OPERATING SYSTEMS**9**

Introduction - Structures - Design Issues - Threads - Process Synchronization - Processor Scheduling - Memory Management: Mach Operating System.

REAL TIME OPERATING SYSTEMS**9**

Basic concepts in real-time operating systems - Characteristics of Real Time Systems - Modeling time constraints - Real Time Task Scheduling: Characteristics - Classification - Clock Driven Scheduling - Event Driven Scheduling - Hybrid Schedulers - Earliest Deadline First Scheduling - Rate Monotonic Algorithm

Total Periods: 45**TEXT BOOKS**

1. Mukesh Singhal and N. G. Shivaratri, "Advanced Concepts in Operating Systems", Tata McGrawHill, Reprint 2012.
2. Rajib Mall, "Real Time Systems: Theory and Practice", Pearson Education, Second Edition, 2009.

REFERENCES

1. Abraham Silberschatz, Peter Baer Galvin and Greg Gagne, "Operating System Concepts", 9th Edition, John Wiley and Sons (ASIA) Pvt. Ltd, 2012.
2. Pradeep K. Sinha, "Distributed Operating System-Concepts and Design", PHI, First Edition, 2003.

WEB REFERENCES

1. https://onlinecourses.nptel.ac.in/noc19_cs21/

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Gain practical exposure on the oundation concepts of Systems and Network Security
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List of Experiments

1. Analyze Trojan wrapping by combining the genuine application with a vulnerable program using IEXPRESS 2.0 tool
2. Analyze working and functionalities to remote accessing system through Prorat Trojan
3. Perform surveillance through Packet sniffer tool like Wireshark& TCPDump
4. Customized packet generation through CAT KARAT Packet builder
5. How Key logger and Spyware breaks user privacy
6. Perform anonymity through e-mail spoofing and bombing using PHP. Subsequently detect these attacks through analyzing the e-mail header.
7. Find vulnerabilities of target system through Nessus vulnerability Scanner
8. Network enumeration through port scanning using spoofed IP address
9. Case study of SNORT IDS in windows and UNIX environment
10. Analyze SYN flooding attacks through Low orbit ION Cannon tool
11. Detect the Operating System running on target machine through OS Finger printing technique.
12. Perform banner grabbing using telnet
13. What is Hibernate File? Shows the steps to read the contents of the Hibernate File.
14. Develop secure coding practices to handle Code Injection Vulnerabilities such as SQL Injection, PHP Injection and Command Injection
15. Study Programming vulnerability such as buffer overflow, Cross Site Scripting (XSS) and its countermeasures
16. Understand security issues through exploiting vulnerabilities in the Damm Web Application Vulnerabilities (DWAV) or WebGoat tools
17. Analyse the vulnerabilities on Remote machine using Metasploit tool.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	To educate learners on how to format research writing.	PO10
CO2:	To assist students in writing techniques that could result in the development of flawless writing abilities.	PO10, PO12
CO3:	To enable students, learn the accepted style for self-scrutinising the mechanics of writing a research paper.	PO10

Module 1: Formatting Research writing

7

Margins, Text Formatting, Title, Running Head and Page Numbers, Internal Headings and Subheadings, Placement of the List of Works Cited, Tables and Illustrations- Bibliography.

Module 2: The mechanics of writing

8

Spelling, Punctuation, Italics, Names of persons, Numbers, Titles of works in the research paper, Quotation- The format of the Research paper- Documentation: Preparing the list or workers cited- Abbreviations- Citations in forms other than print.

Total Hours: 15

Text book :

MLA Handbook ninth edition, The modern Language Association of America, New York 2021.

Reference Book :

APA Style Handbook for In-Text Citations and References : Based on APA Guidelines 7th Edition.



PROFESSIONAL ELECTIVE



COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	To identify the scope and necessity of Data Mining
CO2:	To understand various tools of Data Mining and their techniques to solve the real time problems.
CO3:	To develop ability to design various algorithms based on data mining tools.
CO4:	To develop further interest in research and design of new Data Mining techniques.

INTRODUCTION AND EXPLORING DATA**8**

Definition- Motivating Challenges - Tasks - Types of Data - Data Quality - Data Preprocessing - Measures of Similarity and Dissimilarity - Summary Statistics - Visualization - OLAP and Multidimensional Data Analysis.

ASSOCIATION ANALYSIS**12**

Frequent Itemset Generation - Rule Generation - Compact Representation of Frequent Itemsets - Alternative Methods for Generating Frequent Itemsets - FP Growth Algorithms - Evaluation of Association Patterns - Infrequent Patterns.

CLASSIFICATION Vs CLUSTER ANALYSIS**14**

Decision Tree Induction - Model Overfitting - Evaluating The Performance of a Classifier - Methods for Comparing Classifiers - Rule Based Classifiers - Bayesian Classifiers - Nearest Neighbour Classifiers - ANN - SVM – Genetic algorithm – Rough sets – Fuzzy set approaches - Ensemble Methods - Class Imbalance Problem - Multiclass Problem – Prediction – Cluster analysis- Overview - K-Means - Agglomerative Hierarchical Clustering - DBSCAN - Cluster Evaluation - Anomaly Detection Preliminaries.

APPLICATIONS**11**

Social Network Analytics- Definitions and Metrics - Social Network Learning - Relational Neighborhood Classifier - Probabilistic Relational Neighborhood classifier - Relational Logistic Regression - Collective Inferencing - Egonets - Bigraphs.

Total Period: 45**TEXT BOOKS:**

1. Data Mining- Concepts and Techniques, Third Edition by Han, Kamber & Pei (2013)
2. Jiawei Han, Micheline Kamber, and Jian Pei. Data Mining- Concepts and Techniques (3rd ed.). Morgan Kaufmann, 2012.
3. Ian Witten, Eibe Frank and Mark A Hall, “Data Mining - Practical Machine Learning Tools and Techniques”, Morgan Kaufmann, USA, 2012

REFERENCES:

1. Data Mining- The Textbook by Aggarwal (2015)
2. “Introduction to data mining” by Tan, Steinbach & Kumar (2006)

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	To understand the basics of internet protocols and use Web Designing using HTML and CSS.
CO2:	To learn the basics of client side programming and touse the JavaScript to develop the dynamic web pages.
CO3:	To learn the basics Server side scripts and to use Angular JS to generate the web Pages dynamically.
CO4:	To use PHP and MYSQL to develop web pages.

INTERNET AND WEB DESIGNING BASICS**12**

History of Web - Internet Applications - Protocols - FTP - Telnet - HTTP - SMTP – MIME- Components of Web - Web Search Engine - Web Server - Application Server - An Introduction to HTML -HTML Elements - Lists - Tables - Frames - Forms - HTML5 - CSS3 - Introduction to Cascading Style – Style sheets and its types-Media Types and Media Queries.

JAVA SCRIPT**12**

Client-Side Programming: Introduction to JavaScript - Variables and Data Types - Statements -Operators - Literals - Functions - Objects - Arrays - Built-in Objects-Events, Dynamic HTML with Java Script- Angular JS: Introduction to Angular JS - Web programming using Angular JS-Model View Controller-Data Binding-Expressions-Directives-Controllers-Modules.

SERVER SIDE PROGRAMMING**9**

Web servers – IIS and Tomcat Servers - Servlets- JavaServer Pages-Java Server Faces-Web Technologies in Netbeans-Building a Web Application in Netbeans-JSF Components-Session Tracking-Cookies.

PHP AND MYSQL**12**

PHP- Basics, String Processing and Regular Expressions, Form Processing and Business Logic- Using Cookies - Dynamic Content - Operator Precedence Chart - Database Connectivity with MySQL - Servlets, JSP, PHP.

Total Period: 45**TEXT BOOKS**

1. Paul J. Deitel, Harvey M. Deitel, Abbey Deitel, “Internet & World Wide Web How to Program”, Deitel series, 5th edition, 2012
2. Jeffrey C. Jackson, "Web Technologies-A Computer Science Perspective", Pearson Education, 2009.
3. Jason Gilmore, “Beginning PHP and MySQL From Novice to Professional”, 4th Edition, Apress Publications, 2010.

REFERENCES

1. Robert W. Sebesta, “Programming with World Wide Web”, Pearson, 4th edition, 2008
2. David William Barron, “The World of Scripting Languages”, Wiley Publications, 2000

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	To develop in-depth understanding of relational databases and skills to optimize database performance in practice.
CO2:	To understand and critique on each type of databases.
CO3:	To design faster algorithms in solving practical database problems.
CO4:	To implement intelligent databases and various data models.

RELATIONAL MODEL ISSUES**9**

ER Model - Normalization – Query Processing – Query Optimization – Transaction Processing - Concurrency Control – Recovery - Database Tuning.

DISTRIBUTED DATABASES**9**

Parallel Databases – Inter and Intra Query Parallelism – Distributed Database Features – Distributed Database Architecture – Fragmentation – Distributed Query Processing – Distributed Transactions Processing – Concurrency Control – Recovery – Commit Protocols.

OBJECT ORIENTED DATABASES**9**

Introduction to Object Oriented Data Bases - Approaches - Modeling and Design - Persistence – Query Languages - Transaction - Concurrency – Multi Version Locks – Recovery – POSTGRES – JASMINE – GEMSTONE - ODMG Model.

EMERGING SYSTEMS**9**

Enhanced Data Models - Client/Server Model - Data Warehousing and Data Mining - Web Databases – Mobile Databases- XML and Web Databases.

CURRENT ISSUES**9**

Rules - Knowledge Bases - Active and Deductive Databases - Multimedia Databases – Multimedia data Structures – Multimedia Query languages - Spatial Databases.

Total Periods: 45**TEXT BOOKS:**

1. Thomas Connolly and Carlolyn Begg, “Database Systems, A Practical Approach to Design, Implementation and Management”, Third Edition, Pearson Education 2003.

REFERENCES:

1. R. Elmasri, S.B. Navathe, “Fundamentals of Database Systems”, Fifth Edition, Pearson Education, 2006.
2. Abraham Silberschatz, Henry F. Korth, S. Sudharshan, “Database System Concepts”, Fifth Edition, Tata McGraw Hill, 2006.
3. C.J.Date, A.Kannan, S.Swamynathan, “An Introduction to Database Systems”, Eighth Edition, Pearson Education, 2006.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Explain the internal structure of Linux
CO2:	Write desktop and web applications using python
CO3:	Simple database applications using GUI in Python.
CO4:	Build applications using MongoDB and NodeJS and deploying with Cloud services

INTRODUCTION**10**

Need for free and open source software – Advantages and disadvantages of open source software - Overview of Linux – Distributions Development environment tools and systems - using collaborative version control system - FOSS practices - programming guidelines

APPLICATION DEVELOPMENT USING PYTHON**15**

Conditionals/Loops - Functions - List - Strings - Recursion - tuples - Classes – Inheritance- Database Programming- Introduction - Python DB – API. Django -Introduction - Web Frameworks - Introduction to Django - Projects and Apps - Creating a Model to Add Database Service - The Python Application Shell - The Django Administration App - Creating the Blog's User Interface - Improving the Output - Working with User Input - Forms and Model Forms.

WEB DEVELOPMENT WITH MONGO DB AND NODEJS**20**

Node and MongoDB basics – Introducing Express – Templating with handlebars – controllers and view models – Persisting Data with MongoDB – Creating Restful API – Deploying with Cloud based Services – Popular NodeJS Web Frameworks.

Total Period: 45**Text Books:**

1. Introduction to Linux – A Hands on Guide, URL:<http://tldp.org/guides.html>
2. Wesley J. Chun, "Core Python Programming", Prentice Hall, 3rdEdition, 2012
3. Cyrus Dasadia and AmolNayak, “MongoDB Cookbook”, Second Edition, PACKT Publishing, 2016
4. Mithun Satheesh, Bruno Joseph D'mello and Jason Krol, “Web Development with MongoDB and NodeJS”, Second Edition 2ndEdition, PACKT publishing, 2016

References:

1. Jesús M. González-Barahona, Joaquín Seoane Pascual, Gregorio Robles, Introduction to Free Software, Free Technology Academy, Europe, 2009 (<http://ftacademy.org/materials/fsm/1#1>).
2. SanjeevJaiswal, Ratan Kumar, "Learning Django Web Development", Packet Publishing Limited, 2015.
3. Michel Anders, "Python 3 Web Development Beginner's Guide", Packet Publishing Limited, 2011.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	The know importance of interacting with business stakeholders in determining the requirements for a software system.
CO2:	Apply iterative software development process
CO3:	Apply the impact of social aspects on software development success.

AGILE METHODOLOGY**9**

Theories for Agile management – agile software development – traditional model vs. agile model - classification of agile methods – agile manifesto and principles – agile project management – agile team interactions – ethics in agile teams - agility in design, testing – agile documentations – agile drivers, capabilities and values.

AGILE PROCESSES**9**

Lean production - SCRUM, Crystal, Feature Driven Development, Adaptive Software Development, and Extreme Programming: Method overview – lifecycle – work products, roles and practices.

AGILITY AND KNOWLEDGE MANAGEMENT**9**

Agile information systems – agile decision making - Earl_s schools of KM – institutional knowledge evolution cycle – development, acquisition, refinement, distribution, deployment , leveraging – KM in software engineering – managing software knowledge – challenges of migrating to agile methodologies – agile knowledge sharing – role of story-cards – Story-card Maturity Model (SMM).

AGILITY AND REQUIREMENTS ENGINEERING**9**

Impact of agile processes in RE – current agile practices – variance – overview of RE using agile – managing unstable requirements – requirements elicitation – agile requirements abstraction model – requirements management in agile environment, agile requirements prioritization – agile requirements modeling and generation – concurrency in agile requirements generation.

AGILITY AND QUALITY ASSURANCE**9**

Agile Interaction Design - Agile product development – Agile Metrics – Feature Driven Development (FDD) – Financial and Production Metrics in FDD – Agile approach to Quality Assurance - Test Driven Development – Pair programming: Issues and Challenges - Agile approach to Global Software Development.

Total Periods: 45**Text Books:**

1. Craig Larman, —Agile and Iterative Development: A manager_s Guidel, Addison-Wesley, 2004
2. David J. Anderson; Eli Schragenheim, —Agile Management for Software Engineering: Applying the Theory of Constraints for Business Resultsl, Prentice Hall, 2003
3. Dingsoyr, Torgeir, Dyba, Tore, Moe, Nils Brede (Eds.), —Agile Software Development, Current Research and Future Directionsl, Springer-Verlag Berlin Heidelberg, 2010

References:

1. Hazza& Dubinsky, —Agile Software Engineering, Series: Undergraduate Topics in Computer Sciencel, Springer, VIII edition, 2009
2. Kevin C. Desouza, —Agile information systems: conceptualization, construction, and managementl, Butterworth-Heinemann, 2007.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the different Software Automation Tools.
CO2:	Apply the Cloud and VM Automation.
CO3:	Understand the Automation in Database and Web.
CO4:	Infer about different types of Testing Tools.

INFRASTRUCTURE AUTOMATION**10**

IT Management Automation for Data Center Infrastructures - Automation of Servers - Network Assets - Storage - Case Study

CLOUD AND VM AUTOMATION**20**

Data Center Automation for Clouds - Incident Response - Change and Compliance - Provisioning and more - Workflow Automation Engine for VMware vSphere - IT Automation Tool for Virtualized Data Centers - Automation in Database Environment - Automation in Web Applications and Web Browsers - Automation in Mobile and Desktop applications Case Study : Selenium -TestComplete- Watir

SOFTWARE ENGINEERING AUTOMATION**15**

Introduction to Automation in Software Engineering - Factors for choosing a particular Tool - Tools in Analysis, Design, Coding and Testing - An overview for the major Functional Testing Tools - Types of Automation Testing Tools - Overview of Test Management and Bug Tracking Tools - Agile Testing Automation - Case Study : QTP (Quick Test Professional) TelerikTestStudio-HP Unified Functional Testing Software - JIRA

Total Periods: 45**TEXT BOOKS :**

1. Matthias Marschall, "Chef Infrastructure Automation Cookbook ", PACKT Publishing, 2015, by Matthias Marschall
2. Paul Grünbacher and Yves Ledru, "Automated Software Engineering - Introduction", European Research Consortium for Informatics and Mathematics

REFERENCE:

1. Graham, "Experiences of Test Automation: Case Studies of Software Test Automation", 1st Edition, Addison Wesley, 2012.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	To understand the basic concepts of User Interface Design.
CO2:	To understanding about human computer interaction methods that utilize more general, Widespread and easier-to-learn capabilities.
CO3:	To outline user interface navigable options and Device

USER INTERFACE DESIGN CONCEPTS**12**

Introduction: Importance of user interface – definition, importance of good design, brief history – Graphical User Interface – Web User Interface – Theories, Principles and Guidelines of User interface design Design Process: Obstacles in development path deigning for people-Understanding Human Interaction with computers, Importance of Human Characteristics, Human consideration, Human Interaction speeds – Understanding Business function

SCREEN DESIGN**11**

Screen Designing: Design goals - screen meaning and purpose, organizing screen elements ordering of screen data and content – screen navigation and flow – visually pleasing composition – amount of information – focus and emphasis – presenting information simply and meaningfully – information retrieval on web – Statistical graphics – Technological considerations in Interface Design.

MENU & WINDOWS**11**

Menus and navigation schemes-structures of menus-functions of menus- contents of menus - formatting of menus – phrasing the menu- selecting menu choices-navigating menus-kinds of graphical menus- Selection of windows- Window characteristics-components of window window presentation styles-types of windows-window management-organising window functions-window operations-Selection of device based and screen based controls - text and messages – icons and images – Multimedia – colours- uses, problems, choosing colours.

DEVICE**11**

Distributed and Collaborative Interaction-Device consistency-distribution of the user interface-event distribution-graphical package layer-programmable API-Model semantics distribution-data layer distribution-asynchronous collaboration Software tools-specification methods- interface building tools –evaluation and critiquing tools- Interaction devices keyboard and function keys - pointing devices- speech recognition, digitization and generation – image and video displays printers.

TOTAL PERIODS: 45**TEXT BOOKS**

1. Wilbert O. Galitz, The Essential Guide to User Interface Design, 2nd Edn., Wiley Dreamtech, Delhi, 2002
2. Ben Shneiderman, Designing the User Interface , 3rd Edn., Pearson Education Asia, Delhi, 2002

REFERENCE BOOKS

1. Dan R. Olsen, Human Computer Interaction, Cengage, New Delhi, 2009
2. John M. Carroll, Human Computer Interaction, Pearson Education Asia, Delhi, 2002
3. Alan Cooper, The Essentials of User Interface Design , Wiley Dreamtech, Delhi, 2002

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Summarizing the concepts of soft computing and Intelligent systems.
CO2:	Illustrate about the fundamentals of fuzzy logic and working with artificial neural networks.
CO3:	Explain about the fundamentals of Genetic Algorithms and its integration with Fuzzy Genetic Algorithms.

INTELLIGENCE SYSTEM & SOFT COMPUTING 9

Introduction to Intelligence System: Intelligent System – Knowledge based System – Knowledge Representation and Processing. Introduction to Soft Computing: Basics – Techniques – Features - Applications

FUNDAMENTALS OF FUZZY LOGIC SYSTEMS 9

Fundamentals of Fuzzy Logic Systems: Evolution and Use of Fuzzy logic – Sets – Operations – Resolutions and Relations – Composition and Inferences. Fuzzy Logic Controls: Basics – Fuzzification and Defuzzification – Control Architecture – Properties – Robustness and Stability – Fuzzy Clustering

NEURAL NETWORK 9

Neural Network: Perceptron – Functions – Trainings of Neural Network – Artificial Neural Network Features – Industrial and Commercial Applications of ANN – Some Examples: MLFFNN, RBFN, SOM, CPNN, RNN.

NEURO FUZZY SYSTEMS 9

Neuro Fuzzy Systems: Architecture of Neuro Fuzzy Systems – Cooperative Neuro Fuzzy Systems – Neural Network Driven Fuzzy Reasoning – Hybrid Systems - Construction of Neuro Fuzzy Systems – Based on Mamdani Approach – Takagi and Sugeno's Approach –

GENETIC ALGORITHM 9

Genetic Algorithm: Genetic Algorithm and Optimization – Operators – Integration of Genetic Algorithms with Neural Networks and Fuzzy Logic – Fuzzy Genetic Algorithms – Principles of Genetic Fuzzy Systems – Known Issues of GAs - Applications

Total Period: 45

TEXT BOOKS:

1. Fakhereddine O. Karray, Clarence De Silva, Soft Computing and Intelligent Systems Design: Theory, Tools and Applications, Pearson, 2009.
2. Dilip K.Pratihar, Soft Computing: Fundamentals and Applications, Narosa Publishing House (IIT Karagpur Professor Book)

REFERENCES:

1. Madan M. Gupta, Naresh K. Sinha, Soft Computing and Intelligent Systems: Theory and Applications, Academic Press, 1999. ISBN–10: 0126464901, ISBN–13: 9780126464900.
2. S.Rajasekaran and G.A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic, And Genetic Algorithms Synthesis and Applications, Prentice Hall India, 2003. ISBN–81–203–2226–3.
3. S.N.Sivanandam, S.Sumathi, S.N.Deepa, Neural Networks using MATLAB, Tata McGraw Hill, 2005. ISBN: 9780070591127.

WEB REFERENCES

1. https://onlinecourses.nptel.ac.in/noc19_cs23/preview
2. https://onlinecourses.nptel.ac.in/noc19_ge07/preview

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the significance of cryptography to the modern world and the internet.
CO2:	Apply cryptographic algorithms into software projects.
CO3:	Understand the fundamentals of Digital Forensics and Identify how resultant evidence can be applied within legal cases.
CO4:	Apply their competence in the various forensic computing fields.

BASIC CRYPTOGRAPHY CONCEPTS**11**

Basic Cryptography Concepts: Symmetric Encryption Algorithms- Purpose of Cryptography- Caesar cipher- Vigenere cipher- The one-time pad- Block ciphers and their applications, Structure of a block cipher, The Fiestel structure, Key and block size length, The Data Encryption Standard (DES), The Advanced Encryption Standard (AES)

CRYPTANALYSIS AND KEY DISTRIBUTION**12**

HASH FUNCTIONS: One-way hash functions and their applications, SHA-1 and its successors. CRYPTANALYSIS: Linear cryptanalysis, Differential cryptanalysis, Meet-in-the-middle attacks. The key distribution problem, The Diffie-Hellman method, RSA and related methods.

AN OVERVIEW OF DIGITAL FORENSICS INVESTIGATION**10**

Live forensics and investigation –digital evidence – seizure methodology factors limiting the whole sale seizure of hardware- Demystifying computer/cyber crime – explosion of networking – explosion of wireless networks –interpersonal communication.

NETWORK FORENSICS AND E-MAIL FORENSICS**12**

Investigating Wireless Attacks – Basics of wireless – Wireless Penetration Testing – Direct Connections to Wireless Access Point – Wireless Connect to a Wireless Access Point. Forensics Acquisition – Processing Local mail archives – Processing server level archives -categories of steganography in Forensics – Types of password cracking.

Total Period: 45**TEXT BOOKS:**

1. A Course in Number Theory and Cryptography, Æ Neal Koblitz, (Springer 2006)
2. An Introduction to Mathematical Cryptography, Jill Pipher, Jeffrey Hoffstein, Joseph H. Silverman (Springer, 2008)
3. Anthony Reyes, Jack Wiles, “Cybercrime and Digital Forensics”, Syngress Publishers, Elsevier 2007.

REFERENCES:

1. An Introduction to Cryptography, R.A. Mollin (Chapman & Hall, 2001)
2. Rational Points on Elliptic Curves, Silverman and Tate (Springer 2005)
3. Guide to elliptic curve cryptography Hankerson, Menezes, Vanstone (Springer, 2004)
4. John Sammons, “The Basics of Digital Forensics”, Elsevier 2012
5. Linda Volonins, Reynalds Anzaldua, “Computer Forensics for dummies”, Wiley Publishing 2008.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the basic concepts of multimedia system architecture and I/O devices.
CO2:	Design and implement basic Compression and hypermedia Standards in multimedia applications with hypermedia standards.
CO3:	Demonstrate the techniques, processes, technologies and equipment used in immersive virtual reality.

MULTIMEDIA SYSTEM DESIGN& INPUT AND OUTPUT TECHNOLOGIES**12**

Introduction-Multimedia Elements, Multimedia Applications, Multimedia System Architecture, Evolving Technologies for Multimedia Systems, Multimedia Databases- Key Technology Issues, Pen Input, Video and Image Display Systems, Print Output Technologies, Image Scanners, Digital Voice and Audio, Video Images and Animation, Full Motion Video.

MULTIMEDIA FILE HANDLING & APPLICATION DESIGN**12**

Compression and Decompression Techniques-Types of Compression, Binary Image Compression Schemes, Color, gray scale, still-video image compression, Discrete Cosine Transform, Video Image compression, MPEG Coding methodology, Audio Compression, Data and File format standards- RTF, TIFF,RIFF, MIDI, JPEG, AVI, JPEG, TWAIN Architecture. Types of Multimedia systems - Components of Multimedia system - Distributed Application Design Issues – Multimedia Authoring and User Interface - Hypermedia Messaging – Distributed Multimedia Systems.

VIRTUAL REALITY**21**

Introduction: The three I's of virtual reality, commercial VR technology and the five classic components of a VR system. Input Devices: (Trackers, Navigation, and Gesture Interfaces): Three-dimensional position trackers, navigation and manipulation, interfaces and gesture interfaces. Output Devices: Graphics displays, sound displays & haptic feedback. Modeling: Geometric modeling, kinematics modeling, physical modeling, behavior modeling, model management. Applications: Medical applications, military applications, robotics applications.

Total Period: 45**TEXT BOOKS:**

1. Prabat K Andleigh and Kiran Thakrar, “Multimedia Systems and Design”, Pearson Education India; 1 edition (2015)
2. Gregory C. Burdea & Philippe Coiffet, “Virtual Reality Technology”, Second Edition John Wiley & Sons Incorporated, 2004

REFERENCES:

1. David Hillman, "Multimedia Technology and Applications", Galgotia Publications, 2000
2. Understanding Virtual Reality, interface, Application and Design, William R.Sherman, Alan Craig, Elsevier (Morgan Kaufmann).
3. 3D Modeling and surfacing, Bill Fleming, Elsevier (Morgan Kauffman).
4. 3D Game Engine Design, David H. Eberly, Elsevier.
5. Virtual Reality Systems, John Vince, Pearson Education.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	To have an overview of ISA design, Instruction Pipelining and Performance related issues
CO2:	To do a detailed study of ILP with Dynamic Approaches
CO3:	To do a detailed study of ILP with Software Approaches
CO4:	To know the concepts of different Multiprocessor Architectures and related issues
CO5:	To know the concepts of Memory and I/O systems and their Performance issues
CO6:	To know the concepts of Domain Specific Architectures

FUNDAMENTALS OF COMPUTER DESIGN**9**

Introduction – Measuring and Reporting Performance – Quantitative Principles of Computer Design – Instruction Set Principles and Examples – Classifying Instructions – Set Architectures – Memory Addressing – Addressing Modes for Signal Processing – Type and Size of Operands.

INSTRUCTION LEVEL PARALLELISM**9**

Concepts and Challenges – Overcoming Data Hazards with Dynamic Scheduling – Examples – Reducing Branch Costs with Dynamic Hardware Prediction – High Performance Instruction Delivery – Taking Advantages of ILP with Multiple Issues Limitations of ILP.

ILP WITH SOFTWARE APPROACHES**9**

Basic Compiler Techniques for Exposing ILP – Static Branch Prediction – Static Multiple Issues: VLIW Approach – Advanced Compiler Support for Exposing and Exploiting ILP Hardware Support – Cross Cutting Issues – Intel IA64 Architecture.

MEMORY HIERARCHY DESIGN**6**

Introduction – Review of Caches – Cache Performance – Reducing Cache Miss Penalty Reducing Miss Rate – Miss Rate via Parallelism – Reducing Hit Time – Main Memory and Organizations for Improving Performance – Memory Technology – Virtual Memory.

MULTIPROCESSORS AND THREAD LEVEL PARALLELISM**12**

Symmetric Shared Memory Architectures – Performance of Symmetric Shared Memory Multiprocessors – Distributed Shared Memory Architectures – Synchronization – Domain Specific Architecture: Introduction – Guidelines for DSAs - Example Domain: Deep Neural Networks - Google's Tensor Processing Unit, an Inference Data Center Accelerator - Microsoft Catapult, a Flexible Data Center Accelerator - Intel Crest, a Data Center Accelerator for Training - Pixel Visual Core, a Personal Mobile Device Image Processing Unit - Cross-Cutting Issues - Putting It All Together: CPUs Versus GPUs Versus DNN Accelerators - Fallacies and Pitfalls

Total Periods: 45**TEXT BOOK**

1. John L. Hennessey and David A. Patterson, Computer Architecture: A Quantitative Approach, Morgan Kaufmann, 6th Edition, 2019. ISBN: 978-0-12-811905-1.

REFERENCE BOOKS

1. D.Sima, T. Fountain and P. Kacsuk, Advanced Computer Architectures: A Design Space Approach, Addison Wesley, 2000. ISBN: 0201422913.
2. Kai Hwang, Advanced Computer Architecture: Parallelism, Scalability, Programmability Tata McGraw Hill Edition, 2001.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Identify basic concepts, terminology, theories, models and methods in the field of computer vision.
CO2:	Demonstrate the mathematical underpinnings of Computer Vision and image processing techniques.
CO3:	Apply the different techniques in computer vision.
CO4:	Analyze various models and computer vision system for real-world challenges.

COMPUTER VISION AND RELATED AREAS**16**

Emergence of Computer Vision - Basic Image Operations - Mathematical Operations on Images - Sunglass Filter: A Simple Application - Bitwise Operations - Image Annotation - QR Code Detection - Extraction of features from images - Probabilistic Modelling in Images - Camera Calibration - Epipolar Geometry Estimation - Statistical Estimation, Model Reconstruction from Images - Statistical Filtering and Tracking in Video Sequences, Motion Estimation in Video Sequences - Optical Flow - Object Recognition.

PROCESSING MORPHOLOGY AND COMPUTATIONAL PHOTOGRAPHY**9**

Thresholding - Erosion/ Dilation - Opening and Closing - Connected Component Analysis - Contour Analysis - Hough Transforms - High Dynamic Range Imaging - Seamless Cloning - Image Inpainting - Affine Transforms - Feature Matching - Image Alignment. Case Studies: Blob Detection, Coin Detection

HIGH - LEVEL VISION**8**

Object Recognition - Image Classification - Object Localization - Object Detection - Image Segmentation - Object Tracking and Motion Estimation - Filtering for Video Analytics. Case studies: Detecting various objects in a given scenario

COMPUTER VISION AND DEEP LEARNING**12**

Computer Vision: Image Formation - Visual Features and Representations - Visual Matching - Deep Learning: Convolutional Neural Networks - Visualization Kernels - Deconvolution methods - Deep Dream - Hallucination - Neural Style Transfer - CAM and its variants - CNN Architectures for Recognition and Verification, Detection and Segmentation - CNN for Video Understanding.

Total Periods: 45**TEXTBOOKS**

1. Wataru Ohyama, Soon Ki Jung, Frontiers of Computer Vision, Springer, 2020.
2. David Forsyth and Jean Ponce, Computer Vision: A Modern Approach, 2nd Edition, Pearson, 2011.
3. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2011.
4. Mohamed Elgendy, Deep Learning for Vision Systems, Manning Publications, 2020.

REFERENCES

1. Jan Erik Solem, Programming Computer vision with python, 1st Edition, O'Reilly, 2012.
2. Robert Laganiere, OpenCV Computer Vision Applications Programming cookbook, 2nd Edition, Packt publishing.

WEB REFERENCES

1. <https://learnopencv.com/>
2. <https://www.coursera.org/learn/computer-vision-basics>
3. <https://www.coursera.org/lecture/python-project/opencv-SJMeh>
4. <https://www.udemy.com/course/hands-on-computer-vision-with-opencv-4-keras-tensorflow-2>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Create finite state automata for lexical analysis
CO2:	Create parsing algorithms for common categories of grammars.
CO3:	Apply type theory to find bugs in compiled programs
CO4:	Create direct and pattern-matching code generators.
CO5:	Understand and apply basic optimization techniques.
CO6:	Employ standard tools to create scanners, parsers, and code generators.

Scanning **9**

Kinds of Tokens - A Hand-Made Scanner - Regular Expressions - Finite Automata - Conversion Algorithms - Limits of Finite Automata - Using a Scanner Generator

Parsing **9**

Context Free Grammars - Deriving Sentences - Ambiguous Grammars - LL Grammars - LR Grammars Parsing in Practice - The Bison Parser Generator - Expression Validator - Expression Interpreter - Expression Trees

Intermediate Code Generation **9**

The Abstract Syntax Tree - Declarations - Statements - Types - Building the AST - Semantic Analysis - Type Systems - Designing a Type System - The B-Minor Type System - The Symbol Table - Name Resolution - Implementing Type Checking - Error Messages - Intermediate Representations - Abstract Syntax Tree - Directed Acyclic Graph - Control Flow Graph - Static Single Assignment Form - Linear IR - Stack Machine IR - Memory Organization - Assembly Language - Open Source Assembler Tools - X86 Assembly Language - ARM Assembly

Code Generation **9**

Introduction - Supporting Functions - Generating Expressions - Generating Statements - Conditional Expressions - Generating Declarations - Exercises

Optimization **9**

Optimization in Perspective - High Level Optimizations - Low-Level Optimizations - Register Allocation

Total Hours : 45

Text Books

1. Introduction to Compilers and Language Design, Prof. Douglas Thain, Second Edition, 2022
2. Compilers: Principles, Techniques, and Tools (2nd edition). Alfred V. Aho, Monica S. Lam, Ravi Sethi and Jeff Ullman. Publisher: Addison Wesley, 2014.
3. Introduction to Automata Theory, Languages, and Computation (3rd edition). J.E. Hopcroft, R. Motwani, J.D. Ullman. Addison Wesley, 2007.

Reference Books

1. Compiler Construction: Principles and Practice, Kenneth C. Louden. Publisher: Brooks Cole, 1997.
2. Advanced Compiler Design and Implementation, Steven Muchnick. Publisher: Morgan Kaufmann, 1997.
3. Programming Language Processors in Java: Compilers and Interpreters, David Watt and Deryck Brown. Publisher: Prentice Hall, 2000.

Web Reference

1. https://onlinecourses.nptel.ac.in/noc20_cs13/
2. <https://online.stanford.edu/courses/soe-yccscs1-compilersn>



Department of Electronics and Instrumentation Engineering
M.E Control and Instrumentation Engineering



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S. No.	Course Code	Course Title	L	T	P	C	Category	CA	ES	Total
SEMESTER - I										
THEORY										
1	22MA1001	Advanced Applied Mathematics	3	1	0	4	HS	40	60	100
2	22EI1101	Wireless Sensors Networks	3	0	0	3	PC	40	60	100
3	22EI1102	Computational Intelligent Techniques	3	0	0	3	PC	40	60	100
4	22EI1103	Advanced Instrumentation Systems	3	0	0	3	PC	40	60	100
5	22EI1104	Control System Design	3	0	0	3	PC	40	60	100
6	22EI1105	Process Control: Design and Analysis	3	0	0	3	PC	40	60	100
7	22ME1A004	Research Methodology and IPR	3	0	0	3	EEC	40	60	100
PRACTICAL										
8	22EI1106	Process Control: Design and Analysis Laboratory	0	0	1	1	PC	60	40	100
SEMESTER - II										
THEORY										
1	22EI1201	Process Data Analytics	3	1	0	4	PC	40	60	100
2	22EI1202	Smart Sensors and Automation Systems	3	0	0	3	PC	40	60	100
3	22EI1203	Applied Machine Learning	3	0	0	3	PC	40	60	100
4	22EI1EXX	Professional Elective -I	3	0	0	3	PE	40	60	100
5	22EI1EXX	Professional Elective - II	3	0	0	3	PE	40	60	100
6	22EI1EXX	Professional Elective - III	3	0	0	3	PE	40	60	100
7	22EN1001	English for Research Paper Writing	1	0	0	0	AC	AUDIT COURSE GRADE ONLY		
PRACTICAL										
8	22EI1205	Smart Sensors and Automation Systems Laboratory	0	0	1	1	PC	60	40	100
SEMESTER - III										
THEORY										
1	22EI1EXX	Professional Elective - IV	3	0	0	3	PE	40	60	100
2	22EI1EXX	Professional Elective - V	3	0	0	3	PE	40	60	100

2	22EI1EXX	Professional Elective – V	3	0	0	3	PE	40	60	100
3	22EI1EXX	Professional Elective - VI	3	0	0	3	PE	40	60	100
PRACTICAL										
4	22EI1301	Project Dissertation-I	0	0		6	EEC	60	40	100
SEMESTER IV										
1	22EI1401	Project Dissertation-II	3	0	0	12	EEC	60	40	100
PROFESSIONAL ELECTIVES										
1	22EI1E01	Industrial Internet of Things	3	0	0	3	PE	40	60	100
2	22EI1E02	Automotive Embedded Systems	3	0	0	3	PE	40	60	100
3	22EI1E03	Bio sensors and Wearable Sensors	3	0	0	3	PE	40	60	100
4	22EI1E04	Multisensor Data Fusion	3	0	0	3	PE	40	60	100
5	22EI1E05	Big Data Mining and Analytics	3	0	0	3	PE	40	60	100
6	22EI1E06	Advanced Digital Signal Processing	3	0	0	3	PE	40	60	100

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Use the concept of matrix theory to decompose matrices.
CO2:	Apply the method of calculus of variation to extremize the functionals.
CO3:	Apply graph model and algorithm for solving network problems.
CO4:	Apply simplex method for solving linear programming problems and optimize transportation and assignment problems.
CO5:	Solve nonlinear functions subjected to linear and nonlinear constraints using optimization technique.

MATRIX THEORY**12**

Matrix Decomposition: QR factorization - Least square approximations - Pseudo inverse - Singular value decomposition - Toeplitz matrices.

CALCULUS OF VARIATIONS**12**

Variation and its properties - Euler's equation - Functional dependent on first and higher order derivatives - Functional dependent on functions of several independent variables.

DIRECTED GRAPHS, GRAPH THEORETIC ALGORITHMS**12**

Digraphs - Types of digraphs - Directed paths and connectedness - Euler graphs - Adjacency matrix of a digraph - Tournament. Algorithms - Connectedness and components - Spanning tree - Fundamental circuits - Cut vertices - Directed circuits - Shortest path algorithm.

LINEAR PROGRAMMING**12**

Formulation - Graphical solution - Simplex method - Big M method - Two phase method - Transportation and Assignment models.

OPTIMIZATION TECHNIQUES**12**

Classical Optimization - Unconstrained problem of Maxima and Minima - Constrained problem of Maxima and Minima - Lagrangian method - Kuhn Tucker conditions.

Total Hours: 60

TEXT BOOKS:

1. Bronson. R, "Matrix Operation, Schaum's outline series", 2nd Edition, McGraw-Hill, 2011.
2. Elsgolc. L.D., "Calculus of Variations" Dover Publications, 2007.
3. Narasing Deo, "Graph theory: with application to Engineering and Computer Science", Prentice Hall India, 2017.
4. Taha H.A, "Operations Research: An introduction" Tenth Edition, Pearson Education, 2019.

REFERENCES:

1. Andrews, L.C. and Philips, R.L., "Mathematical Techniques for Engineers and Scientists", Prentice Hall of India, 2005.
2. West, D.B, "Introduction to Graph Theory", Pearson Education, 2019.
3. Kombo, N.S, "Mathematical Programming Techniques", East-West Press, 2012.

WEB REFERENCES

1. <https://archive.nptel.ac.in/courses/111/108/111108157/>
2. <https://archive.nptel.ac.in/courses/111/104/111104025/>
3. <https://archive.nptel.ac.in/courses/111/105/111105039/>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Explain the characteristics of wireless sensor networks
CO2:	Classify the different types of wireless sensor networks
CO3:	Infer the network operations of wireless communication
CO4:	Summarize the different protocols involved in wireless technologies
CO5:	Interpret the different topologies in wireless sensor networks

OVERVIEW OF WIRELESS SENSOR NETWORKS 12

Single-Node Architecture - Hardware Components - Network Characteristics- unique constraints and challenges-Enabling Technologies for Wireless Sensor Networks - Types of wireless sensor networks.

NETWORK OPERATION 12

Network Architecture- Sensor Networks-Scenarios- Design Principle-Physical Layer and Transceiver Design Considerations-Optimization Goals and Figures of Merit-Introduction to TinyOS and nesC- Internet to WSN Communication

WIRELESS PROTOCOLS 12

MAC Protocols for Wireless Sensor Networks-Low Duty Cycle Protocols and Wakeup Concepts - SMAC, - B-MAC Protocol, IEEE 802.15.4 standard and ZigBee, the Mediation Device Protocol

INFRASTRUCTURE ESTABLISHMENT 9

Topology Control-Clustering-Time Synchronization-Localization and Positioning-Sensor Tasking and Control.

Total Hours: 45

TEXT BOOKS:

1. Holger Karl, Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", 1st Edition, John Wiley Publications, 2005.
2. Feng Zhao , Leonidas J.Guibas, "Wireless Sensor Networks-An Information Processing Approach", 2nd Edition,Elsevier Publications, 2007.

REFERENCES:

1. KazemSohraby, Daniel Minoli, & TaiebZnati, "Wireless Sensor Networks-Technology, Protocols, and Applications", 2nd Edition. John Wiley Publications, 2007.
2. Anna Hac, "Wireless Sensor Network Designs", 3rd Edition,John Wiley Publications, 2003.
3. Waltenequs Dargie , Christian Poellabauer, "Fundamentals Of Wireless Sensor Networks - Theory and Practice",3rd Edition, John Wiley & Sons Publications, 2011.

WEB REFERENCES:

1. <https://archive.nptel.ac.in/courses/106/105/106105160/>
2. <https://www.digimat.in/nptel/courses/video/106105160/L22.html>
3. <https://www.digimat.in/nptel/courses/video/106105160/L26.html>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Recall the structure of artificial neural network.
CO2:	Outline the construction and operations of back propagation networks
CO3:	Infer the concepts and configurations of neural schemes
CO4:	Construct the models using fuzzy control schemes
CO5:	Explain the various hybrid control schemes

ARTIFICIAL NEURAL NETWORKS**12**

Introduction to intelligent systems - Nerve structure of biological neuron - Artificial Neuron and its model- Neural network architecture- single layer and multilayer feed forward networks- Mc Culloch Pitts neuron model- back propagation learning methods- effect of learning rule coefficient -back propagation algorithm- factors affecting back propagation training- applications.

ARTIFICIAL NEURAL NETWORKS AND ASSOCIATIVE MEMORY**12**

Counter propagation network- architecture - Functioning & characteristics of counter Propagation network- Hopfield/ Recurrent network configuration - stability constraints associative memory and characteristics- limitations and applications - Hopfield v/s Boltzman machine - Adaptive Resonance Theory- Architecture- classifications - Implementation and training - Associative Memory.

FUZZY LOGIC SYSTEM**12**

Introduction to crisp sets and fuzzy sets- Basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modelling and control- Fuzzification inferencing and defuzzification- Fuzzy knowledge and rule bases- Fuzzy modelling and control schemes for nonlinear systems- Self-organizing fuzzy logic control- Fuzzy logic control for nonlinear time delay system.

HYBRID CONTROL SCHEMES**9**

Fuzzification and rule base using ANN-Neuro fuzzy systems-ANFIS - Fuzzy Neuron - Optimization of membership function and rule base using Genetic Algorithm -Introduction to Support Vector Machine- Evolutionary Programming-Particle Swarm Optimization

Total Hours: 45**TEXT BOOKS**

1. Laurene V. Fausett, "Fundamentals of Neural Networks: Architectures, Algorithms and Applications", 3rd Edition, Pearson Education, 2008
2. Timothy J. Ross, "Fuzzy Logic with Engineering Applications", 2nd Edition, Wiley India Publications, 2008.

REFERENCES

1. W.T.Miller, R.S.Sutton and P.J.Webrose, "Neural Networks for Control", 1st Edition, MIT Press, 1996.
2. T. Ross, "Fuzzy Logic with Engineering Applications", 2nd Edition, Tata McGraw Hill Publications, 1995.
3. Ethem Alpaydin, "Introduction to Machine Learning (Adaptive Computation and Machine Learning Series)", 3rd Edition, MIT Press, 2004.

WEB REFERENCES

1. <https://nptel.ac.in/courses/117/101/117101106/>
2. <https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-ee24/>
3. <http://www.ti.com/lit/an/sloa020a/sloa020a.pdf>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Select the appropriate instrument for measurement of temperature
CO2:	Explain the different types of gauges for measuring pressure and vacuum
CO3:	Choose the various transducers used for the measurement of flow and level
CO4:	Interpret the available methods for chemical analysis of the chemical sample
CO5:	Illustrate the concepts of safety instrumentation system

MEASUREMENT OF PROCESS PARAMETERS - TEMPERATURE AND PRESSURE 9

Resistance Temperature Detectors -Thermocouple- Radiation thermometers - Fiber optic temperature sensor- Temperature sensor selection, Installation and Calibration. Elastic type pressure gauges - Electrical pressure transducers- Fiber optic pressure sensor. Measurement of vacuum: McLeod gauge, Cold cathode type and hot cathode type ionization gauges - Pressure gauge selection, installation and calibration.

MEASUREMENT OF PROCESS PARAMETERS - FLOW AND LEVEL 9

Variable head flow meters - positive displacement flow meters-variable area flow meters- Electrical type flow meters - Open channel flow measurement -Solid flow measurement.Float gauges - Displacer type - Bubbler system - Load cell - Conductivity sensors - Capacitive sensors - D/P methods - Ultrasonic level sensors -Solid level measurement.

INSTRUMENT FOR CHEMICAL ANALYSIS 12

Ion selective electrodes - pH and Conductivity measurement - UV Visible and IR Spectrometry- Gas & Liquid Chromatography - Mass Spectrometry- Oxygen analysers for gas and liquid -CO,CO₂,NO and SO Analyzers.

SAFETY INSTRUMENTATION 15

Introduction to Safety Instrumented Systems - Process Hazards Analysis (PHA) - Safety Life Cycle - Control and Safety Systems - Safety Instrumented Function - Safety Integrity Level (SIL) - Selection, Verification and Validation of SIL.

Total Hours: 45

TEXT BOOKS

1. Doebelin, E.O. and Manik D.N., "Measurement systems Application and Design", 5th Edition, Tata McGraw-Hill Education Pvt. Ltd, 2009.
2. Braun, R.D., "Introduction to Instrumental Analysis", Pharma Book Syndicate, Singapore, 7th Edition 2012.

3.REFERENCE BOOKS

1. B.G.Liptak, “Instrumentation Engineers Handbook (Process Measurement & Analysis)”, 4th Edition, CRC Press, 2005.
2. Standards - ANSI/ISA-75.01.01 -2002 (60534-2-1 Mod): Flow Equations for Sizing control Valves; ISA84 Process Safety Standards and User Resources, Second Edition, ISA, 2011; ISA88 Batch Standards and User Resources, 4th Edition, ISA, 2011.
3. Documentation Standards - ANSI/ISA5.4-1991 - Instrument Loop Diagrams; ANSI/ISA5.06.01-2007 - Functional Requirements Documentation for Control Software Applications; ANSI/ISA20-1981 - Specification Forms for Process Measurement and Control Instruments, Primary Elements, and Control Valves

WEB REFERENCES

1. [https://www.studocu.com/en-gb/document/university-of-central-lancashire/electronics-](https://www.studocu.com/en-gb/document/university-of-central-lancashire/electronics-instrumentation/instrumentation-1-lecture-notes-with-proper-explanations/1550633)
2. [instrumentation/instrumentation-1-lecture-notes-with-proper-explanations/1550633](https://www.studocu.com/en-gb/document/university-of-central-lancashire/electronics-instrumentation/instrumentation-1-lecture-notes-with-proper-explanations/1550633)
3. https://link.springer.com/chapter/10.1007/1-84628-251-9_8
4. <https://control.com/technical-articles/industrial-instrumentation-and-control-an-introduction-to-the-basic-principles/>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Apply state space modelling for modern control systems
CO2:	Illustrate the controllability and Observability for control system
CO3:	Make use of phase plane for non-linear systems
CO4:	Utilize the describing function of highly non-linear systems
CO5:	Identify the appropriate stability analysis for non-linear systems

STATE SPACE ANALYSIS**12**

State space analysis of continuous and discrete systems - Solution of time invariant autonomous systems, forced system - State transition matrix - Relationship between state equations and transfer function - Properties of state transition matrix - Computation of state transition matrix - Test for controllability and Observability- Full-order and reduced-order observer design

PHASE PLANE ANALYSIS**12**

Concept of phase portraits - Singular points - Limit cycles - Construction of phase portraits - Phase plane analysis of linear and non-linear systems - Isocline method - Delta method

DESCRIBING FUNCTION ANALYSIS**12**

Basic concepts, derivation of describing functions for common non-linearities - Describing function analysis of non-linear systems - Conditions for stability - Stability of oscillations.

STABILITY ANALYSIS**9**

Introduction - Lyapunov's stability concept - Lyapunov's direct method - Lure's transformation - Aizerman's and Kalman's conjecture - Popov's criterion - Circle criterion.

Total Hours: 45**TEXT BOOKS**

1. Gopal M, 'Modern Control System Theory', 3rd Edition, New Age International, , 2014
2. K. Ogata, 'Modern Control Engineering', 5th Edition, Pearson Education, 2012.
3. Franklin, G. F., David Powell, J, Emami-Naeini, A, 'Feedback Control of Dynamic Systems', 7th Edition, Prentice Hall, 2014.

REFERENCE BOOKS

1. William S Levine, "Control System Fundamentals", The Control Handbook, CRC Press, Taylor and Francis Group, 2011.
2. Ashish Tewari, "Modern Control Design with Matlab and Simulink", John Wiley, New Delhi, 2002.
3. T. Glad and L. Ljung, "Control Theory -Multivariable and Non-Linear Methods", Taylor & Francis, 2002.

WEB REFERENCES

1. https://www.vssut.ac.in/lecture_notes/lecture1450172554.pdf
2. http://howellkb.uah.edu/DEtext/Additional_Chapters/Part6/NonLinSys1.pdf
3. <https://www.youtube.com/watch?v=w9hWgSHR M>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Explain the importance of process control in industrial process plants
CO2:	Develop the mathematical model of the process to design the control
CO3:	Choose the appropriate tuning methods for various controllers
CO4:	Summarize the characteristics of different types of control Strategies
CO5:	Make use of appropriate software tools for the modelling multi variable control

PROCESS DYNAMICS**9**

Hierarchical decomposition of Control Functions - Continuous and batch processes - Self regulation - Interacting and non-interacting systems - Mathematical model of Level, Flow and Thermal processes - Lumped and Distributed parameter models - Linearization of nonlinear systems - System Identification-motivation and overview

TUNING METHODS**9**

Practical forms of PID Controller - PID based Fuzzy Controller - Evaluation criteria - IAE, ISE, ITAE

Tuning: Process reaction curve method:- Z-N and Cohen-Coon methods, Continuous cycling method and Damped oscillation method - optimization methods - Auto tuning -Tuning PID Controller using Fuzzy Logic.

MODEL BASED CONTROL SCHEMES**9**

Cascade control - Split-range - Feed-forward control - Ratio control - Inferential control -Override control - Smith predictor control scheme - Internal Model Controller - IMC PID controller -Dynamic Matrix Control - Generalized Predictive Control.

MULTIVARIABLE SYSTEMS & MULTI- LOOP REGULATORY CONTROL**9**

Multivariable Systems - Transfer Matrix Representation - Poles and Zeros of MIMO System - Multivariable frequency response analysis - Multi-loop Control - Process Interaction - Pairing of Inputs and Outputs -The Relative Gain Array (RGA) - Properties and Application of RGA - Multi-loop PID Controller - Biggest Log Modulus Tuning Method Decoupling Control.

MULTIVARIABLE REGULATORY CONTROL & CASE STUDIES**9**

Introduction to Multivariable control - Multivariable PID Controller -Multivariable IMC - Multivariable Dynamic Matrix Controller - Multiple Model based Predictive Controller -Predictive PID Control - Control Schemes for Distillation Column, CSTR, Four-tank system.

Total Hours: 45**TEXT BOOKS**

1. B.Wayne Bequette, "Process Control: Modeling, Design, and Simulation", 1st Edition, Prentice Hall of India, 2004.
2. Dale E. Seborg , Duncan A. Mellichamp , Thomas F. Edgar, and Francis J. Doyle, "III-Process Dynamics and Control", 3rd Edition, John Wiley and Sons, 2010.

REFERENCE BOOKS

1. Jose A. Romagnoli and Ahmet Palazoglu, “Introduction to Process Control”, 2nd Edition, CRC Press, 2012.
2. Coleman Brosilow and Babu Joseph, “Techniques of Model-based Control”, 2nd Edition, Prentice Hall International Series, 2002.
3. D.R. Coughanour, S.E. LeBlanc, Process Systems analysis and Control, McGrawHill, 2nd Edition, 2009.

WEB REFERENCES

1. <https://nptel.ac.in/courses/103106148>
2. https://onlinecourses.nptel.ac.in/noc20_ch11/preview
3. https://onlinecourses.nptel.ac.in/noc22_ch21/previe

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Identify there search problem and state its scope and objectives
CO2:	Prepare a report and research proposal after conducting literature survey considering plagiarism and research ethics.
CO3:	Outline the types of intellectual property rights
CO4:	Administer patent systems and new developments in IPR.

APPROACHES IN RESEARCH**15**

Meaning of research problem, Sources of research problem, criteria characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations. Effective literature studies approaches, analysis. Plagiarism, Research ethics, Effective technical writing , how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

NATURE OF INTELLECTUAL PROPERTY**15**

Patents, Designs, Trade and Copyright. Process of Patenting and development Technical research, innovation, patenting, development. International scenario: International cooperation on intellectual property. Procedure for grants of patents, Patenting under PCT.

PATENT RIGHTS AND DEVELOPMENTS IN IPR**15**

Scope of patent rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. Administration of patent System. New developments in IPR; IPR of biological Systems, Computer software etc., Traditional knowledge case studies, IPR and IITs.

Total Periods: 45**TEXT BOOKS**

1. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 2016
2. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008.
3. Halbert, “Resisting Intellectual Property,” Taylor and Francis Ltd, 2007.

REFERENCE BOOKS

1. Stuart Melville and Wayne Goddaed, “ Research methodology : An introduction for science and engineering students “
2. Wayne Goddard and Stuart Melville, “Research methodology : An introduction”
3. Ranjit Kumar, 2nd edition,” Research Methodology : A Step by Step Guide for beginners “
4. Halbert, “Resisting Intellectual Property,” Taylor and Francis Ltd, 2007.
5. Mayall, “Industrial Design “, McGraw Hill, 1992.
6. Niebel, “Product Design”, McGraw Hill, 1974.
7. Asimov, “Introduction to Design “, Prentice Hall, 1962.

