FACULTY OF ENGINEERING AND TECHNOLOGY

UNDER GRADUATE PROGRAMMES

REGULATIONS - 2025

CHOICE BASED CREDIT SYSTEM (CBCS)

Effective from the Academic Year 2025-2026

St. PETER'S INSTITUTE OF HIGHER EDUCATION AND RESEARCH

(Deemed to be university U/S 3 of UGC Act 1956)

Accredited with Grade "A+" by NAAC | ISO 9001:2015 Certified| Approved by AICTE

AVADI, Chennai - 600054

TABLES OF CONTENTS

I. PREAMBLE

As per the recommendations of UGC, St. Peter's Institute of Higher Education and Research (SPIHER) has introduced Choice Based Credit System (CBCS) from the academic year 2015-16. Along with Choice Based Credit System the institution also adopted Outcome based Education (OBE) from 2015-16 academic year, with more emphasis on modified academic curriculum to meet corporate needs. Open electives, credits for internship, and semester abroad program are the measures taken to induce prolific quality component into the system. Continuous evaluation system is further strengthened with 40-60 percentage weightage that is in place for internal and external examinations respectively.

SPIHER has always strived to be a pioneer in delivering quality education. SPIHER has taken incremental steps in the right direction to provide holistic development to students through its academic curriculum. The four verticals namely knowledge, skill, self-development and learning to learn are considered while designing the curriculum. The curriculum is designed to facilitate multi-disciplinary learning, experiential learning through Project Based Learning as part of the learning process.

II. DEFINITIONS AND NOMENCLATURE

PRELIMINARY DEFINITIONS & NOMENCLATURE

i. **Degree**: Refers to the academic award conferred upon a student after the successful completion of the program within the stipulated period, fulfilling the required credits and prescribed procedures. The degree is an undergraduate program **Bachelor of Technology**, commonly referred to as **B.Tech**.

ii. **Programme**: Refers to the undergraduate degree program in engineering or technology.

iii. **Branch**: Denotes the specialization or discipline within the undergraduate degree program, such as Civil Engineering, Mechanical Engineering, etc.

iv. **Course**: Represents a unit of study within a semester, including theory, practical, laboratory-integrated theory, seminar, internship, or project work. Examples include subjects like English, Mathematics, Environmental Science, Engineering Graphics, and Electronic Devices.

v. **Institution**: Refers to **St. Peter's Institute of Higher Education and Research, Avadi, Chennai**.

vi. **Academic Council**: The apex body responsible for all academic matters within the institution.

vii. **Director (Academic Affairs)**: The official responsible for implementing relevant academic rules and regulations across all academic activities.

viii. **Controller of Examinations (CoE)**: The official responsible for conducting examinations and declaring results.

ix. **Head of the Department (HoD)**: The head of the respective academic department.

x. **Minor**: A discipline outside the student's major field of study, chosen for secondary specialization.

xi. **UGC**: University Grants Commission.

xii. **AICTE**: All India Council for Technical Education.

xiii. **SWAYAM**: Study Webs of Active-Learning for Young Aspiring Minds—an Indian **Massive Open Online Course (MOOC)** platform.

ACADEMIC REGULATIONS 2025

Under Choice Based Credit System (CBCS)

1.0 VISION AND MISSION OF THE INSTITUTION

1.1 Vision:

To be a globally renowned institution in academic excellence, research and innovation by providing inspirational learning to produce socially conscious leaders capable of addressing future challenges with ethical values.

1.2 Mission:

- To provide a vibrant learning environment, fostering innovation and creativity inspired by cutting edge research.
- To instill ethical values, imbibe a sense of social responsibility and strive for societal wellbeing.
- To promote National and International alliances and collaborative initiatives to achieve global excellence.

2.0 ADMISSION

2.1 Candidates for admission to the first semester of the eight semester B. Tech. degree programme shall be required to have passed the Higher Secondary Examination of the 10+2 curriculum (Academic stream) prescribed by the appropriate authority or any other examination of any University or authority accepted by the Institution as equivalent thereto.