COURSE OUTCOMES**On Successful completion of the course, students will be able to**

CO1:	Design of Kalman filter and validation of grey box, ARX model
CO1:	Experiment with the advanced controllers for real time conical process, three tank and conical tank system
CO1:	Develop using modernized control methods such as DCS and SCADA for real time system
CO1:	Communicate the results of the experiments through reports

List of Experiments

1. Estimation of state variables of a series RLC circuit using Kalman filter
2. Identification and validation of a grey-box model of a temperature process
3. Estimation of Parameters of a ARX model using recursive least squares algorithm for flow process
4. Identification of a Non-Linear Dynamic model (Black Box) of a process using machine learning algorithms for conical tank system
5. Design and Implementation of a Robust-PID Controller on the transfer function model of a three tank level process station.
6. Implementation of Multilayer neural network control for pressure process and compare the performance with conventional controllers.
7. Develop the control structure and data manipulation for the given process using DCS and SCADA
8. Design and implementation of multi-loop PID and multivariable PID control schemes



II Semester



COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Outline the concepts of data analyticsApply the regression model for non linear process
CO2:	Infer the concept of statistical analysis and regularization techniques
CO3:	Analyze the predicting, forecasting, and finding relationships between quantitative data.
CO4:	Make use of data analytics in process control applications

PROCESS DATA ANALYTICS 8

Process data analytics and Statistical learning - Review of Linear Algebra Concepts -Review of Probability & Statistics

REGRESSION 14

Linear Regression:- Simple Linear Regression, Multiple Linear Regression - K-nearest neighbours regression - Practical Consideration in the Regression Model - Validation methods to assess model quality:-The validation set approach, Leave-One-Out Cross Validation, k-Fold Cross Validation - Bias-variance Trade-off for k-Fold Cross Validation.

LINEAR MODEL SELECTION AND REGULARIZATION 14

Subset Selection: - Best Subset Selection, Step-wise Selection and Choosing the Optimal Model -Shrinkage Methods: - LASSO, Ridge regression, Elastic nets - Dimension reduction Methods:- Principal Components Regression, Partial Least Squares.

CLASSIFICATION TECHNIQUES 12

Logistic regression- Linear Discriminant Analysis - Quadratic Discriminant Analysis - Regression & Classification Trees - Random forests, Bagging and boosting.

APPLICATIONS 12

Process data analysis for system identification (under open and closed loops) - Controller Performance Monitoring - Principal components analysis (PCA) for Process Monitoring and Partial Least Squares (PLS) for soft-sensor design - Data-based causality analysis for identification of process topology.

Total Hours: 60

TEXT BOOKS

1. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, "An Introduction to Statistical Learning with Applications in R", 1st Edition, Springer Publications, 2013.
2. Ethem Alpaydin, "Introduction to Machine Learning", 1st Edition, MIT Press, 2013.

REFERENCES

1. Thomas A. Runkler, “Data Analytics: Models and Algorithms for Intelligent Data Analysis”, 2nd Edition, Springer Vieweg, 2016.
2. Arun K. Tangirala, “Principles of System Identification - Theory and Practice”, CRC Press, 2018.
3. Huang, B. and Shah, S.L., “Performance Assessment of Control Loops: Theory and Applications”, Springer-Verlag, 2007.

WEB REFERENCES

1. <https://nptel.ac.in/courses/106107220>
2. https://onlinecourses.nptel.ac.in/noc21_cs45/preview
3. <https://archive.nptel.ac.in/courses/106/107/106107220>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Interpret the functional units of smart sensing system
CO2:	Explain the hardware design of Programmable Logic Controllers
CO3:	Extend the control and monitoring of industrial processes
CO4:	Interpret the working of final control element in automation system
CO5:	Outline the architecture and functional requirements of distributed control system for suitable applications

SMART SENSORS**9**

Integrated smart sensors - Interface electronics - Design, sensing elements and parasitic effects - Universal Sensor Interface – Converters - DAQ - Design - Microcontrollers and digital signal processors for smart sensors - Smart Transducer Interface standard (IEEE 1451)- Smart transmitters.

PROGRAMMABLE LOGIC CONTROLLERS**12**

Relay logic- Block diagram of PLCs-Hardware design - Logic Functions- Input & Output Modules- Programming of PLC Systems- Timer & Counter Instructions

INDUSTRIAL COMMUNICATION SYSTEMS**6**

Field bus architecture - HART network - PROFIBUS-PA: Basics, architecture, network design - MODBUS-CAN BUS

AUTOMATION SYSTEMS**9**

Real time analytics - Actuators- Characteristics - Control of Actuators- SCADA System and RTU-IEDs- Analysis of Automated Flow Lines - Automated Storage Systems - Product identification system: Barcode, RFID.

DISTRIBUTED CONTROL SYSTEMS AND APPLICATIONS**9**

Distributed Control Systems- IIoT in DCS - Industrial cloud platforms - Industrial Gateways-Common vulnerabilities-Remote health monitoring of the plant - Cyber security for Industrial Control Systems.

Automation, Control Applications in Petroleum Refineries - Thermal Power Plant - Water Treatment Plant- Automobile Industries-Smart Energy Management.

Total Hours: 45**TEXT BOOKS**

1. M.P.Grover, “Automation, Production Systems and Computer Integrated Manufacturing,4th Edition, Education Limited, 2016.
2. Frank D.Petruzella, “Programmable Logic Controllers”, 2nd Edition, Tata McGraw Hill Publications, 2008

REFERENCES

1. B.R. Mehta, Y. J. Reddy," Industrial Process Automation Systems Design and Implementation", Butterworth-Heinemann Elsevier Publications, 1st Edition, 2014.
2. S. Mukhopadhyay, S. Sen and A. K. Deb, "Industrial Instrumentation, Control and Automation", Jaico Publishing House Publications, 2013

WEB REFERENCES

1. <http://digimat.in/nptel/courses/video/108108147/L01.html>
2. <https://nptel.ac.in/courses/108105063>
3. <https://www.youtube.com/watch?v=q8UuRkOQ9A0>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Infer the theory underlying the machine learning.
CO2:	Select the appropriate machine learning algorithms for data preprocessing
CO3:	Explain the different algorithms of supervised learning
CO4:	Summarize the various clustering techniques involved in unsupervised learning
CO5:	Interpret the classifications in bayesian models

MACHINE LEARNING**9**

Objectives of machine learning - Human learning/ Machine learning - Types of Machine learning:- Supervised Learning, Unsupervised learning, Reinforcement Learning and Evolutionary Learning.

DATA PREPROCESSING**9**

Data pre-processing: Data Cleaning:- Handling missing data and noisy data-Data integration:- Redundancy and correlation analysis - Data Reduction:- Dimensionality reduction:- Linear Discriminant Analysis, Principal Components Analysis - Data Compression - Data Normalization and Data Discretization

SUPERVISED LEARNING**9**

Linearly separable and nonlinearly separable populations-Multi Layer Perceptron-Back propagation Learning Algorithm-Radial Basis Function Network-Support Vector Machines: Algorithm-Multi Class Classification-Support Vector Regression

UNSUPERVISED LEARNING**9**

Clustering: K-means algorithm - Hierarchical clustering - Fuzzy Clustering - Clustering High - Dimensional Data - Challenges - Subspace Clustering - Biclustering

BAYESIAN LEARNING**9**

Probability based clustering-The expectation maximization algorithm-Bayesian classification-Bayesian Networks-Learning Bayesian Networks-Hidden Markov Models.

TEXT BOOKS

1. Stephen Marsland, Machine Learning: An Algorithmic Perspective , 2nd Edition, CRC Press, 2015
2. Ian H. Witten, Eibe Frank, Mark A. Hall, Data Mining: Practical Machine Learning Tools and Techniques, 3rd Edition, Elsevier Publications, 2011.

REFERENCES

1. Jiawei Han, Micheline Kamber, Jian Pei, Data Mining: Concepts and Techniques: Concepts and Techniques, 1st Edition, Elsevier Publications, 2011.
2. Ferdinand van der Heijden, Robert Duin, Dick de Ridder, David M. J. Tax, Classification, Parameter Estimation and State Estimation: An Engineering Approach Using MATLAB, 1st Edition, John Wiley & Sons, 2005.
3. Shai Shalev-Shwartz, Shai Ben-David, “Understanding Machine Learning from Theory to Algorithms”, Reprint, Cambridge University Press, 2014.

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1. <https://nptel.ac.in/courses/106106139>
2. https://onlinecourses.nptel.ac.in/noc21_cs51/preview
3. <https://nptel.ac.in/courses/1061061984>.

COURSE OUTCOMES**On Successful completion of the course, students will be able to**

CO1:	Make use of smart sensor for city surveillance and data analytics
CO2:	Build a sensor system for measurement of flow, humidity and temperature using IoT.
CO3:	Design an automation system for monitoring and control of industrial parameters
CO4:	Communicate the results of the experiments through reports

List of Experiments

1. Monitoring and analysis of Intelligent Sensor data for smart city surveillance in low-light conditions
2. Develop a data analytic system to determine the average, trend and prediction
3. Demonstrate the sensor system for force measurement using piezoelectric transducer
4. Design the humidity and temperature sensor module using IoT
5. Real time implementation to control the bottling filling system using IoT
6. Online monitoring for pressure process using distributed control system
7. Design human machine interface for continuous control application
8. Construct a ladder diagram for monitoring and control of temperature process
9. Control of level measurement system using industrial type programmable logic controller

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	To educate learners on how to format research writing.
CO2:	To assist students in writing techniques that could result in the development of flawless writing abilities.
CO3:	To enable students, learn the accepted style for self-scrutinising the mechanics of writing a research paper.

Module 1: Formatting Research writing 7

Margins, Text Formatting, Title, Running Head and Page Numbers, Internal Headings and Subheadings, Placement of the List of Works Cited, Tables and Illustrations- Bibliography.

Module 2: The mechanics of writing 8

Spelling, Punctuation, Italics, Names of persons, Numbers, Titles of works in the research paper, Quotation- The format of the Research paper- Documentation: Preparing the list or workers cited- Abbreviations- Citations in forms other than print.

Total Hours: 15

Text book:

MLA Handbook ninth edition, The modern Language Association of America, New York 2021.

Reference Book:

APA Style Handbook for In-Text Citations and References : Based on APA Guidelines 7th Edition.

PROFESSIONAL ELECTIVES

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Interpret the different IoT enabling technologies and its principles
CO2:	Outline the different design methodologies involved in industry
CO3:	Relate the protocols involved in application layer
CO4:	Summarize the structures of IoT application Analyse the concepts of security in Industrial IoT

INTERNET PRINCIPLES**12**

IoT enabling technologies - Levels of deployment - Domain specific IoTs - SDN and NFV for IoT - ISO/OSI model - MAC address and IP address - Overview of TCP/IP and UDP -Basics of DNS - Classes of IP addresses - Static and dynamic addressing -Salient features of IPV4 - Specifications of IPV6 and LoPAN.

PHYSICAL AND LOGICAL DESIGN METHODOLOGIES**12**

Requirements and Specifications - Device and Component Integration - Physical design using prototyping boards - Sensors and actuators, choice of processor, interfacing and networking - Logical Design - Open source platforms - Techniques for writing embedded code

PROTOCOLS AND CLOUDS FOR IOT**12**

Application layer protocols for IoT : MQTT - Introduction to cloud storage models and communication APIs - Web application framework - Designing a web API - Web services -IoT device management

APPLICATIONS IN IIOT AND SECURITY**9**

Networked Control Systems - Network delay modelling - Architecture and design methodologies for developing IoT application for Networked Control Systems - Example using SCADA system - Software Design Concepts - Middleware IIOT platforms- Securing the Industrial Internet- Introduction of Industry 4.0.

Total Hours: 45**TEXT BOOKS**

1. Arshdeep Bahga and Vijay Madiseti, "Internet of Things A Hands-on Approach", Reprint, Universities Press, 2015
2. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", 1st Edition, Apress, 2016.

REFERENCES

1. Adrian McEwen and Hakim Cassimally, "Designing the Internet of Things", Reprint, John Wiley & Sons, 2014
2. Francis Dacosta, "Rethinking the Internet of Things", 1st Edition, Apress Open, 2014.
3. Beheshti, S.-M.-R., Benatallah, B., Sakr, S., Grigori, D., Motahari-Nezhad, H.R., Barukh, M.C., Gater, A., Ryu, S.H. "Process Analytics Concepts and Techniques for Querying and Analyzing Process Data", 1st Edition, Springer International Publications, 2016.

WEB REFERENCES

1. <https://www.digimat.in/nptel/courses/video/106105195/L01.html>
2. <https://www.youtube.com/watch?v=xukuiNFzQuk>
3. <https://www.youtube.com/watch?v=xukuiNFzQuk>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Explain the electronic engine control system for automotive applications.
CO2:	Summarize the various fuel cells used in automotive industry.
CO3:	Outline the vehicle management technology used in automotive applications.
CO4:	Infer the use of communication protocols in automotive systems.
CO5:	Illustrate the diagnostics for vehicle system.

ELECTRONIC ENGINE CONTROL SYSTEM**15**

Automobile sensors-volumetric, thermal, air-fuel ratio, solenoid , hall effect - Exhaust gas oxygen sensors, Oxidizing catalytic efficiency, emission limits and vehicle performance - Open and closed loop fuel control- Electronic ignition system - Architecture of a EMS with multi point fuel injection system.

FUEL CELL FOR AUTOMOTIVE POWER**8**

Fuel cell: Proton exchange membrane (PEM)-Solid oxide fuel cell (SOFC) - Properties of fuel cells for vehicles- Power system of an automobile with fuel cell based drive.

VEHICLE MANAGEMENT SYSTEM**10**

Electronic Engine Control-Engine mapping, air-fuel ratio spark timing control strategy, fuel control, electronic ignition-Vehicle cruise control speed control-anti-locking braking system-Electronic suspension - Electronic steering - Wiper control.

TELEMATICS AND DIAGNOSTICS**12**

Role of Bluetooth, CAN, LIN and flex ray communication protocols in automotive applications; Multiplexed vehicle system architecture :Signal and data / parameter exchange between EMS, ECUs with other vehicle system components and other control systems- Realizing bus interfaces for diagnostics, dashboard display ,multimedia electronics.

Total Hours: 45**TEXT BOOKS**

1. William B.Ribbens, "Understanding Automotive Electronics", 7th edition, Elsevier publication, 2014.
2. Ali Emedi, Mehrded ehsani, John M Miller , "Vehicular Electric power system- land, Sea, Air and Space Vehicles" Marcel Decker, 1st edition, 2013.

REFERENCE BOOKS

1. Jiri Marek, Hans-Peter Trah, Yasutoshi Suzuki, Iwao Yokomori, Sensors for Automotive, Technology, 2010, 4th Edition, Wiley, New York.
2. "Automotive Sensors Handbook", 8th Edition, 2011, BOSCH.
3. John Turner, "Automotive Sensors", Momentum Press, 1st Edition, New York,2010.

WEB REFERENCES

1. https://onlinecourses.nptel.ac.in/noc20_de06/
2. <https://www.coursera.org/learn/state-estimation>
3. <https://www.classcentral.com/course/sensor-fusion-engineer-nanodegree--nd313-1819>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Summarize the principle and elements of biosensors
CO2:	Extend the knowledge on different types of biosensors
CO3:	Explain about the applications of biosensors in various fields
CO4:	Classify the various types of wearable sensors in medical applications
CO5:	Outline the concepts of wearable systems in health Monitoring

ELEMENTS OF BIOSENSORS**05**

Components - Classification of biosensors based on transducers -Membranes used in biosensors for selectivity - Microelectrodes - Enzyme modified microelectrodes -Miniaturized arrays - Semiconductor needle.

BIO SENSORS**15**

Electrochemical Biosensors: Enzyme Electrodes - Non labeled and labeled Immunosensors, Microbial Biosensors: electrochemical, photomicrobial, Microbial thermistor - Application of microbial biosensors in glucose - Enzyme Biosensors - Optical Enzyme Biosensors - Piezoelectric Immunosensors - Optical Immunosensors - Glycan based Biosensors.

WEARABLE HEALTHCARE TECHNOLOGY**15**

Types of wearable sensors - Working principle and fabrication of wearable sensors - Estimation of blood parameters using fingertip photoplethysmography (PPG) - Motion Analysis Sensors - Wearable Blood Pressure (BP) Measurement: Cuffless Blood Pressure Monitor.

APPLICATIONS OF WEARABLE SYSTEMS**10**

Wearable ECG devices: Basics of ECG and its design: ECG electrodes and instrumentation - Wearable EEG devices: Principle and origin of EEG, basic measurement set-up - ECG abnormalities classification using Artificial Intelligence.

Total Hours: 45**TEXT BOOKS**

1. Michael J. McGrath, Clíodhna Ni Scanaill, Dawn Nafus, “Sensor Technologies: Healthcare, Wellness and Environmental Applications”, 1st Edition, Apress Media, 2014.
2. Subhas Mukhopadhyay, “Wearable Sensors: Applications, Design and Implementation”, 1st Edition, Iop Publishing Ltd, 2018

REFERNCES

1. Eduard Jane, “Glyconanotechnology”, 1st Edition, Jenny Stanford Publishing, 2019
2. GuozhenShen, Zhiyong Fan, “Flexible Electronics: From Materials to Devices”, 1st Edition, World Scientific Publishing Co, 2015.
3. Brian R Eggins, Chemical sensors and Biosensors, 1st Edition, John Wiley sons Ltd, 2010.

WEB REFERENCES

1. <https://booksc.org/book/84747467/132ee4>
2. <https://slideplayer.com/slide/4502377/>
3. <https://archive.nptel.ac.in/courses/115/107/115107122/>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Summarize the concepts of multi sensor data fusion.
CO2	Infer the different algorithms used for data fusion.
CO3	Interpret the Kalman filter for decision identity fusion.
CO4	Outline the concepts of advanced filtering for sensor fusion CO5Extent the filtering concepts for sensor fusion applications

MULTISENSOR DATA FUSION**20**

Sensors and sensor data-Use of multiple sensors-Fusion applications-The inference hierarchy: Output data-Data fusion model-Architectural concepts and issues-Benefits of data fusion-Mathematical tools used-Algorithms, coordinate transformations,-Rigid body motion-Dependability and Markov chains-Meta – heuristics- Taxonomy of algorithms for multisensor data fusion-Data association-Identity declaration.

ESTIMATION**12**

Kalman filtering-Practical aspects of Kalman filtering, extended Kalman filters-Decision level identify fusion-Knowledge based approaches.

ADVANCED FILTERING**13**

Data information filter-Extended information filter-Decentralized and scalable decentralized estimation-Sensor fusion and approximate agreement-Optimal sensor fusion using range trees recursively-Distributed dynamic sensor fusion.

Total Hours: 45**TEXT BOOKS**

1. Robert F.Coughlin, Fredrick F.Driscoll, “Operational Amplifier and Linear Integrated Circuits”, 6th Edition, Pearson Education, 2016.
2. Roy Choudhary.D, Sheil B.Jani, “Linear Integrated Circuits”, 4th Edition, New Age Publications, 2010.

REFERENCES

1. David L.Hall, Mathematical techniques in Multisensor Data fusion, Artech House, Boston, 1992.
2. R.R. Brooks and S.S. Iyengar, Multisensor Fusion: Fundamentals and Applications with Software, Prentice Hall Inc., New Jersey, 1998.
3. Arthur Gelb, Applied Optimal Estimation, The M.I.T. Press, 1982.

WEB REFERENCES

1. <https://www.coursera.org/lecture/state-estimation-localization-self-driving-cars/>
2. <https://www.youtube.com/watch?v=TI3Qt36pBuQ>
3. <https://www.youtube.com/watch?v=ndR2Uzy-An0>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Classify the concepts of data mining and functionalities
CO2	Infer the rules involved in data mining classification
CO3	Explain the concepts of big data analytics
CO4	Summarize the various principles of data science for business models CO5Relate the data science tools to carry out visualization techniques and analytics

DATAMINING**9**

Kinds of Data: Database data, data warehouses, transactional data - .Data Mining Functionalities - Classification of data mining system - Data mining techniques - Major issues in data mining - Architectures of Data mining system.

ASSOCIATION AND CLASSIFICATION**12**

Mining association rules in large databases .association rule mining - Mining single dimensional boolean association rules from transactional databases - Mining multidimensional association rules from relational databases and data warehouses - Classification and prediction - Introduction classification by decision tree induction - Bayesian classification

BIG DATA AND DATA SCIENCE**12**

Introduction to big data - Big data analytics application - Data science hype - Getting past the Hype - Datafication - Current landscape - Role of social scientist in Data science - Data Science jobs - Data science profile - Reading and Writing data files using R - Statistical inference - Exploratory data analysis and data science process.

TECHNOLOGIES AND TOOLS FOR DATA SCIENCE**12**

Data visualization techniques using R tool: Histograms box plots - Scatter plots - Time series - Spatial data - Spark - Introduction to Exploratory data mining - Association rule mining - Clustering and classification techniques using WEKA tool.

Total Hours: 45**TEXT BOOKS**

1. Jure Leskovec, Anand Rajaraman, Jeffrey David Ullman, "Mining of Massive Datasets", Cambridge University Press, Second Edition, 2014.
2. Jiawei Han, Micheline Kamber, Jian Pei, "Data Mining Concepts and Techniques", Morgan Kaufman Publications, Third Edition, 2011.

REFERENCES

1. Ian H.Witten, Eibe Frank "Data Mining – Practical Machine Learning Tools and Techniques", Morgan Kaufman Publications, 3rd Edition, 2011.
2. Roger D.Peng, "R Programming for Data Science", Learn Pubulishers, 2015.
3. Time White, "Hadoop: The Definitive Guide", 4th Edition, OReilly Media, 2015.

WEB REFERENCES

1. <https://www.digimat.in/nptel/courses/video/106105174/L01.html>
2. <https://archive.nptel.ac.in/courses/106/105/106105174/>
3. <https://nptel.ac.in/courses/106104189>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Infer the characteristics of a random process with necessary parameters.
CO2:	Outline the functions of special types of random processes.
CO3:	Utilize the parametric and non-parametric methods for power spectrum estimation.
CO4:	Choose the optimum filters for signal processing applications
CO5:	Explain the architecture and operation of digital signal processors.

DISCRETE-TIME RANDOM PROCESSES**12**

Random variables - ensemble averages a review, random processes - ensemble averages, autocorrelation and autocovariance matrices, ergodic random process, white noise, filtering random processes, spectral factorization, special types of random processes - AR, MA, ARMA.

SPECTRUM ESTIMATION**12**

Bias and consistency, Non-parametric methods - Periodogram, modified-Periodogram - performance analysis. Bartlett's method, Welch's method, Blackman-Tukey method. Performance comparison. Parametric methods - autoregressive (AR) spectrum estimation - autocorrelation method, Prony's method, solution using Levinson Durbin recursion.

OPTIMUM FILTERS**12**

Wiener filters - FIR Wiener filter - discrete Wiener Hopf equation, Applications - filtering, linear prediction. IIR Wiener filter - causal and non-causal filters. Recursive estimators - discrete Kalman filter.

ARCHITECTURE OF COMMERCIAL DIGITAL SIGNAL PROCESSORS**9**

Introduction, categorization of DSP Processors-one case example Architecture Processor for Fixed Point (Blackfin), Floating Point & Speech Processor- Basics of Architecture - study of functional variations of Computational building blocks (with comparison onto their MAC, Bus Architecture, I/O interface, application).

Total Hours: 45**TEXT BOOKS**

1. John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing", Pearson Education, 4th edition, 2014.
2. Manson H. Hayes, "Statistical Digital signal processing and Modelling", John Wiley & Sons, 1997.

REFERNCES

1. Raghuvver M. Rao and Ajit S. Bapardikar, "Wavelet transforms- Introduction to theory and applications", Pearson Education, 3rd Edition, 2000.
 2. K.P. Soman and K.L. Ramchandran, "Insight into WAVELETS from theory to practice", Eastern Economy Edition, 4th Edition, , 2008
- B Venkataramani and M Bhaskar "Digital Signal Processors", 2nd Edition, Tata McGraw Hill Publications, 2010

WEB REFERENCES

1. https://onlinecourses.nptel.ac.in/noc21_ee20/preview
2. <https://nptel.ac.in/courses/117101123>
3. https://onlinecourses.nptel.ac.in/noc22_ee32/preview

**M.E. EMBEDDED SYSTEM TECHNOLOGIES
CURRICULUM AND SYLLABI**

M.E. EMBEDDED SYSTEM TECHNOLOGIES

VISION AND MISSION OF THE INSTITUTION

VISION

- To develop into a leading world class Technological University consisting of Schools of Excellence in various disciplines; with a co-existent Centre for Engineering Solutions Development for worldwide clientele.

MISSION

- To provide all necessary inputs to the students for them to grow into knowledge engineers and scientists attaining.
- Excellence in domain knowledge, practice and theory
- Excellence in co-curricular and Extra-curricular talents
- Excellence in character and personality

VISION AND MISSION OF THE DEPARTMENT

VISION

- To excel in education and research in the field of embedded systems, to train students to meet the needs of global industry and to develop them into skilful engineers imbued with human values.

MISSION

- To offer a conducive teaching-learning process that equips the students with adequate knowledge in embedded Engineering and allied disciplines for a successful career.
- To prepare engineers to take up innovative research leading to multidisciplinary projects that provides solutions to the industry and society.
- To foster and instill attitudes, values and vision to the students that will prepare them for lifetimes of continued learning and leadership in their chosen careers.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

After few years of graduation, the M.E., Embedded System Technologies graduates will possess

- **PEO I:** In-depth knowledge and expertise in various domains of embedded engineering, which are required for a successful career in industry/ academia and research.
- **PEO II :** Problem solving ability to undertake significant research or development projects so as to address social, technical and industrial challenges.
- **PEO III :** Professional skills, independent and lifelong learning, the ability to function well on a team, an appreciation for ethical behavior for professional and personal growth.

M.E – EMBEDDED SYSTEM TECHNOLOGIES
CURRICULUM FROM SEMESTER WISE

S. No.	Course Code	Course Title	L	T	P	C	Category	CA	ES	Total
SEMESTER I										
THEORY										
1	22MA1001	Advanced Applied Mathematics	3	1	0	4	FC	40	60	100
2	22ES1001	Embedded Controllers and Applications	3	1	0	4	PC	40	60	100
3	22ES1002	Software for Embedded Systems	3	0	0	3	PC	40	60	100
4	22ES1003	Embedded Computing	3	1	0	4	PC	40	60	100
5	22ES1004	Real-Time Systems	3	0	0	3	PC	40	60	100
6	22ME1A004	Research Methodology and IPR	3	0	0	3	EEC	40	60	100
PRACTICAL										
7	22ES1005	Embedded System Laboratory - I	0	0	2	1	PC	60	40	100
Total Credits						22				
SEMESTER II										
THEORY										
S. No.	Course Code	Course Title	L	T	P	C	Category	CA	ES	Total
1	22ES1006	Computer Architecture and Parallel Processing	3	1	0	4	PC	40	60	100
2	22ES1007	Embedded System Networks	3	0	0	3	PC	40	60	100
3	22ES1008	Model based System Design	3	1	0	4	PC	40	60	100
4	22ES10XX	Professional Elective 1	3	0	0	3	PE	40	60	100
5	22ES10XX	Professional Elective 2	3	0	0	3	PE	40	60	100
6	22ES10XX	Professional Elective 3	3	0	0	3	PE	40	60	100
PRACTICAL										
7	22ES1009	Embedded System Laboratory- II	0	0	2	1	PC	60	40	100
Total Credits						21				
AUDIT COURSE										
8	22EN1001	English for Research Paper Writing	AC - GRADE ONLY							
SEMESTER III										
THEORY										
S. No.	Course Code	Course Title	L	T	P	C	Category	CA	ES	Total
1	22ES10XX	Professional Elective 4	3	0	0	3	PE	40	60	100
2	22ES10XX	Professional Elective 5	3	0	0	3	PE	40	60	100

**M.E – EMBEDDED SYSTEM TECHNOLOGIES
CURRICULUM FROM SEMESTER WISE**

S. No.	Course Code	Course Title	L	T	P	C	Category	CA	ES	Total
1	22ES10XX	Professional Elective 4	3	0	0	3	PE	40	60	100
2	22ES10XX	Professional Elective 5	3	0	0	3	PE	40	60	100
3	22ES10XX	Professional Elective 6	3	0	0	3	PE	40	60	100
PROJECT WORK										
4	22ES1010	Dissertation - I / Industrial Project - I	0	0	0	6	EEC	60	40	100
Total Credits						15				
SEMESTER IV										
PROJECT WORK										
1	22ES1011	Project Dissertation - II / Industrial Project - II	0	0	0	12	EEC	60	40	100
Total Credits						12				

Total Credits to be earned for the Award of Degree: 70

* Audit Course not considered for CGPA Calculation

* Audit Course -Mandatory

S. No.	Course Code	Course Title	L	T	P	C	Category	CA	ES	Total
1	22ES1E01	Machine learning and applications	3	0	0	3	PE	40	60	100
2	22ES1E02	Cyber Physical systems	3	0	0	3	PE	40	60	100
3	22ES1E03	Automotive embedded system	3	0	0	3	PE	40	60	100
4	22ES1E04	Graphical programming for real-time applications	3	0	0	3	PE	40	60	100
5	22ES1E05	Embedded Linux	3	0	0	3	PE	40	60	100
6	22ES1E06	Mobile application development using android	3	0	0	3	PE	40	60	100
7	22ES1E07	Internet of Things	3	0	0	3	PE	40	60	100
8	22ES1E08	Embedded System Design	3	0	0	3	PE	40	60	100
9	22ES1E09	Quantum Computation & Quantum Information	3	0	0	3	PE	40	60	100
10	22ES1E10	Cryptography and Network Security	3	0	0	3	PE	40	60	100

SEMESTER - I

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Use the concept of matrix theory to decompose matrices
CO2:	Apply the method of calculus of variation to extremize the functional
CO3:	Apply graph model and algorithm for solving network problems.
CO4:	Apply simplex method for solving linear programming problems and optimize transportation and assignment problems.
CO5:	Solve nonlinear functions subjected to linear and nonlinear constraints using optimization technique.

MATRIX THEORY**9+3**

Matrix Decomposition: QR factorization - Least square approximations - Pseudo inverse - Singular value decomposition - Toeplitz matrices.

CALCULUS OF VARIATIONS**9+3**

Variation and its properties – Euler's equation – Functional dependent on first and higher order derivatives – Functional dependent on functions of several independent variables.

DIRECTED GRAPHS, GRAPH THEORETIC ALGORITHMS**9+3**

Digraphs – types of digraphs – directed paths and connectedness – Euler graphs – adjacency matrix of a digraph – tournament. Algorithms - connectedness and components – spanning tree – fundamental circuits – cut vertices – directed circuits – shortest path algorithm.

LINEAR PROGRAMMING**9+3**

Formulation -Graphical solution - Simplex method – Big M method - Two phase method - Transportation and Assignment models.

OPTIMIZATION TECHNIQUES**9+3**

Classical Optimization - Unconstrained problem of Maxima and Minima - Constrained problem of Maxima and Minima - Lagrangian method - Kuhn Tucker conditions.

TOTAL: 45+15:60 PERIODS**TEXT BOOKS:**

1. Bronson. R, "Matrix Operation, Schaum's outline series", Second Edition, McGraw-Hill, 2011.
2. Elsgolc. L.D., "Calculus of Variations" Dover Publications, New York, 2007.
3. NarasingDeo, "Graph theory: with application to Engineering and Computer Science", Prentice Hall India 2017.
4. Taha H.A, "Operations Research: An introduction" Tenth Edition, Pearson Education, New Delhi, 2019.

REFERENCES:

1. Andrews,L.C. and Philips.R.L, "Mathematical Techniques for Engineers and Scientists", Prentice Hall of India, New Delhi, 2005.
2. West, D.B, "Introduction to Graph Theory", Pearson Education, New Delhi, 2019.
3. Kombo, N.S, "Mathematical Programming Techniques", East-West Press, New Delhi, 2012.

WEB REFERENCES

1. <https://archive.nptel.ac.in/courses/111/108/111108157/>
2. <https://archive.nptel.ac.in/courses/111/104/111104025/>
3. <https://archive.nptel.ac.in/courses/111/105/111105039/>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Explain the ARM processor architectures
CO2:	Discuss ARM and Thumb Instruction set with example embedded C programs
CO3:	Summarize ARM processor based system for various signal processing and real time applications
CO4:	Describe ARM Cortex M4 Architecture, on-chip peripherals and embedded C programming.

ARM ARCHITECTURE**15**

ARM programmer's model–Registers–Processor modes–Processor state-condition flags–ARM Pipelines–Exception vector table–ARM Processor families Typical 3 stage pipe line organization Typical 5 stage pipeline organization–LPC210X ARM processor features

ARM PROGRAMMING**15**

ARM instruction set–Thumb instruction set–ARM development tools–ARM 'C' compiler programming.

ARM APPLICATION DEVELOPMENT**15**

Introduction to DSP on ARM9 processor –FIR filter – IIR filter – Discrete Fourier transform – Exception handling – Interrupts – Interrupt handling schemes- Firmware and boot loader – Example: Sandstone – User peripheral devices

ARM CORTEX M4 ARCHITECTURE**15**

Architectural Overview – Cortex-M4F Processor – Internal Memory – General Purpose Input/Outputs –General Purpose Timers – Analog to Digital Converter – Universal Asynchronous Receivers/Transmitters –Synchronous Serial Interface-Inter-Integrated Circuit(I2C) Interface–C Language Programming in ARM Cortex M4

Total Periods: 60**TEXTBOOKS**

1. Andrew Sloss, “ARM System Developer's Guide: Designing and Optimizing System Software”, Morgan Kaufmann, 1st Edition, 2005.
2. Steve Furber, “ARM System-on-Chip Architecture”, Addison-Wesley Professional; 2nd Edition, 2000.
3. Dr.Mark Fisher. “ARM Cortex M4 Cook book”, Packt Publishing Ltd, 1st Edition, 2016

REFERENCE BOOKS

1. Trevor Martin, “The Insider's Guide to The Philips ARM 7-Based Microcontrollers, An Engineer's Introduction to the LPC2100 Series' Hitex (UK) Ltd., 2nd Edition, 2006.
2. Muhammad Ali Mazidi, Shujen Chen, “TI Tiva ARM Programming For Embedded Systems: Programming ARM Cortex-M4TM4C123G with C” Micro Digital Ed; First Edition, 2017
3. Dananjay V.Gadre, “Programming and Customizing the AVR microcontroller”, McGraw Hill, 1st Edition, 2001. LPC210x ARM Processor Datasheet, Philips Electronics, 2004

WEB REFERENCES

1. <http://www.ti.com/lit/ds/spms376e/spms376e.pdf>
2. www.arm.com
3. www.nxp.com

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Describe the software build process of embedded programs and its related concepts.
CO2:	Explain the programming concepts related to C and Assembly.
CO3:	Summarize CERT, MISRA coding standards and explain the basics of Autosar.
CO4:	Develop embedded programs using Python programming.

PROGRAMMING EMBEDDED SYSTEMS AND DESIGN PROCESS**12**

Embedded Program – Role of Infinite loop – Compiling, Linking and locating – downloading and debugging –Emulators and simulators - processor–External peripherals – Types of memory–Memory testing–Flash Memory.

C AND ASSEMBLY PROGRAMMING**12**

Programming in assembly – Register usage conventions – Typical use of addressing options – Instruction sequencing – Procedure call and return – Parameter passing – Retrieving parameters –Temporary variables-I/O programming -Polled waiting loop and Interrupt driven I/O.

INTRODUCTION TO CODING STANDARDS and AUTOSAR**12**

Guidelines for the use of the C language in critical systems based on secure coding standards MISRA and CERT- Introduction to AUTOSAR- Layer model, Methods, Interfaces - Basic Software Module (BSM) of AUTOSAR – Functional Safety: Automotive Safety Integrity Levels (ASIL), Safety End to End (E2E) communication protection in module– Introduction to K-SAR Editor Tool chain: Layer model, workflow, Features and Terms used in K-SAR editor tool chain.

PYTHON PROGRAMMING**09**

Basics of Python Programming Syntax and Style –Python Objects –Dictionaries –Comparison with C programming on Conditionals and Loops- Files – Input and Output – Errors and Exceptions – Functions –Modules–Classes and OOP–Execution Environment

Total Periods =45**TEXTBOOKS**

1. Daniel Lewis, “Fundamentals of Embedded Software Where C and Assembly Meet”, Prentice Hall, 1st Edition, 2012.
2. Michael Barr, “Programming Embedded Systems in C and C++”, Oreilly, 2003
3. Wesley J.Chun, “Core Python Programming”, Prentice Hall PTR, First Edition, 2000

REFERENCEBOOKS

1. David. E Simon “An Embedded Software Primer”, Pearson Education, 2007.
2. MISRA C, “Guidelines for the use of the C language in critical systems”, MIRA Limited, Warwickshire, UK, 2004.
3. Robert C. Seacord “The CERT C Coding Standard, The 98 Rules for Developing Safe, Reliable, and Secure Systems”, 2nd Edition , Addison–Wesley Professional, 2014.

WEB REFERENCES

1. https://moam.info/kpit-autosar-handbook_597bb36e1723ddb08ee5fdf3.html
2. https://www.autosar.org/fileadmin/ABOUT/AUTOSAR_EXP_Introduction.pdf

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Discuss the basic hardware organization of Embedded System
CO2:	Interpret the functionality of the Operating Systems and its device driver models.
CO3:	Elaborate on embedded Linux kernel development and discuss the software development tools GNU, GDB along with profiling tools
CO4:	Describe the fundamentals of networking and debugging in embedded Linux

INTRODUCTION TO EMBEDDED COMPUTING**15**

Basic Execution Environment – Application Binary Interface, Processor Instruction Classes, Exceptions/ Interrupt Model, Vector Table, Exception Frame, Masking Interrupts, Interrupt Latency, Memory Mapping and Protection, MMU, Memory Hierarchy, Embedded Platform Boot Sequence, Early Initialization, AP Processor Initialization, Advanced Initialization, Legacy BIOS and UEFI Framework Software.

OPERATING SYSTEM AND DRIVERS**15**

Operating System Overview, Application Interface, Processes, Tasks, Threads, Scheduling, Memory Allocation, Mutual Exclusion/Synchronization, Device Driver Models, Bus Drivers, Networking, Storage File Systems, Embedded Linux, Tool Chain, Building a Kernel, Debugging, Driver Development, Memory Management

PROGRAMMING AND DEVELOPMENT TOOLS**15**

Kernel Build System, Kernel development and Initialization, Introduction to software development tools GNU, GDB, Bin utilities, C scope Tracing and code profiling tools.

NETWORKING AND KERNEL DEBUGGING**15**

Networking basics, sockets, ports, UDP, TCP/IP, client server model, socket programming, Wi-Fi, 802.11, Bluetooth Kernel Debugging Techniques, Debugging Embedded Linux Applications, Open Source Build Systems, Universal Serial Bus

Total Periods (45+15T) : 60**TEXTBOOKS**

1. Peter Barry and Patrick Crowley, “Modern Embedded Computing”, Morgan Kaufmann, 1st Edition, 2012.
2. Michael K. Johnson and Erik W. Troan, “Linux Application Development”, Addison– Wesley professional, 2nd Edition, 2004.
3. Christopher Hallinan, “Embedded Linux Primer”, Pearson, 2nd Edition, 2012.

REFERENCEBOOKS

1. KipR.Irvine, “Assembly Language for x86 Processors”, Prentice–Hall, 6th Edition, 2010.
2. Richard Stevens W., “UNIX Network Programming”, Prentice–Hall, 1st Edition, 1990.
3. Abraham Silberschatz, Peter B. Galvin and Greg Gagne, “Operating System Concepts”, John-Wiley, 8th Edition, 2008.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Discuss the basic concepts of real-time systems, various scheduling algorithms for solving problems in real-time systems.
CO2:	Elaborate the communication tools required for real-time systems.
CO3:	Describe Real-Time kernel objects
CO4:	Explain the features of μ C/OS real time Operating System

REAL-TIME SYSTEMS AND ALGORITHMS**12**

Issues in Real-Time Computing-Structure of a Real-Time System-Task classes-Performance Measures for Real-Time Systems- Estimating Program Run Times. Task Assignment and Scheduling – Classical Uni processor scheduling algorithms- Uniprocessor scheduling of IRIS tasks- Task assignment- Mode changes- and Fault Tolerant Scheduling.

REAL-TIME COMMUNICATION**9**

Communications media- Network Topologies Protocols- Fault Tolerant Routing. Fault Tolerance Techniques–Fault Types-Fault Detection. Fault Error containment Redundancy-Data Diversity-Reversal Checks-Integrated Failure handling

REAL-TIME KERNEL CONCEPT**9**

Foreground/Background Systems — Context Switching – Non-Preemptive Kernel, Preemptive Kernel – Scheduler- Scheduling Reentrancy – Priority Inversion – Priority Inheritance – Mutual Exclusion – Semaphores– Deadlock Synchronization – Event Flags – Inter Task Communications – Message Mailboxes – Message Queues Interrupts- Clock Tick –Memory Requirements–RTOS Applications

 μ C/OS REAL-TIME KERNEL**15**

μ C/OS Features –Task Management – Time Management – Semaphore Management – Message Mailboxes And Message Queues Management–Memory Management–Porting μ C/OS.

Total Periods: 45**TEXTBOOKS**

1. Jane W.S.Liu, “Real-Time Systems”, Pearson Education, 2nd Edition, 2010.
2. C.M.Krishna, Kang G.Shin, “Real-Time Systems”, McGraw Hill International Editions, 1997.
3. Philip.A.Laplante, “Real-Time System Design and Analysis an Engineer's handbook”, 3rd Edition, Wiley-IEEE Press April 2004

REFERENCE BOOKS

1. R.J.A Buhur, D.L Bailey, “An Introduction to Real-Time Systems”, Prentice-Hall International, 1999.
2. S.T.Allworth and R.N.Zobel, “Introduction to real-time software design”, Macmillan, 2nd Edition, 1987
3. Peter D.Lawrence, “Real-Time Micro Computer System Design–An Introduction”, McGraw Hill, 1988.
4. Stuart Bennett, “Real-Time Computer Control–An Introduction”, Prentice Hall of India, 1998.

WEB REFERENCES

1. <https://doc.micrium.com/display/osiidoc/Real-Time+Systems+Concepts>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Identify there search problem and state its scope and objectives
CO2:	Prepare a report and research proposal after conducting literature survey considering plagiarism and research ethics.
CO3:	Outline the types of intellectual property rights
CO4:	Administer patent systems and new developments in IPR.

APPROACHES IN RESEARCH**15**

Meaning of research problem, Sources of research problem, criteria characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations. Effective literature studies approaches, analysis. Plagiarism, Research ethics, Effective technical writing , how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

NATURE OF INTELLECTUAL PROPERTY**15**

Patents, Designs, Trade and Copyright. Process of Patenting and development Technical research, innovation, patenting, development. International scenario: International cooperation on intellectual property. Procedure for grants of patents, Patenting under PCT.

PATENT RIGHTS AND DEVELOPMENTS IN IPR**15**

Scope of patent rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. Administration of patent System. New developments in IPR; IPR of biological Systems, Computer software etc., Traditional knowledge case studies, IPR and IITs.

Total Periods: 45**TEXT BOOKS**

1. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 2016
2. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008.
3. Halbert, “Resisting Intellectual Property,” Taylor and Francis Ltd, 2007.

REFERENCE BOOKS

1. Stuart Melville and Wayne Goddaed, “ Research methodology : An introduction for science and engineering students “
2. Wayne Goddard and Stuart Melville, “Research methodology : An introduction”
3. Ranjit Kumar, 2nd edition, ” Research Methodology : A Step by Step Guide for beginners “
4. Halbert, “Resisting Intellectual Property,” Taylor and Francis Ltd, 2007.
5. Mayall, “Industrial Design “, McGraw Hill, 1992.
6. Niebel, “Product Design”, McGraw Hill, 1974.
7. Asimov, “Introduction to Design “, Prentice Hall, 1962.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Develop real time interfacing programs for ARM controller using KEIL IDE.
CO2:	Implement the Real Time Operating System concepts.
CO3:	Develop real time interfacing programs using MSP430 Kits
CO4:	Develop real time interfacing programs for ARM Cortex –M4
CO5:	Develop IoT applications using TI CC3200 Launch pad

LIST OF EXPERIMENTS

1. Programming with ARM7 Processor (LPC2148) using KEIL IDE
 - GPIO Programming
 - ADC/DAC Programming
 - PWM Programming
 - TIMER Programming
 - WDT Programming
2. Programming with Real Time Operating System using Micrium OS
 - Time Management
 - Task Management
3. Programming with MSP430 kits
 - GPIO Programming
 - ADC/DAC Programming
 - PWM Programming
 - TIMER Programming
4. Programming with ARM Cortex-M4 (TM4C123G)
 - GPIO Programming
 - ADC/DAC Programming
 - PWM Programming
 - TIMER Programming
5. Development of IoT Applications for TI CC3200 Launch pads using CCS IDE.
 - Healthcare Applications
 - Automotive Applications

Total Hours: 30

TOOLS

1. KEIL IDE
2. ARM boards and Interface kits (LPC2148)
3. CC3200 Kit
4. MSP430 Kits
5. ARM Cortex M4 (TM4C123G)

SEMESTER - II

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Interpret the basic operations involved in execution of an instruction , control unit design and pipelining concepts
CO2:	Summarize the several types of memory, performance and the communication process with input and output devices in computer.
CO3:	Describe the concept of parallel and vector processing.
CO4:	Explain the concept of Array and Multiprocessors systems

PROCESSING AND PIPELINING 14

Fundamental concepts – Execution of a complete instruction – Multiple bus organization – Hardwired control – Micro programmed control. Pipelining – Basic concepts – Data hazards – Instruction hazards – Influence on instruction sets – Data path and control considerations – Superscalar operations – Performance considerations

MEMORY SYSTEM AND I/O ORGANIZATION 14

Semiconductor Memories – Speed, Size and cost , Cache memories – Mapping functions, Replacement Algorithms, Memory Interleaving- Virtual memory. Accessing I/O devices – Programmed Input/output – Interrupts – Direct Memory Access

PARALLEL AND VECTOR PROCESSING 14

Basic uniprocessor architecture – Parallel processing mechanisms – Levels of parallelism – Balancing of subsystem bandwidth – Parallel computer structures – Architectural classifications – Parallel processing applications - Vector processing: requirements and characteristics – High performance Architectures: Superscalar Architecture – VLIW Architecture.

ARRAY PROCESSING AND MULTI-PROCESSOR ARCHITECTURE 18

SIMD array processors– SIMD Computer Organizations-Masking and data routing mechanisms – SIMD Interconnection networks – Multiprocessor Architecture - Functional structures: Loosely and Tightly coupled Multiprocessors– Processor characteristics for multiprocessing– Interconnection Networks for multiprocessors: Time shared or Common buses-Crossbar switch and multiport memories-Multistage networks for Multiprocessor – Parallel Memory Organizations – Interleaved Memory Organization – Cache coherence – Classification of Multiprocessor operating systems.

Total Periods: 60

TEXTBOOKS

1. Carl Hamacher, Zvonko Vranesic and Safwat Zaky, “Computer Organization”, 5th Edition, Tata McGraw Hill, 5th Edition, 2014.
2. Kai Hwang and Faye A Briggs., “Computer Architecture and Parallel Processing”, McGraw Hill Book Company, 2016.

REFERENCE BOOKS

1. Stallings W. “Computer Organization and Architecture – Designing for performance”, Pearson Publishers, 9th Edition, 2014.
2. John Hennessy and David Patterson, “Computer Architecture: A Quantitative approach”, Elsevier India Publishers, 5th Edition, 2017.
3. Mano, M.M., “Computer System Architecture”, Pearson Publishers, 3rd Edition, 2013

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Elaborate parallel and serial communication bus protocols
CO2:	Explain the network components and protocols of Embedded Ethernet for Internet communication
CO3:	Discuss features of USB and CAN protocols and its applications using PIC micro controllers
CO4:	Elaborate various wired and wireless communication protocols for automobile networks

EMBEDDED COMMUNICATION PROTOCOLS**9**

Embedded Networking: Introduction – Serial/Parallel Communication – Serial Communication Protocols – RS232 Standard – RS 485 – Synchronous Serial Protocols –Serial Peripheral Interface (SPI) – Inter Integrated Circuits (I2C)–PC Parallel Port Programming–ISA/PCI Bus Protocols.

EMBEDDED ETHERNET**11**

Elements of a network – Inside Ethernet – Building a network: Hardware options – Cables, connections and network speed – Design choices: Selecting components– Rabbit semiconductor RCM3200-Dallas semiconductor DSTINIm400–Ethernet controllers-ASIXAX88796-Realtek RTL8019AS-Using the internet in local and internet communications: Connecting to the Internet-Exchanging messages using UDP and TCP: Basic Communications.

USB AND CAN BUS**11**

USB bus – Introduction – Speed Identification on the bus – USB States – USB bus Communication: Packets –Dataflow types–Enumeration–Descriptors–PIC18 Microcontroller USB Interface–C Programs– CAN Bus– Introduction – Frames – Bit Stuffing – Types of Errors -Nominal Bit Timing – PIC Microcontroller CAN Interface–A Simple Application with CAN.

INDUSTRIAL NETWORKING PROTOCOL AND RF COMMUNICATION**14**

LIN–Local interconnect network-Basic concept of the LIN2.0 protocol-Fail-safe SBC–Gateways-Safe-by- Wire Plus - Audio-Video buses -D2B (Domestic digital) bus –MOST(Media oriented systems transport) bus - IEEE 1394 bus or 'FireWire'- Profi bus- Radio-Frequency communication- Internal and external – Remote control of opening parts- PKE(passive keyless entry) and passive go- TPMS(Tyre Pressure Monitoring Systems) - Wireless networks- GSM-Bluetooth- IEEE 802.11x - NFC (Near-Field Communication).

Total Periods: 45**TEXTBOOKS**

1. Jan Axelson, “Embedded Ethernet and Internet Complete”, Beijing Aeronautics and Astronautics press, 1991.ISBN:978-7810776301.
2. Dogan Ibrahim, “Advanced PIC microcontroller projects in C-From USB to RTOS with the PIC18F Series”,Newnes,Elsevier,2008
3. Dominique Paret and Roderick Riesco MA, “Multiplexed Networks for Embedded Systems-CAN, LIN, Flexray, Safe-by-Wire” JohnWiley & Sons, 1st Edition, 2007

REFERENCEBOOKS

1. FrankVahid, Givargis 'Embedded Systems Design: A Unified Hardware/Software Introduction', Wiley Publications, 2001.
- 2.. J Axelson, Parallel Port Complete: Programming, Interfacing & Using the PC's Parallel Printer Port, Lakeview Research, 1996

WEBREFERENCES

1. <http://www.bosch-semiconductors.com/ip-modules/can-ip-modules/>
2. <https://www.elprocus.com/controller-area-network-can/>
3. <https://www.can-cia.org/can-knowledge/>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the basics of model-based design, MBS methodologies and system modeling language
CO2:	Develop model based system design techniques for hybrid vehicle
CO3:	Develop CAN communication protocols using Model Based System Design (MBSD) techniques
CO3:	Construct controller and testing methods for the given application using MBSD.

MODEL BASED SYSTEM ENGINEERING**15**

Model Based Systems (MBS) engineering-Systems engineering and the life cycle-Systems engineering process overview - Model Based Definition (MBD) - MBS engineering methodologies - Systems modeling Language - MBS Engineering (MBSE) application strategies - Modeling language: Unified Modeling Language (UML), syntax, modelling system logical structure using UML

MODEL BASED DESIGN FOR HYBRID ELECTRIC VEHICLE**15**

Overview of Electric Vehicle Architecture Design and Analysis- Mathematical model: Transfer function- Closed loop control model: PID controller- System level modeling of an HEV: Vehicle Dynamics, Engine, Synchronous Motor/Generator, Power-Splitter, Power Management, Mode Logic - Model Elaboration

MODEL BASED DESIGN FOR COMMUNICATION**15**

CAN basics- CAN using Vehicle Networking Toolbox (VNT): Toolbox Characteristics and Capabilities, Vehicle Network Communication in MATLAB: Transmit and receive CAN Messages, Filter message, Multiplex Signals- Vehicle Network communication in Simulink using CAN- Build CAN communication Simulink model

CONTROL AND TESTING METHODS**15**

Controller on target-Plant on target- Processor in the Loop real-time simulations (PIL)-Model In Loop test (MIL) - Code verification using Software In Loop (SIL) test - Hardware In loop Test (HIL) - HIL implementation using Raspberry: coupled tanks model, quarter car model-FPGA based Hardware in Loop simulation (HIL) for Power Electronics.

Total: 60 Hours**TEXT BOOKS**

1. Roger Aarenstrup, "Managing Model-Based Design", 1st Platform, 2015 Edition, Create Space Independent Publishing
2. Jose L. Fernandez, "Practical Model-Based Systems Engineering", 1st Edition, Artech House, 2019.
3. Bernhard Rumpe, "Modeling with UML Language, Concepts, Methods", 2nd Publishing, 2018.

REFERENCE BOOKS

1. A.Wayne Wymore, "Model-Based Systems Engineering", 1st Edition, CRC Press, 2018
2. David A. Long, Zane Scott, "A Primer for Model-based Systems Engineering", 1st Edition, Vitech Company, 2011
3. Patrice Micouin, "Model Based Systems Engineering: Fundamentals and Methods", 1st Edition, Wiley, 2014

WEB REFERENCES

1. <https://nptel.ac.in/courses/106/105/106105193/>
2. <https://www.ti.com/seclit/ml/ssqu017/ssqu017.pdf>
3. <https://dzone.com/articles/iot-enabled-embedded-web-server-reference-example>
4. https://in.mathworks.com/videos/electric-vehicle-architecture-design-and-analysis-1637770846329.html?s_tid=srchtitle_electric%20vehicle_10
5. <https://in.mathworks.com/products/vehicle-network.html>
6. https://in.mathworks.com/help/vnt/index.html?s_tid=CRUX_lftnav
7. <https://in.mathworks.com/videos/fpga-based-hardware-in-the-loop-hil-simulation-for-power-electronics-1561644009561.html>
8. <https://in.mathworks.com/help/ecoder/software-in-the-loop-sil-simulation.html>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Develop programs for ARM Microcontroller in Embedded Linux
CO2:	Design programs for interfacing peripheral devices with Intel ATOM processor
CO3:	Develop embedded programs for signal processing applications
CO4:	Develop Applications using AI with STM 32 Kits

LIST OF EXPERIMENTS

1. Programming ARM Cortex M4 (TM4C123XL) in Embedded Linux
 - GPIO Interfacing/Sensor Interfacing
 - ADC Interfacing/DAC Interfacing
 - Wireless Communication Protocols
2. Programming and Interfacing with Intel ATOM processor
 - GPIO Interfacing
 - GPS Interfacing
3. Embedded digital signal processing based system designing using CCS C compiler.
4. Embedded AI using STM32 kits

Total: 30 Hours

TOOLS

1. ARM Cortex Kits
2. Intel Atom Boards
3. TICC3200 Kits
4. TMS320C6713 Kits
5. STM32 development board

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	To educate learners on how to format research writing.
CO2:	To assist students in writing techniques that could result in the
CO3:	development of flawless writing abilities.
CO4:	To enable students, learn the accepted style for self-scrutinising the mechanics of writing a research paper.

Module 1: Formatting Research writing

7

Margins, Text Formatting, Title, Running Head and Page Numbers, Internal Headings and Subheadings, Placement of the List of Works Cited, Tables and Illustrations- Bibliography.

Module 2: The mechanics of writing

8

Spelling, Punctuation, Italics, Names of persons, Numbers, Titles of works in the research paper, Quotation-The format of the Research paper- Documentation: Preparing the list or workers cited- Abbreviations- Citations in forms other than print.

Total Hours: 15**Text book:**

1. MLA Handbook ninth edition, The modern Language Association of America, New York 2021.

Reference Book:

1. APA Style Handbook for In-Text Citations and References : Based on APA Guidelines 7th Edition.

PROFESSIONAL ELECTIVES

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Apply probability theory in the solution of machine learning problems.
CO2:	Analyze the various linear models for Regression and Classification
CO3:	Apply various neural networks for regression and classification problems.
CO4:	Describe various applications using Machine Learning algorithms

PROBABILITY DISTRIBUTIONS**11**

Basic Definitions, Types of learning, Probability Theory, Probability Reasoning, Model Selection, Curse of Dimensionality, Decision Theory, Information Theory, Binary Variables, Multinomial Variables, Gaussian Distribution, Exponential Family, Nonparametric Methods, Belief Networks.

LINEAR MODELS FOR REGRESSION AND CLASSIFICATION**11**

Linear Basis Function Models, Bias-Variance Decomposition, Bayesian Linear Regression, Bayesian Model Comparison, Evidence Approximation, Limitations of Fixed Basis Functions, Discriminant Functions, Probabilistic Generative and Discriminative Models, Laplace Approximation, Bayesian Logistic Regression.

NEURAL NETWORKS**11**

Introduction, Reinforcement Learning, Feed-forward Network functions, Error Back propagation, Hessian Matrix, Mixture Density Networks, Bayesian Neural Networks, Convolution Neural Network, Dual Representations, Constructing Kernels, Gaussian Processes, Maximum Margin Classifiers, Relevance Vector Machines.

APPLICATIONS OF MACHINE LEARNING ALGORITHMS**12**

Content Based Image Retrieval, Machine Learning Approach for face Recognition, Computer Aided Diagnosis, Computer Vision, Speech Recognition, Text Mining, Thinking Machines, Smart Machines, Business Applications of Deep Learning, Software Reliability Prediction, Medical Imaging.

TOTAL PERIODS: 45**TEXT BOOKS**

1. Christopher M Bishop., "Pattern Recognition and Machine Learning", Springer New Delhi, 2013.
2. David Barber., "Bayesian Reasoning and Machine Learning", Cambridge University Press, New Delhi, 2014.
3. Siddhi vinayak Kulkarni., "Machine Learning Algorithms for Problem Solving in computational Applications: Intelligent Techniques" IGI Global, 2012

REFERENCE BOOKS

1. Pradeep Kumar and Arvind Tiwari., "Ubiquitous Machine Learning and Its Applications", IGI Global, 2017.
Ethem Alpaydin, "Introduction to Machine Learning", Prentice Hall of India, New Delhi, 2014.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Describe the basic concepts of model based design
CO2:	Analyze the various Sensor based Cyber Physical Systems
CO3:	Discuss the different use cases for CPS
CO4:	Explain the Security aspects of CPS

INTRODUCTION 9

Introduction – Embedded Computing – Design Methodologies – Model based design – formal methods - Computational models – Reliability – Safety – Security – Applications

DESIGN OF EMBEDDED SYSTEMS 9

Embedded processors – Multiprocessor architectures – Operating system and Middleware considerations – hardware/software co-design algorithms.

SENSOR BASED CYBER PHYSICAL SYSTEMS 9

Sensor based Cyber Physical Systems – Wireless sensor and actuator networks – wireless implanted micro systems
Mobile cyber physical systems.

CONSUMER APPLICATIONS 9

Cyber Physical System for Smart Grid Applications – Transportation – Energy Efficient Buildings – Cyber Physical Medication Systems.

SECURITY 9

Securing Cyber Physical Infrastructures – Robustness of Internet Infrastructure – Privacy in Smart Grid – Case Study: Stuxnet

TOTAL PERIODS: 45

TEXT BOOKS

1. Lee Edward, Seshia Sanjit Arun kumar, “Introduction to Embedded Systems – A Cyber Physical Systems Approach”, First Edition, 2012.
2. Marilyn Wolf, “High-Performance Embedded Computing: Applications in Cyber-Physical Systems and Mobile Computing”, Second Edition, 2014.

REFERENCE BOOKS

1. Fei Hu, “Cyber-Physical Systems: Integrated Computing and Engineering Design” CRC Press, First Edition, 2014.
3. Sanjal Das, Krishna Kant, Nan Zhang, “Handbook on Securing Cyber-Physical Critical Infrastructure”, Morgan Kaufmann, 2012.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the components of automobile embedded systems
CO2:	Outline the Automotive Infotronics and Safety embedded systems
CO3:	Describe the working of automotive networking and diagnostic systems
CO4:	Understand the AUTOSAR architecture and standards in automotive industry

INTRODUCTION TO AUTOMOTIVE SYSTEM**10**

Current trends in modern automobiles - Drive by wire Systems - Vehicle functional domains and their requirements - Components of an Automobile Electronic system and their functions: Sensors, Actuators, Control Units and Software structure of Control units.

AUTOMOTIVE INFOTRONICS AND SAFETY & SECURITY SYSTEMS**12**

Automotive Vision System - Advanced Driver Assistant Systems (ADAS) - Multimedia systems - Intelligent Automotive Systems: Navigation Systems - Adaptive Cruise Control (ACC) - Active and Passive safety - Air-bag System - Seat belt tightening system - Electronic Brake Force Distribution (EBD) - Lane Departure Warning System - Anti-theft technologies - Electronic Immobilizers - Remote Keyless entry.

AUTOMOTIVE NETWORKING AND DIAGNOSTICS**11**

Cross-system functions - Bus systems: Requirements, classification and applications - Introduction - Diagnostics Theory - On-Board Diagnostics - Off-board diagnostics - Diagnostics Link Connector - Vehicle Condition Monitoring - Diagnostic Interfaces - examples of networked vehicles.

AUTOSAR ARCHITECTURE AND STANDARDIZATION**12**

Objectives - Working Methods - AUTOSAR Architecture - AUTOSAR Standardization: BSW and RTE - Methodology and Templates - Conformance Testing - Migration to AUTOSAR ECU Demonstration of AUTOSAR-Compliant ECUs

TOTAL PERIODS: 45**TEXTBOOKS**

1. Nicolas Navet and Francoise Simonot- Lion, "Automotive Embedded Systems Handbook", CRC Press, USA, 2008.
2. Robert Bosch, "Automotive Electrics Automotive Electronics", Wiley 5th Edition, 2010.

REFERENCE BOOKS

1. Ljubo Vlacic, Michel Parent & Furnio Harshima, "Intelligent Vehicle Technologies: Theory and Applications", Butterworth-Heinemann publications, 2001.
2. Robert Bosch, "Automotive Hand Book", SAE, 5th Edition, 2000.
3. William B. Ribbens, "Understanding Automotive Electronics, An Engineering Perspective" - Eighth Edition, Butterworth-Heinemann publications, 2017

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Discuss the basics of concepts and Programming of virtual instrumentation
CO2:	Analyze and elaborate the simulation of peripheral blocks and installing and configuring hardware for data acquisition
CO3:	Explain data measurement and control, calibrating measuring instruments, tuning controllers through internet
CO4:	Summarize the design of real time applications using LabVIEW

GRAPHICAL PROGRAMMING CONCEPTS 14

Fundamental Concepts of Virtual Instrumentation and Graphical Programming- Data Flow Programming- Data Types–Modular Programming - Debugging Techniques– Customization of VI Properties-VI Documentation - Formula Nodes-Expression Nodes –Loops –Shift Registers – Feedback Nodes - Local and Global Variables – Case and Sequence Structures –Key Navigation-Dialog Boxes - Arrays and Clusters-Graphs and Charts-Mechanical Action of Boolean Switches - String and File I/O

DATA ACQUISITION AND INTERFACING STANDARDS 9

Temperature Monitoring System using PC based Data Acquisition System- Motion Control- Image Acquisition and Processing-Communication: RS232 - RS485- GPIB – System Interface Buses: USB-PXI

ADVANCED PROGRAMMING OPTIONS 9

Event Driven Programming - Diagram Disable Structures- Sound VI's- Reentrant VIs- VI server -Web publishing tool- Multithreading in LabVIEW-State Machines –Nest Case Selector- Property Nodes-Invoke Nodes- LabVIEW Interface for Arduino – Introduction to Object Oriented Programming in LabVIEW

REAL-TIME APPLICATIONS 13

Real-Time Concepts including Determinism and Jitter – Configuration of Real-Time I/O Hardware in MAX - Host & Target VI – Prioritization of Tasks – Timed Programming Structures in LabVIEW Real- Time – Sharing Data between Deterministic & Non-Deterministic Processes – Real-Time Application Deployment using myRIO Runtime Interaction with Deployed Applications – Running Web Services in myRIO

Total Periods: 45

TEXT BOOKS

1. Garry W Johnson, “LabVIEW Graphical Programming”, Tata McGraw Hill, 2001.
2. Sanjay Gupta and Joseph John, “Virtual Instrumentation Using LabVIEW”, Tata McGraw-Hill, 2008.

REFERENCE BOOKS

1. Rick Bitter, TaqiMohiuddin and Matt Nawrocki, “LabVIEW Advanced Programming Techniques”, CRC Press, 2009.
2. Cory L. Clark, “LabVIEW Digital Signal Processing and Digital Communication”, TMH edition 2005.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Describe the different attributes and architecture of Embedded Linux
CO2:	Explain various embedded storage devices and its drivers
CO3:	Discuss driver software for gadgets and real time programming and porting for stand-alone embedded systems
CO4:	Elaborate the application development tools in Real-Time Linux

INTRODUCTION TO EMBEDDED LINUX**12**

Introduction – Advantages- Embedded Linux Distributions - Architecture of Embedded Linux - Linux kernel architecture - User space – Linux startup sequence -GNU cross platform Tool chain - Inclusion of BSP in kernel build procedure-The boot loader Interface–Memory Map–Interrupt Management–PCI Subsystem–Timers–UART–Power Management.

EMBEDDED STORAGE AND DRIVERS**12**

Embedded Storage – Flash Map – Memory Technology Device (MTD) –MTD Architecture - MTD Driver for NOR Flash – The Flash Mapping drivers – MTD Block and character devices – mtdutils package – Embedded File Systems – Optimizing storage space – Turning kernel memory - Linux serial driver – Ethernet driver – I2C subsystem–USB gadgets–Watchdog timer–Kernel Modules

APPLICATION PORTING AND REALTIME PROGRAMMING**9**

Application porting roadmap - Programming with Pthreads – Operating System Porting Layer (OSPL) – Kernel API Driver–Linux and Real-time–Real-time Programming in Linux–Hard Real-time Linux.

REALTIME LINUX**12**

Linux on MMU-less systems – Program Load and Execution – Memory Management – File/Memory Mapping – Process Creation – Shared Libraries – Porting Applications to uClinux – eXecute In Place (XIP) – Building uC linux Distribution.

Total Periods: 45**TEXTBOOKS**

1. P. Raghavan, Amol Lad, Sriram Neelakandan, 'Embedded Linux System Design and Development', Auerbach Publications, 2006
2. Karim Yaghmour, 'Building Embedded Linux Systems', O'Reilly Publications, 2003.

REFERENCE BOOKS

3. Matthias Kalle Dalheimer, Matt Welsh, 'Running Linux', O'Reilly Publications, 2005
4. Mark Mitchell, Jeffrey Oldham and Alex Samuel, 'Advanced Linux Programming' New Riders Publications.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Discuss the concepts, trends, advantages and disadvantages of mobile computing.
CO2:	Explain the features and development tools of Android OS
CO3:	Summarize the development of android OS
CO4:	Explain the design of android based applications.

INTRODUCTION TO MOBILE DEVELOPMENT**9**

Mobile computing-History of mobile environments – early mobile phones to smart phones and tablets, Development for mobile environments, Differences from traditional application development, Trends in mobile development

MOBILE DEVELOPMENT**9**

Introduction, Advantages, Limitations, Features useful for mobiles – Geolocation, offline web applications, offline web storage, animations, 2D/3D graphics, Audio/Video etc. , Frameworks - HTML5 , Phone Gap (Apache Cordova) framework and jQuery Mobile framework.

INTRODUCTION TO ANDROID**9**

Android Overview -Features, Architecture, Applications, Application frameworks, Libraries, Runtime, Kernel, Android Ecosystem - Application stores, publishing, Android Development Tools – Android SDK, Android emulator, Development on hardware devices

ANDROID DEVELOPMENT**18**

Writing Android Applications, Activity Lifecycle, Multi device support, Fragments, Data storage, Intents, Data sharing, Audio playback, Photo capture

Animations. OpenGL ES, Wireless connections, Data syncing, Location aware applications, Best practices for development, Security, Distribution and Monetizing

Total Periods: 45**TEXT BOOKS**

1. Ed Burnette, “ HelloAndroid : Introducing Google's Mobile Development Platform”, The Pragmatic Programmers, 3rd edition, 2010
2. Pradeep kothari, kogent learning solutions inc. “android application development (with kit kat support), black book” Wiley India, ISBN No. 9789351194095

WEB REFERENCES

1. <http://developer.android.com>
2. <http://www.html5rocks.com/en/mobile>
3. <http://mobilehtml5.org/>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the characteristics and recent trends in IoT
CO2:	Describe the protocols used in IoT
CO3:	Explain the Fundamentals and architecture of cloud computing
CO4:	Discuss on various security issues and applications in IoT

FUNDAMENTALS OF IoT**10**

Introduction to Internet of Things (IoT)–Machine to Machine (M2M)–Functional Characteristics–Recent Trends in the Adoption of IoT–Societal Benefits of IoT–Consumer IoT vs Industrial Functional Components of a typical IoT System: Sensors, Actuators, Embedded Computation Units, Communication Interfaces, Software Development

IoT PROTOCOLS**11**

Physical and Data Link Layer Protocols: RFID: NFC, FFC, ZigBEE, Bluetooth LowEnergy, Z-Wave, Wi- Fi, Wireless HART - Network Layer Protocols: IPv4, IPv6, TCP & UDP, 6LoWPAN - Application Layer Protocols: COAP, MQTT

CLOUD COMPUTING**11**

Basic Concepts And Terminology – Risks And Challenges – Cloud Characteristics – Cloud Delivery And Deployment Models – Cloud Enabling Technology – Cloud Architecture: Workload Distribution, Resource Pooling, Dynamic Scalability, Cloud Bursting - Cloud Security Mechanisms

SECURITY IN IoT**13**

IEEE802.11 Wireless Networks Attacks: Basic Types, RFID Security–Security Issues in ZigBEE: Bluetooth Security: Threats to Bluetooth Devices and Networks-IoT Applications: Health Care, Connected Vehicles, Smart Grid, Smart Home, and Smart City

TOTAL PERIODS: 45**TEXTBOOKS**

1. Olivier Hersent, David Boswarthick and Omar Elloumi, “The Internet of Things: Key Applications and Protocols”, John Wiley and Sons Ltd., UK, 2012.
2. Thomas Erl Zaigham Mahmood Ricardo Puttini , “Cloud Computing Concepts, Technology Architecture” Prentice Hall, 2013
3. Dieter Uckelmann, Mark Harrison, Florian Michahelles, “Architecting the Internet of Things”, Springer, New York, 2011.

REFERENCE BOOKS

1. Johnny Cache, Joshua Wright and Vincent Liu, “Hacking Exposed Wireless: Wireless Security Secrets and Solutions”, Tata McGraw Hill, New Delhi, 2010.
2. Adrian McEwen and Hakim Cassimally, “Designing the Internet of Things”, John Wiley and Sons Ltd, UK, 2014.
3. Vijay Madiseti, Arshdeep Bahga, “Internet of Things (A Hands-on Approach), Universities Press, 2015.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	To understand the initial steps in design process.
CO2:	To gain knowledge on components of embedded computing systems
CO3:	Summarize the design of analysis of embedded programs.
CO4:	Explain various design methodologies used in embedded system design.

EMBEDDED SYSTEM DESIGN PROCESS**10**

Introduction - Computer Systems and microprocessors- The design process - Requirements - Specification - Architecture design - Designing hardware and software components - System integration and testing – Formalisms for system design - Design example - Model Train Controller.

BUS BASED COMPUTER SYSTEMS**10**

The CPU Bus - Memory devices - I/O devices - Component interfacing - Designing with microprocessors - Development and debugging -System level performance analysis- Design example - Alarm clock.

PROGRAM DESIGN AND ANALYSIS**15**

Introduction - Components of embedded programs - Data flow graphs - Control/Data flow graphs - Assembly, linking and loading - Basic compilation techniques - Program optimization - Analysis and optimization of execution time, energy, power and program Size - Program validation and testing - Design example - Software modem.

SYSTEM DESIGN TECHNIQUES**10**

Introduction - Design methodologies - Requirements analysis - Specifications - System analysis and architecture design - Quality assurance - Design examples - Telephone answering machine - Consumer electronics - Elevator controller - Set-Top boxes.

TOTAL PERIODS: 45**TEXT BOOKS**

1. Marilyn Wolf, "Computers as Components: Principles of Embedded Computing System Design", Morgan Kaufmann Publishers, 3rd Edition, 2012.
2. Steve Heath, "Embedded System Design", Newness Publishers, 2nd Edition, 2002.

REFERENCE BOOKS

1. Steve Heath, "Embedded System Design", Newness Publishers, 2nd Edition, 2002.
2. Richard Zurawski, "Embedded Systems Handbook" CRC Press, 2nd Edition, 2009.
3. Arnold S. Berger, "Embedded Systems Design: An Introduction to Processes, Tools and Techniques", CMP Books, 1st Edition, 2001.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the fundamental concepts on quantum computing
CO2:	Explain the algorithms for performing quantum computation
CO3:	Summarize the quantum error correction codes to protect quantum computations against the effect of noise
CO4:	Explain the properties of entropy in both classical and quantum Information theory

INTRODUCTION TO QUANTUM COMPUTING 12

The postulates of quantum mechanics- States, Measurements, Operators, Super dense coding, Quantum teleportation, Quantum gates and circuits.

QUANTUM ALGORITHMS 12

Deutsch-Jozsa, Simon, Grover, Short, period-finding, factoring, Implication of Grover's and Simon's algorithms towards classical symmetric key crypto systems

QUANTUM ERROR CORRECTION 12

Theory of quantum error-correction, Constructing quantum codes, Stabilizer codes, Fault-tolerant quantum computation

QUANTUM INFORMATION THEORY 9

Shannon entropy, noiseless coding theorem, von Neumann entropy and properties, Schumacher compression, noisy-coding theorem, Data compression, Classical and quantum information over noisy quantum channels.

TOTAL HOURS: 45

TEXT BOOKS:

1. M. A. Nielsen and I. L. Chuang, Quantum Computation and Quantum Information, Cambridge University Press, 2010.
2. Eleanor G. Rieffel & Wolfgang H. Polak, "Quantum Computing A Gentle Introduction", The MIT Press Cambridge, 2011

REFERENCE BOOKS:

1. Noson S. Yanofsky, Mirco A. Mannucci, "Quantum computing for computer scientists", Cambridge University Press, 2008
2. Chris Bernhardt, "Quantum Computing for Everyone", MIT Press 2019.
3. Phillip Kaye, Raymond Laflamme, Michele Mosca, "An Introduction to Quantum Computing", Oxford University Press, 2007
4. Benenti G., Casati G. and Strini G., "Principles of Quantum Computation and Information", Vol. I: Basic Concepts, Vol II: Basic Tools and Special Topics, World Scientific

WEB REFERENCES

1. Presskil Lecture notes: Available online: <http://www.theory.caltech.edu/~preskill/ph229/>
2. <https://physics.iitm.ac.in/~prabhamd/qcqi17.html>
3. www.onlinecourses.nptel.ac.in

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the fundamental concepts on quantum computing
CO2:	Explain the algorithms for performing quantum computation
CO3:	Summarize the quantum error correction codes to protect quantum computations against the effect of noise
CO4:	Explain the properties of entropy in both classical and quantum Information theory

INTRODUCTION**11**

The OSI Security Architectures -Conventional Encryption – Classical Techniques and Modern Techniques- Modes of operation - DES, AES, Key Distribution.

PUBLIC KEY CRYPTOGRAPHY AND HASH FUNCTIONS**12**

Number Theory Concepts – Prime numbers- Modular Arithmetic – Fermat & Euler Theorem – Euclid Algorithm RSA Algorithm – Diffie Hellman Key Exchange Elliptic Curve Cryptography –Hashing techniques- SHA- HMAC – Digital Signatures- DSS, Digital Signature Algorithm.

NETWORK SECURITY AND STANDARDS**11**

Intruders and Intrusion – Viruses and Worms – OS Security – Firewalls – Design Principles – Packet Filtering – Application gateways – Trusted systems - Security Standards: IEEE, RSA and ISO standards- Blueprint for Security Design of Security Architecture.

NETWORK ISSUES**11**

Authentication Applications – Kerberos – Electronic Mail Security – PGP – IP Security – Architecture- Web Security- SSL – TLS – SET.

Total Periods: 45**TEXT BOOKS:**

1. William Stallings, “Network Security Essentials, Applications and Standards”, Dorling Kindersley I P.Ltd, Delhi, 2008.
2. William Stallings, “Cryptography and Network Security - Principles and Practice”, Pearson Education, Delhi, 2007.
3. Behrouz A Forouzan, “Cryptography and Network Security”, Tata McGraw Hill Ltd, New Delhi, 2008.

REFERENCE BOOKS:

1. Wenbo Mao, “Modern Cryptography: Theory and Practice”, Prentice Hall, New Delhi, 2003.
2. AtulKahate, “Cryptography and Network Security” Tata McGraw Hill Ltd, New Delhi, 2008.
3. David R Mirza, “Hack Proofing your Network”, Dream Tech (SYNGRESS) Publication, New Delhi, 2002.
4. Richard E. Smith, “Internet Cryptography”, Addison – Wesley, 2004.

WEB REFERENCES

1. <https://www.garykessler.net/library/crypto.html>

Department of Electrical and Electronics Engineering
M.E. – Power Electronics and Drives

Department of Electrical and Electronics Engineering

M.E. – Power Electronics and Drives

Vision

- To achieve excellence in Engineering Education, Domain Expertise and Research in the field of Power Electronics and Drives.

Mission

- To provide quality research programs with relevance to industrial and societal needs in the field of Power Electronics and Drives.
- To provide opportunities and resources for collaborative research with industry and institutions for solving the complex problems.
- To encourage research publications at national and international forums and to encourage enthusiastic participation in seminars and workshops.

Program Educational Objective (PEO)

Graduates passing out of the programme M.E. Power Electronics and Drives will be able to

1. Apply their engineering fundamentals to solve complex engineering problems and would demonstrate active participation in Research and Development activities resulting in research publications in the field of Power Electronics and Drives.
2. Familiarize with professional issues, work effectively in team and engage themselves in the related areas of their career aspirations which will lead to lifelong learning.

Program Specific Outcome (PSO)

Graduates of the Programme M.E. Power Electronics and Drives, at the time of graduation they will be able to

1. Analyze, design, simulate various power electronic converters and controllers and able to test the various range of drive schemes
2. Understand various concepts of power generation from renewable sources and analyze the schemes for extracting the maximum power including power management, energy management and Smartgrid.

Department of Electrical and Electronics Engineering
M.E. – Power Electronics and Drives

S. No.	Course Code	Course Title	L	T	P	C	Category	CA	ES	Total
SEMESTER I THEORY										
1	22MA1001	Advanced Applied Mathematics	3	1	0	4	HS	40	60	100
2	22EE1101	Analysis of Electrical Machines	3	1	0	4	PC	40	60	100
3	22EE1102	Power Semiconductor Devices	3	0	0	3	PC	40	60	100
4	22EE1103	Analysis of Power Converters	3	0	0	3	PC	40	60	100
5	22EE1104	Analysis of Inverters	3	0	0	3	PC	40	60	100
6	22EE1105	System Theory	3	0	0	3	PC	40	60	100
7	22ME1A004	Research Methodology and IPR	0	0	0	3	EEC	40	60	100
PRACTICALS										
8	22EE1151	Power Converters Laboratory	0	0	1	1	PC	60	40	100
SEMESTER II THEORY										
1	22EE1206	Analysis of DC Drives	3	0	0	3	PC	40	60	100
2	22EE1207	Analysis of AC Drives	3	0	0	3	PC	40	60	100
3	22EE1208	Embedded Control of Electric Drives	3	0	0	3	PC	40	60	100
4	22EE1EXX	Professional Elective -I	3	0	0	3	PE	40	60	100
5	22EE1EXX	Professional Elective - II	3	0	0	3	PE	40	60	100
6	22EE1EXX	Professional Elective - III	3	0	0	3	PE	40	60	100
7	22EN1001	English for Research Paper Writing	1	0	0	0	AC	AUDIT COURSE GRADE ONLY		
PRACTICALS										
8	22EE1252	Power Electronics and Drives Laboratory	0	0	1	1	PC	60	40	100
SEMESTER III THEORY										
1	22EE1EXX	Professional Elective - IV	3	0	0	3	PE	40	60	100
2	22EE1EXX	Professional Elective - V	3	0	0	3	PE	40	60	100
3	22EE1EXX	Professional Elective - VI	3	0	0	3	PE	40	60	100
PRACTICALS										
4	22EE1301	Project Dissertation-I	0	0	0	6	EEC	60	40	100
SEMESTER IV										
1	22EE1401	Project Dissertation-II	3	0	0	12	EEC	60	40	100
PROFESSIONAL ELECTIVES										
1	22EE1E01	Modern Rectifiers and Resonant Converters	3	0	0	3	PE	40	60	100
2	22EE1E02	Nonlinear Dynamics for Power Electronic Circuits	3	0	0	3	PE	40	60	100
3	22EE1E03	Control of Power Electronic Circuits	3	0	0	3	PE	40	60	100
4	22EE1E04	Power Electronics for Renewable Energy Systems	3	0	0	3	PE	40	60	100
5	22EE1E05	Wind Energy Conversion System	3	0	0	3	PE	40	60	100
6	22EE1E06	Distributed Generation Control and Automation	3	0	0	3	PE	40	60	100
7	22EE1E07	MEMS Design: Sensors and Actuators	3	0	0	3	PE	40	60	100
8	22EE1E08	Electromagnetic Field Computation and Modelling	3	0	0	3	PE	40	60	100
9	22EE1E09	Electric Vehicles and Power Management	3	0	0	3	PE	40	60	100
10	22EE1E10	Smart Grid	3	0	0	3	PE	40	60	100

Total Credits to be earned for the award of Degree: 70

SEMESTER-I

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Use the concept of matrix theory to decompose matrices.
CO2:	Apply the method of calculus of variation to extremize the functionals.
CO3:	Apply graph model and algorithm for solving network problems.
CO4:	Apply simplex method for solving linear programming problems and optimize transportation and assignment problems.
CO5:	Solve nonlinear functions subjected to linear and nonlinear constraints using optimization technique.

MATRIX THEORY**12**

Matrix Decomposition: QR factorization - Least square approximations - Pseudo inverse - Singular value decomposition - Toeplitz matrices.

CALCULUS OF VARIATIONS**12**

Variation and its properties - Euler's equation - Functional dependent on first and higher order derivatives
- Functional dependent on functions of several independent variables.

DIRECTED GRAPHS, GRAPH THEORETIC ALGORITHMS**12**

Digraphs - Types of digraphs - Directed paths and connectedness - Euler graphs - Adjacency matrix of a digraph - Tournament. Algorithms - Connectedness and components - Spanning tree - Fundamental circuits - Cut vertices - Directed circuits - Shortest path algorithm.

LINEAR PROGRAMMING**12**

Formulation - Graphical solution - Simplex method - Big M method - Two phase method - Transportation and Assignment models.

OPTIMIZATION TECHNIQUES**12**

Classical Optimization - Unconstrained problem of Maxima and Minima - Constrained problem of Maxima and Minima - Lagrangian method - Kuhn Tucker conditions.

Total Hours: 60**TEXT BOOKS:**

1. Bronson. R, "Matrix Operation, Schaum's outline series", 2nd Edition, McGraw-Hill, 2011.
2. Elsgolc. L.D., "Calculus of Variations" Dover Publications, 2007.
3. Narasing Deo, "Graph theory: with application to Engineering and Computer Science", Prentice Hall India, 2017.
4. Taha H.A, "Operations Research: An introduction" Tenth Edition, Pearson Education, 2019.

REFERENCES:

1. Andrews, L.C. and Philips. R.L, "Mathematical Techniques for Engineers and Scientists", Prentice Hall of India, 2005.
2. West, D.B, "Introduction to Graph Theory", Pearson Education, 2019.
3. Kombo, N.S, "Mathematical Programming Techniques", East-West Press, 2012.

WEB REFERENCES

1. <https://archive.nptel.ac.in/courses/111/108/111108157/>
2. <https://archive.nptel.ac.in/courses/111/104/111104025/>
3. <https://archive.nptel.ac.in/courses/111/105/111105039/>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the various electrical parameters in mathematical form.
CO2:	Understand the different types of reference frame theories and transformation relationship
CO3:	Identify the electrical machine equivalent circuit parameters and modeling of electrical machines.

PRINCIPLES OF ELECTROMAGNETIC ENERGY CONVERSION**12**

Magnetic circuits, permanent magnet, stored magnetic energy, co-energy - force and torque in singly and doubly excited systems – machine windings and air gap mmf - winding inductances and voltage equations.

DC MACHINES**12**

Elementary DC machine and analysis of steady state operation - Voltage and torque equations-dynamic characteristics of permanent magnet and shunt d.c. motors – Time domain block diagrams - solution of dynamic characteristic by Laplace transformation – digital computer simulation of permanent magnet and shunt D.C. machines.

REFERENCE FRAME THEORY**12**

Historical background – phase transformation and commutator transformation – transformation of variables from stationary to arbitrary reference frame - variables observed from several frames of reference.

INDUCTION MACHINES**12**

Three phase induction machine, equivalent circuit and analysis of steady state operation – free acceleration characteristics – voltage and torque equations in machine variables and arbitrary reference frame variables – analysis of dynamic performance for load torque variations – digital computer simulation.

SYNCHRONOUS MACHINES**12**

Three phase synchronous machine and analysis of steady state operation - voltage and torque equations in machine variables and rotor reference frame variables (Park's equations) – analysis of dynamic performance for load torque variations – Generalized theory of rotating electrical machine and Krons primitive machine.

Total: 60 Hours**REFERENCES**

1. Paul C.Krause, Oleg Wasyzcuk, Scott S, Sudhoff, “Analysis of Electric Machinery and Drive Systems”, John Wiley, Second Edition, 2010.
2. P S Bimbhra, “Generalized Theory of Electrical Machines”, Khanna Publishers, 2008
3. A.E, Fitzgerald, Charles Kingsley, Jr, and Stephan D, Umanx, “ Electric Machinery”, Tata McGraw Hill, 5th Edition, 1992
4. R. Krishnan, Electric Motor & Drives: Modeling, Analysis and Control, New Delhi, Prentice Hall of India, 2001

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Determine the suitable device for the application.
CO2:	Design of semiconductor device and its parameters.
CO3:	Design of protection circuits and control circuits.
CO4:	Determine the reliability of the system.

INTRODUCTION**9**

Power switching devices overview – Attributes of an ideal switch, application requirements, circuit symbols; Power handling capability – (SOA); Device selection strategy – On-state and switching losses – EMI due to switching - Power diodes - Types, forward and reverse characteristics, switching characteristics – rating.

CURRENT CONTROLLED DEVICES**9**

BJT's – Construction, static characteristics, switching characteristics; Negative temperature coefficient and second breakdown; - Thyristors – Physical and electrical principle underlying operating mode, Two transistor analogy – concept of latching; Gate and switching characteristics; converter grade and inverter grade and other types; series and parallel operation; comparison of BJT and Thyristor – steady state and dynamic models of BJT & Thyristor- Basics of GTO, MCT, FCT, RCT

VOLTAGE CONTROLLED DEVICE**9**

Power MOSFETs and IGBTs – Principle of voltage controlled devices, construction, types, static and switching characteristics, steady state and dynamic models of MOSFET and IGBTs - and IGCT. New semiconductor materials for devices – Intelligent power modules- Integrated gate commutated thyristor (IGCT) - Comparison of all power devices.

FIRING AND PROTECTING CIRCUITS**9**

Necessity of isolation, pulse transformer, optocoupler – Gate drives circuit: SCR, MOSFET, IGBTs and base driving for power BJT. - Over voltage, over current and gate protections; Design of snubbers.

THERMAL PROTECTION**9**

Heat transfer – conduction, convection and radiation; Cooling – liquid cooling, vapour – phase cooling; Guidance for heat sink selection – Thermal resistance and impedance -Electrical analogy of thermal components, heat sink types and design – Mounting types- switching loss calculation for power device.

Total: 45 Hours**REFERENCES**

1. B.W Williams 'Power Electronics Circuit Devices and Applications'.Rashid M.H., " Power Electronics Circuits, Devices and Applications ", Prentice Hall India, Third Edition, New Delhi, 2004
2. MD Singh and K.B Khanchandani, "Power Electronics", Tata McGraw Hill, 2001.
3. Mohan, Undeland and Robins, "Power Electronics – Concepts, applications and Design, John Wiley and Sons, Singapore, 2000.
4. Joseph Vithayathil, Power Electronics: Principles and Applications, Delhi, Tata McGraw- Hill, 2010.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Analyze various single phase and three phase converters.
CO2:	Design DC-DC converter topologies for a broad range of power conversion applications.
CO3:	Develop improved power converters for any stringent application requirements.
CO4:	Design AC-AC converters for variable frequency applications.

SINGLE PHASE & THREE PHASE CONVERTERS 9

Principle of phase controlled converter operation – single-phase full converter and semi- converter (RL,RLE load)- single phase dual converter – Three phase operation full converter and semi-converter (R,RL,RLE load) – reactive power – power factor improvement techniques – PWM rectifiers

DC-DC CONVERTERS 9

Limitations of linear power supplies, switched mode power conversion, Non-isolated DC- DC converters: operation and analysis of Buck, Boost, Buck-Boost, Cuk& SEPIC – under continuous and discontinuous operation – Isolated converters: basic operation of Flyback, Forward and Push- pull topologies.

DESIGN OF POWER CONVERTER COMPONENTS 9

Introduction to magnetic materials- hard and soft magnetic materials –types of cores , copper windings – Design of transformer –Inductor design equations –Examples of inductor design for buck/flyback converter-selection of output filter capacitors – selection of ratings for devices – input filter design.

RESONANT DC-DC CONVERTERS 9

Switching loss, hard switching, and basic principles of soft switching- classification of resonant converters- load resonant converters – series and parallel – resonant switch converters – operation and analysis of ZVS, ZCS converters comparison of ZCS/ZVS- Introduction to ZVT/ZCT PWM converters.

AC-AC CONVERTERS 9

Principle of on-off and phase angle control – single phase ac voltage controller – analysis with R & RL load – Three phase ac voltage controller – principle of operation of cyclo converter – single phase and three phase cyclo converters – Introduction to matrix converters.

Total: 45 Hours

REFERENCES

1. Ned Mohan, T.M. Undeland and W.P. Robbins, "Power Electronics: converters, Application and design" John Wiley and sons. Wiley India edition, 2006.
2. Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall India, Third Edition, New Delhi, 2004.
3. P.C. Sen, "Modern Power Electronics", Wheeler Publishing Co, First Edition, New Delhi, 1998.
4. P.S. Bimbhra, "Power Electronics", Khanna Publishers, Eleventh Edition, 2003
5. Simon Ang, Alejandro Oliva, "Power-Switching Converters, Second Edition, CRC Press, Taylor & Francis Group, 2010
6. V. Ramanarayanan, "Course material on Switched mode power conversion", 2007
7. Alex Van den Bossche and Vencislav Cekov Valchev, "Inductors and Transformers for Power Electronics", CRC Press, Taylor & Francis Group, 2005
8. W. G. Hurley and W. H. Wolfle, "Transformers and Inductors for Power Electronics Theory, Design and Applications", 2013 John Wiley & Sons Ltd.
9. Marian.K. Kazimierczuk and Dariusz Czarkowski, "Resonant Power Converters", John Wiley & Sons limited, 2011

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	To provide the electrical circuit concepts behind the different working modes of inverters so as to enable deep understanding of their operation.
CO2:	To equip with required skills to derive the criteria for the design of inverters for UPS, drives etc.,
CO3:	To analyze and comprehend the various operating modes of different configurations of inverters.
CO4:	To design different single phase and three phase inverters.To impart knowledge on multilevel inverters and modulation techniques

SINGLE PHASE INVERTER**9**

Principle of operation of half and full bridge inverters – Performance parameters – Voltage control of single phase inverters using various PWM techniques – various harmonic elimination techniques – forced commutated thyristor inverters

THREE PHASE VOLTAGE SOURCE INVERTERS**9**

180 degree and 120 degree conduction mode inverters with star and delta connected loads – voltage control of three phase inverters: single, multi pulse, sinusoidal, space vector modulation techniques – Application to drive system

CURRENT SOURCE INVERTERS**9**

Operation of six-step thyristor inverter – inverter operation modes – load – commutated inverters

– Auto sequential current source inverter (ASCI) – current pulsations – comparison of current source inverter and voltage source inverters – PWM techniques for current source inverters.

MULTILEVEL & BOOST INVERTERS**9**

Multilevel concept – diode clamped – flying capacitor – cascade type multilevel inverters - Comparison of multilevel inverters - application of multilevel inverters – PWM techniques for MLI – Single phase & three phase Impedance source inverters.

RESONANT INVERTERS AND POWER CONDITIONERS**9**

Series and parallel resonant inverters - voltage control of resonant inverters – Class E resonant inverter – resonant DC - link inverters.-power line disturbances-power conditioners-UPS: offline UPS, online UPS.

Total: 45 Hours

REFERENCES

1. Rashid M.H., “Power Electronics Circuits, Devices and Applications ”, Prentice Hall India, Third Edition, New Delhi, 2004.
2. Jai P.Agrawal, “Power Electronics Systems”, Pearson Education, Second Edition, 2002
3. BimalK.Bose “Modern Power Electronics and AC Drives”, Pearson Education, Second Edition, 2003.
4. Ned Mohan,T.MUndeland and W.P Robbin, “Power Electronics: converters, Application and design” John Wiley and sons.Wiley India edition, 2006
5. Philip T. krein, “Elements of Power Electronics” Oxford University Press -1998
6. P.C. Sen, “Modern Power Electronics”, Wheeler Publishing Co, First Edition, New Delhi, 1998
7. P.S.Bimbra, “Power Electronics”, Khanna Publishers, Eleventh Edition, 2003

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Design the time-invariant systems in state space form as well as analyze, whether the system is stable, controllable, observable and detectable.
CO2:	Design state feedback controller and state observers.
CO3:	Classify singular points and construct phase trajectory using delta and isoclines methods.
CO4:	Describe the function of Lyapunov Stability, Popov's Stability Criterion and Circle Criterion to assess the stability of certain class of non-linear system.
CO5:	Describe non-linear behaviors such as Limit cycles, input multiplicity and output multiplicity, Bifurcation and Chaos.

STATE VARIABLE REPRESENTATION**9**

Introduction-Concept of State-State equations for Dynamic Systems -Time invariance and linearity- Non uniqueness of state model- Physical Systems and State Assignment - free and forced responses- State Diagrams.

SOLUTION OF STATE EQUATIONS**9**

Existence and uniqueness of solutions to Continuous-time state equations - Solution of Nonlinear and Linear Time Varying State equations - State transition matrix and its properties – Evaluation of matrix exponential- System modes- Role of Eigen values and Eigen vectors.

STABILITY ANALYSIS OF LINEAR SYSTEMS**9**

Controllability and Observability definitions and Kalman rank conditions -Stabilizability and Detectability-Test for Continuous time Systems- Time varying and Time invariant case- Output Controllability-Reducibility- System Realizations.

STATE FEEDBACK CONTROL AND STATE ESTIMATOR**9**

Introduction- Controllable and Observable Companion Forms-SISO and MIMO Systems- The Effect of State Feedback on Controllability and Observability- Pole Placement by State Feedback for both SISO and MIMO Systems- Full Order and Reduced Order Observers.

LYAPUNOV STABILITY ANALYSIS**9**

Introduction-Equilibrium Points- BIBO Stability-Stability of LTI Systems- Stability in the sense of Lyapunov - Equilibrium Stability of Nonlinear Continuous-Time Autonomous Systems-The Direct Method of Lyapunov and the Linear Continuous-Time Autonomous Systems-Finding Lyapunov Functions for Nonlinear Continuous-Time Autonomous Systems – Krasovskil's and Variable- Gradient Method.

Total: 45 Hours**REFERENCES**

1. M. Gopal, "Modern Control System Theory", New Age International, 2005.
2. K. Ogatta, "Modern Control Engineering", PHI, 2002.
3. John S. Bay, "Fundamentals of Linear State Space Systems", McGraw-Hill, 1999.
4. D. Roy Choudhury, "Modern Control Systems", New Age International, 2005.
5. John J. D'Azzo, C. H. Houpis and S. N. Sheldon, "Linear Control System Analysis and Design with MATLAB", Taylor Francis, 2003.
6. Z. Bubnicki, "Modern Control Theory", Springer, 2005.
7. C.T. Chen, "Linear Systems Theory and Design" Oxford University Press, 3rd Edition, 1999.
8. M. Vidyasagar, "Nonlinear Systems Analysis", 2nd edition, Prentice Hall, Englewood Cliffs, New Jersey.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Identify the research problem and state its scope and objectives
CO2:	Prepare a report and research proposal after conducting literature survey considering plagiarism and research ethics.
CO3:	Outline the types of intellectual property rights
CO4:	Administer patent systems and new developments in IPR.

APPROACHES IN RESEARCH**15**

Meaning of research problem, Sources of research problem, criteria characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations. Effective literature studies approaches, analysis. Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

NATURE OF INTELLECTUAL PROPERTY**15**

Patents, Designs, Trade and Copyright. Process of Patenting and development Technical research, innovation, patenting, development. International scenario: International cooperation on intellectual property. Procedure for grants of patents, Patenting under PCT.

PATENT RIGHTS AND DEVELOPMENTS IN IPR**15**

Scope of patent rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. Administration of patent System. New developments in IPR; IPR of biological Systems, Computer software etc., Traditional knowledge case studies, IPR and IITs.

Total Periods: 45**TEXT BOOKS**

1. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016
2. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.
3. Halbert, "Resisting Intellectual Property," Taylor and Francis Ltd, 2007.

REFERENCE BOOKS

1. Stuart Melville and Wayne Goddaed, "Research methodology : An introduction for science and engineering students"
2. Wayne Goddard and Stuart Melville, "Research methodology : An introduction"
3. Ranjit Kumar, 2nd edition, "Research Methodology : A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property," Taylor and Francis Ltd, 2007.
5. Mayall, "Industrial Design", McGraw Hill, 1992.
6. Niebel, "Product Design", McGraw Hill, 1974.
7. Asimov, "Introduction to Design", Prentice Hall, 1962.

SEMESTER-II

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Explain the basic concepts of DC motor fundamentals with multi quadrant operation and performance characteristics of converter control.
CO1:	Analyze the different types of converter control and chopper control.
CO1:	Illustrate the methods of closed loop control and digital control of dc drive.

DC MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS**9**

DC motor- Types, induced emf, speed-torque relations; Speed control – Armature and field speed control- Ward Leonard control – Constant torque and constant horse power operations-Characteristics of mechanical system – Dynamic equations - Components of torque - Types of load - Requirements of drives - Characteristics – Multi-quadrant operation - Drive elements - Types of motor duty and selection of motor rating.

CONVERTER CONTROL**9**

Principle of phase control – Fundamental relations- Analysis of series and separately excited DC motor with single phase and three phase converters – Waveforms, performance parameters - Performance characteristics - Continuous and discontinuous armature current operations - Current ripple and its effect on performance - Operation with free wheeling diode - Implementation of braking schemes - Drives employing dual converter.

CHOPPER CONTROL**9**

Introduction to time ratio control and frequency modulation - Class A, B, C, D and E chopper controlled DC motor – Performance analysis - Multi-quadrant control - Chopper based implementation of braking schemes - Multi-phase chopper - Related problems.

CLOSED LOOP CONTROL**9**

Modeling of drive elements – Equivalent circuit, transfer function of self, separately excited DC motor - Linear transfer function model of power converters - Sensing and feedback elements - Closed loop speed control – Current, hysteresis, PWM current control and speed loops - P, PI and PID controllers response comparison - Speed control by symmetric optimum method.

DIGITAL CONTROL OF DC DRIVE**9**

Phase Locked Loop and micro-computer control of DC drives – program flow chart for constant horse power and load disturbed operations - Speed detection and gate firing - Simulation of converter and chopper fed DC drive.

Total: 45 Hours**REFERENCES**

1. Krishnan.R, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice- Hall of India Pvt. Ltd., New Delhi, 2010.
2. Gopal K.Dubey, “Fundamentals of Electrical Drives”, Narosa Publishing House, New Delhi, 2013
3. Gopal K Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall Inc., New Yersey, 1989.
4. Sen.P.C, “Thyristor DC Drives”, John wiley and sons, New York, 1981.
5. Vedam Subramanyam, “Electric Drives – Concepts and Applications”, Tata McGraw Hill publishing company Ltd., New Delhi, 2002.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the conventional control of induction motor and compare VSI and CSI fed induction motors
CO2:	Discuss the concept of PWM control and field oriented control methods.
CO3:	Analyze the direct torque control based induction motor and control of synchronous motor.

CONVENTIONAL CONTROL OF INDUCTION MOTORS 9

Review of induction machine operation – Equivalent circuit – Performance of the machine with variable voltage - Rotor resistance variation - Pole changing and cascaded induction machines - Slip power recovery – Static Kramer drive.

VSI AND CSI FED INDUCTION MOTOR CONTROL 9

AC voltage controller fed induction machine operation – Energy conservation issues – v/f operation theory – Requirement for slip and stator voltage compensation - CSI fed induction machine – Operation and characteristics – PWM control.

FIELD ORIENTED CONTROL 9

Field oriented control of induction machines – Theory – DC drive analogy – Direct or feed back vector control - Indirect or feed forward vector control – Flux vector estimation - Space Vector Modulation control.

DIRECT TORQUE CONTROL 9

Direct torque control of induction machines – Torque expression with stator and rotor fluxes - DTC control strategy – Optimum switching vector selection – Reduction of torque ripple methods.

SYNCHRONOUS MOTOR CONTROL 9

Synchronous motor control – Open loop v/f control - Brush and brushless excitation – Load commutated inverter fed drive.

Total: 45 Hours

REFERENCES

1. Bimal.K.Bose, “Modern Power Electronics and AC Drives”, Pearson Education Asia, 2nd Edition 2003.
2. Vedam Subramanyam, “Electric Drives – Concepts and Applications”, Tata McGraw Hill, 1994.
3. Krishnan.R, “Electric Motor Drives – Modeling, Analysis and Control”, Prentice Hall of India Pvt. Ltd., New Delhi, 2010.
4. Leonhard.W, “Control of Electrical Drives”, Narosa Publishing House, 1992.
5. Murphy J.M.D and Turnbull, “Thyristor Control of AC Motors”, Pergamon Press, Oxford, 1988.
6. Austin Hughes, “Electric Motors and Drives – Fundamentals, Types and Applications”, Elsevier – a division of Reed Elsevier India Private Limited, New Delhi, 2006.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the basics of embedded systems and understand the architecture, memory organization and addressing modes of PIC 16F87X Microcontroller.
CO1:	Understand instruction set, programming techniques and various peripherals present in PIC 16F87X microcontroller
CO1:	Understand the data acquisition and programming concepts of PIC 16F87X microcontroller and to design a PIC 16F87X micro controller based systems in any real time applications

EMBEDDED SYSTEMS**9**

Embedded systems – Embedded architecture – CISC – RISC – Memory Types Organization of memory – Microprocessors – Microcontrollers - Families- Manufacturers- Introduction to PIC micro controllers- Assembler-Linker- MPLAB Integrated Development Environment (MPLAB IDE).

PIC 16F87X MICROCONTROLLER**9**

Architecture – Memory organization – Addressing modes – Instruction set – Programming techniques- Simple operation.

PORTS AND TIMERS**9**

I/O ports – Parallel ports - I2C bus – Serial ports – USART – Timers – Timer 0, Timer 1 and Timer2.

DATA ACQUISITION AND PROGRAMMING**9**

Analog to digital converter – Capture compare PWM module – Input capture, Output compare, PWM- Introduction to C, Compilers, functions, loops, data manipulation, Interrupts using PICC LITE.

SYSTEM DESIGN USING MICROCONTROLLERS**9**

Interfacing LCD display – Keypad interfacing – AC load control – PID control of DC motor – Stepper motor control – Brushless DC motor control.

Total: 45 Hours**REFERENCES**

1. Tim Wilmshurst, “Designing Embedded systems with PIC Microcontrollers– Principles and Applications”, Newnes (Elsevier Ltd.), 1st Edition, 2007.
2. John B. Peatman, “Design with PIC Microcontrollers”, Pearson Education, Asia, 2004.
3. John B. Peatman, “Design with Micro Controllers”, McGraw Hill International Ltd, Singapore, 1989.
4. www.microchip.com

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	To educate learners on how to format research writing.
CO2:	To assist students in writing techniques that could result in the development of flawless writing abilities.
CO3:	To enable students, learn the accepted style for self-scrutinising the mechanics of writing a research paper.

Module 1: Formatting Research writing

7

Margins, Text Formatting, Title, Running Head and Page Numbers, Internal Headings and Subheadings, Placement of the List of Works Cited, Tables and Illustrations- Bibliography.

Module 2: The mechanics of writing

8

Spelling, Punctuation, Italics, Names of persons, Numbers, Titles of works in the research paper, Quotation- The format of the Research paper- Documentation: Preparing the list or workers cited- Abbreviations- Citations in forms other than print.

Total Hours: 15**Text book:**

MLA Handbook ninth edition, The modern Language Association of America, New York 2021.

Reference Book:

APA Style Handbook for In-Text Citations and References : Based on APA Guidelines 7th Edition.

LABORATORY COURSES

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data through the simulation
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List of experiments:

1. Modeling of PN Junction diode.
2. Modeling of Silicon Controlled Rectifier.
3. Modeling of MOSFET / IGBT / BJT
4. Simulation of single phase semi converter
 - a. R load.
 - b. RL load.
 - c. RLE (Motor) load
5. Simulation of single phase fully controlled converter.
 - a. R load.
 - b. RL load.
 - c. RLE (Motor) load
6. Simulation of single phase dual converter.
7. Simulation of three phase semi converter.
8. Simulation of three phase fully controlled converter
9. Simulation of single phase full bridge inverter
10. Simulation of three phase full bridge inverter
 - a. 180 degree mode operation
 - b. 120 degree mode operation
11. Simulation of single phase AC voltage controller.
 - a. Lamp load
 - b. Motor load

COURSE OUTCOMES**On Successful completion of the course, students will be able to**

CO1:	Understand and design power electronics and drive systems for different applications and conduct experiments, analyze and interpret data
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List of experiments:

1. Single phase semi converter with R load
2. Single phase semi converter with RL load for continuous and discontinuous conduction modes
3. Single phase semi converter with RLE load for continuous and discontinuous conduction modes
4. Single Phase full converter with R load
5. Single Phase full converter with RL load for continuous and discontinuous conduction modes
6. Single phase full converter with RLE load for continuous and discontinuous conduction modes
7. Three phase full converter with RLE load
8. MOSFET, IGBT based choppers
9. IGBT based single phase inverter
10. Single phase AC voltage controller
11. Single phase cycloconverter
12. Series inverter
13. Parallel inverter

PROFESSIONAL ELECTIVES

COURSE OUTCOMES**On Successful completion of the course, students will be able to**

CO1:	Apply the concept of various types of rectifiers.
CO2:	Simulate and design the operation of resonant converter and its importance.
CO3:	Identify the importance of linear system, state space model, PI controller.
CO4:	Design the DC power supplies using advanced techniques.
CO5:	Understand the standards for supply current harmonics and its significance.

POWER SYSTEM HARMONICS & LINE COMMUTATED RECTIFIERS 9

Average power-RMS value of waveform–Effect of Power factor-. current and voltage harmonics – Effect of source and load impedance - AC line current harmonic standards IEC1000-IEEE 519-CCM and DCM operation of single phase full wave rectifier- Behaviour of full wave rectifier for large and small values of capacitance - CCM and DCM operation of three phase full wave rectifier- 12 pulse converters - Harmonic trap filters.

PULSE WIDTH MODULATED RECTIFIERS 9

Properties of Ideal single phase rectifiers-Realization of nearly ideal rectifier-. Single-phase converter systems incorporating ideal rectifiers - Losses and efficiency in CCM high quality rectifiers -single-phase PWM rectifier - PWM concepts - device selection for rectifiers - IGBT based PWM rectifier, comparison with SCR based converters with respect to harmonic content -applications of rectifiers.

RESONANT CONVERTERS 9

Soft Switching - classification of resonant converters - Quasi resonant converters- basics of ZVS and ZCS- half wave and full wave operation (qualitative treatment) - multi resonant converters - operation and analysis of ZVS and ZCS multi resonant converter - zero voltage transition PWM converters -zero current transition PWM converter

DYNAMIC ANALYSIS OF SWITCHING CONVERTERS 9

Review of linear system analysis-State Space Averaging-Basic State Space Average Model- StateSpace Averaged model for an ideal Buck Converter, ideal Boost Converter, ideal Buck Boost Converter and an ideal Cuk Converter. Pulse Width modulation - Voltage Mode PWM Scheme - Current Mode PWM Scheme - design of PI controller.

SOURCE CURRENT SHAPING OF RECTIFIERS 9

Need for current shaping - power factor - functions of current shaper - input current shaping methods - passive shaping methods -input inductor filter - resonant input filter - active methods - boost rectifier employing peak current control - average current control - Hysteresis control- Nonlinear carrier control.

TOTAL: 45 PERIODS

Reference Books:

1. Robert W. Erickson and Dragomir Maksimovic, "Fundamentals of Power Electronics", Second Edition, Springer science and Business media, 2001.
2. William Shepherd and Li zhang, "Power Converters Circuits", Marcel Dekker, C, 2005.
3. Simon Ang and Alejandro Oliva, "Power Switching Converters", Taylor & Francis Group, 2010.
4. Andrzej M. Trzynadlowski, "Introduction To Modern Power Electronics", John Wiley & Sons, 2016.
Marian.K.Kazimierczuk and Dariusz Czarkowski, "Resonant Power Converters", John Wiley & Sons 1. limited, 2011.
5. Keng C .Wu, "Switch Mode Power Converters – Design and Analysis" Elsevier academic press, 2006.
6. Abraham I.Pressman, Keith Billings and Taylor Morey, " Switching Power Supply Design" McGraw-Hill, 2009
7. V.Ramanarayanan, "Course Material on Switched Mode Power Conversion" IISC, Bangalore, 2007.
8. Christophe P. Basso, Switch-Mode Power Supplies, McGraw-Hill ,2014.

22EE1E02 NONLINEAR DYNAMICS FOR POWER ELECTRONIC CIRCUITS 3 0 0 3

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Ability to determine the non-linear phenomena
CO2:	Analyze the behavior of non-linearity in DC-DC Converters
CO3:	Investigate the behavior of non-linearity in DC Drives
CO4:	Realize the concepts of chaos in power converters.

BASICS OF NONLINEAR DYNAMICS **9**

Basics of Nonlinear Dynamics: System, state and state space model, Vector field- Modeling of Linear, nonlinear and Linearized systems, Attractors , chaos, Poincare map, Dynamics of Discrete time system, Lyapunov Exponent, Bifurcations, Bifurcations of smooth map, Bifurcations in piece wise smooth maps, border crossing and border collision bifurcation.