2.2 Candidate shall also write an entrance examination prescribed by the Institution for admission. The entrance examination shall test the proficiency of the candidate in the courses considered eligible for admission on the standards prescribed for 10+2 academic stream.

2.3 Candidates for admission to the third semester of the eight semester B.Tech. programme under lateral entry category shall be required to have passed minimum Three years / Two years (Lateral Entry) Diploma examination in any branch of Engineering / Technology or passed B.Sc. Degree from a recognized University as defined by UGC and passed 10+2 examination with Mathematics as a subject or

Passed three year Diploma of Vocation Stream (D.Voc) in the same or allied sector or any other examination of any other authority accepted by the Institution as equivalent thereto.

2.4 Multiple Entry options (Credit transfer through ABC), credit exemptions as per the direction of duly appointed expert committee in the respective department

2.5 The Institution shall offer suitable bridge courses in Mathematics, Physics, Engineering drawing, etc., for the students of diverse backgrounds.

2.6 The eligibility criteria such as marks, number of attempts and physical fitness shall be as prescribed by the Institution in adherence to the guidelines of regulatory authorities from time to time.

2.7 The duration of the programme for the Degree of Bachelor of Technology will be four academic years, with two semesters in each year. The duration of each semester will normally be 90 working days. However, a student may complete the programme at a slower pace by taking more time, but not more than seven years.

3.0 PROGRAMMES OF STUDY

Regulations are applicable to the following B.Tech. programmes in various branches of Engineering and Technology, each distributed over eight semesters, with two semesters per academic year.

S. No.	Programme	Discipline
1.	B.Tech.	Artificial Intelligence and Data Science
2.	B.Tech.	Biomedical Engineering
3.	B.Tech.	Civil Engineering
4.	B.Tech.	Computer Science and Engineering
5.	B.Tech.	Cyber Security
6.	B.Tech.	Electrical and Electronics Engineering
7.	B.Tech.	Electronics and Communication Engineering
8.	B.Tech.	Information Technology
9.	B.Tech.	Mechanical Engineering

4.0 STRUCTURE OF THE PROGRAMME

The detailed courses of study for a programme will be decided by the respective department's Board of Studies. As per NEP 2020, the structure and lengths of degree programmes are adjustable. The undergraduate degree will be of 4-year duration, with multiple entries/exit options as per AICTE/UGC guidelines.

The students are allowed to exit the programme after I or II or III or IV year with Undergraduate Certificate, Undergraduate Diploma, Undergraduate Degree (B.Sc) and Undergraduate B.Tech. respectively as per the regulations of NEP 2020, Government of India. Similarly, the students from other institutions can join SPIHER institution in the 3rd or 5th or 7th semester with an appropriate Undergraduate Certificate or Undergraduate Diploma or Undergraduate Degree Certificates respectively.

The 4-year multidisciplinary Bachelor's programme, however, shall be the preferred option since it allows the opportunity to experience the full range of holistic and multidisciplinary education in addition with the focus on the chosen major and minors as per the choices of the student. Every programme will have a curriculum with a syllabus consisting of theory, practical, Theory based practical, Project based theory, internship, project work, etc. for 161 credits.

4.1 Categorization of Courses

i. **Humanities, Social Sciences and Management Courses (HSC)** include English for communication, Employability Skills, Engineering Ethics and Human Values and Management courses.

ii. **Basic Science Courses (BSC)** include Mathematics, Physics, Chemistry, Biology, Environmental Science and Sustainability, etc.

iii. **Basic Engineering Courses (BEC)** include Engineering Practices, Engineering Drawing, Basics of Civil / Electrical / Electronics / Mechanical / Computer Engineering, Instrumentation etc.

iv. **Professional Core Courses (PCC)** include the core courses relevant to the chosen specialization/branch.

v. **Professional Elective Courses (PEC)** include the verticals with elective courses and elective courses relevant to the chosen specialization/ branch.