TECHNIQUES FOR INVESTIGATION OF NONLINEAR PHENOMENA **9**

Techniques for experimental investigation, Techniques for numerical investigation, Computation of averages under chaos, Computations of spectral peaks, Computation of the bifurcation and analyzing stability

NONLINEAR PHENOMENA IN DC-DC CONVERTERS **9**

Border collision in the Current Mode controlled Boost Converter, Bifurcation and chaos in the Voltage controlled Buck Converter with latch, Bifurcation and chaos in the Voltage controlled Buck Converter without latch, Bifurcation and chaos in Cuk Converter. Non-linear phenomenon in the inverter under tolerance band control.

NONLINEAR PHENOMENA IN DRIVES **9**

Nonlinear Phenomenon in Current controlled and voltage controlled DC Drives, Nonlinear Phenomenon in PMSM Drives

CONTROL OF CHAOS **9**

Hysteresis control, Sliding mode and switching surface control, OGY Method, Pyragas method, Time Delay control. Application of the techniques to the Power electronics circuit and drives

TOTAL: 45 PERIODS

References Books:

1. George C. Vargheese, July 2001 Wiley – IEEE Press S Banerjee, Nonlinear Phenomena in Power Electronics, IEEE Press 3.
2. Steven H Strogatz, Nonlinear Dynamics and Chaos, Westview Press
3. C.K.TSE Complex Behaviour of Switching Power Converters, CRC Press, 2003.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand an overview on modern linear and nonlinear control strategies for power electronics devices
CO2:	Design modern power electronic converters for industrial applications
CO3:	Design appropriate controllers for modern power electronics devices.

MODELLING OF DC-TO-DC POWER CONVERTERS 9

Modelling of Buck Converter , Boost Converter ,Buck-Boost Converter, Cuk Converter, Sepic Converter, Zeta Converter, Quadratic Buck Converter ,Double Buck-Boost Converter, Boost- Boost Converter General Mathematical Model for Power Electronics Devices

SLIDING MODE CONTROLLER DESIGN 9

Variable Structure Systems. Single Switch Regulated Systems Sliding Surfaces, Accessibility of the Sliding Surface Sliding Mode Control Implementation of Boost Converter ,Buck-Boost Converter, Cuk Converter, Sepic Converter, Zeta Converter, Quadratic Buck Converter, Double Buck-Boost Converter, Boost-Boost Converter

APPROXIMATE LINEARIZATION CONTROLLER DESIGN 9

Linear Feedback Control, Pole Placement by Full State Feedback , Pole Placement Based on Observer Design ,Reduced Order Observers , Generalized Proportional Integral Controllers, Passivity Based Control , Sliding Mode Control Implementation of Buck Converter , Boost Converter ,Buck-Boost Converter

NONLINEAR CONTROLLER DESIGN 9

Feedback Linearization Isidori's Canonical Form ,Input-Output Feedback Linearization ,State Feedback Linearization, Passivity Based Control , Full Order Observers , Reduced Order Observers.

PREDICTIVE CONTROL OF POWER CONVERTERS 9

Basic Concepts, Theory, and Methods, Application of Predictive Control in Power Electronics, AC-DC- AC Converter System, Faults and Diagnosis Systems in Power Converters.

TOTAL: 45 PERIODS

References Books:

1. HeberttSira-Ramírez PhD, Ramón Silva-Ortigoza, “Control Design Techniques in Power Electronics Devices”, Springer 2012
2. Mahesh Patil, PankajRodey, “Control Systems for Power Electronics: A Practical Guide”, Springer India, 2015.
3. Blaabjerg José Rodríguez, “Advanced and Intelligent Control in Power Electronics and Drives” , Springer, 2014
4. Enrique Acha, VassiliosAgelidis, Olimpo Anaya, TJE Miller, “Power Electronic Control in Electrical Systems”, Newnes, 2002.
5. Marija D. Aranya Chakraborty, Marija , “Control and Optimization Methods for Electric Smart Grids”, Springer, 2012.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Analyze the impacts of renewable energy generation on environment.
CO2:	Understand the importance and qualitative analysis of solar and wind energy sources.
CO3:	Apply the principle of operation of electrical machines for wind energy conversion and their performance characteristics.
CO4:	Design suitable power converters for solar PV and wind energy systems.

INTRODUCTION**9**

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) -Qualitative study of different renewable energy resources ocean, Biomass, Hydrogen energy systems : operating principles and characteristics of: Solar PV, Fuel cells, wind electrical systems-control strategy, operating area.

ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION**9**

Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG.

POWER ELECTRONICS FOR SOLAR**9**

Block diagram of solar photo voltaic system : line commutated converters (inversion-mode) - Boost and buck-boost converters-selection of inverter, battery sizing, array sizing- standalone PV systems - Grid tied and grid interactive inverters- grid connection issues.

POWER ELECTRONICS FOR WIND**9**

Three phase AC voltage controllers-AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, matrix converters- Stand alone operation of fixed and variable speed wind energy conversion systems- Grid connection Issues -Grid integrated PMSG and SCIG Based WECS.

HYBRID RENEWABLE ENERGY SYSTEMS**9**

Need for Hybrid Systems -Range and type of Hybrid systems-Case studies of Wind-PV- Maximum Power Point Tracking (MPPT).

TOTAL: 45 PERIODS**References Books:**

1. S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford University Press, 2009.
2. Rashid .M. H "power electronics Hand book", Academic press, 2001.
3. Rai. G.D, "Non conventional energy sources", Khanna publishes, 1993.
4. Rai. G.D," Solar energy utilization", Khanna publishes, 1993.
5. Gray, L. Johnson, "Wind energy system", prentice hall linc, 1995.
6. B.H.Khan, " Non-conventional Energy sources", Tata McGraw-hill Publishing Company.
7. P.S.Bimbhra,"Power Electronics",Khanna Publishers, 3rd Edition,2003.
8. R.Seyezhai and R.Ramaprabha, "Power Electronics for Renewable Energy Systems", Scitech Publications, 2015.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Acquire knowledge on the basic concepts of Wind energy conversion system.
CO2:	Understand the mathematical modeling and control of the Wind turbine
CO3:	Develop more understanding on the design of Fixed speed system
CO4:	Study about the need of Variable speed system and its modeling.
CO5:	Able to learn about Grid integration issues and current practices of wind interconnections with power system.

INTRODUCTION**9**

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory- Power coefficient-Sabinin's theory-Aerodynamics of Wind turbine.

WIND TURBINES**9**

HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations- Tip speed ratio-No. Of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control- stall control- Schemes for maximum power extraction.

FIXED SPEED SYSTEMS**9**

Generating Systems- Constant speed constant frequency systems -Choice of Generators- Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model- Generator model for Steady state and Transient stability analysis.

VARIABLE SPEED SYSTEMS**9**

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG -Variable speed generators modeling - Variable speed variable frequency schemes.

GRID CONNECTED SYSTEMS**9**

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue.

TOTAL: 45 PERIODS**References Books:**

1. L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990
2. S.N.Bhadra, D.Kastha,S.Banerjee,"Wind Electrical Sytems",Oxford University Press,2010.
3. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.
4. E.W.Golding "The generation of Electricity by wind power", Redwood burn Ltd., Trowbridge, 1976.
5. N. Jenkins," Wind Energy Technology" John Wiley & Sons,1997
6. S.Heir "Grid Integration of WECS", Wiley 1998.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Remember various schemes of conventional and nonconventional power generation.
CO2:	Apply knowledge on the topologies and energy sources of distributed generation.
CO3:	Understand the requirements for grid interconnection and its impact with NCE sources
CO4:	Understand the fundamental concept of Micro-grid.

INTRODUCTION 9

Conventional power generation: advantages and disadvantages, Energy crises, Non- conventional energy (NCE) resources: review of Solar PV, Wind Energy systems, Fuel Cells, micro-turbines, biomass, and tidal sources.

DISTRIBUTED GENERATIONS (DG) 9

Concept of distributed generations, topologies, selection of sources, regulatory standards/ framework, Standards for interconnecting Distributed resources to electric power systems: IEEE 1547. DG installation classes, security issues in DG implementations. Energy storage elements: Batteries, ultra- capacitors, flywheels. Captive power plants

IMPACT OF GRID INTEGRATION 9

Requirements for grid interconnection, limits on operational parameters, : voltage, frequency, THD, response to grid abnormal operating conditions, islanding issues. Impact of grid integration with NCE sources on existing power system: reliability, stability and power quality issues.

BASICS OF A MICROGRID 9

Concept and definition of microgrid, microgrid drivers and benefits, review of sources of microgrids, typical structure and configuration of a microgrid, AC and DC microgrids, Power Electronics interfaces in DC and AC microgrids

CONTROL AND OPERATION OF MICROGRID 9

Modes of operation and control of microgrid: grid connected and islanded mode, Active and reactive power control, protection issues, anti-islanding schemes: passive, active and communication based techniques, microgrid communication infrastructure, Power quality issues in microgrids, regulatory standards, Microgrid economics, Introduction to smart microgrids.

TOTAL: 45 PERIODS

Reference Books:

1. Amirnaser Yezdani, and Reza Iravani, “Voltage Source Converters in Power Systems: Modeling, Control and Applications”, IEEE John Wiley Publications, 2010.
2. Dorin Neacsu, “Power Switching Converters: Medium and High Power”, CRC Press, Taylor & Francis, 2006
3. Chetan Singh Solanki, “Solar Photo Voltaics”, PHI learning Pvt. Ltd., New Delhi, 2009
4. J.F. Manwell, J.G. McGowan “Wind Energy Explained, theory design and applications”, Wiley publication 2010.
5. D. D. Hall and R. P. Grover, “Biomass Regenerable Energy”, John Wiley, New York, 1987.
6. John Twidell and Tony Weir, “Renewable Energy Resources” Tylor and Francis Publications, Second edition 2006

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand basics of micro fabrication develop models and simulate electrostatic and electromagnetic sensors and actuators
CO2:	Understand material properties important for MEMS system performance; analyze dynamics of resonant micromechanical structures
CO3:	Understand the process delivers insight onto design of micro sensors, embedded sensors & actuators in power aware systems like grid.
CO4:	Understand the design process and validation for MEMS devices and systems, and learn the state of the art in optical Microsystems

MICRO-FABRICATION, MATERIALS & ELECTRO-MECHANICAL CONCEPTS 9

Overview of micro fabrication – Silicon and other material based fabrication processes – Concepts: Conductivity of semiconductors-Crystal planes and orientation-stress and strain-flexural beam bending analysis-torsional deflections-Intrinsic stress- resonant frequency and quality factor.

ELECTROSTATIC SENSORS AND ACTUATION 9

Principle, material, design and fabrication of parallel plate capacitors as electrostatic sensors and actuators-Applications

THERMAL SENSING AND ACTUATION 9

Principle, material, design and fabrication of thermal couples, thermal bimorph sensors, thermal resistor sensors-Applications.

PIEZOELECTRIC SENSING AND ACTUATION 9

Piezoelectric effect-cantilever piezoelectric actuator model-properties of piezoelectric materials-Applications.

CASE STUDIES 9

Piezoresistive sensors, Magnetic actuation, Micro fluidics applications, Medical applications, Optical MEMS.-NEMS Devices

Note: Class room discussions and tutorials can include the following guidelines for improved teaching /learning process: Discussions/Exercise/Practice on Workbench: on the basics /device model design aspects of thermal/peizo/resistive sensors etc.

TOTAL: 45 PERIODS

Reference Books:

1. Chang Liu, “Foundations of MEMS”, Pearson International Edition, 2006.
2. Marc Madou, “Fundamentals of microfabrication”, CRC Press, 1997.
3. Boston, “Micromachined Transducers Sourcebook”, WCB McGraw Hill, 1998.
4. M.H.Bao “Micromechanical transducers: Pressure sensors, accelerometers and gyroscopes”, Elsevier, Newyork, 2000.

22EE1E08 ELECTROMAGNETIC FIELD COMPUTATION AND MODELLING 3 0 0 3

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the concepts of electromagnetic.
CO2:	Ability to formulate the FEM method and use of the package.
CO3:	Apply the concepts in the design of rotating machines.

INTRODUCTION 9

Review of basic field theory – Maxwell's equations – Constitutive relationships and Continuity equations – Laplace, Poisson and Helmholtz equation – principle of energy conversion – force/torque calculation.

BASIC SOLUTION METHODS FOR FIELD EQUATIONS 9

Limitations of the conventional design procedure, need for the field analysis based design, problem definition, boundary conditions, solution by analytical methods-direct integration method – variable separable method – method of images, solution by numerical methods- Finite Difference Method.

FORMULATION OF FINITE ELEMENT METHOD (FEM) 9

Variational Formulation – Energy minimization – Discretization – Shape functions – Stiffness matrix – 1D and 2D planar and axial symmetry problems.

COMPUTATION OF BASIC QUANTITIES USING FEM PACKAGES 9

Basic quantities – Energy stored in Electric Field – Capacitance – Magnetic Field – Linked Flux– Inductance – Force – Torque – Skin effect – Resistance.

DESIGN APPLICATIONS 9

Design of Insulators – Cylindrical magnetic actuators – Transformers – Rotating machines

TOTAL: 45 PERIODS

Reference Books:

1. Matthew. N.O. Sadiku, "Elements of Electromagnetics", Fourth Edition, Oxford University Press, First Indian Edition 2007.
2. K.J.Binns, P.J.Lawrenson, C.W Trowbridge, "The analytical and numerical solution of Electric and magnetic fields", John Wiley & Sons, 1993.
3. Nicola Biyanchi , "Electrical Machine analysis using Finite Elements", Taylor and Francis Group, CRC Publishers, 2005.
4. Nathan Ida, Joao P.A.Bastos, "Electromagnetics and calculation of fields", SpringerVerlage, 1992.
5. S.J Salon, "Finite Element Analysis of Electrical Machines" Kluwer Academic Publishers, London, 1995, distributed by TBH Publishers & Distributors, Chennai, India.
6. Silvester and Ferrari, "Finite Elements for Electrical Engineers" Cambridge University press, 1983.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the operation of Electric vehicles technologies
CO2:	Design Electric vehicle architecture.
CO3:	Analyze the operation of suitable DC and AC drives for electric vehicle.
CO4:	Understand the operation and types of batteries
CO5:	Discover the emerging energy storage system

ELECTRIC VEHICLES AND VEHICLE MECHANICS 9

Electric Vehicles (EV), Hybrid Electric Vehicles (HEV), Engine ratings, Comparisons of EV with internal combustion Engine vehicles, Fundamentals of vehicle mechanics.

ARCHITECTURE OF EV'S AND POWER TRAIN COMPONENTS 9

Architecture of EV's and HEV's – Plug-n Hybrid Electric Vehicles (PHEV) - Power train components and sizing, Gears, Clutches, Transmission and Brakes.

CONTROL OF DC AND AC DRIVES 9

DC/DC chopper based four quadrant operations of DC drives – Inverter based V/f Operation (motoring and braking) of induction motor drive system – Induction motor and permanent motor based vector control operation – Switched reluctance motor (SRM) drives.

BATTERY ENERGY STORAGE SYSTEM 9

Battery Basics, Different types, Battery Parameters, Battery modeling, Traction Batteries.

ALTERNATIVE ENERGY STORAGE SYSTEMS 9

Fuel cell – Characteristics- Types – hydrogen Storage Systems and Fuel cell EV – Ultra capacitors.

TOTAL: 45 PERIODS

References Books:

1. Iqbal Hussain, “Electric and Hybrid Vehicles: Design Fundamentals, Second Edition” CRC Press, Taylor & Francis Group, Second Edition (2011).
2. Ali Emadi, Mehrdad Ehsani, John M.Miller, “Vehicular Electric Power Systems”, Special Indian Edition, Marcel dekker, Inc 2010

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the concepts of Smart Grid and its present developments.
CO2:	Remember different Smart Grid technologies.
CO3:	Understand different types of smart meters and advanced metering infrastructure.
CO4:	Understand the concepts of power quality management in Smart Grids
CO5:	Develop LAN, WAN and Cloud Computing for Smart Grid applications.

INTRODUCTION TO SMART GRID**9**

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, National and International Initiatives in Smart Grid.

SMART GRID TECHNOLOGIES**9**

Technology Drivers, Smart energy resources, Smart substations, Substation Automation, Feeder Automation, Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV).

SMART METERS AND ADVANCED METERING INFRASTRUCTURE**9**

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit (PMU), Intelligent Electronic Devices (IED) & their application for monitoring & protection.

POWER QUALITY MANAGEMENT IN SMART GRID**9**

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS**9**

Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), IP based Protocols, Basics of Web Service and CLOUD Computing to make Smart Grids smarter, Cyber Security for Smart Grid.

TOTAL: 45 PERIODS**Reference Books:**

1. Stuart Borlase “Smart Grid :Infrastructure, Technology and Solutions”, CRC Press 2012.
2. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, “Smart Grid: Technology and Applications”, Wiley 2012.
3. Vehbi C. Güngör, Dilan Sahin, Taskin Kocak, Salih Ergüt, Concettina Buccella, Carlo Cecati, and Gerhard P. Hancke, “Smart Grid Technologies: Communication Technologies and Standards” IEEE Transactions On Industrial Informatics, Vol. 7, No. 4, November 2011.
4. Xi Fang, Satyajayant Misra, Guoliang Xue, and Dejun Yang “Smart Grid – The New and Improved Power Grid: A Survey”, IEEE Transaction on Smart Grids, vol. 14, 2012.

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**M.E. MANUFACTURING ENGINEERING
CURRICULUM AND SYLLABI**

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Course Code	Course Title	L	T	P	C	Category	CA	ES	Total
SEMESTER I									
THEORY									
22MA1001	Advanced Applied Mathematics	3	1	0	4	PC	40	60	100
22ME1001	Advanced Metallurgical Engineering	3	1	0	4	PC	40	60	100
22ME1002	Metal Forming Processes	3	1	0	4	PC	40	60	100
22ME1003	Advanced Manufacturing Process	3	0	0	3	PC	40	60	100
22ME1004	Industry 4.0	3	0	0	3	PC	40	60	100
22ME1A004	Research Methodology and IPR	3	0	0	3	PC	40	60	100
PRACTICALS									
22ME1051	Modeling and simulation Laboratory	0	0	2	1	PC	60	40	100
SEMESTER II									
THEORY									
22ME1005	Metrology and computer aided inspection	3	1	0	4	PC	40	60	100
22ME1006	Design for manufacturing and assembly	3	1	0	4	PC	40	60	100
22ME1007	Additive Manufacturing Process	3	0	0	3	PC	40	60	100
22ME1Exx	Professional Elective 1	3	0	0	3	PE	40	60	100
22ME1Exx	Professional Elective 2	3	0	0	3	PE	40	60	100
22ME1Exx	Professional Elective 3	3	0	0	3	PE	40	60	100
	Audit Course								
PRACTICALS									
22ME1052	Materials characterization and testing Laboratory	0	0	2	1	PE	60	40	100
SEMESTER III									
THEORY									
22ME1Exx	Professional Elective 4	3	0	0	3	PE	40	60	100
22ME1Exx	Professional Elective 5	3	0	0	3	PE	40	60	100
22ME1Exx	Professional Elective 6	3	0	0	3	PE	40	60	100
PRACTICALS									
22EI1301	Project Dissertation -I	0	0	12	6	EEC	60	40	100

ELECTIVES										
Course Code	Course Title	L	T	P	C	Category	CA		FE	Total
22ME1E01	Welding of Ferrous and Non-Ferrous Materials	3	0	0	3	PE	40		60	100
22ME1E02	Heat treatment of materials	3	0	0	3	PE	40		60	100
22ME1E03	Composite materials	3	0	0	3	PE	40		60	100
22ME1E04	Material testing and characterization techniques	3	0	0	3	PE	40		60	100
22ME1E05	Supply Chain Management	3	0	0	3	PE	40		60	100
22ME1E06	Quality and Reliability Engineering	3	0	0	3	PE	40		60	100
22ME1E07	Industrial Waste management	3	0	0	3	PE	40		60	100
22ME1E08	Fluid Power automation	3	0	0	3	PE	40		60	100
22ME1E09	Data analysis	3	0	0	3	PE	40		60	100
22ME1E10	Mechanical Behavior of materials	3	0	0	3	PE	40		60	100
22ME1E11	MEMS and NEMS	3	0	0	3	PE	40		60	100
22ME1E12	Corrosion Technology	3	0	0	3	PE	40		60	100

SEMESTER – I

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Use the concept of matrix theory to decompose matrices.
CO2:	Apply the method of calculus of variation to extremize the functionals.
CO3:	Apply graph model and algorithm for solving network problems.
CO4:	Apply simplex method for solving linear programming problems and optimize transportation and assignment problems.
CO5:	Solve nonlinear functions subjected to linear and nonlinear constraints using optimization technique.

MATRIX THEORY**12**

Matrix Decomposition: QR factorization - Least square approximations - Pseudo inverse - Singular value decomposition - Toeplitz matrices.

CALCULUS OF VARIATIONS**12**

Variation and its properties - Euler's equation - Functional dependent on first and higher order derivatives - Functional dependent on functions of several independent variables.

DIRECTED GRAPHS, GRAPH THEORETIC ALGORITHMS**12**

Digraphs - Types of digraphs - Directed paths and connectedness - Euler graphs - Adjacency matrix of a digraph - Tournament. Algorithms - Connectedness and components - Spanning tree - Fundamental circuits - Cut vertices - Directed circuits - Shortest path algorithm.

LINEAR PROGRAMMING**12**

Formulation - Graphical solution - Simplex method - Big M method - Two phase method - Transportation and Assignment models.

OPTIMIZATION TECHNIQUES**12**

Classical Optimization - Unconstrained problem of Maxima and Minima - Constrained problem of Maxima and Minima - Lagrangian method - Kuhn Tucker conditions.

Total Hours: 60**TEXT BOOKS:**

1. Bronson. R, "Matrix Operation, Schaum's outline series", 2nd Edition, McGraw-Hill, 2011.
2. Elsgolc. L.D., "Calculus of Variations" Dover Publications, 2007.
3. Narasing Deo, "Graph theory: with application to Engineering and Computer Science", Prentice Hall India, 2017.
4. Taha H.A, "Operations Research: An introduction" Tenth Edition, Pearson Education, 2019.

REFERENCES:

1. Andrews, L.C. and Philips. R.L, "Mathematical Techniques for Engineers and Scientists", Prentice Hall of India, 2005.
2. West, D.B, "Introduction to Graph Theory", Pearson Education, 2019.
3. Kombo, N.S, "Mathematical Programming Techniques", East-West Press, 2012.

WEB REFERENCES

1. <https://archive.nptel.ac.in/courses/111/108/111108157/>
2. <https://archive.nptel.ac.in/courses/111/104/111104025/>
3. <https://archive.nptel.ac.in/courses/111/105/111105039/>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Define the elastic and plastic behavior of various Industrial application materials.
CO2:	Understand the concepts of fracture behavior of materials and failure analysis
CO3:	Compare the various metallic and non metallic materials and support the materials selection based on practical requirement.

UNIT - I ELASTIC AND PLASTIC BEHAVIOR**9**

Classification of materials -Elasticity in metals and polymers Anelastic and visco-elastic behaviour – Mechanism of plastic deformation and non metallic shear strength of perfect and real crystals – Strengthening mechanisms- work hardening- solid solutioning- grain boundary strengthening- poly phase mixture- precipitation- particle- fibre and dispersion strengthening. Effect of temperature- strain and strain rate on plastic behaviour – Super plasticity – Deformation of non crystalline materials.

UNIT - II FRACTURE BEHAVIOUR**9**

Griffith's theory- stress intensity factor and fracture toughness – Toughening mechanisms – Ductile- brittle transition in steel – High temperature fracture- creep – Larson Miller parameter – Deformation and fracture mechanism maps – Fatigue- low and high cycle fatigue test- crack initiation and propagation mechanisms and Paris law. Effect of surface

and metallurgical parameters on fatigue – Fracture of non-metallic materials – Failure analysis- sources of failure- procedure of failure analysis.

UNIT - III MODERN METALLIC MATERIALS**9**

Dual phase steels- High strength low alloy (HSLA) steel- Transformation induced plasticity (TRIP) Steel- Maraging steel- Nitrogen steel – Intermetallics- Ni and Ti aluminides – smart materials- shape memory alloys – Metallic glass and nano crystalline materials.

UNIT - IV NON METALLIC MATERIALS**9**

Composite materials -Polymeric materials – Formation of polymer structure – Production techniques of fibers- foams- adhesives and coating – structure- properties and applications of engineering polymers – Advanced structural ceramics- WC- TiC- TaC- Al₂O₃- SiC- Si₃N₄ CBN and diamond – properties- processing and applications.

UNIT - V SELECTION OF MATERIALS**9**

Motivation for selection- cost basis and service requirements – Selection for mechanical properties- strength- toughness- fatigue and creep – Selection for surface durability corrosion and wear resistance – Relationship between materials selection and processing – Case studies in materials selection with relevance to aero- auto- marine- machinery and nuclear applications – Computer aided materials selection.

Total Periods =45 PERIODS**TEXT BOOKS**

1. George E.Dieter, “Mechanical Metallurgy”, 3rd Edition, McGraw Hill, New Delhi 2017
2. Donald R Askeland, Pradeep P Fulay, “Essential of Materials Science and Engineering”, 2nd edition, Cengage Publication, United states 2016
3. William F Smith, “Materials Science and Engineering”, Cengage Publication, 5th Edition, 11th Reprint, 2017.

REFERENCE BOOKS

1. Sidney Avner “Introduction to Physical Metallurgy”, 2nd edition, Tata Mc.Graw Hill publication, 2017.
2. William.P.Hosford, “Physical Metallurgy”, 2nd Edition, CRC Press, London, 2010

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	List the various metal forming processes
CO2:	Illustrate and differentiate the various metal forming theories and equipments
CO3:	Apply the various testing and applications of materials

UNIT – I FUNDAMENTALS OF METAL FORMING**12**

Basics of metal forming - Mohr's circle - isotropic elasticity - yield theories - plastic stress-strain relationship - Levy-mises equation - parandtl-rhesus equations. Calculation of workload-work for homogenous deformation-rolling, rod drawing and extrusion processes determination of load by stress evaluation method: Calculation of drawing load-strip drawing with wedge shaped dies, cylindrical rod drawing with a conical die, tube drawing and tube sinking. Calculation of roll load and roll force.

UNIT-II METAL FORMING THEORIES**12**

Slip line field theory and its solution - Formability and its testing. Sheet Metal forming – Calculation of load by stress evaluation method: Theory on forging load-plane strain forging of a thin strip and a flat circular disc, Extrusion load for round bar and flat strip slip line field theory - Plane strain indentation of punch and Plane strain extrusion process. Upper bound analysis

UNIT-III METAL FORMING EQUIPMENT**12**

High speed forming machine-hot forging types processes and applications. Explosive forming-Explosives-characteristics- process variables-properties of formed components-applications. Electro hydraulic forming-principles, requirements and characteristics- process variables water hammer forming - principle and parameters governing the process.

UNIT-IV METAL CUTTING TOOLS**12**

Cutting tool materials - Types of cutting tools –turning, milling, broaching - turning tool holders – milling tool holders- specification – geometry – design consideration – design of work holding devices for vertical machining centers and horizontal machining centers– case studies

UNIT V TESTING AND APPLICATIONS**12**

Work hardening - compression test, bulge test, plane strain compression test - plastic instability in tension tests. Strain rate - super plasticity - slab analysis for sheet drawing - Extrusion and forging - upper bound solution for Extrusion - Indentation and plane strain forging. CAD/CAM applications in Extrusion, Forging and Sheet metal Forming - Localized necking in biaxial stretching.

TOTAL: 60 PERIODS

TEXT BOOKS

1. Charles Herman Fulton, “An Introduction to the Principles of Metal Working”, Nabu press Publication, India, Reprint 2014
2. George E.Dieter, “Mechanical Metallurgy”, 3rd Edition, McGraw Hill, New Delhi 2017
3. L. Juneja “Fundamentals of Metal Cutting and Machine Tools”, Revised 2nd edition, New age international press, India, 2017

REFERENCE BOOKS:

1. Robert H. Wagoner and Jean Loup Chenot.,” Fundamentals of Metal Forming” John Wiley & Sons Inc., New York, 1996.
2. Calladine C. R., “Plasticity for Engineers”, 2nd Revised edition, Horwood Publishing Ltd, United Kingdom, 2000.
3. Stephen Thimoshenko, JN Goodier, “Theory of Elasticity”, 3rd edition, Tata McGraw hill, New Delhi, 2017

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Summarize various unconventional mechanical and electrical energy processes
CO2:	Illustrate the importance of thermal energy in the unconventional machining process
CO3:	Describe the various micro devices fabrication processes.

UNIT-I MECHANICAL ENERGY PROCESSES 9

Abrasive Jet machining – water jet machining - ultrasonic machining– chemical machining – electro chemical machining –construction- working principle- types- process parameters- derivations – design of tools -problems-merits- demerits and applications-Additive Manufacturing processes.

UNIT – II ELECTRICAL ENERGY PROCESSES 9

Electric discharge machining- Wire cut EDM - Electro Mechanical Grinding – ECG --construction – principle – types – control - circuits – tool design – merits- demerits & applications.

UNIT – III THERMAL ENERGY PROCESSES 9

Laser beam machining – Electron beam machining – Plasma arc machining – Ion beam machining – construction working principle types – process parameter – derivations – problems- merits- demerits and applications.

UNIT - IV FABRICATION OF MICRO DEVICES 9

Semiconductors – films and film depurification – Oxidation - diffusion – ion implantation – etching – metallization – bonding – surface and bulk machining – LIGA Process – Solid free form fabrication.

UNIT - V MICRO-FABRICATION TECHNOLOGY 9

Wafer preparation – monolithic processing – moulding – PCB board hybrid and MCM technology – programmable devices and ASIC – electronic material and processing.– steriolithography SAW devices- Surface Mount Technology-

TOTAL: 45 PERIODS

TEXT BOOKS

1. Serope Kelpekijian & Stevan R. Schmid “Manufacturing Process for Engineering Materials” Pearson Higher Education, 5th Edition, New Delhi 2008 Julian W. Gardner
2. V. K. Varadan, Osama O. Awadelkarim, “Microsensors, MEMS and smart devices”, John Wiley, New Delhi- 2008.

REFERENCE BOOKS

1. Nario Taniguchi, “Nano technology”, Oxford University Press, London- 2007.
2. More Madon, “Fundamentals of Microfabrication”, CRC Press- New York- 2004
3. J.T.Black, Renald A Kohser, “Degramo's Materials and Process in Manufacturing”, 11th Edition, Whiley Student edition, 2013

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Identify various types of plant layout engineering and material study
CO2:	Understand and apply the concepts of process planning and forecasting
CO3:	Apply various scheduling algorithms and gain knowledge in effective management techniques.

UNIT – I INTRODUCTION TO INDUSTRY 4.0**9**

Various Industrial Revolutions - Digitalization and the Networked Economy- Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0- The Journey so far: Developments in USA, Europe, China and other countries- Comparison of Industry 4.0 Factory and Today's Factory- Trends of Industrial Big Data and Predictive Analytics for Smart Business

UNIT – II ROAD TO INDUSTRY 4.0**9**

Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services- Smart Manufacturing-Smart Devices and Products- Smart Logistics - Smart Cities - Predictive Analytics

UNIT – III TECHNOLOGIES FOR ENABLING INDUSTRY 4.0**9**

Cyberphysical Systems - Robotic Automation and Collaborative Robots - Support System for Industry 4.0 - Mobile Computing - Related Disciplines - Cyber Security-IIoT case studies

UNIT – IV ROLE OF DATA, INFORMATION, KNOWLEDGE AND COLLABORATION**9**

Resource-based view of a firm - Data as a new resource for organizations - Harnessing and sharing knowledge in organizations - Cloud Computing Basics - Cloud Computing and Industry 4.0

UNIT – V BUSINESS ISSUES IN INDUSTRY 4.0**9**

Opportunities and Challenges - Future of Works and Skills for Workers in the Industry 4.0 Era - Strategies for competing in an Industry 4.0 world

TOTAL : 45 PERIODS**TEXT BOOKS**

1. Dr. Ovidiu Vermesan, Dr. Peter Friess, “Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems”, River Publishers Series in Communication, 2014
2. Ovidiu, Peter Friess “Internet of Things – From Research and Innovation to Market Deployment”, River Publishers Series in Communication, 2014

REFERENCE BOOKS

1. Jean-Philippe Vasseur, Adam Dunkels, “Interconnecting Smart Objects with IP – The Next Internet”, Morgan Kaufmann Publishers, 2010
2. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things” - Apress 2008
Sabina Jeschke, “Industrial Internet of Things: Cybermanufacturing Systems”- Eswar Press, Chennai- 2005

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Identify the research problem and state its scope and objectives
CO2:	Prepare a report and research proposal after conducting literature survey considering plagiarism and research ethics.
CO3:	Outline the types of intellectual property rights
CO4:	Administer patent systems and new developments in IPR.

APPROACHES IN RESEARCH**15**

Meaning of research problem, Sources of research problem, criteria characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations. Effective literature studies approaches, analysis. Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

NATURE OF INTELLECTUAL PROPERTY**15**

Patents, Designs, Trade and Copyright. Process of Patenting and development Technical research, innovation, patenting, development. International scenario: International cooperation on intellectual property. Procedure for grants of patents, Patenting under PCT.

PATENT RIGHTS AND DEVELOPMENTS IN IPR**15**

Scope of patent rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. Administration of patent System. New developments in IPR; IPR of biological Systems, Computer software etc., Traditional knowledge case studies, IPR and IITs.

Total Periods: 45**TEXT BOOKS**

1. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016
2. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.
3. Halbert, "Resisting Intellectual Property," Taylor and Francis Ltd, 2007.

REFERENCE BOOKS

1. Stuart Melville and Wayne Goddaed, "Research methodology : An introduction for science and engineering students"
2. Wayne Goddard and Stuart Melville, "Research methodology : An introduction"
3. Ranjit Kumar, 2nd edition, "Research Methodology : A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property," Taylor and Francis Ltd, 2007.
5. Mayall, "Industrial Design", McGraw Hill, 1992.
6. Niebel, "Product Design", McGraw Hill, 1974.
7. Asimov, "Introduction to Design", Prentice Hall, 1962.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Design and analyze the mechanical components
CO2:	Link the manufacturing system with CAE
CO3:	Able to understand the interfacing of labvie

LIST OF EXPERIMENTS:

1. Application of proximately sensors for material analysis and positioning.
2. Measure of length and BGS FGS functions using photo electric sensor
3. Identification of color using photo electric sensor
4. Point Teaching and color Identification using Fiber Optic Sensor
5. Demo of machine vision system
6. Design, modeling and assembly of valve components using design softwares
7. Design, modeling and assembly leaf drill jig using design softwares
8. Analysis of machine tools structure using analysis softwares
9. CNC Part programming for Turning Center using manufacturing softwares
 - a. Step and taper turning
 - b. Boring and grooving
 - c. Internal and External threading
10. Simulation and analysis of Simple plant layout using Arena

SEMESTER-II

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Gain knowledge about international standards of length measurements, laser metrology and CMM
CO2:	Describe the concepts of online and inline inspections
CO3:	Know the basics of computer aided inspection and design his own system.

UNIT -I INTERNATIONAL STANDARD OF LENGTH AND LASER METROLOGY 9

Units of length - legal basis for length measurement - Traceability - Characteristics LASER light source - LASER interferometer - LASER alignment telescope - LASER micrometer - on-line and in-process measurements of diameter and surface roughness using LASER - Micro holes and surface topography measurements Straightness and flatness measurement.

UNIT -II CO-ORDINATE MEASURING MACHINES 9

Evolution of measurement - coordinate measuring machines - Non Cartesian CMMS - Accessory elements - Application software - Performance evaluations Temperature fundamentals - Environmental Control - Accuracy enhancement Applications - Measurement integration.

UNIT-III OPTO ELECTRONIC MEASURING SYSTEMS & DEVELOPMENT IN METROLOGY 9

Upto electronic devices contact and non contact types - Applications in on-line and in-process monitoring systems - Tool wear measurement - Manufacturing metrology - 3D surface roughness - Pattern generation studies - Roundness measurement using LASER

UNIT -IV IMAGE PROCESSING AND ITS APPLICATION IN METROLOGY 9

Shape identification - Edge detection techniques - Normalization - Grey scale correlation - Template techniques - Surface roughness using vision system Interfacing robot and image processing system - Measurement of length and diameters.

UNIT – V COMPUTER INTEGRATED COMPUTER INTEGRATED QUALITY ASSURANCE 9

Total quality control - Quality assurance Zero defects - POKE - YOKE Statistical evaluation of data using computer - data integration of CMM and Computers lagging in computers - TQM.

TOTAL PERIODS: 45

TEXT BOOKS

1. Watson.J, "Optoelectronics ", Van Nostrand Reinhold (UK) Co Ltd., 2004.
2. Robert.G. Seippel, "Optoelectronics for technology and Engineering", Prentice Hall New Jersey, 2006.

REFERENCE BOOKS

1. Ulrich-Rembold, Armbruster and Ulzmann, "Interface technology for computer controlled manufacturing processes", Marcel Dekker Pub New York- 1993.
2. Thomas G.G, "International Journals on CIRP Engineering Metrology", Butterworth Pub. United Kingdom- 2004.
3. John Bank, "Essence of TQM", Prentice Hall of India Pvt Ltd., New Delhi- 2001.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Relate process capability with quality control concepts and gain knowledge on attainable tolerances and selective assembly
CO2:	Infer the concept of datum systems and fixture design
CO3:	Apply true position theory concepts and redesign to suite manufacturing.

UNIT I PROCESS CAPABILITY AND TOLERANCES**12**

Process capability- Skewness- Kurtosis- problems- fits and tolerances- geometric tolerances-ISO standards-surface finish- review of attainable tolerance grades for different machining operations. Cumulative effect of tolerances- Worst Case Method- Root Sum Square Method.

UNIT II SELECTIVE ASSEMBLY**12**

Interchangeable part manufacture and selective assembly- deciding the number of groups- Model-I: Group tolerances of mating parts equal; Model-II: total and group tolerances of shaft equal. Control of axial play - introducing secondary machining operations- laminated shims.

UNIT III DATUM SYSTEMS AND FIXTURE DESIGN**12**

Degrees of freedom- grouped datum systems - different types- two and three mutually perpendicular grouped datum planes; Grouped datum system with spigot and recess- pin and hole; Grouped datum system with spigot and recess pair and tongue - slot pair - computation of translational and rotational accuracy- geometric analysis and applications.

UNIT IV TRUE POSITION THEORY**12**

Comparison between co-ordinate and convention method of feature location- tolerancing and true position tolerancing- floating and fixed fasteners- projected tolerance zone- zero true position tolerance- functional gauges- paper layout gauging- compound assembly.

UNIT V REDESIGN FOR MANUFACTURE:**12**

Design features to facilitate machining: datum features - functional and manufacturing. Component design - machining considerations- redesign for manufacture- examples. Operation sequence for shaft type of components. Preparation of process drawings for different operations- tolerance worksheets and centrality analysis. Redesign for cast and sheet metal components.

TOTAL (45 + 15):60 PERIODS**TEXT BOOKS**

1. Spotts M.F, "Dimensioning and Tolerance for Quantity Production", Prentice Hall Inc., New Delhi- 2010.
2. James G Bralla, "Hand Book of Product Design for Manufacturing", McGraw Hill Publications- 2012

REFERENCE BOOKS

1. Xiu-Tian Yan- Benoit Eynard, Chengyu Jiang- "Advance design and manufacture to maintain the competitive edge" Springer- 2010
2. Michael Wader "Lean Tools: A Pocket Guide to Implementing Lean Practices", Productivity and Quality Publishing Pvt Ltd., 2006.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Summarize various CAD systems used for data conversions
CO2:	Illustrate the importance of various prototyping systems and its applications
CO3:	Describe the various additive manufacturing process for large volume productions.

UNIT-I INTRODUCTION**9**

Need - Development of AM systems – AM process chain - Impact of AM on Product Development - Virtual Prototyping- Rapid Tooling – RP to AM -Classification of AM processes-Benefits-Applications

UNIT – II REVERSE ENGINEERING AND CAD MODELING**9**

Basic concept- Digitization techniques – Model reconstruction – Data Processing for Rapid Prototyping: CAD model preparation, Data requirements – Geometric modeling techniques: Wire frame, surface and solid modeling – data formats - Data interfacing, Part orientation and support generation, Support structure design, Model Slicing, Tool path generation-Software for AM- Case studies

UNIT – III LIQUID BASED AND SOLID BASED ADDITIVE MANUFACTURING SYSTEMS**9**

Stereolithography Apparatus (SLA): Principle, pre-build process, part-building and post-build processes, photo polymerization of SL resins, part quality and process planning, recoating issues, materials, advantages, limitations and applications. Solid Ground Curing (SGC): working principle, process, strengths, weaknesses and applications. Fused deposition Modeling (FDM): Principle, details of processes, process variables, types, products, materials and applications. Laminated Object Manufacturing (LOM): Working Principles, details of processes, products, materials, advantages, limitations and applications - Case studies.

UNIT - IV POWDER BASED ADDITIVE MANUFACTURING SYSTEMS**9**

Selective Laser Sintering (SLS): Principle, process, Indirect and direct SLS- powder structures, materials, post processing, surface deviation and accuracy, Applications. Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations and applications– Case Studies

UNIT - V OTHER ADDITIVE MANUFACTURING SYSTEMS**9**

Three dimensional Printing (3DP): Principle, basic process, Physics of 3DP, types of printing, process capabilities, material system. Solid based, Liquid based and powder based 3DP systems, strength and weakness, Applications and case studies. Shape Deposition Manufacturing (SDM), Ballistic Particle Manufacturing (BPM), Selective Laser Melting, Electron Beam Melting.

TOTAL: 45 PERIODS**TEXT BOOKS**

1. Chua, C.K., Leong K.F. and Lim C.S., “Rapid prototyping: Principles and applications”, second edition, World Scientific Publishers, 2010.
2. Gebhardt, A., “Rapid prototyping”, Hanser Gardener Publications, 2003.
3. Gibson, I., Rosen, D.W. and Stucker, B., “Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer, 2010.

REFERENCE BOOKS

4. Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications, CRC press, 2005.
5. Kamrani, A.K. and Nasr, E.A., “Rapid Prototyping: Theory and practice”, Springer, 2006.
6. Liou, L.W. and Liou, F.W., “Rapid Prototyping and Engineering applications: A tool box for prototype development”, CRC Press, 2011.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Identify material microstructure and its characterization.
CO2:	Illustrate and apply various destructive testing procedures.
CO3:	Choose appropriate non-destructive testing methods based on type of defects

LIST OF EXPERIMENTS

1. Study of metallurgical microscope and sample preparation
2. Microscopic examination of plain carbon steels
3. Metallographic examination of cast irons & alloy steels
4. Microscopic examination of Non Ferrous Metals and Alloys
5. Non destructive evolution of materials –Magnetic particle inspection, Liquid penetration testing and ultrasonic flaw detector
6. Corrosion testing
7. Wear testing
8. Geometric measurement for machined components using CMM Roughness testing

SEMESTER-III

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Able to gain knowledge in their field of specialization
CO2:	Identify various methods and techniques to be applied for their project
CO3:	Apply the modeling techniques for the existing models

GUIDELINES

The following are the guidelines to be followed for the project work.

1. The students were advised to take their broad area of research in their respective elective sub-specialization identified during second and third semester
2. The project is a practical, in-depth study of a problem, issue, opportunity, technique or procedure – or some combination of these aspects to the related field of study.
3. Project work is to identify and provide a solution to an application oriented problem. Which will be experimental in nature, and the others will be based on some innovative/ theoretical work
4. Each Project work should be carried out by one student individually.
5. Students of all courses may be encouraged to do the projects in industry to promote academic institute – industrial interaction, acquire knowledge and skills from experts in industry and provide solution to the industrial problems.
6. Each project activity must be supervised by the faculty member of the concerned department. These faculty members are termed as Supervisors (or Guides). Supervisors may be assigned to each project group or by faculty expertise
7. The supervisor must monitor the progress being carried out by the project group on a regular basis.
8. In order to monitor the overall functioning of the activities related to the projects. HODs should depute one senior faculty as Project Coordinator and to create review committee. The review committee should consist of HOD, project coordinator, Supervisor and one senior faculty member from concerned department/ one faculty member from other institution / experts from industry may also be part of the review committee.
9. To ensure proper conduct of each project, progress of should be monitored on continuous basis first by the supervisor and project coordinator and evaluated by the review committee.
10. The review committee will be responsible for evaluating the timely progress of the project work and communicating the observations to the students.
11. Internal mark assessment for the project work as follows
12. Work assessment by review committee -
 - First Review - 15 marks
 - o Second Review- - 15 marks
 - o Third review - 20 marks
13. Work assessment by the guide /supervisor - 50%
14. Each project group has to prepare and submit the project report at the time of end semester project viva – voce examination.
15. Each student has to narrow down the topics and complete the literature review and should not change their final project phase.

SEMESTER-IV

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Able to gain knowledge in their field of specialization
CO2:	Identify various methods and techniques to be applied for their project
CO3:	Apply the modeling techniques for the existing models

GUIDELINES

The following are the guidelines to be followed for the project work.

1. The project is a practical, in-depth study of a problem, issue, opportunity, technique or procedure – or some combination of these aspects to the related field of study.
2. Project work is to identify and provide a solution to an application oriented problem. Which will be experimental in nature, and the others will be based on some innovative/ theoretical work
3. Each Project work should be carried out by one student individually.
4. Students of all courses may be encouraged to do the projects in industry to promote academic institute – industrial interaction, acquire knowledge and skills from experts in industry and provide solution to the industrial problems.
5. Each project activity must be supervised by the faculty member of the concerned department. These faculty members are termed as Supervisors (or Guides). Supervisors may be assigned to each project group or by faculty expertise
6. The supervisor must monitor the progress being carried out by the project group on a regular basis.
7. In order to monitor the overall functioning of the activities related to the projects. HODs should depute one senior faculty as Project Coordinator and to create review committee. The review committee should consist of HOD, project coordinator, Supervisor and one senior faculty member from concerned department/ one faculty member from other institution / experts from industry may also be part of the review committee.
8. To ensure proper conduct of each project, progress of should be monitored on continuous basis first by the supervisor and project coordinator and evaluated by the review committee.
9. The review committee will be responsible for evaluating the timely progress of the project work and communicating the observations to the students.
10. Internal mark assessment for the project work as follows
11. Work assessment by review committee - 50%
 - o First Review - 15 marks
 - o Second Review - 15 marks
 - o Third review - 20 marks
12. Work assessment by the guide / supervisor - 50%
13. Each project group has to prepare and submit the project report at the time of end semester project viva – voce examination.
14. Each student has to submit a paper in International conference and national journal before submitting final project phase II viva.

ELECTIVES

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Enumerate and compare the various characteristics of welding processes
CO2:	Distinguish the various types of welding defects and welding repair processes
CO3:	Illustrate the various weldability tests.

UNIT I BASIC CHARACTERISTICS OF WELDING PROCESSES**9**

Fusion welding processes SMAW- TIG- MIG- Gas welding- (variation in process- Equipments- process description- process variables- arc physics). Solid state welding process: Diffusion bonding- Friction welding- Resistance welding- explosive welding- Friction stir welding; High energy rate welding : EBW- LBW- PAW (process parameters- characteristic features- applications).

UNIT II WELDABILITY OF FERROUS AND NON-FERROUS MATERIALS**9**

Different zones of steel weldments and their properties- microstructure products in weldments Weldability of Carbon Steels- HSLA steels- Q&T steels- Cr-Mo steels- Significance of carbon equivalent- important problems encountered in welding of above steels and remedial steps - Weldability of Stainless Steels: stainless steel classification- Schaffler diagram- Delong diagram- problems associated with welding of austenitic stainless steel- ferritic stainless steel- martensitic stainless steel and duplex stainless steels. Welding of Cu, Al, Ti and Ni alloys – processes, difficulties, microstructures, defects and remedial measures

UNIT III WELDING DEFECTS**9**

Cracks: Hot cracks- cold cracks- nomenclature- location and orientation of weld cracks- chevron cracks- lamellar cracks- reheat cracks stress corrosion cracks - Residual Stresses: mechanism involved- type of residual stress- measuring residual stress by hole drilling method- x-ray diffraction method- method of stress relieving- vibratory stress relief - Distortion: longitudinal traverse- angular distortion- simple problems- bowing- rational distortion- buckling and twisting- controlling of distortions in weldments.

UNIT IV WELDING REPAIR**9**

Engineering aspects of repair, aspects to be considered for repair welding, techno-economics, repair welding procedures for components made of steel casting and cast iron, half bead, temper bead techniques, usage of Ni base filler metals. Damaged bends in gas transmission pipeline, heat exchanger repair techniques-explosive expansion, plugging, etc., creep damaged high temperature components, repair of cracked petroleum pressure vessel/reactor, radiation protection

UNIT V WELDABILITY TESTING**9**

Hot crack Tests: Murex test- Houldcroft test- Vareststraint test- ring weldability test- hot ductility test - Cold Crack Tests: controlled thermal severity test- tekken test- lehigh test- longitudinal bead weld test- implant test - Service Weldability Tests: tensile test-nick break test- bend test- impact test- hardness test- fracture toughness test- fatigue test- creep test and corrosion test. TOTAL: 45 PERIODS

TEXT BOOKS

1. Parmar R.S, "Welding Engineering and Technology", Khanna Publishers, New Delhi-2005.
2. Sindo Kou, "Welding Metallurgy", John Wiley & Son, New Delhi 2005.

REFERENCE BOOKS

1. Kenneth Easterling, "Introduction of Physical Metallurgy of Welding", , Butterworth –,Heinman, Tata McGraw Hill Publishing Co.Ltd., 2nd edition, New Delh 2010.
2. Z.P.Howard, B.Carry, Schott Hezler, "Modern Welding technologies", 6th Edition, Pearson 2004

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Extend the knowledge in the field of heat transformations in steels and various heat treatment processes.
CO2:	Differentiate various case hardening techniques
CO3:	Categorize various heat treatment equipments and select suitable heat treatment for specific alloys.

UNIT I TRANSFORMATIONS IN STEELS**8**

Iron-carbon equilibrium diagram-Transformations on heating and cooling-influence of alloying elements-general principles of heat treatment of steels-isothermal and continuous cooling transformations in steels-Continuous cooling curves TTT and CCT diagrams - mechanism of pearlitic - bainitic and martensitic transformations.

UNIT II HEAT TREATMENT PROCESSES**10**

Annealing - Normalizing, Hardening - retained austenite - measurement and methods of its elimination, hardenability studies- Jominy end quench test - Grossman's experiments Tempering- Hollomon & Jaffe tempering correlations Austempering and Martempering, Precipitation hardening – thermo mechanical treatment – inter critical heat treatment – other heat treatment processes - splat cooling.

UNIT III CASE HARDENING**8**

Introduction – carburizing – principle - carbon potential – mechanism - application of Fick's law - depth of carburization and its control, methods of carburizing - heat treatment after carburizing – structure - properties and common problems in carburizing – Nitriding - introduction - steels used – mechanism - effect of microstructure - white layer – nitriding methods - ion nitriding and nitro-carburizing - Induction and flame hardening – principle – methods - operating variables - Measurement of case depth.

UNIT IV HEAT TREATMENT EQUIPMENT**8**

Various heating media used for heat treatment - Temperature and atmosphere control - carburizing atmosphere and carbon potential measurement - nitriding gas atmospheres - Quenching media and their characteristics - Various heat treatment furnaces – fluidized bed furnaces - cryo chamber - cryo treatment of steels - sealed quenched furnace – plasma equipment.

UNIT V HEAT TREATMENT OF SPECIFIC ALLOYS**11**

Heat treatment of carbon steels - various types of tool steels - high speed steels - maraging steels and die steels - Heat treatment of gray cast irons - white cast irons - malleabilising and S.G.irons - austempering of S.G.Iron - Heat treatment of aluminium alloys - copper alloys and nickel alloys - Defects in heat treated parts - causes and remedies.

TOTAL: 45 PERIODS**TEXTBOOKS**

1. Rajan.T. V., Sharma C.P., Ashok Sharma., “Heat Treatment Principles and Techniques” 2nd Edition Prentice- Hall of India Pvt. Ltd.,New Delhi, 2010.
2. ASM International “Heat Treatment : Metallurgy and Application”,2007
3. Vijendra Singh, “Heat Treatment of Metals”, Standard Publishers Distributors New Delhi, 2009.

REFERENCE BOOKS

1. Prabhudev. K H. “Handbook of Heat Treatment of Steels”, Tata McGraw-Hill Publishing Co., New Delhi, 2003.
2. Novikov, .I, “Heat Treatment: Theory, Techniques & Applications”, Nova Science Publishers Inc, 2011.
3. Denison Kingsley Bullens, “Steel and its heat treatment”, Nabu Press, 2010.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the nature of composite materials and composite reinforcements.
CO2	Develop the skills for manufacturing of composites.
CO3	Evaluate the strength of composite materials.

UNIT I INTRODUCTION 9

Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II REINFORCEMENT 9

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES 9

Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITE 9

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method Compression moulding – Reaction injection moulding. Properties and applications.

UNIT V STRENGTH ANALYSIS OF COMPOSITES 9

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first ply failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

Total: 45 Periods

TEXT BOOKS

1. Lubin, George, “Hand Book of Composite Materials”, Springer, 1982.
2. K.K.Chawla, “Composite Materials”, Springer, 2011
3. Deborah D.L. Chung, “Composite Materials Science and Applications”, Springer, 2010.
4. Danial Gay, Suong V. Hoa, and Stephen W.Tasi, “Composite Materials Design and Applications”, CRC Press, 2002.

REFERENCES

1. R.W.Cahn, “Material Science and Technology – Vol 13 – Composites”, VCH, West Germany, 1996.
2. WD Callister, Jr., Adapted by R. Balasubramaniam, “Materials Science and Engineering, An introduction”, John Wiley & Sons, NY, Indian edition, 2007.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Identify the test and quantify the mechanical properties of Engineering Materials.
CO2:	Characterize the micro structure of various materials and apply various applications.
CO3:	Analyze the behavior of various materials under static and dynamic condition

UNIT – I MICRO AND CRYSTAL STRUCTURE ANALYSIS 9

Principles of Optical Microscopy – Specimen Preparation Techniques – Polishing and Etching – Polarization Techniques – Quantitative Metallographic – Estimation of grain size – ASTM grain size numbers – Microstructure of Engineering Materials - Elements of Crystallography – X- ray Diffraction – Bragg's law – Techniques of X-ray Crystallography– Debye – Scherer camera – Geiger Diffractometer – analysis of Diffraction patterns – Inter planer spacing – Identification of Crystal Structure, Elements of Electron Diffraction.

UNIT – II ELECTRON MICROSCOPY 9

Interaction of Electron Beam with Materials – Transmission Electron Microscopy – Specimen Preparation – Imaging Techniques – BF & DF – SAD – Electron Probe Microanalysis – Scanning Electron Microscopy – Construction & working of SEM – various Imaging Techniques – Applications-Atomic Force Microscopy- Construction & working of AFM - Applications .

UNIT – III CHEMICAL AND THERMAL ANALYSIS 9

Basic Principles, Practice and Applications of X-Ray Spectrometry, Wave Dispersive X Ray Spectrometry, Auger Spectroscopy, Secondary Ion Mass Spectroscopy, Fourier Transform Infra-Red Spectroscopy (FTIR)- Proton Induced X-Ray Emission Spectroscopy, Differential Thermal Analysis, Differential Scanning Calorimetry (DSC) And Thermo Gravity metric Analysis (TGA) -and thermal electron Microscope(TEM).

UNIT – IV MECHANICAL TESTING – STATIC TESTS 9

Hardness – Brinell, Vickers, Rockwell and Micro Hardness Test – Tensile Test – Stress– Strain plot – Proof Stress – Torsion Test - Ductility Measurement – Impact Test – Charpy & Izod – DWTT -Fracture Toughness Test, Codes and standards for testing metallic and composite materials.

UNIT – V MECHANICAL TESTING – DYNAMIC TESTS 9

Fatigue – Low & High Cycle Fatigues – Rotating Beam & Plate Bending HCF tests – S-N curve – LCF tests – Crack Growth studies – Creep Tests – LM parameters – AE Tests modal analysis - Applications of Dynamic Tests.

Total : 45 Periods

TEXT BOOKS:

1. Morita.S, Wiesendanger.R, and Meyer.E, —"Non-contact Atomic Force Microscopy" Springer, 2002,
2. Davis J. R., "Tensile Testing", 2nd Edition, ASM International, 2004.
3. ASM Hand book-"Materials characterization", Vol – 10, 2004.
4. Angelo.P.C,"Material Characterization", Reed Elsevier India Pvt.Ltd,2013.
5. Cullity B.D., Stock S R"Elements of X-ray Diffraction", Prentice Hall, Inc 2001.

REFERENCE BOOKS:

1. Goldsten,I.J., Dale.E., Echin.N.P.& Joy D.C., "Scanning Electron Microscopy & X ray- Micro Analysis", (2nd Edition), ISBN – 0306441756, Plenum Publishing Corp., 2000.
2. Newby J., Metals Hand Book- "Metallography & Micro Structures", (9th Edition), ASM International, 1989.
3. Grundy P.J. and Jones G.A., "Electron Microscopy in the Study of Materials", Edward Arnold Limited, 1976.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Identify and analyze supply chain problems in various business sectors.
CO2:	Devise strategies, plans and operations to solve supply chain problems and/or to improve supply chain efficiency
CO3:	Apply information technology in e-business for corporate demand

UNIT – I INTRODUCTION**6**

Definition of Logistics and SCM: Evolution, Scope, Importance and Decision Phases – process view of a supply chain - Supply chain flows- Examples of supply chains- Competitive and supply chain strategies- Achieving strategic fit- Expanding strategic scope- Drivers of supply chain performance- Framework for structuring drivers –Obstacles to achieving fit.

UNIT – II LOGISTICS MANAGEMENT**10**

Factors – Modes of Transportation - Design options for Transportation Networks-Routing and Scheduling – Inbound and outbound logistics- Reverse Logistics – 3PL- Integrated Logistics Concepts- Integrated Logistics Model –Activities - Measuring logistics cost and performance – Warehouse Management - Case Analysis

UNIT – III SUPPLY CHAIN NETWORK DESIGN**10**

Distribution in Supply Chain – Factors in Distribution network design –Design options-Network Design in Supply Chain – Framework for network Decisions - Managing cycle inventory and safety.

UNIT – IV SOURCING AND PRICING IN SUPPLY CHAIN**9**

Supplier selection and Contracts - Design collaboration - Procurement process. Revenue management in supply chain.

UNIT – V COORDINATION AND TECHNOLOGY IN SUPPLY CHAIN**10**

Supply chain coordination - Bullwhip effect – Effect of lack of co-ordination and obstacles – IT and SCM - supply chain IT frame work. E-Business and SCM. Metrics for SC performance – Case Analysis

TOTAL: 45 PERIODS

TEXT BOOKS

1. Sunil Chopra and Peter Meindl “Supply Chain Management Strategy, Planning, and Operation”, PHI, Second edition, 2007
2. David J. Bloomberg, Stephen Lemay and Joe B. Hanna “Logistics”, PHI 2002
3. Martin Christopher, “Logistics and Supply Chain Management”, Strategies for Reducing Cost and Improving Service. Pearson Education Asia, Second Edition

REFERENCE BOOKS

1. Jeremy F. Shapiro, Thomson Duxbury, "Modeling the Supply Chain", 2002
2. James B. Ayers, “Handbook of Supply Chain Management”, St. Lucie Press, 2007

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Apply the statistical analysis methods in Quality process control.
CO2:	Understand the experimental design concepts for conducting research experiments
CO3:	Understand the reliability and service life concepts for systems.

UNIT –I QUALITY & STATISTICAL PROCESS CONTROL 8

Quality –Definition –Quality Assurance –Variation in process –Factors –process capability –control charts –variables X, R and X, -Attributes P, C and U-Chart tolerance design. Establishing and interpreting control charts –charts for variables –Quality rating –Short run SPC.

UNIT –II ACCEPTANCE SAMPLING 8

Lot by lot sampling –types –probability of acceptance in single, double, multiple sampling plans –OC curves –Producer's risk and consumer's risk. AQL, LTPD, AOQL, Concepts –standard sampling plans for AQL and LTPD –use of standard sampling plans.

UNIT –III EXPERIMENTAL DESIGN AND TAGUCHI METHOD 9

Fundamentals –factorial experiments –random design, Latin square design –Taguchi method –Loss function –experiments –S/N ratio and performance measure –Orthogonal array.

UNIT –IV CONCEPT OF RELIABILITY 9

Definition –reliability vs quality, reliability function –MTBF, MTTR, availability, bathtub curve –time dependent failure models –distributions –normal, weibull, lognormal –Reliability of system and models –serial, parallel and combined configuration –Markove analysis, load sharing systems, standby systems, co-variant models, static models, dynamic models.

UNIT –V DESIGN FOR RELIABILITY AND MAINTAINABILITY 11

Reliability design process, system effectiveness, economic analysis and life cycle cost, reliability allocation, design methods, parts and material selection, de-rating, stress-strength and analysis, failure analysis, identification determination of causes, assessments of effects, computation of criticality index, corrective action, system safety –analysis of down-time –the repair time distribution, stochastic point processes system repair time, reliability under preventive maintenance state dependent system with repair. MTTR –mean system down time, repair vs replacement, replacement models, proactive, preventive, predictive maintenance maintainability and availability, optimization techniques for system reliability with redundancy heuristic methods applied to optimal system reliability.

TOTAL: 45 PERIODS

TEXT BOOKS

1. Amata Mitra “Fundamentals of Quality Control and improvement” Pearson Education, 2002.
2. Bester field D.H., “Quality Control” Prentice Hall, 1993.
3. Patrick D To'connor, Practical Reliability Engineering, John-Wiley and Sons Inc, 2002
4. Charles E Ebling, An Introduction to Reliability and Maintainability Engineering, Tata-McGraw Hill, 2000.

REFERENCE BOOKS

1. David J Smith, Reliability, Maintainability and Risk: Practical Methods for Engineers, Butterworth 2002.
2. Dhillon, Engineering Maintainability –How to design for reliability and easy maintenance, PHI, 2008.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Categorize the waste output from various industries.
CO2:	Understand the concepts of waste audits and recycling methods.
CO3:	Select suitable recycling methods based on the categorized wastes

UNIT I INTRODUCTION 8

Types of industries and industrial pollution – Characteristics of industrial wastes – Population equivalent – Bioassay studies – effects of industrial effluents on streams, sewer, land, sewage treatment plants and human health – Environmental legislations related to prevention and control of industrial effluents and hazardous wastes

UNIT II CLEANER PRODUCTION 8

Waste management Approach – Waste Audit – Volume and strength reduction – Material and process modifications – Recycle, reuse and byproduct recovery – Applications.

UNIT III POLLUTION FROM MAJOR INDUSTRIES 9

Sources, Characteristics, waste treatment flow sheets for selected industries such as Textiles, Tanneries, Pharmaceuticals, Electroplating industries, Dairy, Sugar, Paper, distilleries, Steel plants, Refineries, fertilizer, thermal power plants – Wastewater reclamation concepts

UNIT IV TREATMENT TECHNOLOGIES 11

Equalisation – Neutralisation – Removal of suspended and dissolved organic solids - Chemical oxidation – Adsorption - Removal of dissolved inorganics – Combined treatment of industrial and municipal wastes – Residue management – Dewatering - Disposal

UNIT V HAZARDOUS WASTE MANAGEMENT 9

Hazardous wastes - Physico chemical treatment – solidification – incineration – Secure land fills

TOTAL: 45 PERIODS

TEXT BOOKS:

1. M.N.Rao & A.K.Dutta, “Wastewater Treatment”, Oxford - IBH Publication, 1995.
2. W.W. Eckenfelder Jr., “Industrial Water Pollution Control”, McGraw-Hill Book Company, New Delhi, 2000.

REFERENCE BOOKS:

1. T.T.Shen, “Industrial Pollution Prevention”, Springer, 1999.
2. R.L.Stephenson and J.B.Blackburn, Jr., “Industrial Wastewater Systems Hand book”, Lewis Publisher, New York, 1998
3. H.M.Freeman, “Industrial Pollution Prevention Hand Book”, McGraw-Hill Inc., New Delhi, 1995.
4. Bishop, P.L., “Pollution Prevention: Fundamental & Practice”, McGraw-Hill, 2000.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Compare mechanical, electro mechanical sensors and thermal sensors
CO2:	Understand the concepts of magnetic and radiation sensors
CO3:	Select smart sensors based on its application of sensors

UNIT I INTRODUCTION**5**

Need for Automation, Hydraulic & Pneumatic Comparison – ISO symbols for fluid power elements, Hydraulic, pneumatics – Selection criteria.

UNIT II FLUID POWER GENERATING/UTILIZING ELEMENTS**8**

Hydraulic pumps and motor gears, vane, piston pumps-motors-selection and specification-Drive characteristics – Linear actuator – Types, mounting details, cushioning – power packs – construction. Reservoir capacity, heat dissipation, accumulators – standard circuit symbols, circuit (flow) analysis.

UNIT III CONTROL AND REGULATION ELEMENTS**8**

Direction flow and pressure control valves-Methods of actuation, types, sizing of ports-pressure and temperature compensation, overlapped and underlapped spool valves-operating characteristics- electro hydraulic servo valves-Different types-characteristics and performance.

UNIT IV CIRCUIT DESIGN**10**

Typical industrial hydraulic circuits-Design methodology – Ladder diagram-cascade, method-truth table-Karnaugh map method-sequencing circuits-combinational and logic circuit.

UNIT V ELECTRO PNEUMATICS & ELECTRONIC CONTROL OF**HYDRAULIC AND PNEUMATIC CIRCUITS****7**

Electrical control of pneumatic and hydraulic circuits-use of relays, timers, counters, Ladder diagram. Programmable logic control of Hydraulics Pneumatics circuits, PLC ladder diagram for various circuits, motion controllers, use of field busses in circuits. Electronic drive circuits for various Motors.

TOTAL: 45 PERIODS**TEXT BOOKS**

1. Antony Esposito, Fluid Power Systems and control Prentice-Hall, 1988
2. .Dudbey. A. Peace, Basic Fluid Power, Prentice Hall Inc, 1967.
3. E.C.Fitch and J.B.Suryaatmadyn. Introduction to fluid logic, McGraw Hill, 1978

REFERENCES:

1. Peter Rohner, Fluid Power Logic Circuit Design, Mcmelan Prem, 1994.
2. W.Bolton, Mechatronics, Electronic control systems in Mechanical and Electrical Engineering Pearson Education, 2003.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Apply the statistical analysis methods.
CO2:	Understand the concepts of magnetic and radiation sensors
CO3:	Select smart sensors based on its application of sensors

UNIT I INTRODUCTION TO BIG DATA**8**

Introduction to Big Data Platform – Challenges of conventional systems - Web data – Evolution of Analytic scalability, analytic processes and tools, Analysis vs reporting – Modern data analytic tools, Stastical concepts: Sampling distributions, resampling, statistical inference, prediction error.

UNIT II DATAANALYSIS**12**

Regression modeling, Multivariate analysis, Bayesian modeling, inference and Bayesian networks, Support vector and kernel methods, Analysis of time series: linear systems analysis, nonlinear dynamics – Rule induction – Neural networks: learning and generalization, competitive learning, principal component analysis and neural networks; Fuzzy logic: extracting fuzzy models from data, fuzzy decision trees, Stochastic search methods.

UNIT III MINING DATASTREAMS**8**

Introduction to Streams Concepts – Stream data model and architecture – Stream Computing, Sampling data in a stream – Filtering streams – Counting distinct elements in a stream – Estimating moments – Counting oneness in a window – Decaying window – Realtime Analytics Platform(RTAP) applications - case studies – real time sentiment analysis, stock market predictions.

UNIT IV FREQUENT ITEMSETS AND CLUSTERING**9**

Mining Frequent itemsets – Market based model – Apriori Algorithm – Handling large data sets in Main memory – Limited Pass algorithm – Counting frequent itemsets in a stream – Clustering Techniques – Hierarchical – K- Means – Clustering high dimensional data – CLIQUE and PROCLUS – Frequent pattern based clustering methods – Clustering in non-euclidean space – Clustering for streams and Parallelism.

UNIT V FRAMEWORKS AND VISUALIZATION**8**

MapReduce – Hadoop, Hive, MapR – Sharding – NoSQL Databases – S3 – Hadoop Distributed file systems – Visualizations – Visual data analysis techniques, interaction techniques; Systems and applications:

TOTAL : 45 PERIODS**TEXT BOOKS**

1. Anand Rajaraman and Jeffrey David Ullman, Mining of Massive Datasets, Cambridge Big Data Glossary, O'Reilly, 2011.
2. Bill Franks, Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with advanced analytics, John Wiley & sons, 2012.

REFERENCES:

1. Glenn J. Myatt, Making Sense of Data, John Wiley & Sons, 2007 Pete Warden,
2. Jiawei Han, Micheline Kamber “Data Mining Concepts and Techniques”, Second Edition, Elsevier, Reprinted 2008.
3. Michael Berthold, David J. Hand, Intelligent Data Analysis, Springer, 2007. University Press, 2012.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Compare stress, strain curve for engineering materials and they can relate tensile, hardness and toughness of engineering materials.
CO2:	Demonstrate the concepts of and understand the concepts of fatigue and fracture behavior of materials
CO3:	Gain knowledge on time dependent mechanical behavior

UNIT-I TENSILE BEHAVIOR**9**

Engineering stress-strain Curve: Derivation of tensile strength, yield strength, ductility, modulus of elasticity, resilience and toughness from stress strain curves, comparison of stress-strain curves for different materials - True Stress - Strain Curve: true stress at maximum load, true fracture strain, true uniform strain, true necking strain - necking Criteria - Effect of strain rate, temperature and testing machine on flow properties - Notch tensile test - Tensile properties of steel - strengthening mechanisms - Strain hardening - Strain aging.

UNIT-II HARDNESS & TOUGHNESS BEHAVIOUR**9**

Hardness Measurements: Brinell hardness, Meyer's hardness, Vickers hardness, Rockwell hardness and Microhardness - Relationship between hardness and the flow Curve - Hardness at elevated temperatures - Toughness measurements: Charpy, Izod and Instrumented Charpy - Transition Temperature Curves: significance, various criteria, metallurgical factors affecting the curves, Drop weight test, explosion crack starter test, Dynamic tear test and Robertson crack arrest test.

UNIT-III FATIGUE BEHAVIOUR**9**

Introduction: Stress cycles, S-N curves Goodman diagram, Soderberg diagram, Gerbar diagram - Cyclic stress strain Curve - Low cycle fatigue - Fatigue mechanisms Fatigue crack propagation - Fatigue under combined stresses - Cumulative fatigue damage - Design for fatigue.

UNIT-IV FRACTURE BEHAVIOUR**9**

Fracture behavior: Type of fracture in metals: ductile and brittle fracture - Theoretical cohesive strength of metals - Griffith theory - Metallographic aspects of fracture - Fractography - Notch effect - Concept of fracture curve - Fracture under Combined Stresses - Environment sensitive fracture: hydrogen embrittlement stress corrosion cracking.

UNIT-V TIME DEPENDENT MECHANICAL BEHAVIOUR**9**

Creep curve - Stress rupture Test - Structural changes during creep - Mechanisms of creep deformation - Deformation mechanisms maps - Activation energy for steady state creep - Fracture at elevated temperature - Introduction to high temperature alloys - Prediction of long time properties - Creep under combined stresses - Creep- Fatigue Interaction.

TOTAL : 45 PERIODS**TEXT BOOKS**

1. George E. Dieter, "Mechanical Metallurgy", 3rd Edition, McGraw Hill, New Delhi 2013

2. Thomas H. Courtney, “Mechanical Behavior of Materials”, 2nd edition, Waveland Pr Inc, United states 2005
3. M.A.Meyers and K K.Chawla, “Mechanical Metallurgy”, Prentice all Inc., Englewood Cliffs, NJ, 1983

REFERENCE BOOKS

1. Metals Handbook, Mechanical Testing, Vol.8, 9th edn., American Society for Metals, Metals Park, Ohio, 1985
2. Hertzberg R.W, “Deformation and Fracture Mechanics of Engineering Materials”, 2nd edition. John Wiley & Sons, Inc., New York, 1983.
3. Broek.D, “Elementary Engineering Fracture Mechanics”, 3rd edition, Martinus Nijhoff Publishing, The Hague, 1982.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Gain knowledge in the field of micro materials synthesis
CO2:	Determine the need of characterization of nano materials
CO3:	Compare various micro fabrication and processing techniques

UNIT-I MATERIALS FABRICATION PROCESSES AND MICRO SYSTEM PACKAGING 9

Substrates and wafers- silicon as substrate material- mechanical properties of Si- Silicon Compounds silicon piezo resistors- Gallium arsenide- quartz- polymers for MEMS- conductive polymers. Photolithography- photo resist applications- light sources- in implantation- diffusion process exudation – thermal oxidation- silicon diode- chemical vapour deposition- sputtering - deposition by epoxy – etching – levels of micro system packaging die level- device level and system level.

UNIT II NANOMETER-SCALE STRUCTURE FORMATION ON SOLID SURFACES 9

Introduction - Atomic layer etching processes on silicon surfaces – real time optical measurements - adsorption of halogen atoms - sticking coefficient - potential barrier - site-selective adsorption - desorption of silicon halides and restoration of the DAS structure - Nanoscale fabrication processes of silicon surface with halogens - Self-organized Nano pattern formation on copper surface - introduction experiments- novel phenomena Nano pattern formation at vicinal surface-strain-dependent nucleation of metal islands-strain-dependent dissociation of oxygen molecule

UNIT –III CHARACTERIZATION OF NANO MATERIALS 9

Nano-processing systems – Nano measuring systems – characterization – analytical imaging techniques – microscopy techniques- scanning electron microscopy- transmission electron microscopy- transmission electron microscopy- scanning tunneling microscopy- atomic force microscopy- 3D surface analysis – Mechanical- Magnetic and thermal properties – Nano positioning systems

UNIT IV ULTRAFAST LASER SPECTROSCOPY ON NANO AND MICROMATERIALS 9

Introduction- femtosecond optical kerr gate luminescence -spectroscopy- time resolved luminescence spectroscopy - Up conversion technique vs. optical kerr gate method - femtosecond OKG method-principle of transient grating spectroscopy - transient grating spectroscopy combined with a phase mask - femtosecond real time pump probe imaging spectroscopy - principle of real time pump probe imaging spectroscopy - experimental demonstration of real time pump probe - imaging spectroscopy.

UNIT V MICRO FABRICATION AND PROCESSING 9

Micro fabrication-overview-wafer-level processes-substrates- wafer cleaning-oxidation of silicon-local oxidation-doping-thin-film deposition-wafer bonding-pattern transfer-optical lithography-design rules- mask making-wet etching - dry etching - additive processes- planarization -process design issues - sample process flows -a bulk –micro machined diaphragm pressure sensor - a surface-micro machined suspended filament

TOTAL: 45 PERIODS

TEXT BOOKS

1. Sergey Edward Lyshevski, “MEMS and NEMS: Systems, Devices, and Structures” Nano- and Micro science, Engineering, Technology and Medicine, CRC Press 2002.2. Zhaoying Zhou and Shanhong Xia, “MEMS/NEMS Technology and Applications” – Proceedings of Spie SPIE Press 2009
3. Nicola Bianchi, “MEMS and NEMS: System Devices and Structures – Power Electronics and Application Series.” CRC Press; First edition June 2005

REFERENCE BOOKS

1. N.P.Mahalik, “Micro manufacturing and Nanotechnology”, Springer , 2010
2. Chang Liu – McCormick School of Engineering and Applied Science Northwestern University, “Foundation of MEMS”, Published by Dorling Kindersley (India) Pvt.Ltd 2012
3. Kaoru Ohno Masatoshi Tanaka Jun Takeda Yoshiyuki Kawazoe, “Nano and Micro materials”, Springer, 2010

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Memorize the causes testing and types of corrosion
CO2:	Illustrate the various methods to prevent corrosion and corrosion behavior on materials.
CO3:	Understand the need of surface engineering and thin layer engineering processes

UNIT -I MECHANISMS AND TYPES OF CORROSION 9

Principles of direct and Electro chemical Corrosion- Hydrogen evolution and Oxygen absorption mechanisms – Galvanic corrosion- Galvanic series-specific types of corrosion such as uniform- Pitting- Inter granular- Cavitation's- Crevice Fretting- Erosion- and Stress Corrosion –Factors influencing corrosion

UNIT- II TESTING AND PREVENTION OF CORROSION 9

Corrosion testing techniques and procedures- Prevention of Corrosion-Design against corrosion –Modifications of corrosive environment –Inhibitors – Cathodic Protection –Protective surface coatings.

UNIT- III CORROSION BEHAVIOR OF MATERIALS 9

Corrosion of steels- stainless steel- Aluminum alloys- copper alloys- Nickel and Titanium alloys- corrosion of Polymers- Ceramics and Composite materials.

UNIT- IV SURFACE ENGINEERING FOR WEAR AND CORROSION RESISTANCE 9

Diffusion coatings –Electro and Electro less Plating –Hot dip coating –Hard facing-Metal spraying- Flame and Arc processes- Conversion coating –Selection of coating for wear and Corrosion resistance.

UNIT -V THIN LAYER ENGINEERING PROCESSES 9

Laser and Electron Beam hardening –Effect of process variables such as power and scan speed - Physical vapor deposition- Thermal evaporation- Arc vaporization- Sputtering- Ion plating - Chemical vapor deposition – Coating of tools- TiC- TiN- Al₂O₃ and Diamond coating – Proprieties and applications of thin coatings.

TOTAL: 45 PERIODS

TEXT BOOKS

1. Fontana. G., “Corrosion Engineering”, McGraw Hill, New Delhi 2005
2. Schweitzer.P.A., “Corrosion Engineering Hand Book”, 3rd Edition-, Marcel Decker, Australia 2006.

REFERENCE BOOKS

1. Winston Revie.R. Uhlig, “Corrosion- Hand Book”, 2nd edition. John Wiley New Delhi 2000.
2. Kameth G.Budinski, “Surface Engineering for Wear Resistance”, Prentice hall, New Delhi 2007.
3. Nestorferez, “Electro chemistry and corrosion science”, Springer Verlag EPZ, 2010

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M.E. VLSI DESIGN
CURRICULUM AND SYLLABI

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VISION AND MISSION OF THE INSTITUTION

VISION OF THE INSTITUTION

To develop into a leading world class Technological University consisting of Schools of Excellence in various disciplines with a co-existent Centre for Engineering Solutions Development for world- wide clientele.

MISSION OF THE INSTITUTION

To provide all necessary inputs to the students for them to grow into knowledge engineers and scientists attaining

- Excellence in domain knowledge- practice and theory.
- Excellence in co-curricular and extracurricular talents.
- Excellence in character and personality.

VISION AND MISSION OF THE DEPARTMENT

VISION OF THE DEPARTMENT

To obtain remarkable recognition in educational and research activities in the field of VLSI design catering to the growing needs of industry and society.

MISSION OF THE DEPARTMENT

- To provide an environment that encourages the graduates to learn and develop a disciplined and innovative approach to their career in the area of VLSI design.
- To provide state-of-the art facilities to perform research through interaction with industry and research organizations.
- To equip the graduates with strong foundation in VLSI design and allied areas for life-long learning.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

After few years of graduation, the M.E., VLSI Design graduates will possess

- PEO I** : The graduates will be successful professionals in academia, industry and undertake research in VLSI and its allied fields.
- PEO II** : The graduates will formulate and develop optimal solutions that are socially acceptable using emerging technologies and tools.
- PEO III** : The graduates will exhibit professional, ethical and communicative skills, engage themselves in life-long reflective learning and work as individual or a part of a team.

Department of Electronics and Communication Engineering

M.E VLSI Design

S. No.	Course Code	Course Title	L	T	P	C	Category	CA	ES	Total
SEMESTER I										
THEORY										
1	22MA1001	Advanced Applied Mathematics	3	1	0	4	HS	40	60	100
2	22EC1001	Designing with FPGAs	3	0	0	3	PC	40	60	100
3	22EC1002	Digital IC Design	3	0	0	3	PC	40	60	100
4	22EC1003	VLSI Testing	3	0	0	3	PC	40	60	100
5	22EC1004	Hardware Verification Techniques	3	0	0	3	PC	40	60	100
6	22EC1005	Device Modeling	3	0	0	3	PC	40	60	100
7	22ME1A004	Research Methodology and IPR	0	0	0	3	EEC	40	60	100
PRACTICALS										
8	22EC1051	Microelectronics Laboratory	0	0	2	1	PC	60	40	100
SEMESTER II										
1	22EC1006	VLSI Signal Processing	3	1	0	4	PC	40	60	100
2	22EC1007	Analog VLSI Circuit Design	3	0	0	3	PC	40	60	100
3	22EC1008	Physical Design Automation	3	0	0	3	PC	40	60	100
4	22EC1EXX	Professional Elective -I	3	0	0	3	PE	40	60	100
5	22EC1EXX	Professional Elective -II	3	0	0	3	PE	40	60	100
6	22EC1EXX	Professional Elective -III	3	0	0	3	PE	40	60	100
7	22EN1001	English Audit Course					EEC	60	40	100
PRACTICALS										
8	22EC1052	Physical Design Laboratory	0	0	2	1	PC	60	40	100
III Semester										
1	22EC1EXX	Professional Elective -IV	3	0	0	3	PE	40	60	100
2	22EC1EXX	Professional Elective -V	3	0	0	3	PE	40	60	100
3	22EC1EXX	Professional Elective -VI	3	0	0	3	PE	40	60	100

PRACTICALS										
4	22EC1053	Dissertation-I / Industrial Project I	0	0	0	6	EEC	60	40	100
IV Semester										
1	22EC1054	Dissertation-II / Industrial Project II	0	0	0	12	EEC	60	40	100
PROFESSIONAL ELECTIVES(PEs)										
1	22EC1E01	Low Power VLSI Design	3	0	0	3	PE	40	60	100
2	22EC1E02	System on Chip Design	3	0	0	3	PE	40	60	100
3	22EC1E03	VLSI Architecture for Image and Video Processing	3	0	0	3	PE	40	60	100
4	22EC1E04	Semiconductor Memory Design	3	0	0	3	PE	40	60	100
5	22EC1E05	Mixed Signal VLSI Design	3	0	0	3	PE	40	60	100
6	22EC1E06	Reconfigurable Computing	3	0	0	3	PE	40	60	100
7	22EC1E07	VLSI for Artificial Intelligence and Neural Networks	3	0	0	3	PE	40	60	100
8	22EC1E08	VLSI for Wireless Communication	3	0	0	3	PE	40	60	100
9	22EC1E09	VLSI Technology	3	0	0	3	PE	40	60	100
10	22EC1E10	Multirate Digital Signal Processing	3	0	0	3	PE	40	60	100
11	22EC1E11	Advanced Computer Architecture and Parallel Processing	3	0	0	3	PE	40	60	100
12	22EC1E12	Hardware / Software Co Design	3	0	0	3	PE	40	60	100
13	22EC1E13	Hardware Security	3	0	0	3	PE	40	60	100
14	22EC1E14	Electronic Packaging Technologies	3	0	0	3	PE	40	60	100



SEMESTER I



COURSE OUTCOMES

On successful completion of the course, the students will be able to

CO1	Use the concept of matrix theory to decompose matrices.
CO2	Apply the method of calculus of variation to extremize the functionals.
CO3	Apply graph model and algorithm for solving network problems.
CO4	Apply simplex method for solving linear programming problems and optimize transportation and assignment problems.
CO5	Solve nonlinear functions subjected to linear and nonlinear constraints using optimization technique.

MATRIX THEORY**12**

Matrix Decomposition: QR factorization - Least square approximations - Pseudo inverse - Singular value decomposition - Toeplitz matrices.

CALCULUS OF VARIATIONS**12**

Variation and its properties - Euler's equation - Functional dependent on first and higher order derivatives - Functional dependent on functions of several independent variables.

DIRECTED GRAPHS, GRAPH THEORETIC ALGORITHMS**12**

Digraphs - Types of digraphs - Directed paths and connectedness - Euler graphs - Adjacency matrix of a digraph - Tournament. Algorithms - Connectedness and components - Spanning tree - Fundamental circuits - Cut vertices - Directed circuits - Shortest path algorithm.

LINEAR PROGRAMMING**12**

Formulation - Graphical solution - Simplex method - Big M method - Two phase method - Transportation and Assignment models.

OPTIMIZATION TECHNIQUES**12**

Classical Optimization - Unconstrained problem of Maxima and Minima - Constrained problem of Maxima and Minima - Lagrangian method - Kuhn Tucker conditions.

Total Hours: 60**REFERENCES**

1. Taha H.A, "Operations Research: An introduction" Tenth Edition, Pearson Education, 2019.
2. West, D.B, "Introduction to Graph Theory", Pearson Education, 2019.
3. Narasing Deo, "Graph theory: with application to Engineering and Computer Science", Prentice Hall India, 2017.
4. Kombo, N.S, "Mathematical Programming Techniques", East-West Press, 2012.
5. Bronson. R, "Matrix Operation, Schaum's outline series", 2nd Edition, McGraw-Hill, 2011.
6. Elsgolc. L.D., "Calculus of Variations" Dover Publications, 2007.
7. Andrews, L.C. and Philips. R.L, "Mathematical Techniques for Engineers and Scientists", Prentice Hall of India, 2005.

WEB REFERENCES

1. <https://archive.nptel.ac.in/courses/111/108/111108157/>
2. <https://archive.nptel.ac.in/courses/111/104/111104025/>
3. <https://archive.nptel.ac.in/courses/111/105/111105039/>

COURSE OUTCOMES

On Completion of this course the student will be able to,

CO1	Design digital circuits using Verilog HDL
CO2	Explore FPGA architectures and programming technologies
CO3	Design datapath and control path modules.
CO4	Design real time applications using FPGAs.

VERILOG**13**

Signals, Identifier, Net and variable types, Operators, Gate instantiations, Modules and ports, data flow, gate level, Behavioral level, Switch level and state machine modeling, Concurrent and procedural statements, UDP, sub circuit parameters, function and task, timing and delays - test benches - design of combinational and sequential circuits using Verilog.

FPGA ARCHITECTURES**12**

Design flow using FPGAs, - Architecture of Xilinx and Altera FPGAs - Partial Reconfiguration on FPGAs- clock circuits – programming technologies – antifuse, SRAM, EPROM, EEPROM - Implementation using FPGA – Static Timing Analysis - timing models – critical path - calculation of maximum clock frequency - power analysis.

CONTROL PATH AND DATA PATH DESIGN**10**

Design of memories - ROM, single and dual port RAM - synchronous and asynchronous read - arithmetic circuit design - serial/parallel adder, subtractor, floating point adder/subtractor multiplier - sequential multiplier, array multiplier, signed multiplier – ALU – Hardwired Control Design – Micro programmed Control Design.

CONTROLLER AND DSP DESIGN**10**

Memory controller, processor control unit, communication controllers - UART, I2C, VGA controller, USB, DSP blocks- FIR and IIR filters.

Total Periods : 45**REFERENCES**

1. Morris Mano M, Charles R Kime, "Logic and Computer Design Fundamentals", Pearson Education, 2015.
2. Charles H. Roth, "Digital system design using VHDL", Thomson, 2014.
3. Seetharaman Ramachandran, "Digital VLSI systems design," Springer, 2011.
4. Michael D Ciletti, "Advanced Digital Design with Verilog HDL," Pearson education, 2005.
5. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis," Prentice Hall, 2003.

WEB REFERENCES

1. <https://www.digimat.in/nptel/courses/video/117108040/L01.html>
2. <http://nptel.ac.in/courses/117106092/23>
3. <http://nptel.ac.in/courses/117106092/48>

COURSE OUTCOMES

On Completion of this course the student will be able to,

CO1	Make use of the concepts of MOS transistor to design the VLSI circuits.
CO2	Design MOS inverter and analyse its static and transient characteristics.
CO3	Analyse and design various static and dynamic CMOS circuits.
CO4	Analyse building blocks for subsystem design and Memory design.

MOS TRANSISTOR**9**

MOS transistor theory - Enhancement and Depletion mode transistor action - Ideal I-V characteristics –Design equations - MOS capacitance Models - Second order effects - Lumped and distributed RC model for interconnects - Latchup - CMOS process technology – layout and design rules.

MOS INVERTER**12**

Static characteristics-Resistive load inverter - Inverter with n-type MOSFET load - CMOS inverter - Transient characteristics-Delay time definitions, calculation of delay times.

LOGIC DESIGN**12**

Static CMOS Design-Complementary CMOS, Ratioed logic, Pass transistor and transmission gate – Dynamic CMOS logic - CMOS logic - Precharged domino logic- Static Sequential circuits Bistability, CMOS static FF, Dynamic sequential circuits – Pseudo static latch, Dynamic two phase FF, Clocked- CMOS latch, NORA CMOS logic, TSPCL logic.

VLSI BUILDING BLOCKS DESIGN**12**

Adders, Shifters, Arithmetic logic unit design, Multipliers-Array, Carry Save, Wallace tree, Booth's algorithm, Modified Booth's Algorithm. Designing Memory and Array Structures-Memory peripheral circuit.

Total Periods: 45**REFERENCES**

1. Jan M Rabaey, "Digital Integrated Circuits", Prentice Hall, second edition, 2016.
2. Kang, "CMOS Digital integrated Circuits", McGraw Hill, 2016.
3. Neil Weste and David Harris, "CMOS VLSI Design: A Circuits and Systems Perspective", Pearson, 4th edition 2015.
4. Douglas A Pucknell, Kamran Eshraghian, "Basic VLSI Design", PHI learning, New Delhi, 2011.

WEB REFERENCES

1. <https://nptel.ac.in/downloads/117101058/>
2. <https://nptel.ac.in/courses/117106093/>

COURSE OUTCOMES

On Completion of this course the student will be able to,

CO1	Identify the occurrence of faults in digital circuits.
CO2	Generate test pattern for combinational & sequential circuits.
CO3	Explain the concept of testability viz., Ad Hoc design and Scan based design.
CO4	Design testing and testability methods for memory, core-based designs, board level designs and FPGA.
CO5	Describe fault diagnosis methods

INTRODUCTION TO TESTING**9**

Introduction to Testing - Faults in digital circuits - Modeling of faults – Fault detection - Fault location – Fault dominance- Single and Multiple Stuck fault models, Fault variables - Logic Simulation – Types of simulation – Compiled Simulation – Event-Driven Simulation - Delay models.

TEST GENERATION AND DESIGN FOR TESTABILITY**12**

Test generation for combinational logic circuits – Design of testable combinational logic circuits – Test generation for sequential circuits - Design of testable sequential circuits. Testability – Ad Hoc design – Controllability and Observability - Generic scan-based design - Classical scan design – Signature analysis – Compression Techniques.

BIST AND MEMORY TESTING**12**

Built-in self-test -Architectures-Boundary scan standard- Boundary scan architectures for Board level testing-FPGA testing. Memory: Fault models- Test algorithms-BIST architectures for memory –Testable memory design – Test generation for embedded RAM

FAULT DIAGNOSIS**12**

Logical Level Diagnosis – Diagnosis by UUT reduction – Fault Diagnosis for Combinational Circuits– Self-checking design – System Level Diagnosis.

Total Periods: 45**REFERENCES**

1. Wang, Wu and Wen, “VLSI Test Principles and Architectures”, Morgan Kaufmann, 2006.
2. Vishwani D Agarwal, “Essential of Electronic Testing for Digital, Memory and Mixed Signal Circuits”, Springer, 2005.
3. N.K.Jha, S.Gupta, “Testing of Digital systems”, Cambridge university press, 2003.
4. Parag K Lala, “Digital Circuit Testing and Testability”, Academic Press, 1997.
5. Abramovici M, Breuer MA and Friedman AD, “Digital Systems Testing and Testable Design”, Wiley, 1994.

WEB REFERENCES

1. <https://nptel.ac.in/courses/106103016/21>
2. <https://nptel.ac.in/courses/117105137/>

COURSE OUTCOMES

On Completion of this course the student will be able to,

CO1	Design a digital system using verilog HDL.
CO2	Apply verilog coding for logic synthesis.
CO3	Elucidate the different verification techniques, tools, methodologies, and system verilog.

VERILOG HDL BASED PROCESSOR AND CONTROLLER MODEL**9**

Modeling delay- Timing modeling-Timing Assertion-Setup and hold times for clocked devices- Processor model- RAM model- UART model- Interrupt controller

DIGITAL LOGIC SYNTHESIS**12**

Design partitioning- Clock and reset- Timing loop- Blocking and non-blocking statements- Latch inference- Setup and hold time- Meta stability-False path- Multi cycle path- State machine design-Programmable timer design example- Programmable peripheral interface design example.

VERIFICATION TECHNIQUES AND TOOLS**12**

Testing versus verification- Verification and design reuse, Functional verification-Timing verification- Formal verification- Linting tools- Simulators- Third party models- Waveform viewers- Code coverage – Issue- Tracking metrics. Verification plan: Verification plan- Levels of verification strategies- Specification features- Test cases- Test benches.

SYSTEM VERILOG AND VERIFICATION METHODOLOGIES**12**

Basics of C++ - New data types- Classes- Structures and objects- Program blocks- Interfaces- Modports- Clocking blocks-Assertions Test bench automation and constraints. Constrained random verification-UVM Basic SPI/AHB master/slave environment with UVM.

Total Periods: 45**REFERENCES**

1. Chris Spear, "System Verilog for Verification: A Guide to Learning the Test Bench Language Futures", Springer, 3rd Edition, 2012.
2. Sharon Rosenberg and Kathleen A. Meade, "A Practical Guide to adopting the Universal Verification Methodology", Cadence Design Systems, 1st Edition, 2010.
3. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and synthesis", Prentice Hall, 2nd Edition, 2003.
4. Andreas Meyer, "Principles of Functional Verification", Newness, 1st Edition, 2003.
5. Weng Fook Lee, "Verilog Coding for Logic Synthesis", Wiley Interscience, 1st Edition, 2003.

WEB REFERENCES

1. <https://nptel.ac.in/courses/106103182>
2. <https://nptel.ac.in/courses/117/103/117103125/>

COURSE OUTCOMES

On completion of this course, the students will be able to,

CO1	Explain basic equation of semiconductor physics necessary for understanding phenomena related to diode.
CO2	Analyze and model MOS capacitor.
CO3	Explain the noise model in CMOS devices.
CO4	Analyze and model MOSFET and FINFET.

SEMICONDUCTOR PHYSICS AND DIODE MODELLING**12**

Review of Quantum Mechanics – Boltzmann transport equation - Continuity equation - Poisson equation. Junction and Schottky diodes in monolithic technologies – static and dynamic behavior - small and large signal models - SPICE models.

INTEGRATED MOS CAPACITANCE**9**

Band diagram- flat band condition and flat band voltage-surface accumulation, surface depletion-threshold condition and threshold voltage, charge versus gate voltage, MOS C-V Characteristics, Poly Si gate depletion-effective Increase in Tox.

NOISE MODELING**12**

Noise sources in MOSFET, Flicker noise modeling, Thermal noise modeling, model for accurate distortion analysis, nonlinearities in CMOS devices and modeling, calculation of distortion in analog CMOS circuit

INTEGRATED MOS TRANSISTOR**12**

NMOS and PMOS Transistor - Threshold voltage - Threshold voltage equations – MOS device equations - Basic DC equations Second order effects - Small signal AC Characteristics- MOS models SPICE model, EKV Model, BSIM Model. Technology scaling for cost, speed and power consumption, Subthreshold Current –Subthreshold Swing, Threshold voltage Roll Off-Short Channel Leakage, reducing gate insulator electrical thickness And Tunneling Leakage, Short Channel Effects. SOI and Multigate MOSFET - FINFET. MOSFET Compact Model for Circuit Simulation using Verilog.

Total Periods: 45**REFERENCES**

1. Chenming C.Hu, "Modern Semiconductors for Integrated Circuits", Prentice Hall, 2010.
2. Neil Weste and David Harris, "A Circuits and Systems Perspective", Pearson, 2010.
3. Yannis Tsividis, "Operation and modeling of the MOS transistor" Oxford University Press, 2010.
4. Tyagi M S, "Introduction to Semi-conductor Materials and Devices", John Wiley, 2008.
5. Richard S. Muller, Theodore I. Kamins, Mansun Chan, "Device electronics for integrated circuits", John Wiley, 2003.

WEB REFERENCES

1. <https://archive.nptel.ac.in/courses/117/106/117106033/>
2. <http://www.nitttrc.edu.in/nptel/courses/video/117106033/L51.html>

COURSE OUTCOMES

On successful completion of the course, the students will be able to,

CO1 Identify the research problem and state its scope and objectives

CO2 Prepare a report and research proposal after conducting literature survey considering plagiarism and research ethics.

CO3 Outline the types of intellectual property rights

CO4 Administer patent systems and new developments in IPR.

APPROACHES IN RESEARCH**15**

Meaning of research problem, Sources of research problem, criteria characteristics of a good research problem, Errors in selecting a research problem, Scope, and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations. Effective literature studies approaches, analysis. Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

NATURE OF INTELLECTUAL PROPERTY**15**

Patents, Designs, Trade and Copyright. Process of Patenting and development Technical research, innovation, patenting, development. International scenario: International cooperation on intellectual property. Procedure for grants of patents, Patenting under PCT.

PATENT RIGHTS AND DEVELOPMENTS IN IPR**15**

Scope of patent rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. Administration of patent System. New developments in IPR; IPR of biological Systems, Computer software etc., Traditional knowledge case studies, IPR and IITs.

Total Periods: 45**REFERENCES**

1. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
2. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.
3. Halbert, "Resisting Intellectual Property," Taylor and Francis Ltd, 2007.
4. Stuart Melville and Wayne Goddaed, " Research methodology : An introduction for science and engineering students", 1996.
5. Wayne Goddard and Stuart Melville, " Research methodology : An introduction".
6. Ranjit Kumar, 2nd edition, " Research Methodology : A Step by Step Guide for beginners
7. Halbert, "Resisting Intellectual Property," Taylor and Francis Ltd, 2007.
8. Mayall, "Industrial Design ", McGraw Hill, 1992.
9. Niebel, "Product Design", McGraw Hill, 1974.
10. Asimov, "Introduction to Design ", Prentice Hall, 1962.

COURSE OUTCOMES

On Completion of this course the student will be able to,

CO1 Model Sequential and combinational circuits, write test benches, verify the functionality of the design, Interface I/Os and implement the design in FPGA, apply Partial reconfiguration technique.

1. Simulation of CMOS logic circuits.
2. Design and implementation of Power and area optimized Combinational Circuits in Verilog/ VHDL.
3. Design and implementation of High speed Sequential Circuits in Verilog/VHDL
4. Design and implementation of 8 bit general purpose processor in Verilog/VHDL
5. Design and implementation of MAC unit in Verilog/ VHDL
6. Design and implementation of digital filter in Verilog/ VHDL.
7. FPGA Programming and I/O Interfacing.
8. Partial reconfiguration of FPGA with VHDL/Verilog Design files, studying the behavior of FPGA with reconfiguration bits.
9. Design of Memories with Peripherals.
10. Model parameter extraction for diode, BJT, MOSFET.

TOOLS REQUIRED

XILINX/ALTERA/CADENCE/TANNER

Total Periods: 45



SEMESTER II



COURSE OUTCOMES

On completion of this course, the students will be able to,

- CO1** In depth study of DSP filters structures to VLSI implementation.
- CO2** Analyze Pipelining and parallel processing in FIR and IIR systems to achieve high speed and low power.
- CO3** Apply transformation techniques to improve the speed of DSP system.
- CO4** Apply algorithmic strength reduction in the filter structures to enhance speed and to reduce power and area.

REALIZATION OF DIGITAL FILTERS ARCHITECTURES**12**

FIR filter design - IIR filter design - Direct form I, II, Cascade, parallel, Ladder - Lattice filters.

ITERATION BOUND**16**

Introduction, Data flow graph representations, loop bound and iteration bound, Algorithms for computing Iteration bound, iteration Bound of multirate Data - Flow Graphs. PIPELINING AND PARALLEL PROCESSING: Introduction - Pipelining of FIR Digital filters - Parallel processing - Pipelining and parallel processing for Low power.

TRANSFORMATIONS**16**

RETIMING: Introduction - Definitions and Properties - Solving system of Inequalities - Retiming Techniques. UNFOLDING: Introduction - An algorithm for unfolding - Properties of unfolding - Critical path, unfolding and retiming - Application of unfolding. FOLDING: Introduction - folding Transformation - Register Minimization Techniques - Register Minimization in folded Architectures.

FAST CONVOLUTION**16**

Cook-Toom algorithm - modified Cook-Toom algorithm Winograd algorithm- modified Winograd algorithm, Algorithmic strength reduction in filters and transforms-parallel FIR filters, Parallel architectures for Rank-order filter.

Total Periods: 60**REFERENCES**

1. John G Proakis and Dimitris G Manolakis, "Digital signal processing - Principles, Algorithms and Applications" Pearson, 2014.
2. Uwe Meyer Baese, "Digital Signal Processing with Field Programmable Gate Arrays", Springer, 2014.
3. Lonnie C Ludeman, "Fundamentals of Digital Signal Processing", Wiley India (P) Ltd., 2010.
4. Keshab K Parhi, "VLSI Digital Signal Processing Systems Design and Implementation", Wiley - Inter science, 2007.
5. Peter Pirsch "Architectures for Digital Signal Processing", Wiley India (P) Ltd., 2009.

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1. <https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-ee57/>
2. <https://www.digimat.in/nptel/courses/video/108105157/L01.html>

COURSE OUTCOMES

On Completion of this course the student will be able to,

CO1 Explain the concepts of Analog Building blocks and Amplifier Design.

CO2 Design the active filters and realize Switched Capacitor circuits.

CO3 Enumerate the concepts of PLL, Noise models of IC and CMOS circuit techniques.

ANALOG CIRCUIT BUILDING BLOCKS**9**

Switches - Active resistors - Current sources and sinks - Current mirrors / Amplifiers - Voltage and current references.

AMPLIFIERS**9**

Introduction of Comparator- MOS and BJT inverting amplifier-Improving performance of inverting amplifier- CMOS and BJT differential amplifiers-Characterization of Op-Amp -The BJT two Stage op-amp- The CMOS two stage op-amp -Op-amps with output stage.

FILTERS**9**

Low pass filters-High pass filters-Band pass filters. Switched capacitor filters: Switched resistors-comparators sample & hold circuits-integrator.

PLL AND NOISE ANALYSIS**9**

Phase locked loops -Voltage controlled oscillator- Closed loop analysis of PLL- Monolithic PLL design in integrated circuits: Sources of noise- Noise models of integrated-Circuit components - Circuit noise calculations - Equivalent Input Noise Generators - Noise bandwidth - Noise figure and Noise temperature.

CMOS CIRCUIT TECHNIQUES AND LOW VOLTAGE SIGNAL PROCESSING**9**

Introduction: Mixed -signal VLSI chips-basic CMOS circuits-basic gain stage -gain boosting techniques -super MOS transistor-primitive analog cells- MOS multipliers and resistors -CMOS, bipolar and low-voltage BICMOS op-amp design instrumentation amplifier design -low voltage filters.

Total Periods: 45**REFERENCES**

1. Behzad Razavi, "Design of Analog CMOS Integrated Circuits", McGraw-hill, 2nd Edition, 2017.
2. David A. Johns and Ken Martin, "Analog Integrated Circuit Design", John Wiley & Sons; 2nd Edition edition, 2011.
3. Phillip Allen and Douglas Holmberg, "CMOS Analog Circuit Design", Oxford University Press, 3rd Edition, 2011.
4. Randall L. Geiger, Phillip E. Allen and Noel R. Strader, "VLSI Design Techniques for Analog and Digital Circuits", Tata McGraw Hill Education, 1st Edition, 2010.
5. Gray, P.R., Hurst, P.J., Lewis, S.H., and Meyer, R.G., Analysis and Design of Analog Integrated Circuits, John Wiley, 5th Edition, 2009..
6. Mohammed Ismail, Terri Fiez, "Analog VLSI signal and information processing", McGraw-Hill International Edition, 1994.

WEB REFERENCES

1. <https://nptel.ac.in/courses/117101105>
2. <http://www.nitttrc.edu.in/nptel/courses/video/117101105/L26.html>

COURSE OUTCOMES

On completion of this course, the students will be able to,

- CO1** Understand the concepts of Physical Design Process such as partitioning, Floorplanning, Placement and Routing.
- CO2** Discuss the concepts of design optimization algorithms and their application to physical design automation.
- CO3** Understand the concepts of simulation and synthesis in VLSI Design Automation.
- CO4** Formulate CAD design problems using algorithmic methods.

VLSI DESIGN AUTOMATION**9**

VLSI design automation tools- algorithms and system design. Structural and logic design. Transistor level design. Layout design. Verification methods. Design management tools.

LAYOUT COMPACTION, PLACEMENT AND ROUTING**9**

Design rules, symbolic layout. Applications of compaction. Formulation methods. Algorithms for constrained graph compaction. Circuit representation. Wire length estimation. Placement algorithms. Partitioning algorithms.

FLOOR PLANNING AND ROUTING**9**

Floor planning concepts. Shape functions and floor planning sizing. Local routing. Area routing. Channel routing, global routing and its algorithms.

SIMULATION AND LOGIC SYNTHESIS**9**

Gate level and switch level modeling and simulation. Introduction to combinational logic synthesis. ROBDD principles, implementation, construction and manipulation. Two level logic synthesis.

HIGH-LEVEL SYNTHESIS**9**

Hardware model for high level synthesis. Internal representation of input algorithms. Allocation, assignment and scheduling. Scheduling algorithms. Aspects of assignment. High level transformations.

Total Periods: 45**REFERENCES**

1. Sabih H. Gerez, "Algorithms for VLSI Design Automation", Wiley India Pvt. Ltd, 1st Edition, 2006.
2. Sherwani N.A., "Algorithms for VLSI Physical Design Automation", Springer, 3rd Edition, 2005.
3. Sait S M and Youssef H, "VLSI Physical Design Automation", World Scientific, 2004.
4. M.Sarrafzadeh, "Introduction to VLSI Physical Design", McGraw Hill (IE), 1996.

WEB REFERENCES

1. <https://nptel.ac.in/courses/106106088/>
2. https://onlinecourses.nptel.ac.in/noc18_cs06/preview

COURSE OUTCOMES

On completion of this course, the students will be able to,

CO1 Exploration of ASIC design flow from specification to GDSII for different types of analog and digital building blocks using EDA tools.

Specification, Design, synthesis and layout design (floorplanning, place and route, power and clock distribution, clock tree synthesis, timing analysis, power analysis, signal integrity, post-layout simulation and back annotation, GDS-II generation) of digital building block. (Sample digital blocks include Memory design, AHB/AMBA bus architecture, High speed adders/Multipliers, BIST Architecture, etc.,)

Specification, Schematic Design, simulation, layout generation, Physical verification (LVS, DRC, RC extraction, post layout simulation, back annotation, GDS-II generation) of analog building block.(Sample analog blocks include CMOS Inverter, 2 input NAND gate, 3 input NOR Gate, etc.,)

TOOLS REQUIRED

CADENCE

Total Periods: 45



SEMESTER III



COURSE OUTCOMES

On completion of this course, the students will be able to,

- CO1** Choose the techniques, skills, modern engineering tools, software and equipment necessary to evaluate and analyze the systems.
- CO2** Apply advanced knowledge to identify, formulate, design and testing of systems that include both hardware and software.
- CO3** Develop awareness on professional, ethical, legal, security, social issues and develop team work, write effective technical reports and design documentation and develop oral communication skills and finance management.
1. Project phase-I will be an individual effort by every candidate.
 2. The project phase I should be a research gap analysis in the area of interest/specialization.
 3. Project may lead to problem identification statement of project phase II.
 4. There will be three reviews conducted during this semester.
 5. Review committee for the project phase I shall be constituted by the professor in charge
 6. The review committee, constituted by the Head of the department, will evaluate the timely progress of the project work and communicate the observations to the students.
 7. Each student has to prepare and submit the project report at the time of end semester project viva voce examination.



SEMESTER IV



COURSE OUTCOMES

On completion of this course, the students will be able to,

- CO1** Adapt to apply appropriate research methodologies, techniques and tools to analyze and solve engineering problems
- CO2** Design, execution and evaluation of projects on VLSI platforms in tune with industry.
- CO3** Develop potential solutions for contemporary problems after considerations of professional, ethical, public health and safety, societal and environmental factors and convey technical material through formal written reports and demonstrate effective communication skill.

1. Project phase II is carried out under the supervision of a qualified teacher in the concerned department.
2. Qualified teacher means faculty member possessing PhD degree or PG degree with the minimum of three year experience in teaching the PG course.
3. A candidate may be permitted to work on industry project in an industry/research organization on the recommendation of the head of the concerned department. This promotes academic institute- industrial interaction, acquire knowledge and skills from experts in industry and provide solution to the industrial problems. In such cases project phase II shall be jointly supervised by a supervisor of the department and an expert as a joint supervisor from the industry/organization and the students shall be instructed to meet the supervisor periodically.
4. He/she must attend the review committee meeting for evaluating the progress of the project phase II, constituted by the Head of the department. There will be three assessments during the semester by a review committee. The student will make presentation before the committee.
5. The project phase II shall be pursued for the minimum period of 90 working days (16 weeks) during the final semester.
6. Every student shall communicate a paper for publication of their project phase II in a reputed journal or an international conference.
7. If a paper is published/reprints/valid proof shall be attached to project report. If the publication is pending then the acknowledgement from the supervisor/guide for having communicated to the journal or international conference shall be attached to the report of the project. In the absence of such acknowledgement the reports shall not be accepted.
8. Each student has to prepare and submit the project report at the time of end semester project viva-voce examination. The evaluation will be based on the project report and viva-voce examination.
9. A copy of the approved project report shall be kept in the library of the department after successful completion of the viva-voce examination.

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PROFESSIONAL ELECTIVES

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COURSE OUTCOMES

On completion of this course, the students will be able to,

CO1 Examine the principle behind different sources of power dissipation & optimization in CMOS Circuits.

CO2 Design different circuit techniques to reduce power in CMOS circuits.

CO3 Discuss on power estimation techniques and software design for low power.

POWER DISSIPATION IN CMOS**9**

Hierarchy of limits of power - Sources of power consumption - Physics of power dissipation in CMOS, FET devices- Basic principle of low power design.

POWER OPTIMIZATION**9**

Logical level power optimization - Circuit level low power design - Circuit techniques for reducing power consumption in adders and multipliers.

DESIGN OF LOW POWER CMOS CIRCUITS**9**

Computer arithmetic techniques for low power systems - Reducing power consumption in memories - Low power clock, Interconnect and layout design - Advanced techniques - Special Techniques.

POWER ESTIMATION**9**

Power estimation techniques - Logic level power estimation - Simulation power analysis - Probabilistic Power Analysis.