vi. **Open Elective Courses (OEC)** are Multidisciplinary courses that include the courses from Humanities and other disciplines of Engineering and Technology. Students can choose these courses from the list of Open Elective courses specified in the respective curriculum. Students may also choose courses from other disciplines from Swayam/NPTEL platform, including non-engineering courses.

vii. **Project Courses (PC)** Includes Project Work and/or Internship, Career Development Skills, Creative and Innovative Project, Seminar, Professional Practices, Case Study and Industrial/Practical Training

viii. **Mandatory Audit Courses (MAC)** Mandatory Audit Courses like Indian Constitution and Humanity Rights, NCC/YRC/NSS/Rotary Club, Yoga Behavioral Science and entrepreneurship and Startups are offered to all engineering programs of the Institution.

- The activities will include Practical / Field activities / Extension lectures. The activities shall be beyond class hours. The student participation shall be for a minimum period of 2 hours per week during the respective semester and the activities will be monitored by the respective faculty in charge.
- Grades will be awarded on the basis of participation, attendance, performance and behavior. Grades shall be entered in the Grade statement as given below:
  Very Good, Good, Satisfactory and Unsatisfactory
- The Grades awarded by the faculty in-charge shall be entered in the respective semester Grade Sheet. If a student gets an unsatisfactory Grade, he/she has to repeat the above activity in the subsequent years.

4.1.2 Online Courses for Credit Transfer

The department shall approve the list of online courses offered by approved external agencies such as SWAYAM / NPTEL / MOOC. While listing the courses, the department shall consider the following points:

a. The course evaluation is carried out by the same external agency

b. Equivalent grading mechanism to be arrived at by the department

A student can register up to a maximum of 32 credits (total) as online courses during the entire programme of study. These shall be treated as Elective courses (programme elective or open elective). Students may be allowed to register for one course per semester. The student shall produce a Pass Certificate from the respective agencies. The credits(s) earned by the students will be transferred to the concerned course in the Grade Sheet.

4.1.3 Value Added Courses

The students are permitted to pursue department approved online courses (excluding courses registered for credit transfer) or courses offered / approved by the department as value added courses. The details of the value-added course viz., syllabus, schedule of classes and the course faculty shall be sent to the Director (Academic) for approval. The students may also undergo the valued added courses offered by other departments with the consent of the Head of the Department offering the course. These value-added courses shall be specified in the consolidated mark sheet as additional courses pursued by the student over and above the curriculum during the period of study

4.1.4 Industry Internship

The students shall undergo training for a period as specified in the curriculum during the summer vacation in any industry relevant to the field of study. The students are also permitted to undergo internship at research organizations / eminent academic institutions for the period prescribed in the curriculum during the summer vacation, in lieu of Industrial training. In any case, the student shall obtain necessary approval from the Head of the Department / Dean Academic and the training has to be taken up at a stretch.

4.1.5 Industrial Visit

The student shall undergo at least one industrial visit every year from the second year of the programme. The Heads of Departments / Dean Academic shall ensure the same.

4.2 CREDIT ASSIGNMENT FOR SEMESTER PROGRAM OF 15 WEEKS

Each course is normally assigned certain number of credits:

Lecture Hours (Theory)	1 Credit / 1 Lecture hour / week
Practical Hours	1 Credit / 2 Practical hours / week, 2 Credits / 4 Practical hours / week
Tutorial	1 Credit / 1 hour / week.
Courses with Project Based Learning Approach (PBLA)	1 Credit / 1 Lecture Hour / week
Project Work Phase I	6 Credits / 6 hours of project work (Phase-I) / week
Project Work Phase II	12 Credits / 18 hours of project work (Phase - II) / week
Internship/Entrepreneurship/ Consultancy/In plant training/	1 Credit / minimum 2 weeks during vacation

4.3 Each semester curriculum shall normally have a blend of lecture courses, laboratory courses, laboratory integrated theory courses, Project integrated theory courses, skill based courses etc.

4.3.1 Course Coordinator for Common Course

Each common theory course offered to more than one class or branch or group of branches, shall have a "course coordinator". The course coordinator will be nominated by the Dean in consultation with respective Head of the Department. The Course Coordinator will be normally a senior faculty member who is one among the teachers teaching the course.

The "Course Coordinator" shall meet the teachers handling the course, as often as possible and ensure

- A common teaching methodology is followed for the course.
- The study materials are prepared by the staff members and communicated to the students periodically.
- The involvement of students in course-based projects and assignments.
- To prepare common question paper for continuous internal assessment tests.
- For uniform evaluation of continuous internal assessments answer sheets by arriving at a common scheme of evaluation.

The course coordinator is responsible for evaluating the performance of the students in the continuous internal assessments and end semester examinations and analyse them to find suitable methodologies for improvement in the performance. The analysis should be submitted to the HoD and Dean for suitable action.

4.4 The medium of instruction, examinations and project report shall be in English, except for courses in languages other than English.

4.5 ENROLLMENT FOR B.Tech. (Honours) and B.Tech. minor with specialization in another discipline. (OPTIONAL)

4.5.1 B.Tech. (Hons.)

a) The students should have taken additional courses from a specified group of Professional Electives (vertical) or from any of the verticals of the same programme and earned a minimum of 18 credits.

b) Should have passed all the courses prescribed in the curriculum and additional courses in the first attempt.

c) Should have earned a minimum of 7.50 CGPA taking into account of all the courses prescribed in the curriculum and additional courses.

d) Lateral Entry students shall be permitted to register for the courses from Semester V onwards provided the students have earned a minimum CGPA of 7.50 until Semester III and have cleared all the courses in the first attempt.

e) If a student decides not to opt for Honor's, after completing certain number of additional courses, such additional courses studied shall be considered instead of the Professional Elective courses which are part of the curriculum.

If the student has studied more number of such courses than the number of Professional Elective courses required as per the curriculum, the courses with higher grades shall be considered for the calculation of CGPA. Remaining courses shall be printed in the grade sheet, however, they will not be considered for calculation of CGPA and the same shall be indicated in a foot note appropriately.

If the student has failed in the additional courses or faced shortage of attendance, they will not be printed in the grade sheet and will not be considered for CPGA calculation and classification of degree.

4.5.2 B.Tech. Minor with specialisation in another discipline:

The student should have earned additionally a minimum of 18 credits in any one of the verticals offered from other Engineering Disciplines / Science and Humanities / Management.

a) For these 18 credits students can optionally enroll and study a maximum of 6 credits in online mode from SWAYAM-NPTEL platform (in addition to the three online courses permitted for courses of curriculum), as approved by Head of the Department / Director Academic

b) B.Tech. (Hons.) and B.Tech. minor with specialization in another discipline will be optional for students and the students shall be permitted to select any one of them only.

c) For the category 4.5.2, the students, including Lateral Entry, will be permitted to register the courses from Semester V onwards provided the marks earned by the students until Semester III is CGPA 7.50 and above.

d) B.Tech. (Hons.) or B.Tech. Minor shall be offered by the Department irrespective of the number of students enrolled.

e) If a student decides not to opt for Minor, after completing certain number of courses, the additional courses studied shall be considered instead of Open Elective courses which are part of the curriculum.

If the student has studied more number of such courses than the number of open electives required as per the curriculum, the courses with higher grades shall be considered for calculation of CGPA. Remaining courses shall be printed in the grade sheet, however, they will not be considered for calculation of CGPA and the same shall be indicated in a foot note appropriately.

If the student has failed in the additional courses or faced shortage of attendance, they will not be printed in the grade sheet and will not be considered for CGPA calculation and classification of degree.

The student has to enroll for these additional courses separately and pay a tuition fee for studying these six additional courses and pay additional exam fee.