SYNTHESIS AND SOFTWARE DESIGN FOR LOW POWER**9**

Synthesis for low power -Behavioral level transforms- Software design for low power.

Total Periods: 45**REFERENCES**

1. Kaushik Roy and Sharat C Prasad, "Low Power CMOS VLSI circuit design", Wiley-Interscience, 1st Edition, 2000.
2. Dimitrios Soudris, Christian Pignet and Costas Goutis, "Designing CMOS Circuits For Low Power", Kluwer Academic Publishers, 2002 Edition, 2002.
3. Gary Yeap, "Practical low power digital VLSI design", Kluwer Academic Publishers, Illustrated Edition, 1998.
4. James B. Kuo, Jea-hong Lou and Kuo, "Low voltage CMOS VLSI Circuits", Wiley-Interscience, Illustrated Edition, 1999.
5. Chandrakasan A. P. and Brodersen R.W., "Low power digital CMOS design", Kluwer Publishers, 5th Reprint, 2002.
6. James B. Kuo and Shin Chia Lin, "Low voltage SOI CMOS VLSI Devices and Circuits", John Wiley, 1st Edition, 2008.

WEB REFERENCES

<https://nptel.ac.in/courses/106105034/19>.

COURSE OUTCOMES

On completion of this course, the students will be able to,

CO1 Illustrate the concepts and various components in SoC design.

CO2 Explore the bus standards and network on chip architectures in SoC.

CO3 Analyse the implementation methods and challenges in SoC testing.

INTRODUCTION**15**

Components of SoC - Design flow - Driving factors for hardware-software codesign, design space, system specification and modeling- Hardware Software tradeoffs- Co-Design Approaches, System Design Methodologies - Models of Computation- Platform based SoC design - Concepts in Processor Architecture: Instruction set architecture (ISA).

COMMUNICATION ARCHITECTURES**15**

On-chip Buses: Characteristics - Data Transfer Modes - Bus Topology Types - Standard on-chip bus-based communication architectures: AMBA, CoreConnect, STBus, SMART Interconnect, Wishbone, and Avalon - Socket-based on-chip bus interface standards: Open Core Protocol, virtual component interface, and device transaction level - Network-on-chip - Network Topology.

IMPLEMENTATION AND TESTING**15**

System synthesis - Transaction Level Modeling (TLM) based design - Software synthesis - Hardware synthesis - IP based system design: Types of IP, IP Generation - HDL based IPs, Model based IPs and High Level Language based IPs - IP Sources - Built-in IPs, Custom IPs and Third Party IPs. - Real-time operating system (RTOS) - Peripheral Interfacing and Programming - SOC TESTING: Manufacturing test of SoC: Core layer, system layer, application layer-P1500 Wrapper Standardization-SoC Test Automation (STAT).

Total Periods: 45**REFERENCES**

1. Patrick Schaumont "A Practical Introduction to Hardware/Software Co-design", Patrick Schaumont, 2nd Edition, Springer, 2012.
2. Michael J Flynn and Wayne Luk, "Computer system Design: System-on-Chip", Wiley-India, 2012.
3. Sudeep Pasricha and NikilDutt, "On Chip Communication Architectures: System on Chip Interconnect", Morgan Kaufmann Publishers, 2008.
4. Wang, Wu and Wen, "VLSI Test Principles and Architectures", Morgan Kaufmann, 2006.
5. Daniel D. Gajski, Samar Abdi, Andreas Gerstlauer and GunarSchirner, "Embedded System Design: Modeling, Synthesis and Verification", Springer, 2009.

WEB REFERENCES

1. <https://nptel.ac.in/courses/117105137/5>
2. <https://nptel.ac.in/courses/108102045>

COURSE OUTCOMES

On completion of this course, the students will be able to,

CO1 Describe different levels of image processing operations and classify different architectures.

CO2 Discuss the different design aspects of imaging processors, 2D and 3D architectures.

CO3 Explain different algorithms and architectures for video processing.

IMAGE PROCESSING ALGORITHMS**9**

Introduction - Image Processing Tasks- Low level Image Processing Operations - Description of some intermediate level operations - Requirements for Image processor architecture.

IMAGE PROCESSING ARCHITECTURES AND PIPELINED LOW LEVEL IMAGE PROCESSING**9**

Classification of Architectures - Uni and Multi processors - MIMD systems - SIMD systems - Pipelines - Devices for cellular logic processing - Design aspects of real time low level image processors - Design method for special architectures.

PIPELINED ARCHITECTURES & 2D AND 3D IMAGE PROCESSING ARCHITECTURES**9**

Architecture of a cellular logic processing element - Second decomposition in datapath and control - Real time pipeline for low level image processing - Design aspects of Image Processing architectures - Implementation of Low level 2D and 3D and Intermediate level algorithms.

VIDEO PROCESSING ALGORITHMS**9**

Motion Estimation Algorithms - Complexity Analysis Methodology - Complexity analysis of MPEG - 4 Visual - Analysis of Fast Motion Estimation Algorithms.

VLSI ARCHITECTURES FOR VIDEO PROCESSING**9**

General design space evaluation - Design space motion estimation architectures - Motion estimation architectures for MPEG-4 - Design Tradeoffs - VLSI Implementation search engine I and Search engine II.

Total Periods: 45**REFERENCES**

1. Peter M. Kuhn, "Algorithms, Complexity Analysis and VLSI Architectures for MPEG-4 Motion Estimation", Springer US, 1st Edition, 2010.
2. Murat Tekalp A, "Digital Video Processing", Pearson Education, Noida, 1st Edition, 2010.
3. Rafael C. Gonzalez & Richard E. Woods, "Digital Image Processing", Prentice Hall, 3rd Edition, 2007.
4. Pieter Jonker, "Morphological Image Processing: Architecture and VLSI design", Springer US, 1st Edition, 1992.

WEB REFERENCES

1. <https://nptel.ac.in/courses/117105135>

COURSE OUTCOMES

On completion of this course, the students will be able to,

- CO1 Design SRAM and DRAM cells based architectures.
- CO2 Analyze the various architectures of non-volatile memory cells.
- CO3 Examine the reliability issues and radiation effects while designing a memory cell.
- CO4 Illustrate the direction and future of advanced memory and packaging technologies.

RANDOM ACCESS MEMORY TECHNOLOGIES**11**

Static Random Access Memories (SRAM): SRAM cell structures, MOS SRAM Architecture, MOS SRAM cell and peripheral Circuit Operation, SOI Technology, Advanced SRAM Architectures and

Technologies, Application Specific SRAMs. Dynamic Random Access Memories (DRAM): DRAM Technology Development, CMOS DRAM, DRAM cell theory and advanced cell structures, BiCMOS DRAM, soft error failures in DRAM, Advanced DRAM Design and Architecture, Application Specific DRAM.

NON-VOLATILE MEMORIES**12**

Masked ROM, High Density ROMs, Programmable ROM, Bipolar ROMs, CMOS PROMs, Erasable(UV) Programmable ROM(EPROM), Floating Gate EPROM Cell, One time Programmable EPROM (OTPEPROM), Electrically Erasable PROMS, EEPROM Technology and Architecture, Non volatile SRAM, Flash Memories (EPROM or EEPROM), Advanced Flash Memory Architecture.

SEMICONDUCTOR MEMORY RELIABILITY AND RADIATION EFFECTS**11**

General Reliability Issues-RAM Failure Modes and Mechanism-Nonvolatile Memory Reliability. Radiation Effects- Radiation Hardening Techniques-Radiation Hardening Process and Design Issues-Radiation Hardened Memory Characteristics.

ADVANCED MEMORY TECHNOLOGIES**11**

Ferroelectric Random Access Memories (FRAMs)-Analog Memories- Magnetoresistive Random Access Memories (MRAMs)-Experimental Memory Devices. Memory Hybrids and MCMs (2D)- Memory Stacks and MCMs (3D)-Memory MCM Testing and Reliability Issues.

Total Periods: 45**REFERENCES**

1. Jesse Russell and Ronald Cohn, "Content-Addressable Memory", Bookvika Publishing, 2012.
2. Kiyoo Itoh, Masashi Horiguchi and Hitoshi Tanaka, "Ultra-Low Voltage Nano-Scale Memories", Springer, 2007.
3. Ashok K Sharma, "Semiconductor Memories Technology, Testing and Reliability", Wiley, 2002.
4. Ashok K Sharma, "Advanced Semiconductor Memories - Architecture, Design and Applications, Wiley, 2002.
5. Betty Prince, "Emerging Memories - Technologies and Trends", Kluwer Academic Publishers, 2002.

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2. <https://www.digimat.in/nptel/courses/video/108108122/L01.html>

COURSE OUTCOMES

On completion of this course, the students will be able to,

CO1 Analyze and design submicron CMOS circuits and continuous time filters.

CO2 Analyze and design switched capacitor circuits, digital to analog converters and analog to digital converters, oscillators and PLLs.

SUBMICRON CMOS CIRCUIT DESIGN**9**

CMOS Process flow - Capacitors and resistors -Digital circuit design: MOSFET switch - Delay elements -adder- Analog circuit design: Biasing - Op amp Design - Mixed-Signal Layout Issues: Floor Planning- PowerSupply and Grounding Issues- Fully Differential Design- Guard Rings- Shielding -Interconnect.

CONTINUOUS TIME FILTERS**9**

First order filters-Second order filters- Gm-C filters- Transconductors Using Fixed Resistors- CMOS

Transconductors Using Triode Transistors- CMOS Transconductors Using Active Transistors- Bipolar

Transconductors - BICMOS Transconductors - Active RC And MOSFET-C Filters- Tuning Circuitry-Complex Filters.

NONLINEARITY AND SWITCHED CAPACITOR CIRCUITS**9**

Basic building blocks - Basic operation and analysis - Noise in Switched Capacitor Circuits - First-Order Filters- Biquad Filters- Charge Injection- Switched Capacitor Gain Circuits- Correlated Double-Sampling Techniques- Switched capacitor amplifiers - Switched capacitor integrator - Nonlinearity - Mismatch.

DIGITAL TO ANALOG AND ANALOG TO DIGITAL CONVERTERS**9**

Introduction and characterization of DAC - Parallel DAC - Extending the resolution of parallel DAC - Serial DAC- Introduction and characterization of ADC - Serial ADC - Medium ADC - High speed ADC.

OSCILLATORS AND PLLs**9**

Oscillatory system - Ring oscillators - LC oscillators - Voltage Controlled Oscillators (VCO) -Mathematical model of VCO - Simple PLL - Charge pump PLLs - Non ideal effects in PLLs: PFD/CP non idealities - jitter in PLLs - Delay locked loops - PLL applications.

Total Periods: 45**REFERENCES**

1. Tony Chan Carusone, David A. Johns and Ken Martin, "Analog Integrated Circuit Design", John Wiley and Sons, 2nd Edition, 2011.
2. R.J. Baker, H.W. Li, D.E. Boyce, "CMOS Circuit design, Layout, and Simulation", Wiley-IEEE Press, 3rd Edition, 2010.
3. B. Razavi, "Design of Analog CMOS Integrated Circuits", Tata McGraw Hill, 2002.
4. R.J. Baker, "CMOS Mixed-Signal Circuit Design", Wiley Publications, 2002.
5. Phillip E. Allen and Douglas R. Holberg, "CMOS Analog Circuit Design", Oxford University Press, 2002.

COURSE OUTCOMES

On completion of this course, the students will be able to,

CO1 Explain the device architectures and reconfigurable computing architectures.

CO2 Compute program for different types of reconfigurable systems.

CO3 Map design to reconfigurable platforms for FPGA applications.

CO4 Discuss case studies on reconfigurable computing systems and management.

DEVICE ARCHITECTURE

9

General Purpose Computing Vs Reconfigurable Computing - Simple Programmable Logic Devices - Complex Programmable Logic Devices - FPGAs - Device Architecture - Case Studies.

RECONFIGURABLE COMPUTING ARCHITECTURES AND SYSTEMS

9

Reconfigurable Processing Fabric Architectures - RPF Integration into traditional Computing systems - Reconfigurable Computing Systems.

PROGRAMMING RECONFIGURABLE SYSTEMS

9

Compute Models - Programming FPGA Applications in HDL - Compiling C for Spatial Computing - Operating System Support for Reconfigurable Computing.

MAPPING DESIGNS TO RECONFIGURABLE PLATFORMS

9

Technology Mapping - FPGA Placement - Retiming, Repipelining and C-slow Retiming - Configuration Bit stream Generation - Fast Compilation Techniques.

CASE STUDIES OF FPGA APPLICATIONS

9

SPIHT Image Compression, Automatic target recognition systems on reconfigurable devices, Multi-FPGA Systems, Network packet processing in Reconfigurable Hardware. Bioinformatics applications-Dynamic programming algorithms Seed-based Heuristics.

Total Periods: 45

REFERENCES

1. Scott Hauck and Andre Dehon, "Reconfigurable Computing - The Theory and practice of FPGA-Based Computation", Elsevier /Morgan Kaufmann, 1st Edition, 2008.
2. Christophe Bobda, "Introduction to Reconfigurable Computing - Architectures, Algorithms and Applications", Springer, 2007.
3. Maya B. Gokhale and Paul S. Graham, "Reconfigurable Computing: Accelerating Computation with Field-Programmable Gate Arrays", Springer, 2005.
4. Ramachandran Vaidhyanathan and Jerry. L. Trahan "Dynamic Reconfiguration: Architectures and Algorithms", Kluwer Academic publishers, 2003.

WEB REFERENCES

1. <https://nptel.ac.in/courses/117108040>
2. <https://www.coursera.org/lecture/fpga-intro/fpga-configuration-an-overview-KwCvM>

COURSE OUTCOMES

On completion of this course, the students will be able to,

CO1 Explain the architectures and hardware support for AI.

CO2 Discuss on machines for prolog and the computational capabilities for analogue neural networks.

CO3 Implement digital architecture for neural networks.

ARCHITECTURE AND HARDWARE SUPPORT FOR AI PROCESSING**11**

VLSI Design of a 3-D Highly Parallel Message-Passing Architecture - Architectural Design of the Rewrite Rule Machine Ensemble - Dataflow Architecture for AI - Architectural Support of PIM - COLIBRI - CAM Based Architecture for Production System Matching - SIMD Parallelism for Symbol Mapping - Logic Flow in Active Data.

MACHINES FOR PROLOG**11**

Extended Prolog Instruction Set for RISC Processors - VLSI Engine for Structured Logic Programming - Performance Evaluation of a VLSI Associative Unifier in a WAM Based Environment - Parallel Incremental Architecture for Prolog Program Execution - An Architectural Characterization of Prolog Execution - Prolog abstract Machine for Content Addressable Memory.

ANALOGUE NEURAL NETWORKS**11**

Computational Capabilities of Biologically-Realistic Analog Processing Elements - Analog VLSI Models of Mean Field Networks - An Analogue Neuron Suitable for a Data Frame Architecture - Fully Cascadable Analogue Synapses Using Distributed Feedback.

DIGITAL IMPLEMENTATIONS OF NEURAL NETWORKS**12**

Cascadable VLSI Architecture for the Realization of Large Binary Associative Networks - Digital VLSI

Implementations of an Associative Memory Based on Neural Networks - Syntactic Neural Networks in VLSI - VLSI Implementation of a Generic Systolic Synaptic Building Block for Neural Networks.

Total Periods: 45**REFERENCES**

1. Jose G. Delgado-Frias and William R. Moore, "VLSI for Artificial Intelligence and Neural Networks", Springer Science Business Media, LLC, 1991.
2. Mohamed I. Elmasry, "VLSI Artificial Neural Networks Engineering", Springer Science Business Media, LLC, 1994.
3. Sied Mehdi Fakhraie and Kenneth C. Smith, "VLSI - Compatible Implementations for Artificial Neural Networks", Springer Science Business Media, LLC, 1996.

WEB REFERENCES

1. <https://nptel.ac.in/courses/117105084>

COURSE OUTCOMES

On completion of this course, the students will be able to,

CO1 Discuss about different modulation schemes and design parameters relating to receiver front end filter design.

CO2 Design Low Noise Amplifiers, active and passive mixers.

CO3 Design PLL based synthesizers and understands transmitter architectures and amplifiers.

OVERVIEW OF MODULATION SCHEMES**9**

Modulation schemes, Classical channel- Wireless channel description-Path loss-Channel model and envelope fading- Frequency selective and fast fading.

RECEIVER ARCHITECTURES**9**

Receiver front end- filter design, low noise amplifier- wideband LNA design, narrow band LNA-impedance matching- core amplifier.

ACTIVE AND PASSIVE MIXER**9**

Balancing low-frequency and high-frequency case analysis- switching mixer, distortion in unbalanced switching mixer, conversion gain, noise, sampling mixer, distortion, intrinsic and extrinsic noise in single-ended sampling mixer, design methodology.

PHASE/FREQUENCY PROCESSING COMPONENTS**9**

PLL-based frequency synthesizer- phase detector- dividers- Oscillators, Loop filter- first-order, second order higher order filters- design approaches- implementation of a frequency synthesizer with a fractional divider.

TRANSMITTER ARCHITECTURES**9**

Transmitter block end- design philosophy, direct conversion and other architectures- Quadrature LO generator single ended RC- single ended LC- RC with differential stages- divider based generator, power amplifier design specifications, power output control, PA design issues, Class A, AB/B/C/E amplifiers.

Total Periods: 45**REFERENCES**

1. Wei Zhang, "Wireless Receiver Designs: From Information Theory to VLSI Implementation", Proquest, UMI Dissertation Publishing, 2011.
2. Bosco H. Leung, "VLSI for wireless communications" Springer, 2nd Edition, 2011.
3. David Tse and Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge Press, 2005.
4. Emad N. Farag and Mohamed I. Elmasry, "Mixed signal VLSI wireless design- Circuits and systems", Springer, 1st Edition, 2000.
5. Leung Bh., "VLSI for wireless communications", Dorling Kindersley (rs), 1st Edition, 2003.

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1. <https://www.digimat.in/nptel/courses/video/117102062/L03.html>
2. <https://www.digimat.in/nptel/courses/video/117104118/L15.html>

COURSE OUTCOMES

On completion of this course, the students will be able to,

CO1 Identify semiconductor materials based on their structure growth, explain the Epitaxy, oxidation and Lithography process.

CO2 Describe the process of Reactive Plasma Etching, Deposition, Diffusion, ion implantation and Metallization.

CO3 Explain Process simulation, VLSI Process Integration, Analytical, Assembly techniques and Packaging of VLSI Devices

CRYSTAL GROWTH, EPITAXY & OXIDATION**9**

Electronic Grade Silicon, Crystal Defects, Czochralski crystal growing, Silicon Shaping, processing considerations, Vapor phase Epitaxy, Molecular Beam Epitaxy, Silicon on Insulators, Epitaxial Evaluation, Growth Mechanism and kinetics, Thin Oxides, Oxidation Techniques and Systems, Oxide properties, Redistribution of Dopants at interface, Oxidation of Poly Silicon, Oxidation induced Defects.

LITHOGRAPHY AND REACTIVE PLASMA ETCHING**9**

Optical Lithography, Electron Lithography, X-Ray Lithography, Ion Lithography, Plasma properties, Feature Size control and Anisotropic Etch mechanism, reactive Plasma Etching techniques and Equipment.

DEPOSITION, DIFFUSION, ION IMPLEMENTATION & METALLIZATION**9**

Deposition process, Poly silicon, plasma assisted Deposition, Models of Diffusion in Solids, Fick's one dimensional Diffusion Equations - Atomic Diffusion Mechanism - Measurement techniques - Range theory - Implant equipment. Annealing Shallow junctions - High energy implantation - Physical vapor deposition - Patterning.

PROCESS SIMULATION AND VLSI PROCESS INTEGRATION**9**

Ion implantation - Diffusion and oxidation - Epitaxy - Lithography - Etching and Deposition - NMOS IC Technology - CMOS IC Technology - MOS Memory IC technology - Bipolar IC Technology - IC Fabrication.

ANALYTICAL, ASSEMBLY TECHNIQUES AND PACKAGING OF VLSI DEVICES**9**

Analytical Beams - Beam Specimen interactions - Chemical methods - Package types - packaging design considerations - VLSI assembly technology - Package fabrication technology.

Total Periods: 45**REFERENCES**

1. Sze S.M., "VLSI Technology", McGraw Hill, New York, 2nd Edition, 2008.
2. Sorab K. Gandhi, "VLSI Fabrication Principles - Silicon and Gallium Arsenide", Wiley Interscience publications, 2nd Edition, New York, 2009.
3. Wai -Kai Chen, "VLSI Technology", CRC press, Illustrated Edition, 2003.
4. Sze S.M., and Kwok K. Ng., "Physics of Semiconductor Devices", John Wiley and Sons, 3rd Edition, 2008.

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1. <https://archive.nptel.ac.in/noc/courses/noc15/SEM1/noc15-ec02/>
2. <https://archive.nptel.ac.in/courses/117/106/117106093/>

COURSE OUTCOMES

On completion of this course, the students will be able to,

- CO1** Describe multi-rate signal processing and analyze and synthesize filter banks.
- CO2** Design and implement perfect reconstruction filter bank systems.
- CO3** Examine linear estimation prediction and Develop adaptive systems for various applications.
- CO4** Explain the DSP architectures and synthesis.

INTRODUCTION**10**

Sampling and Signal Reconstruction-Sampling rate conversion - Decimation by an integer factor - interpolation by an integer factor -Sampling rate conversion by a rational factor - Multistage design of decimator and interpolator - Applications of Interpolation and decimation in signal.

MULTIRATE FIR FILTER DESIGN**11**

Design of FIR filters for sampling rate conversion -Near perfect reconstruction (NPR) filter banks: Design of uniform and non-uniform cosine modulated filter banks and modified DFT filter banks, Reducing amplitude distortion-meta heuristic optimization techniques Use of Interpolated FIR (IFIR) filters, Multiplier-less filter banks to reduce hardware complexity, implementation.

LINEAR ESTIMATION PREDICTION AND ADAPTIVE FILTERS**12**

Linear prediction- Forward and backward predictions - Levinson-Durbin algorithms - Least mean squared error criterion - Wiener filter for filtering and prediction - FIR Adaptive filters - Newton's steepest descent method - LMS Adaptive algorithm - RLS Adaptive filters - Exponentially weighted RLS - Sliding window RLS - Adaptive filter- Applications: Adaptive channel equalization -Adaptive echo canceller - Adaptive noise cancellation.

DSP ARCHITECTURES AND SYNTHESIS**12**

DSP system architectures - Standard and Ideal DSP architecture - Multiprocessors and multi computers -Systolic and Wave front arrays - Mapping of DSP algorithms onto hardware - Implementation based on complex PEs - Shared memory architecture with Bit - serial PEs - Layout of VLSI circuits - FFT processor - DCT processor and Interpolator as case studies.

Total Periods: 45**REFERENCES**

1. John G. Proakis and Dimitris G. Manolakis, "Digital Signal Processing, Algorithms and Applications", Person Education, 4th Edition, 2008.
2. Monson H. Hayes, "Statistical Digital Signal Processing and modeling", John Wiley and sons, 1st Edition, 2008.
3. P.P.Vaidyanathan, Multirate Systems and Filter Banks, Pearson Education, 2nd Edition 2008.
4. Fredric J Harris, "Multirate Signal Processing for Communication Systems", 1st Edition, Pearson Education, 2007.
5. Sanjit K. Mitra, "Digital Signal Processing - A Computer Based Approach", Tata McGraw Hill Publishing Company Ltd., 4th Edition, 2010.
6. Lars Wanhammar, "DSP Integrated Circuits", Academic press, New York 2001.

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1. <https://archive.nptel.ac.in/courses/108/106/108106136/>
2. https://onlinecourses.nptel.ac.in/noc20_ee21/preview

COURSE OUTCOMES

On completion of this course, the students will be able to,

CO1 Explore parallel processing mechanisms, Memory and I/O subsystem organisations.

CO2 Design and analyse pipelines and vectorization methods.

CO3 Illustrate array processing architectures and design parallel algorithms.

CO4 Develop multiprocessor architectures and analyze their complexities.

PARALLEL PROCESSING MECHANISMS AND MEMORY**12**

Evolution of computer systems. Generation of computer systems - Trends towards parallel processing- Parallel processing mechanisms- parallel computer structure- Architectural classification schemes -Memory and I/O subsystems: Hierarchical Memory structure - Virtual memory system - cache memory management- Memory allocation and management - I/O subsystems.

PIPELINING**10**

Principles - Classification of pipeline processors - Reservation tables - Interleaved memory organization - Design of arithmetic pipeline - Design of instruction pipeline. Vector Processing: Need - Basic vector processing architecture - Issues in vector processing - Vectorization and optimization methods.

ARRAY PROCESSING**11**

Array processing: SIMD Array processors - SIMD interconnection networks - Parallel algorithms for array processors - associative array processing .principles of parallel algorithm design: Design approaches-Design issues- Performance measures and analysis-Complexities-Anomalies in parallel algorithms.

MULTIPROCESSOR ARCHITECTURE**12**

Functional structures - Interconnection network - Multi cache problems and solutions - Exploiting concurrency for multiprocessing. Network Computing: Client/Server Systems-clusters.

Total Periods: 45**REFERENCES**

1. Kai Hwang, "Advanced Computer Architecture", McGraw Hill International, 2012.
2. Dimitrios Soudris, Axel Jantsch, "Scalable Multi-core Architectures: Design Methodologies and Tools", Springer, 2012.
3. William Stallings, "Computer Organization and Architecture - Designing for Performance", Pearson Education, 7th Edition, 2006.
4. John L. Hennessey and David A. Patterson, "Computer Architecture - A quantitative approach", Morgan Kaufmann / Elsevier, 4th Edition, 2007.
5. SeyedRoosta, "Parallel Processing and Parallel Algorithms", Springer Series, 2000.
6. Hesham El-Rewini, Mostafa Abd-El-Barr, "Advanced Computer Architecture And Parallel Processing", John Wiley & Sons, 2005.
7. John P. Shen, "Modern processor design. Fundamentals of super scalar processors", Tata McGraw Hill, 2003.

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1. <http://15418.courses.cs.cmu.edu/spring2017/>
2. <https://nptel.ac.in/courses/106102062/>
3. https://onlinecourses.nptel.ac.in/noc22_cs10/preview

COURSE OUTCOMES

On completion of this course, the students will be able to,

- CO1** Explain the Co-Design approaches for system specification and Hardware/ Software partitioning.
- CO2** Analyze the HW/SW partitioning algorithms and apply the prototyping and emulation techniques for developing architecture.
- CO3** Apply the design verification tool for HW/SW co-design.
- CO4** Use various languages to represent system level synthesis and co-simulation.

SYSTEM SPECIFICATION AND MODELLING**10**

Embedded systems - Hardware/software co-design- Co-design for system specification and modelling- Processor synthesis-Single-processor architectures with one ASIC Single- processor architectures with many ASICs- Multi-processor architectures- Other Co Design Approaches- Comparison of co-design approaches.

HARDWARE/SOFTWARE PARTITIONING AND CO-SYNTHESIS**15**

The hardware/software partitioning problem - Hardware/software cost estimation - Generation of the partitioning Graph - Formulation of the HW/SW partitioning problem - Optimization- HW/SW partitioning based on genetic algorithms.The co-synthesis problem - State-transition graph - Refinement and controller generation - Application study of a fuzzy controller.

PROTOTYPING AND EMULATION**10**

Introduction - Prototyping and emulation techniques- Prototyping and emulation environments- Future developments in emulation and prototyping - Target architecture - Architecture specialization techniques - System communication infrastructure - Target architectures and application system classes - Architectures for control dominated systems - Architectures for data dominated systems - Mixed systems and less specialized systems.

DESIGN SPECIFICATION AND VERIFICATION**10**

Concurrency - Coordinating concurrent computations - Interfacing components -Verification -Design verification- Implementation verification-Verification Tools-Interface verifications.System - level specification-Heterogeneous specification and multi languageco simulation.

Total Periods: 45**REFERENCES**

1. Schaumont, Patrick, "A Practical Introduction to Hardware/ Software Co-Design",2013.
2. Ralf Niemann, "Hardware/Software Co-Design for Data Flow Dominated Embedded Systems", Springer-Verlag, 1st Edition, New York, 2010.
3. Jorgen Staunstrup and Wayne Wolf, "Hardware/Software Co-Design: Principles and Practice", Springer/ BSP Books, Reprint 2007.
4. Giovanni De Micheli and Rolf Ernst Morgon, "Readings in Hardware/Software Co-Design", Morgan Kaufmann Publishers, 1st Edition, 2001.

WEB REFERENCE

1. <https://www.digimat.in/nptel/courses/video/106105159/L01.html>

COURSE OUTCOMES

On completion of this course, the students will be able to,

- CO1 Develop the various cryptographic algorithm implementations in hardware and explore the attacks and countermeasures using side channel analysis.
- CO2 Describe the effects of hardware trojans and methods to mitigate them.
- CO3 Model and test physically unclonable functions
- CO4 Analyze the effects of counterfeiting ICs, mitigation methods and examine the various Intellectual Property (IP) protection techniques.

CRYPTOGRAPHIC ALGORITHMS IMPLEMENTATION AND SIDE CHANNEL ANALYSIS 12

Introduction - Need for hardware security - Basics and vulnerabilities - Design for security - Hardware Implementation of Public-key Cryptographic Algorithm - Private-key Cryptographic Algorithm - Stream Ciphers - Hash Functions - Introduction to Side Channel Analysis - Power Analysis Attack - Timing Attack - Fault Attack - Cache Attack - Scan Chain Based Attack - Design Techniques To Prevent Side Channel Analysis Attacks.

HARDWARE TROJANS 11

Overview - Nomenclature and Operating Modes - Hardware Trojan Detection Techniques - Logic Testing - Countermeasures - Design Technique - Manufacturing Technique.

PHYSICALLY UNCLONABLE FUNCTIONS 11

Introduction - Design Approaches - Modeling of PUFs - Sources of Mismatch and Errors - Testing of PUFs - Practical Realizations - Applications.

COUNTERFEITICS 11

Taxonomies - Assessment - Challenges - Detection and Prevention of Recycled ICs - Path Delay Fingerprinting - Secure Hardware Intellectual Properties: - Need for IP protection - Digital Watermarking - Constraint-based Watermarking to Design IP Protection - Watermarking HDL Source Codes by Duplicating Modules.

Total Periods: 45

REFERENCES

1. Debdeep Mukhopadhyay, Rajat Subhra Chakraborty, "Hardware Security - Design, Threats, and Safeguards", CRC Press, 2015.
2. Mohammad Tehranipoor, Hassan Salmani, Xuehui Zhang, "Integrated Circuit Authentication Hardware Trojans and Counterfeit Detection", Springer, 2014.
3. Christoph Bohm, Maximilian Hofer, "Physical Unclonable Functions in Theory and Practice", Springer, 2013.
4. Mohammad Tehranipoor, Cliff Wang, "Introduction to Hardware Security and Trust", Springer, 2012.
5. Koc K C, "Cryptographic Engineering", Springer, 2009.

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1. <https://archive.nptel.ac.in/noc/courses/noc19/SEM1/noc19-cs24/>
2. <https://archive.nptel.ac.in/courses/106/105/106105194/>
3. <https://www.digimat.in/nptel/courses/video/106105194/L01.html>

COURSE OUTCOMES

On completion of this course, the students will be able to,

- CO1** Brief the trends and levels of electronic systems packaging.
- CO2** Analyze the commonly used and advanced packaging technologies.
- CO3** Identify the electrical design considerations in systems packaging.
- CO4** Illustrate the thermal management and reliability issues in packaging.

OVERVIEW OF ELECTRONIC SYSTEMS PACKAGING**8**

Packaged Electronics - Technologies- Trends- Products and levelsof packaging- Packaging aspects of handheld products.

SEMICONDUCTOR PACKAGING**14**

Basics of Semiconductor and Process flowchart; Wafer packaging; Packaging evolution-Chip connection choices - Wire bonding, TAB and flipchip. Single chip packages or modules (SCM)-. Commonly used packagesand advanced packages; Materials in packages- Advanced packages - Thermal mismatch in packages; Current trends inpackaging- Multichip modules (MCM)-types; System-in package(SIP)- Packaging roadmaps- Hybrid circuits.

ELECTRICAL DESIGN CONSIDERATIONS IN SYSTEMS PACKAGING**12**

Electrical Issues - Resistive Parasitic - Capacitiveand Inductive Parasitic- Layout guidelines and the Reflection problem-Interconnection.

THERMAL MANAGEMENT AND RELIABILITY**11**

Heat-transfer fundamentals-. Thermal conductivity and resistance-Conduction, convection and radiation- Cooling - Reliability- Basic concepts- Environmental interactions- Thermal mismatch and fatigue.

Total Periods: 45**REFERENCES**

1. R.G.Kaduskar and V.B.Baru, "Electronic Product Design", Wiley India, 2011.
2. Tummala, Rao R, "Microelectronics Packaging Handbook", McGraw Hill, 2008.
3. Rao R Tummala, "Fundamentals of Microsystems Packaging", McGraw Hill, NY, 2001.
4. Glenn R. Blackwell, "The Electronic Packaging Handbook", CRC Press, 1999.
5. William D Brown, "Advanced Electronic Packaging", IEEE Press, 1999.

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1. <https://archive.nptel.ac.in/courses/112/105/112105267/>
2. <https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-me61/>



**M.TECH. NANO SCIENCE
AND TECHNOLOGY**



VISION AND MISSION OF THE DEPARTMENT

VISION

To attain global recognition as a Center of Excellence in advanced research. The Programme prepares the graduates to contribute in international Nanotechnology community as the best research talent, promoting entrepreneurship and providing general socioeconomic strength based on Nanotechnology.

MISSION

1. Nanoscience and Technology programme will provide quality interdisciplinary science and engineering education in such a way that, the graduates can advance the frontiers of knowledge in Nanotechnology by developing and transforming them through research and innovations
2. The program will prepare qualified graduates for human capital development towards the discovery of alternative technologies, efficient knowledge transfer and for the creation of societal values and morals

PROGRAMME EDUCATION OBJECTIVES:

- PEOI I:** Lead successful professional careers or engage in higher studies in the broad area of multidisciplinary Nanoscience & Technology and allied specializations at the regional, national and international levels
- PEOI II:** Consider societal, environmental and ethical issues in executing their work and fulfill their professional responsibilities by continuous updating of their knowledge, to themselves, to employers, to employees, to co-workers and to the local & global communities

PROGRAMME OBJECTIVES:

- PO1:** An ability to independently carry out research /investigation and development work to solve practical problems.
- PO2:** An ability to write and present a substantial technical report/document.
- PO3:** Students should be able to demonstrate a degree of mastery over nanoparticles synthesis, characterization.
- PO4:** The ability to conceptualize an idea to fabricate a device or a material which can function towards the area of application based on the choice of nanoparticle and its properties.

PROGRAMME SPECIFIC OUTCOMES:

- PSO1:** Comprehend the properties and applications of Nanotechnology enabled systems using various analytical and modeling tools.
- PSO2:** Implement research oriented knowledge of Nanoscience and Technology in their respective domains.
- PSO3:** Independently resolve real time problems to address the societal requirements.

Curriculum from Semester I to IV

S. No.	Course Code	Course Title	L	T	P	C	Category	CA	EF	Total
SEMESTER I										
THEORY										
1	22NT1101	Mathematical Modeling and Simulation	3	1	0	4	FC	40	60	100
2	22NT1102	Synthesis of Nanostructured Materials	3	0	0	3	PC	40	60	100
3	22NT1103	Introduction to Nanotechnology	3	0	0	3	PC	40	60	100
4	22NT1104	Elements of Materials Science and Properties of Nanomaterials	3	0	0	3	PC	40	60	100
5	22NT1105	Characterization of Nanostructured Materials	3	0	0	3	PC	40	60	100
6	22ME1A004	Research Methodology and IPR	3	0	0	3	EEC	40	60	100
PRACTICALS										
7	22NT1106	Nanotechnology Laboratory – I	0	0	3	2	PC	60	40	100
Total			18	1	3	21		-	-	-
SEMESTER II										
THEORY										
1	22NT1201	Nanostructured Materials for Clean Energy Systems	3	0	0	3	PC	40	60	100
2	22NT1202	Nanofabrication and Lithography Techniques	3	0	0	3	PC	40	60	100
3	22NT1203	Synthesis and Properties of Nanocomposites	3	1	0	4	PC	40	60	100
4	22NT1204	Fundamentals of Quantum Mechanics	3	1	0	4	PC	40	60	100
5	22NT1E*	Elective – I	3	0	0	3	PE	40	60	100
6	22NT1E*	Elective – II	3	0	0	3	PE	40	60	100
7	22EN1001	English for Research Paper Writing	1	0	0	0	AC	GRADE ONLY		
PRACTICALS										
8	22NT1205	Nanotechnology Laboratory – II	0	0	3	2	PC	60	40	100
Total			19	2	3	22		-	-	-
SEMESTER III										
THEORY										
1	22NT1E*	Elective – III(Self Study*)	0	0	0	3	PE	40	60	100
2	22NT1E*	Elective – IV(Self Study*)	0	0	0	3	PE	40	60	100
3	22NT1E*	Elective – V(Self Study*)	0	0	0	3	PE	40	60	100
PRACTICALS										
4	22NT1301	Project Dissertation-I	0	0	6	6	EEC	60	40	100
Total			0	0	6	15		-	-	-
SEMESTER IV										
1	22NT1401	Project Dissertation-II	0	0	21	12	EEC	60	40	100
Total			0	0	21	12		-	-	-

M.Tech Nano Science and Technology

Electives

S. No.	Course Code	Course Title	L	T	P	C	Category	CA	EF	Total
1	22NT1E01	Nano Sensors and Devices	3	0	0	3	PE	40	60	100
2	22NT1E02	Principles of Nanodevices	3	0	0	3	PE	40	60	100
3	22NT1E03	Nano Scale Technologies from VLSI	3	0	0	3	PE	40	60	100
4	22NT1E04	Design and Applications of MEMS and NEMS Technologies	3	0	0	3	PE	40	60	100
5	22NT1E05	Nanomaterials and its Physiochemical Properties	3	0	0	3	PE	40	60	100
6	22NT1E06	Nano Surface Engineering and Nanometerology	3	0	0	3	PE	40	60	100
7	22NT1E07	An Introduction to Biomaterials	3	0	0	3	PE	40	60	100
8.	22NT1E08	Fundamentals on Medical Nanotechnology	3	0	0	3	PE	40	60	100
9.	22NT1E09	Ethics and Challenges in Environmental Nanotechnology	3	0	0	3	PE	40	60	100
10.	22NT1E10	Product Design, Management Techniques and Entrepreneurship	3	0	0	3	PE	40	60	100
11.	22NT1E11	Applications of Nanotechnology	3	0	0	3	PE	40	60	100
12.	22NT1E12	Drug Delivery Systems and its Trends	3	0	0	3	PE	40	60	100
13.	22NT1E13	Coating Techniques and Photovoltaic Applications	3	0	0	3	PE	40	60	100
14.	22NT1E15	Science and Engineering of Corrosion	3	0	0	3	PE	40	60	100
15.	22NT1E16	Molecular Spectroscopy and Applications	3	0	0	3	PE	40	60	100
16.	22NT1E17	Properties and Applications of Ceramic Materials	3	0	0	3	PE	40	60	100
17.	22NT1E18	Magnetic Nanomaterials and Device Applications	3	0	0	3	PE	40	60	100
18.	22NT1E19	Thin Film Process and Technology	3	0	0	3	PE	40	60	100
19.	22NT1E20	Properties and Toxicology of Carbon Nanostructures	3	0	0	3	PE	40	60	100
20.	22NT1E21	Principles of Coating Technology	3	0	0	3	PE	40	60	100
21.	22NT1E22	Smart Biosensor Technology and Future directions	3	0	0	3	PE	40	60	100
22	22NT1E23	Nanofluids and Transport Phenomena	3	0	0	3	PE	40	60	100
23	22NT1E24	Nanomaterials in Wearables	3	0	0	3	PE	40	60	100
23	22NT1E25	Fundamentals and Applications of Biotechnology	3	0	0	3	PE	40	60	100
24.	20NT2E01	Fundamentals and Applications of Nanoscience and Technology	3	0	0	3	OE	40	60	100
25.	20NT2E02	Nanotechnology in Environmental Remediation	3	0	0	3	OE	40	60	100



SEMESTER I



COURSE OUTCOMES

On completion of this course the students will be able to

CO1: Apply the concepts of simulation in the micro and nanoscale

CO2: Utilize differential equations in building simulation models

CO3: Understand the importance of probability theory and hypothesis testing in modelling

UNIT - I INTRODUCTION TO SIMULATION**12**

Basic concepts of simulation - Simulation Terminologies - Advantages and limitations - Application areas - Model Classification - Types of Simulation - Steps in a Simulation study - Concepts in Discrete Event Simulation - Three dimensional models examples - Multiscale modeling

UNIT - II SIMULATION APPROACHES**12**

Basics of Molecular Dynamics Simulation and Applications - Basics of the Monte Carlo method - Algorithms for Monte Carlo simulation - Application to systems of classical particles.

UNIT - III DIFFERENTIAL EQUATIONS & APPLICATIONS**12**

Euler method, Runge - Kutta method, Multi step - Differential equations -Boundary values - Elliptic equations - One dimensional parabolic equation - Hyperbolic equation - Partial differential equations -Separation of variables - Wave equation - Laplace equation.

UNIT - IV RANDOM VARIABLE**12**

Random variable - Probability mass function - Probability density function -Properties - Mean - Variance. Standard Distributions: Binomial, Poisson, Exponential, Normal distributions - Properties.

UNIT - V TESTING OF HYPOTHESIS**12**

Hypothesis testing - Errors in sampling - Large samples: Tests of significance for mean and proportions - Small samples: Tests of significance for mean and variances using 't' and 'F' distributions - Chi square test for independence of attributes and goodness of fit.

Total Periods (45+15T):60**TEXT BOOKS**

1. Law A.L, "Simulation Modeling and Analysis", McGraw Hill, 3rd Edition, 2007.
2. Steven.C.chapra, Raymond P Canale "Numerical Methods for Engineers" - 7th Edition, Tata McGraw Hill Publications, 2015.
3. T Veerarajan, "Probability & Statistics, Random Processes and Queuing theory", Reprint, Tata McGraw Hill Publications, 2019.

REFERENCE BOOKS

1. Banks J, John.S. Carson, Barry C.Nelson and Nicol M, "Discrete Event System Simulation", Prentice Hall, 4th Edition, 2009.
2. Steven.C.chapra, Raymond P Canale "Numerical Methods for Engineers" - 7th Edition, Tata McGraw Hill Publications, 2015.
3. Frenkel D and Smith B, "Understanding molecular simulation from algorithm to applications", Academic Press, 2002.
4. Ohno K, Esfarjani K and Kawazoe Y, "Computational Materials Science from Ab initio to Monte Carlo Methods", Springer-Verlag, 1999.

WEB REFERENCE

1. <https://nptel.ac.in/courses/111107113>
2. <https://nptel.ac.in/courses/112107214>

RESEARCH & REVIEW PAPERS

1. Priya Gumber, Moh Yaseen, Sawan Kumar Rawat, Manoj Kumar, Heat transfer in micropolar hybrid nanofluid flow past a vertical plate in the presence of thermal radiation and suction/injection effects, Partial Differential Equations in Applied Mathematics, 5 (2022) 100240.
2. J. Ssebuliba, J.N. Nakakawa, A. Ssematimba, J.Y.T. Mugisha, Mathematical modelling of COVID-19 transmission dynamics in a partially comorbid community, Partial Differential Equations in Applied Mathematics, 5 (2022) 100212.
3. Kumbinarasaiah S., Manohara G., A novel approach for the system of coupled differential equations using clique polynomials of graph, Partial Differential Equations in Applied Mathematics, 5 (2022) 100181.
4. Alexei G. Kushner, Ruslan I. Matviichuk, Dynamics and exact solutions of non-evolutionary partial differential equations, Differential Geometry and its Applications, 76 (2021) 101761.

COURSE OUTCOMES

On Completion of this course the students will be able to

CO1: Understand the various methods of preparation of nanoparticles

CO2: Elucidate the critical adjustments to be made in the preparation of the nanomaterials

CO3: Perform manipulation to the various parameters responsible for the fabrication of monodisperse and uniform nanostructures

UNIT - I NUCLEATION AND GROWTH OF NANOPARTICLES**9**

Various preparation techniques -Basic concepts of nano structured materials - Nucleation : surface nucleation growth - Grain size distribution - Nano particle transport in low density media - Vapour nano phase thermodynamics - Coagulation of nano particles, determination of grain size - Aggregate formation - Mass fractal morphologies - Bottom up approach & Top-down approach

UNIT - II PHYSICAL METHODS**9**

Thermal beam evaporation, Electron beam evaporation, Arc discharge, RF-Sputtering, DC-Sputtering; Epitaxial growth - MBE; Plasma arc technique - Electric explosion of wires, ball milling.

UNIT - III CHEMICAL METHODS**9**

Nanocrystals by chemical reduction - Photochemical synthesis - Electrochemical synthesis -Nanocrystals of semiconductors and other materials by arrested precipitation - Emulsion synthesis - Sonochemical routes.

UNIT - IV THERMOLYSIS ROUTE**9**

Spray pyrolysis - Flame pyrolysis - Solvated metal atom dispersion - Sol-gel method - Solvothermal and hydrothermal routes - Solution combustion synthesis - Chemical vapor synthesis

UNIT - V BIOLOGICAL METHODS**9**

Bacteria- Magnetotactic bacteria for natural synthesis of magnetic nano-particles - Fungi - Actinomycetes for nano particle synthesis- Plant Mediated Nanoparticle synthesis

Total Periods (45L): 45**TEXT BOOKS**

1. Rao C.N.R, Muller.A and Cheetham A.K, "The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Volume-I and II", John Wiley & Sons Inc, 2005.

REFERENCE BOOKS

1. Lalena J.N, Cleary D.A, Carpenter E.E., N.F. Dean, "Inorganic Materials Synthesis and Fabrication" John Wiley & Sons Inc, 2007.
2. Ajayan P.M, Schadler L.S, Braun P.V, "Nanocomposite science and technology" Wiley-VCH, Verlag, Weinheim, 2003.

3. Waser R, "Nanoelectronics and information technology: Advanced electronic materials and novel devices" Second Edition, Wiley- VCH Verlag, Weiheim, 2005.
4. Poole Jr C.P, and Owens F.J, "Introduction to Nanotechnology" Wiley India Pvt Ltd, 2003
5. Balakrishna Rao.M and Krishna Reddy K, "Encyclopedia of Nanotechnology", Vol I to X, Campus Books, 2007.

WEB REFERENCES

1. NPTEL, Nanotechnology materials synthesis and applications: <https://nptel.ac.in/courses/118102003/>

RESEARCH & REVIEW PAPERS

1. James A. Oke, Olufunsho O. Olotu, Tien-Chien Jen, Atomic layer deposition of chalcogenide thin films: processes, film properties, applications, and bibliometric prospect, *Journal of Materials Research and Technology*, 20 (2022) 991-1019.
2. Nicola Calisi, Emanuele Galvanetto, Francesca Borgioli, Stefano Mauro Martinuzzi, Tiberio Bacci, Stefano Caporali, Thin films deposition of fully inorganic metal halide perovskites: A review, *Materials Science in Semiconductor Processing*, 147 (2022) 106721
3. B. Amudhavalli, R. Mariappan, M. Prasath, Synthesis chemical methods for deposition of ZnO, CdO and CdZnO thin films to facilitate further research, *Journal of Alloys and Compounds*, 925 (2022) 166511.
4. James A. Stewart, Recent progress on the mesoscale modeling of architected thin-films via phase-field formulations of physical vapor deposition, *Computational Materials Science*, 211 (2022) 111503.

COURSE OUTCOMES

On completion of this course, the students will be able to

CO1: Comprehend the various fundamental aspects of atoms like bonding, properties, forces, etc.

CO2: Relate the theory of thermodynamics with nanomaterial synthesis and formation

CO3: Understand and relate the theories of basic physics of surface changes in nanomaterials

UNIT - I INTRODUCTION**9**

Classification of nanostructures - Nanoscale architecture; Summary of the electronic properties of atoms and solids - The isolated atom - Bonding between atoms - Molecular and atomic size - Giant molecular solids - The free electron model and energy bands - Crystalline solids - Periodicity of crystal lattices - Electronic conduction.

UNIT-II INTERMOLECULAR FORCES**9**

Strong intermolecular forces - Van der waals and electronic forces between surfaces - Similarities and differences between intermolecular and interparticle forces - covalent and coulomb interactions - interactions involving polar molecules and polarization Weak intermolecular forces and total intermolecular pair potentials

UNIT - III CLASSIFICATION OF NANOSYSTEMS**9**

Definition of a nanosystem - Dimensionality and size dependant phenomena; Carbon based nanomaterials; Quantum dots, nanowires and nanotubes, 2D films; nano and meso pores - Size dependant variation in magnetic, electronic transport, reactivity etc.; Metal based nanomaterials (Metal nanoparticles and Metal oxide nanoparticles), Nano composites, Nano Polymers and Nano Ceramics.

UNIT - IV THERMODYNAMIC BASICS OF NANOSTRUCTURE FORMATION**9**

Introductory concepts of thermodynamics- Laws of thermodynamics, Enthalpy, Entropy, Free energy; Nucleation - Homogeneous and heterogeneous nucleation- Growth controlled by diffusion, Growth controlled by surface process; Fundamentals of thin film deposition.

UNIT - V SOLID SURFACES**9**

Introduction - Surface energy; Electrostatic Stabilization - Surface stress, Surface defects, Surface charge density, Electric potential at the proximity of solid surface, Fraction of Surface atoms, Vander waals attraction potential, DLVO theory - Steric Stabilization, Mixed Steric & electric interactions.

Total Periods (45L): 45**TEXT BOOKS**

1. G. Z. Cao, Y. Wang, "Nanostructures & Nanomaterials: Synthesis, Properties & Applications", World Scientific Publishing, Singapore, 2nd Edition, 2011.
2. T. Pradeep, "A Text book of Nanoscience & Technology", Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2012.

REFERENCE BOOKS

1. M. Wilson, K. Kannangara, G. Smith, M. Simmons, B. Raghuse, "Nanotechnology: Basic Science & Emerging Technologies", Chapman & Hall/CRC, Washington DC, 1st Edition, 2002.
2. C. P. Poole, F. J. Owens, "Introduction to Nanotechnology" John Wiley & Sons, First Edition, New Jersey, 2011.
3. T. Pradeep, "Nano: The essentials- Understanding Nanoscience & Technology" Tata McGraw Hill, New Delhi, 2007.
4. H. S. Nalva, "Nanostructured Materials & Nanotechnology" Academic Press, Tokyo, Concise edition, 2007.
5. R. W. Kelsall, I. W. Hamley, M. Geoghegan, "Nanoscale Science & Technology", John. Wiley & Sons, UK, 1st Edition, 2005.

WEB REFERENCES

1. Introduction to Nanotechnology, <https://nptel.ac.in/courses/118102003/>, IITD 2014
2. Introduction to Nanomaterials, <https://nptel.ac.in/courses/118104008/6>, IITK 2014

RESEARCH & REVIEW PAPERS

1. Angel Barranco, Ana Borrás, Agustín R. González-Elipé, Alberto Palmero, Perspectives on oblique angle deposition of thin films: From fundamentals to devices, *Progress in Materials Science*, 76 (2016) 59-153.
2. Shuang Zhu, Huan Meng, Zhanjun Gu, Yuliang Zhao, Research trend of nanoscience and nanotechnology - A bibliometric analysis of *Nano Today*, *Nano Today*, 39 (2021) 101233
3. Subhranshu Sekhar Samal, S.R. Manohara, Nanoscience and Nanotechnology in India: A broad perspective, *Materials Today: Proceedings*, 10 (2019) 151-158.

COURSE OUTCOMES

On completion of this course the students will be able to

CO1: Illustrate the fundamentals of crystal and density of energy states in bulk and nano structures.

CO2: Explain the semiconducting, dielectric and optical properties of materials.

CO3: Describe the electrical and magnetic phenomenon of materials.

UNIT - I INTRODUCTION**9**

Atomic structure - Atomic bonding in solids - Crystalline state of solids - Unit cells and Space lattices - Crystal structures - Crystal planes and directions - Miller Indices - Diffraction of X-rays by crystal - Bragg's equation - Debye Scherrer equation - Particle size - Reciprocal lattice - Crystal Defects - Point, line and surface defects.

UNIT - II SEMICONDUCTORS AND THEIR PROPERTIES**9**

Fermi - Dirac distribution function - Variation of Fermi function with temperature - Density of states - Band model of semiconductors - Intrinsic and extrinsic semiconductors - carrier concentrations in intrinsic and extrinsic semiconductors - Fermi level - Variation of conductivity and mobility with temperature - Quantum confinement in nanostructures.

UNIT - III DIELECTRIC AND OPTICAL PROPERTIES**9**

Static dielectric constant - Electronic, ionic and orientation polarizations - Dielectric losses - Frequency dependence of electronic, ionic and orientation polarizabilities - Local field or internal field - Clausius-Mosotti relation - Optical absorption - Luminescence - Electro luminescence - Cathodoluminescence - Applications.

UNIT - IV FERROELECTRIC AND PIEZOELECTRIC MATERIALS**9**

General properties - Classification of ferroelectric materials - Dipole theory of ferroelectricity - Ferroelectric domains - Applications - Super Capacitors - Piezoelectric materials and applications - Nanodomain Engineering - Nanotweezers - Nanorobots.

UNIT - V MAGNETIC PROPERTIES**9**

Diamagnetism - Paramagnetism - Ferromagnetism - Domain theory - Magnetic hysteresis - Weiss molecular field theory - Heisenberg's theory - Magnetic anisotropy - Domain walls - Exchange energy - Antiferromagnetism - Hard and soft magnetic materials - Garnets magnetic bubbles - Magnetic resonance - EPR and NMR.

Total Hours (45L): 45**TEXT BOOK**

1. Kittel C., "Introduction to Solid State Physics" Wiley Eastern Ltd., 8th Edition, 2005.

REFERENCE BOOKS

1. Dekker A. J., "Solid State Physics", Macmillan & Co., 2000.
2. Callister W. D., "Materials Science and Engineering: An Introduction", John Wiley & Sons, 7th Edition, 2007.

3. Raghavan V, "Materials Science and Engineering: A First Course", Prentice Hall, 5th Edition, 2006.
4. Shur M, "Physics of Semiconductor Devices", Prentice Hall of India, 1995.
5. Pillai S.O, "Solid State Physics" New age international Ltd., 6th Edition, 2002

WEB REFERENCE

1. <https://nptel.ac.in/courses/118104008>

RESEARCH & REVIEW PAPERS

1. A. Alqahtani, H.A. Yakout, E.R. Shaaban, Ammar Qasem, Extended study into the prominence of aluminum content in controlling optical parameters, thermal properties, electrical conductivity and dielectric behavior of amorphous Al-Se-Te thin films for optoelectronic applications, Optics & Laser Technology, 156 (2022) 108459.
2. Xi Zhang, Ming Liu, Yi Fu, Kai Kang, Xin Ding, Jianquan Yao, Zhiyong Wang, Liang Wu, Dielectric property and tunability of multilayer BST-BTO thin film in the terahertz range, Optics & Laser Technology, 155 (2022) 108366.
3. Jicheng Fang, Qingshan Xu, Yuanxing Xia, Lele Fang, Research on super-capacitor fast power control system, Energy Reports, 8 (2022) 710-717.
4. Shashank Bhushan Das, Rakesh Kumar Singh, Vivek Kumar, Nishant Kumar, Pallavi Singh, Naman Kumar Naik, Structural, magnetic, optical and ferroelectric properties of Y³⁺ substituted cobalt ferrite nanomaterials prepared by a cost-effective sol-gel route, Materials Science in Semiconductor Processing, 145 (2022) 106632.

COURSE OUTCOMES

On completion of this course the students will be able to

CO1: Define the theoretical principles behind various characterization techniques such as spectroscopic, thermal, electrical, surface, etc.

CO2: Apply the suitable characterization technique to analyze nanoparticles and correlate the theoretical principles behind analytical data

CO3: Illustrate the methodology of various analyses used and compare that with the other types of characterization techniques

UNIT - I COMPOSITIONAL AND STRUCTURAL CHARACTERIZATION TECHNIQUES 9

Principles and applications of X-ray diffraction - electron diffraction - Energy Dispersive X-ray analysis (EDAX) - X-ray Photoelectron Spectroscopy (XPS) - Electron probe microanalysis (EPMA) - Ion beam techniques: SIMS & RBS.

UNIT - II SURFACE CHARACTERIZATION TECHNIQUES 9

High resolution optical microscopy - Scanning electron microscopy (SEM) - Transmission electron microscopy (TEM) - Atomic force microscopy (AFM) - Scanning tunneling microscopy (STM) - Nano indentation technique - Quartz Crystal Microbalance

UNIT - III SPECTROSCOPIC TECHNIQUES 9

Fourier Transform infrared (FTIR) spectroscopy - Photon Correlation Spectroscopy - Raman spectroscopy techniques: micro Raman and laser Raman; UV-Visible - XAFS - ARPES techniques - Electron Energy Loss Spectroscopy - Auger Electron Spectroscopy - Circular Dichroism.

UNIT - IV ELECTRICAL CHARACTERIZATION TECHNIQUES 9

Measurement of resistivity by 4-probe method - Hall measurement - Seebeck coefficient measurements - Electron beam induced current measurement (EBIC) - Impedance and ferroelectric measurements.

UNIT - V THERMAL AND MAGNETIC CHARACTERIZATION 9

Thermal analysis - TGA - DTA - DSC - VSM - SCQUID techniques.

Total Hours (45L): 45

TEXT BOOKS

1. Z. L. Wang, "Characterization of nanophase materials", Wiley Interscience International, 2001.
2. E. R. Pike, J. B. Abbiss, "Light Scattering and Photon Correlation Spectroscopy", Springer, The Netherlands, 1997.

REFERENCE BOOKS

1. C. Suryanarayana, "A practical approach to X-Ray diffraction analysis", Springer, 1998.
2. J. I. Goldstein, "Scanning electron microscopy and X-Ray microanalysis", Wiley, 2003.

3. D. A. Skoog, "Principles of Instrumental analysis", Richard and Winston, Second edition, 1980.
4. T. Pradeep, "Nano: The Essentials-Understanding Nano Science and Nanotechnology" Tata Mc.GrawHill, 2007.
5. C. L. Poole, "Introduction to Nano Technology" Owens, Wiley India Pvt Ltd, 2003 .
6. G. A. Ozing, A. C. Arsenault, L. Cademartiri, "Nanochemistry: A Chemical Approach to Nanomaterials", 2nd Edition, RSC, 2009.

WEB REFERENCES

1. Nanostructures and Nanomaterials: Characterization and Properties, <https://freevideolectures.com/course/3400/nanostructures-and-nanomaterials-characterization-and-properties>

RESEARCH & REVIEW PAPERS

1. Eileen McCarron, Gordon Chambers, A review of suitable analytical technology for physio-chemical characterisation of nanomaterials in the customs laboratory, *Talanta Open*, 4 (2021) 100069.
2. Óscar Cebadero-Domínguez, Angeles Jos, Ana M. Cameán, Giorgiana M. C?tunescu, Hazard characterization of graphene nanomaterials in the frame of their food risk assessment: A review, *Food and Chemical Toxicology*, 164 (2022) 113014.
3. Faris Matakah, Ayman Ababneh, Ruba Aqel, Effects of nanomaterials on mechanical properties, durability characteristics and microstructural features of alkali-activated binders: A comprehensive review, *Construction and Building Materials*, Volume 336 (2022) 127545.
4. De Wang, Jianfeng Zhang, Ruya Cao, Yingzi Zhang, Jiaying Li, The detection and characterization techniques for the interaction between graphene oxide and natural colloids: A review, *Science of The Total Environment*, 808 (2022) 151906

COURSE OUTCOMES

CO1: Identify the research problem and state its scope and objectives

CO2: Prepare a report and research proposal after conducting literature survey considering plagiarism and research ethics.

CO3: Outline the types of intellectual property rights

CO4: Administer patent systems and new developments in IPR.

UNIT - I APPROACHES IN RESEARCH**15**

Meaning of research problem, Sources of research problem, criteria characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations. Effective literature studies approaches, analysis. Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT - II NATURE OF INTELLECTUAL PROPERTY**15**

Patents, Designs, Trade and Copyright. Process of Patenting and development Technical research, innovation, patenting, development. International scenario: International cooperation on intellectual property. Procedure for grants of patents, Patenting under PCT.

UNIT - III PATENT RIGHTS AND DEVELOPMENTS IN IPR**15**

Scope of patent rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. Administration of patent System. New developments in IPR; IPR of biological Systems, Computer software etc., Traditional knowledge case studies, IPR and IITs

Total Hours (45L): 45**TEXT BOOKS**

1. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016
2. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.
3. Halbert, "Resisting Intellectual Property," Taylor and Francis Ltd, 2007.

REFERENCE BOOKS

1. Stuart Melville and Wayne Goddaed, " Research methodology : An introduction for science and engineering students "
2. Wayne Goddard and Stuart Melville, " Research methodology : An introduction"
3. Ranjit Kumar, 2nd edition, " Research Methodology : A Step by Step Guide for beginners "
4. Halbert, "Resisting Intellectual Property," Taylor and Francis Ltd, 2007.

COURSE OUTCOMES

On Completion of this course, the students will be able to

CO1: Understand about the various routes of synthesis of nanoparticles

CO2: Perform basic characterization of the synthesized nanoparticles

CO3: Perform in-silico experiments using simulation software

List of experiments

1. Synthesis of iron oxide nanoparticles by co precipitation and analysis by UV-Vis Spectroscopy and size evaluation by DLS
2. Silver nanoparticles synthesis by wet chemical and evaluation of SPR by UV-Vis Spectroscopy and size evaluation by DLS
3. Zinc oxide by chemical reduction and characterization by UV-Vis Spectroscopy UV-Vis Spectroscopy and size evaluation by DLS
4. Bio synthesis of silver nanoparticles and evaluation by UV-Vis Spectroscopy and size evaluation by DLS
5. Ball mill size reduction of TiO₂ nanoparticles and analysis of size by DLS
6. Combustion synthesis of Copper Oxide nanoparticles and confirmation by UV-Vis Spectroscopy and size evaluation by DLS
7. Linear algebra Matrix manipulation
8. Simulation of Ordinary Differential equation



SEMESTER II



COURSE OUTCOMES

On completion of this course the students will be able to

CO1: Recognize the importance of improvisation in energy transport, conversion and storage techniques along with the working mechanisms of various nano based energy products

CO2: Acquire a sharp knowledge on nanotechnology based alternate energy sources with importance to solar energy

CO3: a. Identify hydrogen as an alternative to fossil fuels

b. Illustrate various methods for production, storage and utilization of hydrogen fuel.

UNIT - I NANOTECHNOLOGY IN RENEWABLE ENERGY SYSTEMS**9**

Energy challenges - Environmental Impact - Development and implementation of renewable energy technologies - Nanotechnology enabled renewable energy technologies - Energy transport, conversion and storage.

UNIT - II ENERGY SECTOR PRODUCTS USING NANOMATERIALS**9**

Organic Light emitting diodes - Catalytic reactors - Super capacitors - Batteries - Redox flow batteries - Microfluidic systems - Nano engines - Biogas - Biodiesel.

UNIT - III SOLAR ENERGY TECHNOLOGY**9**

Electromagnetic spectrum - Availability of solar radiation - Photovoltaic devices - Silicon technology for solar cells - First generation, second generation and third generation solar cells - Photoelectrochemical cells for hydrogen production - Flexible solar cells - Semi-transparent solar cell - Applications of Solar cells

UNIT - IV FUEL CELL TECHNOLOGY**9**

Fuel cell technologies - Integration and performance for micro - Fuel cell systems - Thin film and microfabrication methods - Design methodologies - Micro-fuel cell power sources.

UNIT - V HYDROGEN STORAGE TECHNOLOGY**9**

Hydrogen storage methods - Metal hydrides - Hydrogen storage capacity - Hydrogen reaction kinetics - Carbon-free cycle - Gravimetric and volumetric storage capacities - Hydriding/dehydriding kinetics - High enthalpy of formation - Thermal management during the hydriding reaction- Degradation of the sorption properties - Hydride storage materials for automotive applications.

Total Hours (45L): 45

TEXT BOOKS

1. Twidell. J, Weir. T, "Renewable Energy Resources", E & FN Spon Ltd, 2nd Edition 1986.
2. Shatwell. R.A, "Fuel Storage on Board Hydrogen Storage in Carbon Nanostructures - in Fuel cell technology handbook", CRC Press, 2003.

REFERENCE BOOKS

1. Hoogers.G, "Fuel cell technology handbook", CRC Press, 2003.

2. Vielstich L, "Handbook of fuel cells: Fuel cell technology and applications", CRC Press, 2003.
3. Leon F, "Renewable Energy in Power Systems", Wiley, 2008.
4. Kreith.J.F, Solar Energy Handbook: McGraw Hill, 1981.

WEB REFERENCES

1. <http://ocw.mit.edu/2-627F11>
2. <https://nptel.ac.in/courses/108105058>

RESEARCH & REVIEW PAPERS

1. Katherine Moore, Wei Wei, Applications of carbon nanomaterials in perovskite solar cells for solar energy conversion, Nano Materials Science, 3, (2021) 276-290.
2. Tina Kegl, Anita Kova? Kralj, Breda Kegl, Marko Kegl, Nanomaterials as fuel additives in diesel engines: A review of current state, opportunities, and challenges, Progress in Energy and Combustion Science, 83 (2021) 100897.
3. Chingis Daulbayev, Bakhytzhana Lesbayev, Baglan Bakbolat, Bayan Kaidar, Fail Sultanov, Mukhtar Yeleuov, Gauhar Ustayeva, Nurgali Rakhymzhan, A mini-review on recent trends in prospective use of porous 1D nanomaterials for hydrogen storage, South African Journal of Chemical Engineering, 39 (2022) 52-61.

COURSE OUTCOMES

On completion of this course, the students will be able to

CO1: Understand the importance of clean environment needed for the lithography and basic techniques in pattern formation.

CO2: Summarize and compare advanced lithography techniques and its types

CO3: Employ studies on mechanical method for pattern creation under lithography

UNIT - I PATTERNING OF THIN FILMS**9**

Introduction - Necessity for a clean room - Protocol - Different types of clean rooms - Construction and maintenance of a clean room - Lithography - Optical lithography - Optical projection lithography - Multistage scanners resolution - Photomask - Binary mask - Phase shift mask - Attenuated phase shift masks - Alternating phase shift masks - Off axis illumination - Optical proximity correction - Optical immersion lithography - Optical interferometric lithography - Holographic lithography - Roll to roll printing.

UNIT - II MASKLESS OPTICAL LITHOGRAPHY**9**

Maskless optical projection lithography - Zone plate array lithography - Extreme ultraviolet lithography.

UNIT - III ELECTRON BEAM LITHOGRAPHY**9**

Scanning electron beam lithography - Maskless EBL - Parallel direct - Write e-beam systems - Electron beam projection lithography - Scattering with angular limitation projection e-beam lithography - Projection reduction exposure with variable axis immersion lenses.

UNIT - IV X-RAY LITHOGRAPHY**9**

Ion beam lithography - Focused ion beam lithography - Ion projection lithography - Projection focused ion multi-beam - Masked ion beam lithography - Masked ion beam direct structuring - Atom lithography.

UNIT - V NANOIMPRINT LITHOGRAPHY AND SOFT LITHOGRAPHY**9**

Nanoimprint lithography (NIL) - NIL - Hot embossing - UV - NIL - Soft lithography - Moulding / Replica moulding: Printing with soft stamps - Edge lithography - Dip-Pen Lithography - Setup and working principle - Etching techniques- (RIE) Reactive Ion Etching - Magnetically enhanced RIE - (IBE) Ion beam etching - Other etching techniques.

Total Periods (45L):45**TEXT BOOK**

1. Poole C.P. Jr, "Introduction to Nanotechnology", Wiley Interscience, 2003.

REFERENCE BOOKS

1. Tai Ran - Hsu, "MEMS and Microsystems, Design, Manufacture and Nanoscale Engineering", John Wiley & Sons, 2008.
2. Gentili M, Giovannella .C, Selci S., "Nanolithography: A Borderland between STM, EB, IB and X-Ray Lithographies" (NATO ASI Series), Kluwer Academic Publishers, 1994.

3. Sulabha K. "Nanotechnology: Principles and Practices", Capital publishing Company, 2007.
4. Schiff.H., "Fabrication of polymer photonic crystals using nano imprint lithography", Nanotechnology 16: 261-265, 2005.
5. Dhaliwal D.S, PREVAIL: "Electron projection technology approach for next generation lithography", IBM Journal Res. & Dev. 45, 615, 2001.
6. Madou.M, "Fundamentals of Microfabrication", CRC Press Newyork, 1997.

WEB REFERENCE

1. NPTEL, Lithography - <https://nptel.ac.in/courses/103106075/3>

RESEARCH & REVIEW PAPERS

1. Nan Jiang, Dong Su, John C.H. Spence, Local electric field direct writing - Electron-beam lithography and mechanism, Microelectronic Engineering, 182 (2017) 8-14
2. Lei Wu, Kedong Shang, Tingting Chen, Chengqiang Feng, Tingting Yang, Zhi-Jun Zhao, Bingjun Yu, Linmao Qian, Template-free lithography for cross-scale channels towards enhancing nanofluidic devices, Sensors and Actuators B: Chemical, 372 (2022) 132642.
3. Ryota Akama, Takao Okabe, Kazuyoshi Sato, Yoshiki Inaba, Naoki Shikazono, Anna Sciazko, Jun Taniguchi, Fabrication of a micropatterned composite electrode for solid oxide fuel cells via ultraviolet nanoimprint lithography, Microelectronic Engineering, 225 (2020) 111277
4. Gerry Hamdana, Prabowo Puranto, Jannick Langfahl-Klabes, Zhi Li, Frank Pohlenz, Min Xu, Tony Granz, Maik Bertke, Hutomo Suryo Wasisto, Uwe Brand, Erwin Peiner, Nanoindentation of crystalline silicon pillars fabricated by soft UV nanoimprint lithography and cryogenic deep reactive ion etching, Sensors and Actuators A: Physical, 283 (2018) 65-78.

COURSE OUTCOMES

On completion of this course, the students will be able to

CO1: Explain the structure of nanocomposites and design methods.

CO2: Design the various nanocomposite synthesis techniques

CO3: Infer the optical, electrical and mechanical properties of nanocomposites

UNIT - I INTRODUCTION**12**

Nanocomposites - Composite material - Components of Nanocomposites - Mechanical properties of nanocomposites - Stress-strain relationship - Toughness - Strength - Plasticity

UNIT - II NANOCOMPOSITES DESIGN**12**

Ceramic/Metal Nanocomposites - Metal matrix nanocomposites - Carbon based nanocomposites - Polymer based nanocomposites - Natural Nanobiocomposites - Biologically Inspired Nanocomposites - Nanoporous structures

UNIT - III SYNTHESIS**12**

Synthesis - Mechanical alloying - Sol-gel - Thermal spray synthesis - Processing of Polymer Nanocomposites - Layered Filler Polymer Composite Processing - Nanoparticle/Polymer Composite Processing - Biologically Synthesized Nanoparticles and Nanostructures - Biologically Derived Synthetic Nanocomposites

UNIT - IV OPTICAL AND ELECTRICAL PROPERTIES**12**

Electrical and Optical Properties - Resistivity, Permittivity, and Breakdown Strength - Optical Clarity - Refractive Index Control - Light-Emitting Devices - Applications of Nanocomposite Wires and Particles - Inorganic Nanocomposites for optical, electrical and magnetic Applications.

UNIT - V MECHANICAL PROPERTIES**12**

Mechanical Properties - Abrasion and Wear Resistance - Permeability - Dimensional Stability - Thermal Stability and Flammability

Total Periods (45L+15T):60**TEXT BOOK**

1. Pulickel M, Ajayan, Linda S. Schadler, Paul V, "Nanocomposite Science and Technology", Wiley-VCH, 2006.

REFERENCE BOOKS

1. Twardowski T.E, "Introduction to Nanocomposite Materials - Properties, processing, Characterization" DesTech Publications, April 2007
2. Friedrich K, Fakivov S, Shang Z, "Polymer Composites from Nano - to Macro - scale", Springer, USA, 2005.
3. Diwan P and Bharadwaj A. "Nanocomposites" Pentagon Press, 2003

4. Mai Y.W and Yu Z.Z, "Polymer nanocomposites" CRC Press, Boca Raton, 2000NPTEL VIDEO Nano structured materials-synthesis, properties, self-assembly and applications by Prof. A.K. Ganguli, Department of Nanotechnology, IIT Delhi

WEB REFERENCE

1. https://ocw.mit.edu/courses/materials-science-and-engineering/3-063-polymer-physics-spring-2007/lecture-notes/lec15_07.pdf

RESEARCH & REVIEW PAPERS

1. Zinashbizu Mengesha Ayalew, Xuejun Guo, Xiangyuan Zhang, Synthesis and application of polyethyleneimine (PEI)-based composite/nanocomposite material for heavy metals removal from wastewater: A critical review, *Journal of Hazardous Materials Advances*, 8 (2022) 100158.
2. Augustine U. Agobi, Azubike J. Ekpunobi, Alexander I. Ikeuba, Hitler Louis, The effects of graphene oxide load on the optical, structural and electrical properties of ternary nanocomposites (Polyvinyl alcohol/copper/graphene oxide) for electronic and photovoltaic application, *Results in Optics*, 8 (2022) 100261.
3. Chengkai Li, Yihan Nie, Haifei Zhan, Jinshuai Bai, Tianshu Liu, Yuantong Gu, Mechanical properties of polymer nanocomposites with randomly dispersed and cross-linked two-dimensional diamond, *Composites Science and Technology*, 230 (2022) 109722

COURSE OUTCOMES

On completion of this course, the students will be able to

CO1: Describe the theory and fundamentals behind the quantum Physics

CO2: Appraise the importance and necessity of approximation methods in quantum mechanics

CO3: Analyze many electron systems and understand the theories behind formation of atomic & molecular orbital

UNIT - I BASICS OF QUANTUM MECHANICS**12**

Wave particle duality - Uncertainty principle - Applications - Postulates of Quantum Mechanics - Schrodinger equation (time dependent and independent) - Eigen function and Eigen values - Probability density - Applications to one dimensional problems (Tunnel Effect) - Dirac's Bra and Ket notation - Schrodinger, Heisenberg's and interaction representation - Equation of motion - Introduction to bits and qbits

UNIT - II VECTOR SPACES AND ANGULAR MOMENTUM**12**

Representation of operators by Matrix - Adjoint of an Operator - Hermitian operator - Unitary operator - Similarity transformation - Hilbert space - Matrix theory of Harmonic Oscillator - Eigen value and Eigen function of L^2 and L_z operators - Ladder operators L_+ and L_- - Pauli theory of spins (Pauli matrices) - Matrix representation of J in l, m basis - Addition of angular momenta - Computation of Clebsch-Gordan Co-efficients in simple cases.

UNIT - III TIME INDEPENDENT AND TIME DEPENDENT PERTURBATION THEORY**12**

Perturbation method - Time independent Perturbation of non-degenerate and degenerate cases - First order correction - Applications - Stark effect and Zeeman Effect of Hydrogen atom - Harmonic oscillator - Helium atom - First order correction - Interaction between electromagnetic wave and atoms - Transition Probabilities - Einstein's Co-efficients - Selection rules for harmonic oscillator.

UNIT - IV HARTREE FOCK APPROXIMATION AND VARIATION METHOD**12**

Hartree - Fock equation - Coulomb and Exchange operators - Fock operators - Principles of the Variation method for ground state with proof - Application of Variation method to He atom - Other simple examples.

UNIT - V THEORY OF MOLECULES**12**

LCAO and Variation method - Hydrogen molecule - Heitler London theory (rigorous derivation not included) - General discussion of results - Discussion of Molecular Orbital theory and Valence bond theory - SCF MO treatment of polyatomic molecules - Basis set - LC STO Molecular Orbitals - Gaussian type functions - Molecular electrostatic potential and Atomic charges - Molecular geometry.

Total Periods (45L+15T):60**TEXT BOOKS**

1. Aruldas. G, "Quantum Mechanics", Prentice - Hall of India Pvt. Ltd., 2014 (second edition).
2. Agarwal B.K. and Hariprakash, "Quantum Mechanics", Prentice - Hall of India Pvt. Ltd., 2004.

REFERENCE BOOKS

1. Beiser A, "Concepts of Modern Physics", Tata McGraw-Hill Publishing Company Limited, 2005.
2. Atkins P.W. and Friedman R.S, "Molecular Quantum Mechanics", Oxford University Press, 1997.
3. Mathews P. M. and Venkatesan. K, "A Text book of Quantum Mechanics", Tata McGraw- Hill, NewDelhi, 1976.
4. Goswami A, "Quantum Mechanics", WCB Publishers, 1992.

NPTEL VIDEOS

1. <http://nptel.ac.in/courses/122106034/> (Quantum Physics by Prof. V. Balakrishnan, Department of Physics, Indian Institute of Technology, Madras)

WEB RESOURCES

<https://ocw.mit.edu/courses/physics/8-04-quantum-physics-i-spring-2013/>

RESEARCH & REVIEW PAPERS

1. Yong-Yi Huang, The perturbation theory of matrix mechanics based on its canonical transformations, Results in Physics, 43 (2022) 106047.
2. P. Marevi, N. Schunck, E.M. Ney, R. Navarro Pérez, M. Verriere, J. O'Neal, Axially-deformed solution of the Skyrme-Hartree-Fock-Bogoliubov equations using the transformed harmonic oscillator basis (IV) hfbtho (v4.0): A new version of the program, Computer Physics Communications, 276 (2022) 108367.
3. J. Rosato, Stark broadening of low-n hydrogen lines in strongly magnetized hydrogen plasmas: Influence of l-degeneracy removal due to the quadratic Zeeman effect, Journal of Quantitative Spectroscopy and Radiative Transfer 278 (2022) 108014.

COURSE OUTCOMES

On completion of this course, the students will be able to

CO1: Experiment various parameters of synthesis of nanoparticles.

CO2: Evaluate the properties of the synthesized nanoparticles.

CO3: Practice in-silico experiments using simulation software

List of experiments

1. Hydrothermal synthesis of ZnO and TiO₂ nanoparticles and evaluation by XRD, DLS and FTIR Spectroscopy
2. Porous silica fabrication by wet chemical method and evaluation by XRD and DLS.
3. Spin coating of poly styrene and chitosan membranes over glass substrates and evaluation of thickness and I/V characteristics.
4. Synthesis of graphene nanoparticles by CVD method and evaluation of their properties by EFM, FMM and evaluation of size by non-contact mode AFM.
5. Finite element method
6. Monte Carlo simulation

22EN1001

ENGLISH FOR RESEARCH PAPER WRITING
Audit Course

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COURSE OUTCOMES

On successful completion of this course, the students will be able

CO1: To educate learners on how to format research writing.

CO2: To assist students in writing techniques that could result in the development of flawless writing abilities.

CO3: To enable students, learn the accepted style for self-scrutinising the mechanics of writing a research paper.

UNIT - I FORMATTING RESEARCH WRITING

7

Margins, Text Formatting, Title, Running Head and Page Numbers, Internal Headings and Subheadings, Placement of the List of Works Cited, Tables and Illustrations- Bibliography.

UNIT - II THE MECHANICS OF WRITING

8

Spelling, Punctuation, Italics, Names of persons, Numbers, Titles of works in the research paper, Quotation- The format of the Research paper- Documentation: Preparing the list or workers cited- Abbreviations- Citations in forms other than print.

Total Periods (15L): 15

TEXT BOOK

1. MLA Handbook ninth edition, The modern Language Association of America, New York 2021.

REFERENCE BOOK

1. APA Style Handbook for In-Text Citations and References : Based on APA Guidelines 7th Edition.



SEMESTER III



COURSE OUTCOMES

On Completion of this course the students will be able to

CO1: Understand the various methods of preparation of nanoparticles

CO2: Elucidate the critical adjustments to be made in the preparation of the nanomaterials

CO3: Fabricate a device or structure made of nanoparticles and apply it for a research problem



SEMESTER IV



COURSE OUTCOMES

On Completion of this course the students will be able to

CO1: Understand the various methods of preparation of nanoparticles

CO2: Elucidate the critical adjustments to be made in the preparation of the nanomaterials

CO3: Fabricate a device or structure made of nanoparticles and apply it for a research problem



ELECTIVES



COURSE OUTCOMES

On Completion of this course the students will be able to

CO1: Explain the working principles of various semiconductor nanodevices

CO2: Compare the functionality of nanotechnology based optoelectronic devices and practical sensors

CO3: Demonstrate the working principles of gas sensors and bio sensors

UNIT – I SEMICONDUCTOR NANODEVICES 9

Single-electron devices – Nano scale MOSFET – Resonant tunneling transistor – Single-electron transistors – Single electron dynamics – Nanorobotics and Nanomanipulation – Mechanical molecular nanodevices – Nanocomputers – Theoretical models – Optical fibers for nanodevices – Photochemical molecular devices – DNA-based nanodevices – GaAs-based nanodevices – Micro and nanomechanics.

UNIT – II ELECTRONIC AND PHOTONIC MOLECULAR MATERIALS 9

Preparation – Electroluminescent organic materials – Laser diodes – Quantum well lasers – Quantum cascade lasers – Cascade surface emitting photonic crystal laser – Quantum dot lasers – Quantum wire lasers – White LEDs – LEDs based on nanowires – LEDs based on nanotubes – LEDs based on nanorods – High Efficiency Materials for OLEDs – Quantum well infrared photo detectors.

UNIT – III THERMAL SENSORS 9

Thermal energy sensors – Temperature sensors, heat sensors – Electromagnetic sensors – Electrical resistance sensors, electrical current sensors, electrical voltage sensors, electrical power sensors and magnetism sensors – Mechanical sensors – Pressure sensors, gas and liquid flow sensors, position sensors – Chemical sensors – Optical and radiation sensors.

UNIT – IV GAS SENSOR MATERIALS 9

Criteria for the choice of materials – Experimental aspects – Materials and properties – Measurement of gas sensing property – Sensitivity – Selectivity – Stability - Discussion of sensors for various gases – Gas sensors based on semiconductor devices.

UNIT – V BIOSENSORS 9

Principles – DNA based biosensors – Protein based biosensors – Materials for biosensor applications – Fabrication of biosensors – Future potential.

Total Periods (45L): 45

TEXT BOOK

1. Ranier W., “Nano Electronics and Information Technology”, Wiley, 1st Edition, 2003.

REFERENCE BOOKS

1. Drexler K.E., “Nano systems”, Wiley, 1st Edition, 1992.
2. Pettey M. C., “Introduction to Molecular Electronics”. John Wiley & Sons, Ltd., 2007.
3. Meijer C.M., “Smart sensor systems” John Wiley & Sons, 1st Edition, 2008.
4. Sinclair I.R., “Sensors and Transducers” Newnes publications, 3rd edition, 2001.
5. Soloman S., “Sensors Handbook” McGraw-Hill, 2nd Edition, 2010.

WEB RESOURCES

1. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-701-introduction-to-nanoelectronics-spring-2010/>
2. <https://nptel.ac.in/courses/117108047/>

RESEARCH & REVIEW PAPERS

1. Mohammed A. Alanazi, Thomas E. Diller, Non-invasive thermal energy flow rate sensor for turbulent pipe flows, Flow Measurement and Instrumentation, 88 (2022) 102236.
2. Kurugundla Gopi Krishna, Saidireddy Parne, Nagaraju Pothukanuri, Velavan Kathirvelu, Suman Gandhi, Dhananjay Joshi, Nanostructured metal oxide semiconductor-based gas sensors: A comprehensive review, Sensors and Actuators A: Physical, 341 (2022) 113578
3. Daniele Tosi, Madina Shaimerdenova, Marzhan Sypabekova, Takhmina Ayupova, Minimalistic design and rapid-fabrication single-mode fiber biosensors: Review and perspectives, Optical Fiber Technology, 72 (2022) 102968.
4. Vimala Rani Samuel, K.Jagajjanani Rao, A review on label free biosensors, Biosensors and Bioelectronics: X, 11 (2022) 100216.

COURSE OUTCOMES

On Completion of this course the students will be able to

CO1: Enhance their knowledge on quantum mechanics towards the application of Electronics and Computing

CO2: Identify the Recently Enhanced Tunneling, superconductivity and photonics based devices

CO3: Explore the limitations in nano devices and Organic way of Electronics implementations

UNIT – I QUANTUM DEVICES**9**

Quantum Electronic devices –upcoming electronic devices –Electrons in mesoscopic structures –Short- channel MOS Transistor – Split gate transistor – Electron wave transistor – Electron spin transistor – Quantum cellular Automata – Quantum Dot array–Quantum computer-Bit and Qubit–Coherence and Entanglement–Quantum Parallelism.

UNIT – II TUNNELING DEVICES**9**

Tunneling element–Tunnel Effect and Tunneling Elements–Tunneling Diode–Resonant Tunneling Diode– Three-Terminal Resonate Tunneling Devices–Technology of RTD–Digital circuits design based on RTDs – Memory Applications–BasicsLogicCircuits–DynamicLogicGates–DigitalcircuitsdesignbasedonRTBT– RTBT Mobile –RTBT Threshold Gate –RTBT Multiplexer –Single Electron Transistor(SET) –Principle – Coulomb Blockade–Performance – Technology- Circuit Design–Writing and Drivers–Logic and Memory Circuits–SET adder as an Example of a Distributed Circuit–Comparison between FET and SET.

UNIT – III SUPER CONDUCTING DEVICES AND PHOTONICS**9**

Basics–Macroscopic characteristics–Macroscopic model–Superconducting switching Devices–Cryotron- Josephson Tunneling Devices–Elementary circuits–Associative or Content–Addressable Memory–SQUID– Flux Quantum device –LC –Gate – Magnetic Flux Quantum –Quantum cellular Automata- Quantum computer with Single Flux devices – SFQD-RSFQD–Application of superconducting devices –Integrated Electronics– Comparison of FET Electronics. Introduction to Photonics - Principle- Fabrication – application.

UNIT – IV UNCERTAINTY OF NANODEVICES**9**

Limits of Integrated Electronics- Survey of Limits– Replacement of Technologies–Energy Supply and Heat Dissipation–Parameter Spread as Limiting Effect–Limits due to Thermal Particle motion- Debye Length– Thermal Noise–Reliability of as Limiting Factor–Physical limits–Thermodynamic Limits- Relativistic Limits–Equal Failure Rates by Tunneling and Thermal Noise –Final Objectives of Integrated Electronic Systems- Removal of uncertainty by Nanomachines– Uncertainties in Nanosystems- Uncertainties in the Development of Nanoelectronics.

UNIT – V MOLECULAR AND BIO ELECTRONICS**9**

Bioelectronics–molecular processor–DNA Analyser molecular electronics –switches based on fullerenes and nanotubes – polymer electronic – self Assembling circuits – optical molecular memories – DNA computer– Information Processing with chemical reaction –Nanomachines–Parallel Processing–Drexler– Smalley debate– realistic projection–Synergy of Nano-Bio-Info

Total Periods (45L): 45

TEXT BOOK

1.Rao C.N.R, Muller.A and CheethamA.K, “The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Volume-I and II”,John Wiley & Sons Inc, 2005.

REFERENCE BOOKS

1.Goser K,Glosekottter P and Diens J, “ Nanoelectronics and Nanosystems - From Transistors to Molecular Quantum Devices”,Springer, 2004.

2. Rigneault H,Lourtioz J.M,Delalande C,Levenson A,“Nanophotonics”,Wiley ISTE, 2006.

3.Fahrner W.R,“Nanotechnology and Nanoelectronics–Materials, Devices and Measurement Techniques”Springer, 2006.

WEB REFERENCES

1. Stanford Seminar - From Nanodevices to Nanosystems: The Carbon Nanotube Case Study,

<https://www.youtube.com/watch?v=QvtakD9YYB8>

2. NEGF Simulation of Graphene Nanodevices (Colloquium on Graphene Physics and Devices),

<https://www.youtube.com/watch?v=eDZve4I7lsU>

3. Lecture 4: Sensing Methodologies, Integrated BioMEMS and Nanodevices,

<https://www.youtube.com/watch?v=vQqUM7OhM7w>

RESEARCH & REVIEW PAPERS

1. Hailong Li, Shengyi Yang, Jinming Hu, Zhenheng Zhang, Peiyun Tang, Yurong Jiang, Libin Tang, Bingsuo Zou, Which method is more efficient on enhancing light absorption for silicon nanowires array based solar cells: Plasmonic metal nanoparticles or narrow-bandgap semiconductor quantum dots?, Materials Science in Semiconductor Processing, 146 (2022) 106661.

2. Jun Zheng, Minghui Wei, Siyi Quan, Yicheng Feng, Peng Wen, Review on thermal-related measurement methods for superconducting devices and prospect for high-speed maglev transportation application, Superconductivity, 3 (2022) 100020

3 .Ravi N, Veena MB, Design of an efficient ALU blocks in quantum dot cellular automata (QCA), Global Transitions Proceedings, 3 (2022) 157-168.

4. Xusheng Wang, Designing digital circuits based on quantum-dots cellular automata using nature-inspired metaheuristic algorithms: A systematic literature review, Optik, 262 (2022) 169251

COURSE OUTCOMES

On Completion of this course the students will be able to

CO1: a) Explain scaling laws, evolution of electronic devices and its integration

b) Describe the substrate materials for device fabrication

CO2: Analyze the work function, issues and importance of gate dielectrics

CO3: a) Select the various gate electrode materials

b) Probe reliability issues of electronic devices at various environments

UNIT – I ULTRA-DIP SUBMICRON TECHNOLOGIES 9

Basic concepts of MOSFET devices- Schematic diagram, classification and functional issues, Scaling of CMOS technologies, Evaluation of different technologies - Moore's law, down scaling and device performance- LSI, ULSI and VLSI.

UNIT – II SUBSTRATES 9

Si, strained SiGe, Strained Si, SiC, SiGeC, SOI, fabrication steps- Strained and misfit dislocations - Physical and chemical properties of substrates.

UNIT – III GATE DIELECTRICS AND INTEGRATION ISSUES 9

Issues related to scaling of gate dielectrics - Properties of ultrathin SiO₂ layers - Quantum-mechanical tunneling - Leakage current and equivalent oxide thickness - concepts of equivalent oxide thickness (EOT) - Alternative dielectrics – Categories - Deposition techniques, Nitridation - Process integration challenges - Defects, interface issues - Annealing effect – High-k materials in gate-stack applications.

UNIT – IV METAL GATE ELECTRODES 9

Conventional Poly-Si gate - Difficulties: boron diffusion in thin gate - Dielectric layers in PMOSFETs, poly-Si depletion effects, Fermi-level-pinning in Poly-Si/dielectrics gate stacks - Extraction of metal work function for PMOS and NMOS devices - Gate electrode materials: mid-band gap metals (TiN, TaN) - Fully-Silicided Gate Materials (NiSi FUSI) - Dual-metal gates - Tunable Work - Function Metal Gates - Doping FUSI - Bi-Metal Layers (Ru-Ta Alloys), deposition techniques, chemical and physical characterization, compatibility with underlying gate dielectrics.

UNIT – V RELIABILITY ISSUES 9

Reliability: Thermal, electrical, environmental, challenges to implement the alternative gate dielectrics and gate electrodes in 45 nm technology nodes.

Total Periods (45L): 45

TEXT BOOK

1. Wolf. S. “Silicon processing for the VLSI era”, Vol-1 to 4, Lattice Press, 2005.

REFERENCE BOOKS

1. Chang.C.Y and S.M.Sze, ”ULSI Technology”, McGraw-Hill Companies Inc., Singapore, 1996.
2. Ghandhi, S.K, “VLSI fabrication principles: Silicon and Gallium Arsenide”, 2nd Edition, Wiley-Interscience, 1994
3. Kelsall, R, Hamley,I.W and Geoghegan, M, “Nanoscale Science and Technology”, Wiley, 2005

WEB RESOURCES

1. <https://ocw.mit.edu/courses/mechanical-engineering/2-57-nano-to-macro-transport-processes-spring-2012/video-lectures/lecture-1-intro-to-nanotechnology-nanoscale-transport-phenomena/>
2. <https://nptel.ac.in/courses/117101058/>

RESEARCH & REVIEW PAPERS

1. Dun-Bao Ruan, Kuei-Shu Chang-Liao, Ji-Syuan Li, Shih-Han Yi, Guan-Ting Liu, Po-Chen Chiu, Yan-Lin Li, Effects of fluorine based double plasma treatment on electrical and reliability characteristics of Ge MOSFETs, Microelectronic Engineering, 215 (2019) 111025.
2. Dun-Bao Ruan, Kuei-Shu Chang-Liao, Zi-Qin Hong, Jiayi Huang, Shih-Han Yi, Guan-Ting Liu, Po-Chen Chiu, Yan-Lin Li, Radiation effects and reliability characteristics of Ge pMOSFETs, Microelectronic Engineering, 216 (2019) 111034.
3. Guangyuan Jiang, Peng Cui, Guangyuan Zhang, Yuping Zeng, Guang Yang, Chen Fu, Zhaojun Lin, Mingyan Wang, Heng Zhou, Influence of the ZrO₂ gate dielectric layer on polarization coulomb field scattering in InAlN/GaN metal–insulator–semiconductor high-electron -mobility transistors, Microelectronics Journal, 129 (2022) 105602.

COURSE OUTCOMES

On Completion of this course the students will be able to

CO1: Summarize the fundamentals of devices of different length scales

CO2: Select the wide array of fabrication techniques and materials required

CO3: a) Probe the technical difficulties and limitations of the system

b) Develop the applications involving MEMS / NEMS

UNIT – I INTRODUCTION TO MEMS AND NEMS 9

MEMS and NEMS – Multidisciplinary nature of MEMS/NEMS – Working principles – As micro sensors (acoustic wave sensor, biomedical and biosensor, chemical sensor, optical sensor, capacitive sensor, pressure sensor and thermal sensor) – Micro actuation (thermal actuation, piezoelectric actuation and electrostatic actuation) – Micro grippers – Micro motors – Micro valves – Micro pumps – Accelerometers – Micro fluidics and capillary electrophoresis – Active and passive micro fluidic devices – Industrial products involving MEMS and NEMS.

UNIT – II MATERIALS FOR MEMS / NEMS 9

Silicon – Compatible material systems – Silicon, Silicon oxide and nitride – Thin metal films – Polymers – Other materials and substrates – Glass and fused quartz substrates – Silicon carbide and diamond – Gallium Arsenide and other group III-V compound semiconductors – Shape-memory alloys transduction – Important material properties and physical effects – Pizoresistivity, Pizelectricity and thermoelectricity – Inter atomic bonds – Material structures.

UNIT – III MEMS / NEMS DESIGN, PROCESSING AND TECHNOLOGIES 9

Basic process tools – Epitaxy, Oxidation, Sputter deposition, Evaporation and Chemical vapor deposition – Spin on methods – Lithography – Lift off process – Bulk Micro machining – Etching processes – Wet etching, Plasma etching and Ion milling – Wafer bonding – Silicon fusion bonding, Anodic bonding and Silicon direct bonding – Sol gel deposition methods – Self assembled mono layers – EFAB – LIGA – Electromagnetic micro drive – DRIE.

UNIT – IV MEMS / NEMS SCALING ISSUES AND PACKAGING 9

Introduction – Scaling of physical systems – Geometric scaling, Mechanical system scaling, Thermal system scaling, Fluidic system scaling and Electrical system scaling – Packaging – Package design considerations – Process steps – Wafer thickness and dicing issues – Thermal management – Hermetic packaging – Electrical/Micro fluidic/and optical interconnects – Quality control-reliability and failure modes and analysis – Signal mapping transduction.

UNIT – V MEMS / NEMS APPLICATIONS 9

MEMS sensors - Applications in automotive industry – Health care – Aerospace – Industrial product consumer products – Lab on chip – Molecular machines – Data storage devices – Micro reactor – Telecommunications – Servo systems.

Total Periods (45L): 45

TEXT BOOK

1. Tai – Ran Hsu, “MEMS and Microsystems Design and manufacture”, Tata Mc Graw Hill Publishing Co. Ltd, New Delhi, 1st Edition, 2002.

REFERENCE BOOKS

1. Malut N. and Williams K., “An introduction to Micro electro mechanical systems Engineering” Artech House, Inc, Boston, 2nd Edition, 2004.
2. Lysherski S. E., “Nano and Micro electro Mechanical systems” CRC Press, 2001.
3. James J Allen, “Micro electro mechanical systems Design” CRC Press – Taylor and Francis, 2005.
4. Lobontiu N and Garcia E, “Mechanics of micro electro mechanical systems” Kluwer Academic Publishers – Boston, 2005.
5. Madou M., “Fundamentals of Microfabrication”, CRC Press Newyork 1997.

WEB RESOURCES

1. Mems and microsystems by prof. Santiramkal, department of electronics and electrical communication engineering, indian institute of technology, kharagpur (lecture no. # 04) applications of mems
2. <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-777j-design-and-fabrication-of-microelectromechanical-devices-spring-2007/lecture-notes/>

RESEARCH & REVIEW PAPERS

1. Shahrzad Forouzanfar, Nezih Pala, Marc Madou, Chunlei Wang, Perspectives on C-MEMS and C-NEMS biotech applications, Biosensors and Bioelectronics, 180 (2021) 113119.
2. Alokik Kanwal, B. Robert Ilic, Christopher H. Ray, Kerry Siebein, J. Alexander Liddle, Chromium oxide – A novel sacrificial layer material for MEMS/NEMS and micro/nanofluidic device fabrication, Micro and Nano Engineering, 16 (2022) 100145
3. Zohre Moradi, Farzad Ebrahimi, Mohsen Davoudi, Coupled Newmark beta technique and GDQ method for energy harvesting and vibration control of the piezoelectric MEMS/NEMS subjected to a blast load, Engineering Analysis with Boundary Elements, 144 (2022) 492-506.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Attain a clear understanding of the risks related to nanotechnology related products, their routes of entry into the human body with significance to pulmonary system.
CO2:	Understand the effect of various nanomaterials over the cardiovascular system and the need for ethical regulations in handling nanomaterials.
CO3:	Interpret various laboratory practice and legal aspects of health hazards along with applications of nanotechnology in environmental remediation

UNIT – I INTRODUCTION 9

Identification of Specific Risks – Challenges- Human health hazard – Risk reduction – Standards – Safety – Transportation of nanoparticles – Emergency responders- Risk assessment –Environmental Impact – Predicting hazard – Materials Characterization – Environmental and policy making – Ecotoxicity measurement of Polychlorinated biphenyl and intermediates in their degradation

UNIT – II NANOTOXICOLOGY 9

Inhalation, deposition and Pulmonary clearance of insoluble solids – Bio persistence of Inhaled solid material – Systemic Translocation of inhaled Particulates – Pulmonary effects of CNTs – Inflammatory response– In-vivo interactions of pulmonary inflammation with oxidative stress – Interactions of CNTs with Macrophages

UNIT – III EXPERIMENTAL ISSUES 9

Nanoparticle exposure and systematic cardiovascular effects – experimental data – respiratory particulate matter exposure and cardiovascular toxicity – Toxicity of polymer nanoparticles – Drug carriers – Particle exposure in indoor and air environment – Measurement of indoor particulate matter.

UNIT – IV ETHICS 9

Nanoparticle Hypothesis – Need for regulations, health protection and environmental security – Laboratory practices – Definition- Benefits – Potential risks – Assessment of exposure – Bioethics and legal aspects of potential health and environmental risks.

UNIT – V ENVIRONMENTAL REMEDIATION 9

Environmental treatment using nanotechnology – Gas sensors – Nanomembranes - Nanosorbants – Mesoporous materials – Ground water remediation – Air purifiers – Nano photocatalysis - Heavy metal removal.

Total Hours (45L): 45

TEXT BOOK

1. Simeonova P.P, Opopol N, and Luster M.I, “Nanotechnology – Toxicological Issues and Environmental Safety”, Springer 2006.

REFERENCE BOOKS

1. Grassian V.H, “Nanoscience and Nanotechnology – Environmental and health impacts”, John Wiley & Sons, 2008.
2. Sellers.K, Mackay.C, Bergeson.L.L, Clough S.R, Nanotechnology and Environment, CRC Press, 2009.
3. Ram.M, Andreescu.S.E, Hanming.D, “Nanotechnology for Environmental Decontamination”, 2011, McGraw Hill
4. Wiesner M and Bottero J.Y, “Environmental Nanotechnology”, McGraw-Hill, 2007.

WEB REFERENCES

1. <https://nptel.ac.in/courses/118107015>
2. <https://nptel.ac.in/courses/102107058>

RESEARCH & REVIEW PAPERS

1. Dimitrios Bitounis, Jérémie Pourchez, Valérie Forest, Delphine Boudard, Michèle Cottier, Jean-Philippe Klein, Detection and analysis of nanoparticles in patients: A critical review of the status quo of clinical nototoxicology, *Biomaterials*, 76 (2020) 302-312.
2. Banglin Deng, Yiwen Wang, Haiyan Huang, Xiongbo Duan, Aodong Liu, Effects of inhalation frequency on inhalation/exposure dose of hazardous nanoparticles and toxic gases during cigarette smoking, *Ecotoxicology and Environmental Safety*, 240 (2022) 113709.
3. Kuhn R, Bryant IM, Jensch R, Böllmann J. Applications of Environmental Nanotechnologies in Remediation, Wastewater Treatment, Drinking Water Treatment, and Agriculture. *Applied Nano*. 3 (2022) 54-90.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	To identify product development strategies to improve their personality
CO2:	To classify the various management skills needed for skill and man management
CO3:	To develop the necessary competence to plan, initiate and manage a small scale idea into a possibility

UNIT – I PRODUCT DESIGN 9

Concept generation – Product Architecture – Industrial Design Process – Management of Industrial design Process and assessing the quality of Industrial Design – Establishing the product specification

UNIT – II PRODUCT DEVELOPMENT 9

Criteria for selection of product - Product development process- Design for Manufacture - Estimate the manufacturing cost - Reduce the support cost – Prototyping - Economics of Product development projects - Elements of Economic analysis - financial models - Sensitive analysis and influence of the quantitative factors.

UNIT – III MANAGEMENT TECHNIQUES 9

Technology Management - Scientific Management - Development of management Thought-Principles of Management -Functions of management - planning - organization - Directing, Staffing and Controlling - Management by objective - SWOT analysis - Enterprise Resource planning and supply chain management.

UNIT – IV ENTREPRENEURIAL COMPETENCE AND ENVIRONMENT 9

Concept of Entrepreneurship - Entrepreneurship as a career - Personality Characteristic a successful Entrepreneur Knowledge and skill required for an Entrepreneur - Business environment - Entrepreneurship Development Training - Center and State government policies and Regulations - International Business.

UNIT – V MANAGEMENT OF SMALL BUSINESS 9

Pre-feasibility study – Ownership - budgeting - project profile preparation - Feasibility Report preparation - Evaluation Criteria - Market and channel selection - Product launching - Monitoring and Evaluation of Business - Effective Management of Small business.

Total Hours (45L): 45

TEXT BOOK

1. Karal, T.Ulrich Steven, D.Eppinger, “Product Design and Development”, McGraw- Hill International, editions, 2003.

REFERENCE BOOKS

1. S.Rosenthal, “Effective Product Design and Development”, Irwin, 1992.
2. H.Koontz and H.Weihrich, “Essentials of management”, McGraw Hill Publishing company, Singapore international edition, 1980.
3. J.J.Massie, “Essentials of Management” Prentice Hall of India Pvt. Ltd., 1985.
4. Hisrich, “Entrepreneurship” Tata Mc Grew Hill, New Delhi, 2001

WEB REFERENCES

1. PRODUCT DESIGN AND DEVELOPMENT
<https://swayam.gov.in/courses/5537-jan-2019-product-design-anddevelopment>, IITR 2019
2. <https://ocw.mit.edu/courses/sloan-school-of-management/15-783j-product-design-and-development-spring-2006/>

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Identify the unique properties of nanoscale materials
CO2:	Analyze the possibility of using one or more nanomaterial for a product
CO3:	Fabricate a strategy for using single or complex nanomaterials systems for appropriate requirements

UNIT - I INTRODUCTION TO NANOTECHNOLOGY BASED INDUSTRIES**9**

General introduction to Nanotech industries - Scope, Trends and key issues in industry - Organization, financing, policy, trends, problems and issues in the healthcare, pharmaceutical, Agri and other biotech industries - Overview of cost, quality, access issues.

UNIT - II NANO ELECTRONICS**9**

Memory devices and sensors – Nano ferroelectrics – Ferroelectric random access memory – Fe-RAM circuit design – ferroelectric thin film properties and integration – calorimetric -sensors – electrochemical cells – surface and bulk acoustic devices – gas sensitive FETs – resistive semiconductor gas sensors – electronic noses – Sensors for identification of hazardous solvents and gases – semiconductor sensor array – Graphene electronics.

UNIT - III NANOTECHNOLOGY IN AGRICULTURE**9**

Nanotechnology in Agriculture - Precision farming, Smart delivery system – Insecticides using nanotechnology – Potential of nano-fertilizers – Enzyme Biosensors and Diagnostics, DNA-Based Biosensors and Diagnostics, Radiofrequency Identification (RFID), Integrated Nanosensor Networks: Detection and Response, Precision Agriculture, Potential Changes in Farming Methods and Sustainable Agriculture production.

UNIT - IV NANOTECHNOLOGY IN FOOD INDUSTRY**9**

Nanotechnology in Food industry - Packaging, Food processing - Food safety and bio-security – Contaminant detection – Smart packaging. Introduction, Improving Quality, Safety, and Security of Agricultural Production, Food Processing, Packaging and Distribution. Concerns about using Nanotechnology in Food Production. Reasons to Package Food Products, Physical Properties of Packaging Materials – Nanotechnology in refrigeration and preservation of foods – Nano sensors for food quality analysis

UNIT - V NANOTECHNOLOGY IN TEXTILES AND COSMETICS**9**

Nanofibre production - Electrospinning – Controlling morphologies of nanofibers – Tissue engineering application – Polymer nanofibers - Nylon-6 nanocomposites from polymerization - Nano-filled polypropylene fibers - Bionics– Swim-suits with shark-skin-effect, Soil repellence, Lotus effect - Nanofinishing in textiles (UV resistant, antibacterial, hydrophilic, self-cleaning, flame retardant finishes and surgical applications) – Modern textiles (Lightweight bulletproof vests and shirts, Color changing property, Waterproof and Germ proof, Cleaner kids clothes, Wired and Ready to Wear) Cosmetics – Formulation of Gels, Shampoos, Hair-conditioners (Micellar self-assembly and its manipulation) – Sun-screen dispersions for UV protection using Titanium oxide – Color cosmetics – Self Healing nanomaterials for medical and day to day use

Total Hours (45L): 45

TEXT BOOKS

1. Ratner MA and Ratner D, Nanotechnology: A Gentle Introduction to the Next Big Idea, Pearson (2003)
2. Kuzma J and Verhage P, Nanotechnology in agriculture and food production, Woodrow Wilson International Center, (2006).

REFERENCE BOOKS

1. Nalwa H S, Handbook of Nanostructured materials and Nanotechnology, Academic Press, (2000)
2. Labhassetwar V and Pelecky D L, Biomedical applications of nanotechnology, Wiley- Interscience (2007)
3. Karkare M, Nanotechnology: Fundamentals and Applications, IK International Publishing house (2008)
4. Ashby M F, Schodek M D. Ferriera P J, Nanomaterials, nanotechnologies and design, Elsevier (2009)

WEB REFERENCE

1. NPTEL, Nanoelectronics, <https://nptel.ac.in/courses/117108047/>

RESEARCH & REVIEW PAPERS

1. Mohammad Haris, Touseef Hussain, Heba I. Mohamed, Amir Khan, Moh. Sajid Ansari, Atirah Tauseef, Abrar Ahmad Khan, Naseem Akhtar, Nanotechnology – A new frontier of nano-farming in agricultural and food production and its development, Science of The Total Environment, 857 (2023) 159639.
2. Kumera Neme, Ayman Nafady, Siraj Uddin, Yetenayet B. Tola, Application of nanotechnology in agriculture, postharvest loss reduction and food processing: food security implication and challenges, Heliyon, 7 (2021) e08539.
3. Tabli Ghosh, G.V.S. Bhagya Raj, and Kshirod Kumar Dash. A comprehensive review on nanotechnology based sensors for monitoring quality and shelf life of food products Measurement 7 (2022) 100049.
4. Jugal Barman, Akriti Tirkey, Shivani Batra, Abraham Abbey Paul, Kingshuk Panda, Rahul Deka, Punuri Jayasekhar Babu, The role of nanotechnology based wearable electronic textiles in biomedical and healthcare applications, Materials Today Communications, 32 (2022) 104055.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the various materials used for drug delivery systems
CO2:	Analyze various routes of administration for various diseases and organs.
CO3:	Fabricate a drug delivery system based on bodily state of requirement

UNIT - I INTRODUCTION**9**

Introduction, concept, advantages and limitations - Factors to be considered for designing controlled release dosage forms. Dissolution, Diffusion, Combination of dissolution and diffusion controlled drug delivery systems - Fick's first & second laws

UNIT - II MUCOADHESIVE DRUG DELIVERY SYSTEMS**9**

Concepts - advantages and limitations, structure of oral mucosa, transmucosal permeability, mucosal membrane models, permeability enhancers - Development and evaluation of buccal, nasal, pulmonary and ocular drug delivery systems and their applications.

UNIT - III NANOPARTICULATES AS DELIVERY SYSTEMS**9**

Virus Based Nanoparticles - Tumour targetting invivo – Use in biomedical Imaging and therapeutic applications - Micelles - Liposomes, Transferosomes, Ethosomes, Niosomes, Virosomes, and Carbon Nano Tubes - Dendrimers- Synthesis and characterization – Photo dynamic therapy – IR mediated theranostics – MRI Enhancement using iron oxide nanoparticles.

UNIT - IV PROPERTIES OF DRUG TARGETING DELIVERY SYSTEMS**9**

Properties of drug targeting delivery systems-ADME hypothesis- site specific drugs- Synthetic carrier for drugs Liposomes- Concept, advantages and limitations, types of targeting and applications. Monoclonal antibodies- hybridoma cell production, diagnostic and therapeutic applications.

UNIT - V TARGETED NANO PARTICLES**9**

Targeted Nano particles for drug delivery – Target ligands for cells in human system -Polymers nanotubes- Issues for specific diseases – Cancer, AIDS and Asthma – Radioactive nanoparticles for targeted therapy - Modification by bioconjugation.