5.0 REGISTRATION AND ENROLLMENT

5.1 Each student, on admission, shall be assigned to a Mentor, who shall advise and counsel the student about the details of the academic programme and the choice of courses, considering the student's academic background and career objectives.

5.2 After registering for a course, a student shall attend the classes, satisfy the attendance requirements, earn continuous assessment marks and appear for the end semester examinations.

5.3 Each student on admission shall register for all the courses prescribed in the curriculum in the student's first Semester of study.

The enrollment for all the courses of curriculum from the Semesters II to VIII and additional courses for Honours and Minor from the semesters V and VIII will commence 5 working days prior to the commencement of the succeeding semester. The courses for Honours and Minor shall be registered separately under additional courses. The student shall enroll for the courses with the guidance of the student's Mentor. If the student wishes, the student may drop or add courses within 10 working days after the commencement of the concerned semester and complete the registration process duly authorized by the faculty in - charge within 30 days from the commencement of concerned semester. The list of students approved by the respective faculty-in-charge shall be final and would be considered for attendance, grades and calculation of CGPA and no changes shall be made thereafter.

5.4 For enrollment, a student MUST have

I. Cleared all the Institute and Hostel dues of the previous semesters and the current semester fees.

II. Not been debarred from registering for a specified period on disciplinary or any other ground.

5.5 Flexibility to Add or Drop courses:

5.5.1 A student has to earn the total number of credits specified in the curriculum of the respective programme of study in order to be eligible to obtain the degree. From the II to VII semesters, the student has the option of registering for additional courses or dropping existing courses in a semester. The total number of credits that a student can add or drop in a semester is limited to 8, subject to a maximum of 2 courses. Maximum number of credits enrolled in a semester (including Shortage of Attendance (SA), Honours and Minor) shall not exceed 30. The online courses registered shall be over and above this 30 credits.

5.5.2 If the student wishes to earn more than the total number of credits prescribed in the curriculum of the student's programme within the minimum duration of the programme, then he/she can enroll for such additional courses in any programme with the permission of Head of the Department to which student belongs and Head of the Department in which the course is offered by paying the examination fee. The credits earned will be neither considered for the computation of CGPA nor for the classification of the degree. The courses successfully completed will be printed in the grade sheet, however if there is shortage of attendance or failure, it shall neither be reflected in the grade sheet nor be considered for classification.

5.6 Choice of Professional Elective Courses

The professional Elective Courses are listed in the Curriculum in Table format as verticals (Specialisation groups). A student can choose all the Professional Elective Courses either from one of the verticals or a combination of courses from all verticals in a semester. However, students irrespective of enrolling for additional courses for B.Tech. (Hons.) are not permitted to choose more than one course from a row. Students are permitted to enroll more than one elective course from the same vertical in a semester. In the subsequent semesters students are permitted to enroll one more course in a row, provided if he/she has cleared the earlier course of the same row. For a professional elective course and open elective course, minimum number of students enrolment permitted shall be 10. However, the minimum number is not applicable for students enrolling B.Tech. (Hons) and B.Tech. Minor.

For each professional elective course at least two choices shall be offered.

5.7 Redoing a Course

Redoing a Course refers to the process of re-registering for a course, attending all classes, meeting the attendance requirements as per Clause 6, obtaining fresh Continuous Assessment marks, and appearing for the End Semester Examinations. A student is required to redo a course under the following conditions.

5.7.1 If a student is prevented from writing end semester examination of any core course due to lack of attendance, the student has to register for that course again when offered next and redo the course.

5.7.2 If a student is prevented from writing the end semester examination of any professional/open elective course due to lack of attendance, the student can opt to register for the same course again when offered next and redo the course, or he/she can opt to register for a different professional/open elective course when it is offered, attend the classes, fulfill the attendance requirements as per clause 6, secure Continuous Assessment marks and appear for the End Semester Examinations.