Total Hours (45L): 45**TEXT BOOKS**

1. Mathiowitz E, Encyclopedia of controlled delivery, Wiley Interscience Publication, (1999)
2. Salzman M W, Drug Delivery: Engineering Principles for Drug Therapy, Oxform University Press (2001)

REFERENCE BOOKS

1. Hillery A M, Drug Delivery and Targeting, CRC Press, 2002.
2. Wang B, Drug Delivery: Principles and Applications, Wiley Interscience, 2005
3. Labhasetwar Vand Leslie D L – Pelecky, Biomedical applications of nanotechnology.
4. Goodsell D S, Bio nanotechnology: lessons from nature, Wiley – Liss (2004)

WEB REFERENCE

1. NPTEL, Stimuli Responsive Drug delivery systems: <https://nptel.ac.in/courses/118106019/22>

RESEARCH & REVIEW PAPERS

1. Noriaki Nagai, Hiroko Otake, Novel drug delivery systems for the management of dry eye, *Advanced Drug Delivery Reviews*, 191 (2022) 114582
2. Lushuang Xu, Yue Sun, Yue Li, Junli Sun, Yong Guo, Qiyang Shen, Qiaolin Wei, Jia-Wei Shen, Disulfiram: A Food and Drug Administration-approved multifunctional role in synergistically drug delivery systems for tumor treatment, *International Journal of Pharmaceutics*, 626 (2022) 122130
3. Afreen Sultana, Mina Zare, Vinoy Thomas, T.S. Sampath Kumar, Seeram Ramakrishna, Nano-based drug delivery systems: Conventional drug delivery routes, recent developments and future prospects, *Medicine in Drug Discovery*, 15 (2022) 100134.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Design a Solar cell to overcome all the limitations for the future energy crisis
CO2:	Analyze the significance of photovoltaic system w.r.t thickness of the cell for high efficiency
CO3:	Investigate the importance of physical properties of photovoltaic system and mechanism of power conversion efficiency

UNIT - I INTRODUCTION**9**

Introduction to photovoltaics- Review of Semiconductor Physics: Electrons and holes in semiconductors, doping, electrical transport, Photo carrier generation and recombination, Junctions; p-n, p-i-n, metal semiconductor contacts, band bending, Ohmic and rectifying contacts, Surface and interface states, homo and hetero-junctions

UNIT - II SOLAR CELL**9**

Device Physics of Solar Cells: Solar radiation, conversion efficiency, p-n junction model, Effect of Parasitic resistance, irradiation and temperature on I-V characteristics. Numerical solar cell modelling, Principle of cell design: Cell type, Optical design, surface and bulk recombination losses, design and fabrication of metal contacts Crystalline Silicon – Generation of solar cell – Applications of solar cell

UNIT - III COATING TECHNIQUES**9**

Study of thin film vacuum coating unit, Physical vapour deposition-Thermal evaporation-electron beam evaporation-Sputtering-Study of glow Discharge-Physical nature of sputtering-Sputtering yield - Experimental set up for DC and RF magnetron sputtering, LASER ablation - Pulsed laser deposition and Ion beam assisted deposition, Basics of Chemical vapour deposition

UNIT - IV PROPERTIES OF THIN FILM**9**

Mechanism of Thin Film: Nucleation and Growth, deposition monitoring and control, electrical properties, dielectric properties, structural and optical properties of thin film, Applications: Thin film field effect transistor and thin film solar cells

UNIT - V PHOTOVOLTAIC SYSTEM AND APPLICATION**9**

Photovoltaic System Engineering: Thermo-photovoltaic generation of electricity, Concentration and storage of electrical energy, photovoltaic modules, system and application, Photovoltaic System Installation technique and mechanism, Power Conversion Efficiency Calculation

Total Periods (45L): 45

TEXT BOOKS

1. Seshan, K. Handbook of Thin-Film deposition processes and Techniques: Principle, Methods, Equipments and Application (2nd Edition), Noyes publication, USA, 2002.
2. Venables, J. A. Introduction to surface and Thin film processes, Cambridge University Press, 2003.

REFERENCE BOOKS

1. Sing, J. Semiconductor Devices, Basic Principles, Wiley, 2001.
2. Nelson, J. The Physics of Solar Cells, Imperial College Press, 2003.
3. Oring, M. Materials Science of thin films, Academic Press, 2002.

4. Goswami, A. Thin Film Fundamentals, New Age International (P) Ltd, 1996.
5. Fonash, S. J. Solar Cell Device Physics (2nd Edition), Academic Press, 2010.
6. Luque, A. and Hegedus, S. (Eds), Handbook of Photovoltaic Science & Engineering, Wiley, 2003.

WEB REFERENCES

1. <http://https://ocw.mit.edu/courses/mechanical-engineering/2-627-fundamentals-of-photovoltaics-fall-2013/lecture-videos-%20slides/>
2. Energy Resources and Technology, <https://nptel.ac.in/courses/108105058/IITKGP>, 2009
3. PV Cell, <https://nptel.ac.in/courses/117108141/IISc>, 2017

RESEARCH & REVIEW PAPERS

1. Mahya Ghorab, Ali Fattah, Mojtaba Joodaki, Fundamentals of organic solar cells: A review on mobility issues and measurement methods, *Optik*, 267 (2022) 169730.
2. Shahriyar Safat Dipta, Jean Schoenlaub, Md Habibur Rahaman, Ashraf Uddin, Estimating the potential for semitransparent organic solar cells in agrophotovoltaic greenhouses, *Applied Energy*, 328 (2022)120208
3. Jinzhao Xu, Jun Wang, Yuzhu Chen, Zhicheng Xu, Peter D. Lund, Thermo-ecological cost optimization of a solar thermal and photovoltaic integrated energy system considering energy level, *Sustainable Production and Consumption*, 33 (2022)298-311.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Identify the different types of techniques to prevent corrosion
CO2:	Analyze the different parameters which causes problems to environmental
CO3:	Understand the role of different morphological nanostructures in preventing corrosion

UNIT - I CORROSION MONITORING**9**

Introduction, Corrosion Testing and Monitoring, electrical resistance, linear polarization, hydrogen test probe, ultrasonic testing, radiography and corrosion coupons, on- and off- stream monitoring equipments, eddy current inspection, liquid penetration inspection. Effect of environmental variables, effect of pH, oxidation potential, temperature, velocity/fluid flow rate, concentration, Corrosion in Industries.

UNIT - II THERMODYNAMICS OF AQUEOUS CORROSION**9**

Electrode processes - electrode potential, free energy, emf series, potential measurements with reference electrodes, three electrode systems, practical use of E-pH diagrams, Chemical Vs electrochemical mechanism of corrosion reactions, corrosion rate expressions.

UNIT - III KINETICS OF AQUEOUS CORROSION**9**

Corrosion current density and corrosion rate, exchange current density, polarization - activation control, Tafel equation, mass transport control, effect of oxidizer, combined polarization, factors affecting polarizations and rate of corrosion, passivity, potentiostatic polarization curves, factors affecting passivity, mechanism of action of passivators.

UNIT - IV MARINE CORROSION AND BIOFOULING**9**

Definition, corrosion reactions, factors affecting corrosion of metals in sea water, corrosion classification of corrosion, protective coatings for metals: cathodic protection types, prevention of marine corrosion, Biofouling and Control technology - Biofouling organisms - Problems due to biofouling - Antifouling paints and its environmental pollution - Biotechnological approach to biofouling control.

UNIT - V CORROSION INHIBITION**9**

Purpose and classification – chemical, electrochemical, biochemical corrosion, dimensional change, ultrasonic thickness measurements, microscopic examination, weight change, specimen preparation, test conditions and evaluation of results for overall corrosion, electrochemical techniques, polarization curves, AC impedance methods (EIS) - Corrosion Failure Analysis

Total Periods (45L): 45

TEXT BOOKS

1. Colwell, R. R. (ed): Biotechnology in Marine Science, 1982.
2. Rittmann, B. E. and McCarthy, P. L. "Environmental Biotechnology, Principles and Applications", McGraw Hill, 2007.

REFERENCE BOOKS

1. ASM hand book - Vol 13: "Corrosion", ASM International, 2001.
2. Jones, D. A. "Principles and Prevention of Corrosion", 2nd Edn., Prentice Hall Inc., 1996

3. Rajnarayan, “Metallic Corrosion and Prevention”, Oxford Publications, 1988
4. Schweitzer, P. A. “Corrosion and Corrosion Protection Handbook”, USA, 1983
5. Fontana, M. G. “Corrosion Engineering”, 3rd Edn., Mc Graw Hill Inc., 1987.

WEB REFERENCES

1. Corrosion: Introduction – Definitions and Types, <https://nptel.ac.in/courses/113108051/IISc>, 2012
2. Introduction, Basic definition of Corrosion, <https://www.youtube.com/watch?v=5OxdXq91TV0>
3. Advances in Corrosion Engineering, <https://www.btechguru.com/courses--nptel--advances-in-corrosion-engineering-video-lecture.html>

RESEARCH & REVIEW PAPERS

1. Els Verstrynghe, Charlotte Van Steen, Eline Vandecruys, Martine Wevers, Steel corrosion damage monitoring in reinforced concrete structures with the acoustic emission technique: A review, *Construction and Building Materials*, 349 (2022) 128732.
2. Liang Fan, Yi Bao, Review of fiber optic sensors for corrosion monitoring in reinforced concrete, *Cement and Concrete Composites*, 120 (2021) 104029.
3. Z.B. Wang, L. Pang, Y.G. Zheng, A review on under-deposit corrosion of pipelines in oil and gas fields: Testing methods, corrosion mechanisms and mitigation strategies, *Corrosion Communications*, 7 (2022) 70-81.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the principles of various spectroscopic characterization techniques
CO2 :	Interpret the molecular structure and geometry of the organic and inorganic compounds.
CO3:	Utilize these different spectroscopic techniques for biological applications

UNIT - I INTRODUCTION**9**

Different aspects of molecular spectroscopy, Born-Oppenheimer approximation, transition probability, oscillator strength, integrated absorption coefficient and absorption cross-section, induced emission, near-field optical spectroscopy.

UNIT - II MAGNETIC RESONANCE SPECTROSCOPY**9**

Nuclear moments, nuclear spin states in a magnetic field and the resonance phenomenon, relaxation processes, chemical shifts and spin-spin coupling, spectra of a two-spin system (A₂, AB and AX cases); interpretation of simple first order spectra of organic molecules, NMR line shapes and molecular dynamics. FT-NMR spectroscopy, measurement of relaxation times, introduction to ¹H-NMR and ¹³C-NMR spectroscopy – Chemical shift, and coupling constant calculation – Nuclear Over Hauser effect (NOE).

UNIT - III ELECTRON SPIN RESONANCE SPECTROSCOPY**9**

Detection of ESR spectra, spectra of simple organic radicals, g-values and hyperfine structure, spectra of inorganic complexes, zero field splitting and Kramers degeneracy, general introduction to double resonance experiments, and biological applications.

UNIT – IV NQR AND MÖSSBAUER SPECTROSCOPY**9**

Nuclear quadrupole moment and EFG tensors, quadrupole coupling constants and asymmetry parameters, pure NQR and Zeeman spectra of spin 1/2 and spin 3/2 systems, the Towners-Dailey theory and interpretation of NQCC in terms of bond characteristics, Mössbauer effect, isomer shifts and NQCC's ⁵⁷Fe spectra of complexes, other Mössbauer nuclei, applications.

UNIT - V PHOTOELECTRON SPECTROSCOPY**9**

Photoionization processes, Auger and autoionization processes, deexcitation by fluorescence, cross-sections, optical properties of assembled nanostructures, interaction between nanoparticles, Direct and indirect gap transitions, Single molecule and single nanoparticles spectroscopy-Dynamic light scattering spectroscopy Fluorimetry and chemiluminescence, X-ray fluorescence spectrometry, Atomic emission spectroscopy.

Total Periods (45L): 45**TEXT BOOKS**

1. Banwell, C., and McCash, Fundamentals of Molecular Spectroscopy, McGraw Hill (1994).
2. Lakowicz, J. R. Principles of fluorescence spectroscopy, Springer, 3rd Edition (2010).
3. Pavia, Lampman, Kriz, Vyvyan, Introduction to spectroscopy, Cengage learning, (2009).

REFERENCES BOOKS

1. Banwell C.N. and McCash E.L.M., "Fundamentals of Molecular Spectroscopy", 4th Ed, McGraw Hill, N.Y., 1999

2. Slichter C.P., "Principles of Magnetic Resonance", Springer Verlag, 1981
3. Graybeal J.D., "Molecular Spectroscopy", McGraw-Hill, 1988

WEB REFERENCES

1. Molecular Spectroscopy, <https://nptel.ac.in/courses/104106083/5> IITM, 2017
2. <https://ocw.mit.edu/courses/chemistry/5-80-small-molecule-spectroscopy-and-dynamics-fall-2008/video-lectures/lecture-1/>

RESEARCH & REVIEW PAPERS

1. Alejandro Santos-Díaz, Michael D. Noseworthy, Phosphorus magnetic resonance spectroscopy and imaging (31P-MRS/MRSI) as a window to brain and muscle metabolism: A review of the methods, *Biomedical Signal Processing and Control*, 60 (2020) 101967.
2. Yue Sun, Haibin Tang, Xiaobo Zou, Guowen Meng, Nianqiang Wu, Raman spectroscopy for food quality assurance and safety monitoring: a review, *Current Opinion in Food Science*, 47 (2022) 100910
3. Jun Kawai, Total reflection X-ray photoelectron spectroscopy: A review, *Journal of Electron Spectroscopy and Related Phenomena*, 178–179 (2010) 268-272.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Design and develop ceramic materials, nanostructured ceramics and glasses
CO2:	Describe the thermal, electrical and mechanical properties of ceramic materials
CO3:	Relate the importance of refractory science and Engineering

UNIT - I STRUCTURE OF CERAMIC CRYSTAL & GLASSES**9**

Pauling's rules – oxide structures Silicate structures – the clay minerals – polymorphism: displacive transformations, reconstructive transformation, Silica – Glass formation – Random network model – structure of oxide glasses – glass formation – composition as a variable, heat flow and precipitation from glasses – growth controlled by diffusion of solutes – crystalline glazes – opacified enamels – photosensitive and photochromic glasses. Bioglass and Nanoglass – Multifunctional applications of Bioionic liquid crystals.

UNIT - II CERAMIC FORMING METHODS**9**

Solid state sintering: Local driving force for sintering, atomic mechanisms occurring during sintering – sintering kinetics: initial stage sintering, densification kinetics, coarsening and grain growth kinetics – factors affecting solid state sintering – hot iso-static processing – sol gel processing – CVD – plasma spraying (qualitative treatment only)

UNIT - III THERMAL PROPERTIES**9**

Heat capacity – thermal expansion of crystals, glasses and composite bodies – thermal conduction processes – phonon conductivity of single phase crystalline ceramics – phonon conductivity of single phase glasses – photon conductivity – conductivity of multiphase ceramics

UNIT - IV ELECTRICAL & MECHANICAL PROPERTIES**9**

Modulus of Elasticity of 2-phase and porous ceramics – Griffith's theory – abrasives – Knoop's scale – ceramic cutting tools – cements. Conductivity of ceramic materials – ceramic semiconductors and their uses as fixed resistors, heating elements, thermistors and varistors – piezoelectric ceramics – insulators

UNIT - V REFRACTORIES**9**

Fundamentals of refractory science and Engineering – Gap grading – continuous grading – Fabrication and firing – Importance of phase diagram in refractors. Manufacturing, properties and application of refractories.

Total Periods (45L): 45**TEXT BOOK**

1. William F Smith, "Foundations of Materials Science and Engineering", McGraw Hill Book Co., 2000

REFERENCE BOOKS

1. Michel W Barsoum, "Fundamentals of Ceramics", McGraw Hill Book Co., 1997.
2. Kingery "Introduction to Ceramics", John Wiley Publications, 1991.
3. Kwan Chi Kao "Dielectric Phenomena in Solids", Elsevier Academic Press, 2004.
4. Charles A. Schacht, "Refractories Handbook", Marcel Dekker Inc., 2004.

WEB REFERENCES

1. Metallurgy and Material Science, <https://nptel.ac.in/courses/113105015/>, IITKGP 2014
2. Introduction to Advanced Ceramics, <https://cosmolearning.org/video-lectures/introduction-advanced-ceramics/>

RESEARCH & REVIEW PAPERS

1. Ojo Jeremiah Akinribide, Gadifele Nicolene Mekgwe, Samuel Olukayode Akinwamide, Fehmi Gamaoun, Chamil Abeykoon, Oluwagbenga T. Johnson, Peter Apata Olubambi, A review on optical properties and application of transparent ceramics, *Journal of Materials Research and Technology*, 21 (2022) 712-738.
2. Gurbinder Kaur, Vishal Kumar, Francesco Baino, John C. Mauro, Gary Pickrell, Iain Evans, Oana Breteanu, Mechanical properties of bioactive glasses, ceramics, glass-ceramics and composites: State-of-the-art review and future challenges, *Materials Science and Engineering: C*, 104 (2019) 109895.
3. Laifei Cheng, Mengyong Sun, Fang Ye, Yuhang Bai, Mingxing Li, Shangwu Fan, Litong Zhang, Structure design, fabrication, properties of laminated ceramics: A review, *International Journal of Lightweight Materials and Manufacture*, 1 (2018) 126-141.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Illustrate the fundamentals of nanomagnetism and associated theoretical formulations
CO2:	Describe the scaling laws in fabricating nanostructured magnets
CO3:	Point-out the potential applications involving nanomagnetism

UNIT - I INTRODUCTION**9**

Magnetic fundamentals – Antiferromagnetic materials – Domains and the magnetization process – Coercivity of fine particles – Super paramagnetism in fine particles – Exchange anisotropy – Induced anisotropy in thin films - Electron transport in magnetic multi-layers - Spin polarized electron tunneling – Interlayer exchange coupling – Spin relaxation in magnetic metallic layers and multi-layers – Non-equilibrium spin dynamics in laterally defined magnetic structures.

UNIT - II NANOMAGNETISM**9**

Two-spin channel model – Two terminal spin electronics – Three terminal spin electronics – Spin tunneling – Study of ferromagnetic and antiferromagnet interfaces – Photoemission Electron Microscopy – X-ray Absorption Spectroscopy – Magnetic force microscopy - Lorentz microscopy - X-ray Magnetic Linear Dichroism (XMLD) – X-ray Magnetic Circular Dichroism (XMCD) – Temperature dependence of X-ray Magnetic Dichroism.

UNIT - III FABRICATION AND IMAGING**9**

Molecular nanomagnets – Mesoscopic magnetism – Particulate nanomagnets – Geometrical nanomagnets – Fabrication techniques scaling – Characterization using various techniques – Imaging magnetic micro spectroscopy – Optical Imaging – Lorentz Microscopy – Electron Holography of Magnetic Nanostructures – Magnetic Force Microscopy.

UNIT - IV MAGNETIC DATA STORAGE AND RECORDING**9**

Magnetic data storage – Disk formatting – Partitioning – Hard disk features – Hard disk data transfer modes – Programmed I/O – Direct memory access – Ultra DMA – Data addressing – Standard CHS addressing – Extended CHS addressing – Logical Block Addressing – Magnetic recording – Principles of magnetic recording – Magnetic digital recording – Perpendicular recording – Magneto-Optic recording – Magnetic media - Kerr effect – Faraday effect

UNIT - V MAGNETIC STRUCTURES AND APPLICATIONS**9**

Magnetic sensors and Giant Magnetoresistance – Optically transparent materials – Soft ferrites – Nanocomposite magnets – Magnetic refrigerant – High TC superconductor – Ferro/biofluids – Biomedical applications of magnetic nanoparticles – Diagnostic applications – Therapeutic applications – Physiological aspects – Toxic effects.

Total Periods (45L): 45**TEXT BOOK**

1. Hans P.O., and Hopster H., “Magnetic Microscopy of Nanostructures”, Springer (2004).

REFERENCE BOOKS

1. Bland J.A.C., and B. Heinrich.B.,”Ultra thin Magnetic Structures III – Fundamentals of Nanomagnetism”, Springer (2004).
2. Nicola A.S., “Magnetic Materials: Fundamentals and Device Applications”, Cambridge University Press (2003).

WEB REFERENCES

1. Lecture 21: Magnetic Materials, Dia-, Para-, and Ferromagnetism, http://videlectures.net/mit802s02_lewin_lec21/
2. <https://ieeetv.ieee.org/mobile/video/magnetic-materials-and-magnetic-devices-josep-fontcuberta-ieee-magnetics-distinguished-lecture-2016>

RESEARCH & REVIEW PAPERS

1. Nandan Murali, Simran Kaur Rainu, Neetu Singh, Soutik Betal, Advanced materials and processes for magnetically driven micro- and nano-machines for biomedical application, *Biosensors and Bioelectronics*: X, 11 (2022) 100206.
2. Hitoshi Makino, Ján Ruzs, Jian Wang, Diego Turenne, Masahiro Ohtsuka, Yukiko K. Takahashi, Hermann A. Dürr, Shunsuke Muto, A study on the relationship of magnetic moments orientation in L10 FePt network nanostructured film by electron energy-loss magnetic chiral dichroism using semi-core excitation spectra, *Journal of Magnetism and Magnetic Materials*, 558 (2022) 169522
3. Umesh P. Borole, Jakeer Khan, Harish C. Barshilia, P. Chowdhury, Design, fabrication, and characterization of giant magnetoresistance (GMR) based open-loop current sensor with U-shaped current carrying conductor, *Sensors and Actuators A: Physical*, 332 (2021) 113103.

COURSE OUTCOMES**On Successful completion of the course, students will be able to**

CO1:	Visualize different methods available for thin film fabrication
CO2:	Understand the principles and laws governing the thin film fabrication process
CO3:	Explain various properties of thin films

UNIT - I PREPARATION OF THIN FILMS

12

Study of thin film vacuum coating unit - Construction and uses of vapour sources-wire, sublimation, crucible and electron bombardment heated sources. Physical vapour deposition - Thermal evaporation -Electron beam evaporation - Sputtering - Study of glow Discharge - Physical nature of sputtering - Sputtering yield -Experimental set up for DC and RF magnetron sputtering, Pulsed laser deposition and Ion beam assisted deposition - Chemical vapour deposition - Thermodynamics of CVD - Atmospheric pressure CVD - MOCVD and PECVD processes. Chemical methods: Qualitative study of preparation of thin films by Spray pyrolysis, Electroplating, vapour phase growth and anodization

UNIT - II NUCLEATION AND GROWTH

9

Nucleation and growth of thin films – Four stages of film growth - thermal accommodation, surface diffusion, nucleation, island growth - Directionality of evaporation molecules - Cosine law of emission. Emission from a point source. Mass of material condensing on the substrate.

UNIT - III DEPOSITION MONITORING AND CONTROL

9

Microbalance, Crystal oscillator thickness monitor, optical monitor, Resistance Monitor. Thickness measurement: Multiple Beam Interferometer, Fizeau (Tolansky) technique - Fringes of equal chromatic order (FECO) method - Ellipsometry (qualitative only).

UNIT - IV ELECTRICAL & DIELECTRIC PROPERTIES

9

Sheet resistance - size effect - Electrical conduction in thin metallic films. Effect of ageing and annealing - Oxidation - Agglomeration. DC conduction mechanism - Low field and high field conduction. Breakdown mechanism in dielectric films - AC conduction mechanism. Temperature dependence of conductivity

UNIT - V STRUCTURE AND OPTICAL PROPERTIES

6

Study of structure of thin films using x-ray diffraction method, Grain size measurement - Optical constants of thin films -spectrophotometer- Transmittance, Absorption, Band Gap Determination using Tauc plot

Total Periods (45L): 45**TEXT BOOK**

1. Oring M, "Materials Science of Thin Films", Academic Press, 2002

REFERENCE BOOKS

1. IchaElshabini-Riadaud Fred D Barlow III "Thin Film Technology Hand book", McGraw Hill Company, 1997.
2. Goswami A, "Thin Film Fundamentals", New Age International (P) Ltd., 1996.
3. Smith D, "Thin Film Deposition", McGraw – Hill, 1995
4. Maissel L I and Glang R, "Hand Book of Thin Film Technology", McGraw Hill, 1970

WEB REFERENCE

<https://nptel.ac.in/courses/113104075>

RESEARCH & REVIEW PAPERS

1. Nicola Calisi, Emanuele Galvanetto, Francesca Borgioli, Stefano Mauro Martinuzzi, Tiberio Bacci, Stefano Caporali, Thin films deposition of fully inorganic metal halide perovskites: A review, *Materials Science in Semiconductor Processing*, 147 (2022) 106721.
2. Rui M.R. Pinto, Ved Gund, Carlos Calaza, K.K. Nagaraja, K.B. Vinayakumar, Piezoelectric aluminum nitride thin-films: A review of wet and dry etching techniques, *Microelectronic Engineering*, 257 (2022) 111753.
3. Martin Magnuson, Lars Hultman, Hans Högberg, Review of transition-metal diboride thin films, *Vacuum*, 196 (2022) 110567.
4. Jyothi Gutpa, Habibuddin Shaik, K. Naveen Kumar, Sheik Abdul Sattar, PVD techniques proffering avenues for fabrication of porous tungsten oxide (WO₃) thin films: A review, *Materials Science in Semiconductor Processing*, 143 (2022) 106534.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Describe the control parameters of various synthesis procedures and summarize relevant properties
CO2:	Recognize the suitable characterization techniques and functionalization routes for CNTs
CO3:	a) Develop CNT peapod materials and characterize the same b) Attain a clear understanding on the risks related with CNTs and their products

U N I T – I I N T R O D U C T I O N A N D S Y N T H E S I S 9

Introduction to Carbon Nanomaterials and structures, Carbon allotropes and their bonding between carbon atoms - CNT, Graphene, fullerenes - Shape and Structure - Symmetry –vector model – Synthesis: Exfoliation - Arc discharge - Laser ablation - Chemical vapour deposition - PECVD synthesis - Growth, Diameter and chirality control - Growth of ultralong SWCNTs - Water assisted growth of SWCNTs.

UNIT – II PROPERTIES 9

Electronic properties of Graphene and CNTs - Magnetic properties: Band structure in magnetic fields, Magnetic susceptibilities, Magneto transport phenomena - Electromechanical properties: Piezoresistance, Theory of strain-induced band-gap changes in carbon nanotubes, Electrostatic actuation.

UNIT – III FUNCTIONALISATION AND CHARACTERISATION 9

Purification - functionalization methodologies - Covalent, non-covalent, and biological approaches - selective functionalization and separation - Raman Spectroscopy of carbon nanostructures: Probing electronic and chemical behaviour

UNIT – IV CARBON NANOTUBE PEAPOD MATERIALS 9

C60@SWNT - Mechanism of formation - Structural characterization - Properties: Band structure, Electrical and thermal conduction, Optical properties - Transformations of peapods - Peapods of metallofullerenes - Ordered phases of fullerenes in larger nanotubes - Double-wall carbon nanotubes.

UNIT – V TOXICOLOGY 9

Behaviour and Fate of Carbon Nanotubes in Mammals - Cellular Uptake - Cytotoxicity – Immunotoxicity- Pulmonary effects - Inflammatory response – In-vivo interactions of pulmonary inflammation with oxidative stress – Interactions of CNTs with Macrophages.

Total Periods (45L):45

TEXT BOOK

1. Michael J. O'Connel., “Carbon Nanotubes: Properties and Applications” Taylor and Francis, 2006

REFERENCE BOOKS

1. M Endo, S Iijima and M S Dresselhaus., “Carbon Nanotubes” Pergamon, 1996

2. H S Nalwa., “Encyclopedia of Nanoscience and Nanotechnology” American Scientific Publishers, 2004

3. Simeonova P.P, Opopol N, and Luster M.I., “Nanotechnology – Toxicological Issues and Environmental Safety” Springer 2006.

4. Silvana Fiorito., “Carbon Nanotubes – Angels and Demons” Pan Stanford Publishing Pte. Ltd, 2008

WEB RESOURCES

1. Carbon Nanostructures by Prof. Kantesh Balani and Prof. Anandh Subramaniam, Dept. of Materials Science and Engineering, IIT Kanpur
2. The New carbon Family I – Fullerenes and Nanotubes by Prof. S. Sundar Manoharan, Dept. of Chemistry, IIT Kanpur
3. The New carbon Family II – Graphene by Prof. S. Sundar Manoharan, Dept. of Chemistry, IIT Kanpur
4. Fullerenes and Carbon Nanotubes – I by Prof. Ashok K Ganguli, Dept. of Chemistry, IIT Delhi
5. Fullerenes and Carbon Nanotubes – II by Prof. Ashok K Ganguli, Dept. of Chemistry, IIT Delhi
6. Fullerenes and Carbon Nanotubes – III by Prof. Ashok K Ganguli, Dept. of Chemistry, IIT Delhi

RESEARCH & REVIEW PAPERS

1. Munirasu Selvaraj, Abdul Hai, Fawzi Banat, Mohammad Abu Haija, Application and prospects of carbon nanostructured materials in water treatment: A review, *Journal of Water Process Engineering*, 33 (2020) 100996.
2. Xiaoyan Li, Yuming Chen, Haitao Huang, Yiu-Wing Mai, Limin Zhou, Electrospun carbon-based nanostructured electrodes for advanced energy storage – A review, *Energy Storage Materials*, 5 (2016) 58-92.
3. Xiaohui Liang, Wei Liu, Yan Cheng, Jing Lv, Sisi Dai, Dongming Tang, Baoshan Zhang, Guangbin Ji, Review: Recent process in the design of carbon-based nanostructures with optimized electromagnetic properties, *Journal of Alloys and Compounds*, 749 (2018) 887-899.
4. Nora Nyholm, Nuria Espallargas, Functionalized carbon nanostructures as lubricant additives – A review, *Carbon*, 201 (2023) 1200-1228.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Recognize various applications of coating technology
CO2:	Experiment on advanced Physical and Chemical Vapor deposition technologies
CO3:	Experiment on Chemical and Electrochemical Coating Techniques

UNIT - I INTRODUCTION AND APPLICATION OF THIN FILMS 9

Fundamentals of film growth- nucleation models – Applications (Materials and Design): - Resistors - Capacitors - Field effect transistors - Sensors - Solar cells - Anti reflection – Corrosion Resistance – Lubrication – Adhesion.

UNIT - II PHYSICAL VAPOR DEPOSITION 9

Arc Vapor Deposition - Electron beam physical vapor deposition - Thermal Evaporation - Pulsed laser deposition - Sputter deposition – Atomic Layer deposition – LASER ablation

UNIT - III CHEMICAL VAPOR DEPOSITION 9

Introduction – Mechanism - Heat Transport – Mass Transport – Volatility - Entropy and Trouton's Rule - Equilibrium Kinetics - Surface Reactions and Film Formation - Silicon dioxide films by CVD.

UNIT - IV ELECTROCHEMICAL DEPOSITION 9

Electrochemical Atomic Layer Epitaxy - Electrochemical Deposition Methods for Metallic Nanostructures - Electroless plating - Electrochemical Nanolithography - Electrochemical Etching and LIGA Technique

UNIT - V CHEMICAL SOLUTION TECHNIQUES 9

Chemical Bath Deposition – Dip Coating - Spin Coating – Hydrothermal Method – Spray pyrolysis - Langmuir-Blodgett Films - Self assembly - Screen printing - Inkjet printing – Doctor Blade Coating.

Total Periods (45L): 45

TEXT BOOK

1. Cao G., “Nanostructures & Nanomaterials - Synthesis, Properties and Applications” Imperial College Press, 2004.

REFERENCE BOOKS

1. Dobkin D M, Zuraw M K., “Principles of Chemical Vapor Deposition” Kluwer Academic Publishers, 2003.
2. Wei D., “Electrochemical Fabrication – Principles and Applications” Taylor & Francis Group, 2012.
3. Donald M, “Handbook of Physical Vapor Deposition (PVD) Processing” Elsevier Inc, 2010.

WEB RESOURCE

1. <https://ocw.mit.edu/courses/mechanical-engineering/2-627-fundamentals-of-photovoltaics-fall-2013/lecture-videos-slides/2011-lecture-12-thin-films-materials-choices-and-manufacturing-part-i/>

RESEARCH & REVIEW PAPERS

1. Liang Liu, Daniel Mandler, Using nanomaterials as building blocks for electrochemical deposition: A mini review, Electrochemistry Communications, 120 (2020) 106830.
2. F. Gonca Aras, Alp Yilmaz, H. Gunalp Tasdelen, Ayberk Ozden, Feridun Ay, Nihan Kosku Perkgoz, Aydan Yeltik, A review on recent advances of chemical vapor deposition technique for monolayer transition metal dichalcogenides (MX₂: Mo, W; S, Se, Te), Materials Science in Semiconductor Processing, 148 (2022) 106829.
3. Yang Deng, Wanglin Chen, Bingxin Li, Chengyong Wang, Tongchun Kuang, Yanqiu Li, Physical vapor deposition technology for coated cutting tools: A review, Ceramics International, 46 (2020) 18373-18390.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Identify the various components of a biosensor
CO2:	Analyze the different analyte and analate compositional behavior in a suspended or dispersed media
CO3:	Fabricate a sensor and identify its potential in applied fields

UNIT - I PROTEIN BASED BIOSENSORS 9

Nano structure for enzyme stabilization - single enzyme nano particles - nano tubes microporus silica – protein based nano crystalline Diamond thin film for processing.

UNIT - II DNA BASED BIOSENSOR 9

Heavy metal complexing with DNA and its determination water and food samples – DNA zymo Biosensors.

UNIT - III DETECTION IN BIOSENSORS 9

Fluorescence - absorption – electrochemical biosensing - Integration of various Techniques - Fibre optic Biosensors.

UNIT - IV FABRICATION OF BIOSENSOR 9

Techniques used for microfabrication - microfabrication of electrodes –Lab on chip analysis – Bioconjugates and chemical conjugates

UNIT - V FUTURE DIRECTION IN BIOSENSOR RESEARCH 9

Designed protein pores - as components of biosensors - Molecular design - Bioimplants - Biosensors for drug discovery – biosensors and point-of-care diagnostics systems, Noninvasive biosensors in clinical analysis - Molecular switches- 3 D printing – Wearable electronics–Factors governing the molecular devices – Health Monitoring sensors – Disposable sensors – Applications - Food processing and packaging.

Total Hours (45L): 45

TEXT BOOK

1. Cooper J and Tass C, Biosensors: A Practical Approach,, Oxford University Press, (2004).

REFERENCE BOOKS

1. Kumar C S, Nanomaterials for Biosensors, Wiley - VCH, (2007).
2. Knoff G K, Bassi A S, Smart Biosensor Technology, CRC Press, (2006).

WEB REFERENCE

1. NPTEL, Biosensors Overview, <https://nptel.ac.in/courses/117108037/17>

RESEARCH & REVIEW PAPERS

1. Sora Yasri, Viroj Wiwanitkit, Sustainable materials and COVID-19 detection biosensor: A brief review, Sensors International, 3 (2022) 100171.
2. Sangam Srikanth, Jayapiriya U. S, Satish Kumar Dubey, Arshad Javed, Sanket Goel, A Lab-On-Chip Platform for Simultaneous Culture and Electrochemical Detection of Bacteria, iScience, 2022, 105388.
3. M.R. Saidur, A.R. Abdul Aziz, W.J. Basirun, Recent advances in DNA-based electrochemical biosensors for heavy metal ion detection: A review, Biosensors and Bioelectronics, 90 (2017) 125-139.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the basic of transport phenomena in nanomaterials
CO2:	Explain the transfer of energy in various formats between the material and the environment
CO3:	Visualize various application of nanofluids

UNIT - I INTRODUCTION 9

Principle of momentum, mass and energy balance - Dimensional analysis and its applications - Generalized interface models for transport phenomena - unusual scale effects in composite nanomaterial – Dimensionless numbers.

UNIT - II FLUID FLOW 9

Laminar and Turbulent Fluid Flow – Viscosity - Mass balance continuity equation for steady state, incompressible fluid -Momentum balance - equation of motion - Laminar flow through pipes - Over all mass and momentum balance - Flow meters - Flow through packed and fluidized beds - Motion of gas bubbles in liquids, Theory of transport phenomena on nanomaterials, Process parameters including the application in nanotechnology.

UNIT - III HEAT CONDUCTION AND CONVECTION 9

Fourier's law of heat conduction – Conductivity - Heat conduction equation in rectangular, cylindrical and spherical coordinates - Steady state one dimensional and multidimensional heat conduction - Unsteady state heat conduction. Forced convection - Natural convection - Overall thermal energy balance and concept of heat transfer coefficient - Convective mass transfer - natural and forced convection

UNIT - IV HEAT AND MASS TRANSFER 9

Heat Transfer: Thermal radiations and related properties of materials like two dimensional nanomaterials (thin films); Emissivity and absorptivity of substances Mass Transfer: Modes of mass transfer viz. diffusion and convection; Diffusion - Fick's laws of diffusion - Diffusion in gases, liquids and solid - Application in nanomaterials.

UNIT – V APPLICATIONS OF NANOFLUIDS 9

Fundamentals of Nanofluids - Nanomaterials and their application in enhancement of thermal conductivity and heat convection - Nanofluids for heat transfer applications – Nanofluids for Industrial Cooling Applications

Total Periods (45L): 45

TEXT BOOK

1. Bird, R. B. , Stewart, W.E. and Lightfoot, E.N., “Transport Phenomena”, Revised 2nd Edition, John Wiley & Sons, Inc. 2007

REFERENCE BOOKS

1. Geankoplis, C.J., “Transport Processes & Separation Processes Principles”,4th Edition, PHI Learning Pvt. Ltd., NewDelhi. 2012
2. Incroperia, F.P., Dewitt, D.P., Bergman, T.L. and Lavine, A.S., “Principles of Heat and Mass Transfer”; 7th Edition, John Wiley & Sons, Inc. 2013
3. Nag, P.K., “Heat and Mass Transfer”, 3rd Edition, McGraw Hill Education(India) Pvt. Ltd. 2011
4. Thirumaleshwar, M., “Fundamentals of Heat and Mass Transfer” Pearson Education in South Asia. 2012
5. Rathore, M.M., “Engineering Heat and Mass Transfer” 2nd Edition, University Science Press, New Delhi. 2006

6. Arora, D., “A Course of Heat Mass Transfer” DhanpatRai Publishing Company (P) Limited.

WEB REFERENCES

1. Intro to Nanotechnology, Nanoscale Transport Phenomena, <https://ocw.mit.edu/courses/mechanical-engineering/2-57-nano-to-macro-transport-processes-spring-2012/video-lectures/lecture-1-intro-to-nanotechnology-nanoscale-transport-phenomena/>
2. Transport Phenomena, https://onlinecourses.nptel.ac.in/noc17_ch11/preview, IITKGP 2017

RESEARCH & REVIEW PAPERS

1. Shuai Liu, Shihong Ma, Yan Liu, Yongzhen Wang, Analysis of the energy conversion properties and applications of Nanofluids: A review, Energy Reports 8 (2022) 175–184
2. Javier P. Vallejo, Jose I. Prado, Luis Lugo, Hybrid or mono nanofluids for convective heat transfer applications. A critical review of experimental research, Applied Thermal Engineering, 203 (2022) 117926,
3. Zhongwei Zhang, Yulou Ouyang, Yuan Cheng, Jie Chen, Nianbei Li, Gang Zhang, Size-dependent phononic thermal transport in low-dimensional nanomaterials, Physics Reports, 860 (2020) 1-26.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand the basics of wearables and nanobiosensors
CO2:	Explain the functions of various components of wearables
CO3:	Visualize various applications of wearables and their augmentation by nanotechnology

UNIT - I SCOPE OF WEARABLES**9**

Textiles and clothing –Agriculture; Pest detection – Soil health monitoring– Cattle rearing; Health monitoring of cattle – Waste management in storage houses –Laboratory hazard management for harmful chemicals - Smart homes; food and water quality monitoring and management– Healthcare; Patient monitoring – Home detection kits

UNIT - II SENSORS IN WEARABLES**9**

Resistive sensors for work safety – Radiation sensors – LASER Safety- Piezoelectric sensors - Accelerometers, Gyroscopes and Pressure sensors for aiding physically impaired stress and strain detection - Packaging sensors- Adulteration sensors – Sweat sensors – Soil Sensors; NPK sensors, pH and Electrical Conductivity of soil – Self sensing cement composites.

UNIT - III NANOBIOSENSORS**9**

Biomarkers and food markers; Macromolecules – DNA and RNA based biosensors – Protein and Peptide based biosensors – Electrolyte based biosensors – Pathogen based biosensors – Monoclonal Antibodies synthesis – Lab on a chip

UNIT - IV NANOTECHNOLOGY IN WEARABLES AUGMENTATION**9**

Nanomaterials for cancer diagnosis - Nanomaterials for cancer therapy - Nanotechnology in tissue engineering- Nano artificial cells - Nanotechnology in 3D and 4D printed healthcare devices – Smart drug delivery systems.

UNIT - V FLEXIBLE WEARABLE ELECTRONICS**9**

Flexible electronics; Flexible power sources - Flexible batteries - flexible displays - Organic electronics - Stress strain connectivity - Muscle movement tracking — Nanogenerators - Textile and polymer platform - Self healing polymer membranes - Paper based sensors

Total Periods (45L): 45**TEXT BOOK**

1. Enderle J, Blanchard S, Bronzino J, “Introduction to Biomedical Engineering”, Elsevier Academic Press, 2012.
2. Mirkin C.A. and Niemeyer, C.M., “Nanobiotechnology II: More Concepts and Applications”, Wiley-VCH, 2007.
3. Kumar C. S. S. R., Hormes, J. and Leuschner C., “Nanofabrication Towards Biomedical Applications: Techniques, Tools, Applications, and Impact”, WILEY -VCH Verlag GmbH & Co., 2005
4. Tong, R., “Wearable Technology in Medicine and Health Care”, Elsevier Science., 2018
5. Singh V.K., Singh A.K, Ali Z., Dubey V., Tiwari R., “Design and Optimization of Sensors and Antennas for Wearable Devices”, IGI Global, 2019

REFERENCE BOOKS

1. Fraden J, “Hand Book of Modern Sensors: physics, Designs and Applications”, 4th edition. Springer, 2010.
2. Webster J. G, “Medical Instrumentation: Application and Design”, John Wiley and Sons, 2003.
3. Malsch, N. H., “Biomedical Nanotechnology”, CRC Press, 2005
4. Yilmaz N.D., “Smart Textiles, Wearable Nanotechnology”, Wiley, 2018

RESEARCH & REVIEW PAPERS

1. Butt MA, Kazanskiy NL, Khonina SN. Revolution in Flexible Wearable Electronics for Temperature and Pressure Monitoring—A Review. *Electronics*. 11 (2022) 716
2. Rani Puthukulangara Ramachandran, Chelladurai Vellaichamy, Chyngyz Erkinbaev, Smart nano-biosensors in sustainable agriculture and environmental applications, In *Micro and Nano Technologies, Food, Medical, and Environmental Applications of Nanomaterials*, Elsevier, 2022, 527-542,
3. Cheng, Y., Wang, K., Xu, H. et al. Recent developments in sensors for wearable device applications. *Anal Bioanal Chem* 413 (2021) 6037–6057.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Classify different cell types and discuss the way they live through their life cycle.
CO2:	Explain the various cellular entities present in human, plant and microbiological species.
CO3:	Describe the functions of different types of macromolecules present along with their metabolism.

UNIT – I INTRODUCTION TO BIOLOGICAL SYSTEMS**9**

Cell – Composition, Structure, organelles and function – Eukaryotic and Prokaryotic cells, Principle of membrane organization, cytoskeletal proteins, types of cell division, mitosis and meiosis, cell cycle and molecules that control cell cycle, structural organization and multiplication of microbes

UNIT-II CELLULAR FUNCTIONS**9**

DNA - Experiments, DNA replication-Mechanism of replication - Enzymes involved and its details, Mechanism of transcription in prokaryotes and eukaryotes, splicing and transcriptional factors, inhibitors, mechanism of translation, translational factors

UNIT-III MACROMOLECULES**9**

Physical and chemical properties of amino acids, different types of protein, Proteins of pharmaceutical importance, role of covalent and non-covalent interactions important to protein structure and functions - Protein structures and the utilization of genomic databases– Function – Lipids – Structure – Functions

UNIT – IV PHYSIOLOGY**9**

Muscular System - Blood – Composition, organelles and function – Bone– Structure, composition and function – Nervous system – Cells of nervous systems – Circulator System – Digestive system – Endocrine and Exocrine systems – Respiratory system – Muscular System – Reproductive system.

UNIT – V IMMUNITY**9**

Immune systems – Innate immunity and adaptive immunity– Cells of immune systems – Reticulo Endothelial system – Complement system – Hyper sensitivity

Total Periods (45L): 45**TEXT BOOKS**

1. R. Cantor, P.R.Samuel, “Biophysical Chemistry”, W.H., Freeman & Co., 1985.

REFERENCE BOOKS

1. Stanfield C.L, Germann W.J, “Principles of human physiology”, 3rd edition, Benjamin Cummings Publishing company, 2008.
2. Watson J, Baker T, Bell S, Gann A, Levine M, and Losick R, “Molecular Biology of the Gene”, 5th edition., San Francisco, Addison-Wesley, 2000.
3. Alberts B, Johnson A, Lewis J, Raff M, Roberts K and Walter P. “Molecular Biology of the Cell” 4th edition, New York: Garland Science, 2002.
4. Branden, Carl-Ivar, and John Tooze. “Introduction to Protein Structure”, 2nd Edition New York: Garland Publications, 1991.
5. Creighton E, Thomas, “Proteins: Structures and Molecular Properties”, 2nd Edition, New York: W.H. Freeman, 1992.
6. B.Lewin, “Genes IX”, International Edition. Sudbury: Jones & Bartlett, 2007.

WEB REFERENCES

1. NPTEL, Introduction to Cell Biology: <https://nptel.ac.in/downloads/102103012/#>

COURSE OUTCOMES**On Successful completion of the course, students will be able to**

CO1:	Understand the various methods of preparation of Nanomaterials
CO2:	Comprehend the properties and functions of nanomaterials used in different industries / domains
CO3:	Acquire knowledge on nanotechnology based alternate energy and healthcare applications

UNIT – I BASICS AND SCALE OF NANOTECHNOLOGY 9

Introduction - Time and length scale in structures - Definition of a Nanosystem - Dimensionality and size dependent phenomena - Surface phenomenon – surface to volume ratio, fraction of surface atoms, surface energy and surface stress, surface defects - Scientific revolutions - Potential applications involving Nanotechnology - Scope of Nanoscience and Technology.

UNIT – II STRUCTURAL NANOMATERIALS 9

Classification of Nanostructured Materials - High strength materials - Carbon nanostructures - Heat exchangers and coolants - Biofouling and Corrosion prevention - Water repellent and insulating paints - Foldable light weight solar cells - Regulation of building environment using nanosensors – Super Hydrophobic Coating - Waste water treatment by photocatalysis – Super insulators : aerogels – Nanosorbents.

UNIT – III NANO ELECTRONICS 9

Nano ferroelectrics – Ferroelectric random access memory – Fe-RAM circuit design - Solar energy conversion - Molecular and printed electronics – Nanoelectronics - Applications in displays and other devices – Nano Robots - Nanomaterials for data storage – NanoBiosensors - Electronic noses – Identification of hazardous solvents and gases – Semiconductor sensor array.

UNIT – IV FUNCTIONAL-HYBRID NANOMATERIALS 9

Nanomaterials for corrosion prevention - Hydrogen fuel: storage and harvesting - Emission control – Nano lubricants - Nanoengines - Nanofluidics – Space applications - Smart and functional fabrics – Fire retardant and insulating materials- Electrochromic glasses – Selfhealing materials – Shape memory alloys.

UNIT – V NANOBIO MATERIALS 9

Bionics– Swim-suits with shark-skin-effect, Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, antibacterial, hydrophilic, self-cleaning, flame retardant finishes) – Modern textiles (Lightweight bulletproof vests and shirts, Color changing property, Smart Fabrics – Smart textiles – Materials for Smart textiles- Cosmetics – Sun-screen dispersions for UV protection using Titanium oxide – Color cosmetics – Nano Drug Delivery systems – Nano Tissue engineering scaffolds.

Total Periods (45L): 45**TEXT BOOKS**

1. B.S. Murty, P. Shankar, B. Raj, B.B. Rath, J. Murday, “Textbook of Nanoscience and Nanotechnology”, Springer, 2013.
2. T. Pradeep, “A Textbook of Nanoscience and Nanotechnology”, McGraw Hill Education (India) Pvt. Ltd., 2012.
3. D. Vollath, “Nanomaterials: An Introduction to Synthesis, Properties and Applications”, 2nd Edition, Wiley, 2013.
4. Mick Wilson, Kamali Kannargare., Geoff Smith, “Nano technology: Basic Science and Emerging technologies”, Overseas Press, 2005.
5. V. Labhassetwar, D. L. Leslie – Pelecky, “Biomedical applications of Nanotechnology”, Wiley, 2007.

REFERENCE BOOKS

1. S. Mohan, S. O. Oluwafemi, N. Kalarikkal, Sabu Thomas, “Applications of Nanomaterials”, 1st Edition, Elsevier, 2018.
2. Mark A. Ratner, Daniel Ratner, “Nanotechnology: A Gentle Introduction to the Next Big Idea”, Prentice Hall P7R:1st Edition, 2002.
3. Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, “Nanoscale Science and Technology”, John Wiley & Sons, Ltd., UK, 2005.
4. A. Nouailhat, “An Introduction to Nanoscience and Nanotechnology”, John Wiley & Sons, Inc., UK, 2008.
5. A.K. Bandhyopadhyay, “Nanomaterials”, NewAge International (P) Ltd., Publishers., New Delhi, 2008

VIDEO LECTURES

1. Nano structured Materials-Synthesis, Properties, Self Assembly and Applications, <http://nptel.ac.in/courses/118102003/>, IITD 2014
2. Soft Nanotechnology, <https://www.class-central.com/course/nptel-soft-nano-technology-9923>, IITKGP 2018

WEB REFERENCES

1. http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0101-20612010000300002
2. <http://journal.frontiersin.org/article/10.3389/fphys.2014.00002/full>

CASE STUDIES

1. Case studies on textile industry effluent treatment
2. Case studies on ultra-low dimension computing processor

RESEARCH & REVIEW PAPERS

1. Samer Bayda, Muhammad Adeel, Tiziano Tuccinardi, Marco Cordani, Flavio Rizzolio, The History of Nanoscience and Nanotechnology: From Chemical–Physical Applications to Nanomedicine, *Molecule*, 25 (2019) 112.
2. Shuang Zhu, Huan Meng, Zhanjun Gu, Yuliang Zhao, Research trend of nanoscience and nanotechnology – A bibliometric analysis of Nano Today, *Nano Today*, 39 (2021) 101233.
3. Freddy C. Adams, Carlo Barbante, Nanoscience, nanotechnology and spectrometry, *Spectrochimica Acta Part B: Atomic Spectroscopy*, 86 (2013) 3-13.

COURSE OUTCOMES

On Successful completion of the course, students will be able to

CO1:	Understand and explain the various methods of environmental augmentation strategies using nanomaterials.
CO2:	Design various detection and remedial measures for large scale agricultural and industrial bodies using nanoparticles.
CO3:	Identify and manage the exposure of various nanoparticles used for environmental remediation activities.

UNIT – I INTRODUCTION TO NANOTECHNOLOGY**9**

Nanomaterials – History of Nanomaterials – Synthesis of Nanomaterials – Nucleation, Ostwald's ripening and grain boundary formation – Aggregation of nanoparticles – Classification of Nanomaterials- Top down techniques - Bottom up techniques – Novel properties of nanomaterials

UNIT – II PHYSICAL PROCESSES FOR ENVIRONMENTAL AUGMENTATION**9**

Necessity for water treatment measures – Adsorption – Agricultural wastage treatment – Nanofertilizers and Nanobiochar – Nanopesticides and pesticides degradation – Use of Nanotechnology in Environmental Remediation

UNIT – III CHEMICAL PROCESSES FOR ENVIRONMENTAL REMEDIATION**9**

Sunlight mediated photocatalytic oxidation of waste from water using semiconductor nanoparticles– Nanosorbents – Nanocatalyst - Industrial treatment processes by Nanomaterials – Soil enrichment by augmenting microbiome growth

UNIT – IV LARGE SCALE ENVIRONMENTAL TREATMENT PROCESSES**10**

Anaerobic method – Aerobic method –Detection and removal of contaminants in large water bodies by nanobiosensors – Nanomembranes for filtration of pathogens – Remediation of potable water using nanoparticles – Anti microbial nanoparticles for air purification in solid landfills.

UNIT – V FATE OF NANOPARTICLES**8**

Effect of non-degradable nanoparticles in the environment – Necessity for recycling and reusing of nanoparticles used in large scale – Monitoring and removal strategies for air and water suspended nanoparticles

Total Periods (45L):45**TEXT BOOKS**

1. Rao C.N.R, Muller.A and Cheetham A.K, “The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Volume-I and II”, John Wiley & Sons Inc, 2005.
2. Grassian V.H, “Nanoscience and Nanotechnology – Environmental and health impacts”, John Wiley & Sons, 2008.

REFERENCE BOOKS

1. Awan T.I, Bashir A, Tehseen A, “Chemistry of Nanomaterials - Fundamentals and Applications”, Elsevier, 2020.
2. Ram M, Andreescu.S.E, Hanming.D, “Nanotechnology for Environmental Decontamination”, McGraw Hill, 2007.

3. Hussain C.M and Mishra A.K, “Nanotechnology in Environmental Science”, Wiley, 2018.
4. Fulekar M.H and Bhawana P. “Environmental Nanotechnology” CRC Press, 2018.
5. Gothandam K.M, Ranjan S, “Nanotechnology, Food Security and Water Treatment”, Springer. 2018.
6. Lofrano G, Libralato G and Brown J, “Nanotechnologies for Environmental Remediation”, Springer, 2017.
7. Islam S U, “Environmental Nanotechnology for Water Purification”, Wiley, 2020.

NPTEL MATERIALS

1. Nanostructures and Nanomaterials: Characterization and Properties, Dr.Anandh Subramaniam, IIT Kanpur, <https://nptel.ac.in/courses/118/104/118104008/>
2. Nanotechnology in ground improvement and site remediation, Dr.G.L.Sivakumar Babu, Iisc Bangalore. <https://nptel.ac.in/content/storage2/courses/105108075/module9/Lecture40.pdf>

WEB RESOURCE

1. Thin films for Wastewater Treatment, by School of Mechanical Engineering at Georgia Tech, <https://www.youtube.com/watch?v=GtxB2vMVaHI>

RESEARCH & REVIEW PAPERS

1. Namra Abid, Aqib Muhammad Khan, Sara Shujait, Kainat Chaudhary, Muhammad Ikram, Muhammad Imran, Junaid Haider, Maaz Khan, Qasim Khan, Muhammad Maqbool, Synthesis of nanomaterials using various top-down and bottom-up approaches, influencing factors, advantages, and disadvantages: A review, *Advances in Colloid and Interface Science*, 300 (2022) 102597
2. Kuhn R, Bryant IM, Jensch R, Böllmann J. Applications of Environmental Nanotechnologies in Remediation, Wastewater Treatment, Drinking Water Treatment, and Agriculture, *Applied Nano*, 3 (2022) 54-90.
3. Kamalpreet Kaur Brar, Sara Magdouli, Amina Othmani, Javad Ghanei, Vivek Narisetty, Raveendran Sindhu, Parameswaran Binod, Arivalagan Pugazhendhi, Mukesh Kumar Awasthi, Ashok Pandey, Green route for recycling of low-cost waste resources for the biosynthesis of nanoparticles (NPs) and nanomaterials (NMs)-A review, *Environmental Research*, 207 (2022)112202.