5.7.3 If the course in which a student fails to secure a pass is a professional/open elective course, then the student can opt for a different professional/ open elective course, register for the same when it is offered, attend classes, fulfill the attendance requirements as per clause 6, secure Continuous Assessment marks and appear for End Semester Examinations.

5.7.4 A student who fails in Project work shall register for the course again, when offered next, and redo the course. In this case, the student shall attend the reviews and fulfill the attendance requirements as per clause 6.

5.7.5 A student who fails in Seminar / Case Study and Creative and Innovative project, where such other courses are evaluated through 100% continuous assessment, shall register for the same in the subsequent semester and redo the course. In this case, the student shall attend the classes and fulfill the attendance requirements as per clause 7 and earn continuous assessment marks.

The student who fails in summer industrial training / internship shall attend the training / internship again and redo the course with the same organization or different organization with the approval of the HOD.

6.0 REQUIREMENTS FOR APPEARING THE END SEMESTER EXAMINATION OF A COURSE

A student who has fulfilled the following conditions (vide clause 6.1 and 6.2) shall be deemed to have satisfied the attendance requirements for appearing for the end semester examination of a particular course.

6.1 Ideally every student is expected to attend all periods and earn 100% attendance. However, the student shall secure not less than 75% attendance, course wise, taking into account the number of periods required for that course, as specified in the curriculum.

6.2 If a student secures attendance between 65% and less than 75% in any course in the current semester, due to medical reasons (hospitalization / accident / specific illness) or due to participation in the College / University / State / National / International level Sports events, with prior permission from the Chairman of Sports Board and Head of the Department concerned, the student shall be given exemption from the prescribed attendance requirement (75%) and the student shall be permitted to appear for the end semester examination of that course. A maximum of 10% shall be allowed under On Duty (OD) / Medical leave category. In all such cases, the students should submit the required documents on joining after the absence to the Head of the Department through the Faculty Coordinator. The HOD shall inform the course instructor to provide necessary attendance at the end of semester before finalizing attendance. Producing such documents while finalizing attendance at the end of semester shall not be accepted.

6.3 A student shall normally be permitted to appear for the end semester examination of the course if the student has satisfied the attendance requirements (vide Clause 6.1 – 6.2) and has registered for the examination in those courses of that semester by paying the prescribed fee.

6.4 Students who do not satisfy clause 6.1 and 6.2 and who secure **less than 65%** attendance in a course will not be permitted to write the end semester examination of that course. The student has to register and redo the course when it is offered next as per Clause 5.4. If the course in which the student has been prevented is a professional/ open elective, the student can opt to redo the same course or opt for different professional/ open elective course as per Clause 5.7.2.

6.5 If a student has shortage of attendance in all the registered courses of the current semester as per curriculum, he/she would not be permitted to move to the higher semester and has to repeat the current semester in the subsequent year.

6.6 In the case of reappearance (Arrear) registration for a course (the courses for which redo is not required), the attendance requirement as mentioned in Clauses 6.1 - 6.3 is not applicable. However, the student has to register for the examination in that course by paying the prescribed fee.

6.7 A student who has already appeared for a course in a semester and passed the examination is not entitled to reappear for the same course for improvement of letter grades / marks.

7.0 STUDENT COUNSELLING

To help students in planning their courses of study and for general advice on the academic programme and personal counselling, Faculty members are assigned.

7.1 MENTOR

To help the students in planning their courses of study and to render general advice regarding either the academic programme or any other activity, the Head of the Department concerned, will assign every year, a certain number of students from the first semester to a faculty member who will be called as Mentor. The set of students thus assigned will continue to be under the guidance of the Mentor till they complete the programme. Mentors will help the students on multiple exits, and also assess the proficiency of the student. Each student should have one-one interaction with the mentor at least once in a month.

7.2 FACULTY COORDINATOR

There is a Faculty Coordinator who will be the in-charge for a particular batch. He will coordinate with the mentors for assessing the proficiency of the batch and report to the Head of the Department. He will also collect the course registration forms from the students. He also ensures whether the student submitted feedback at the end of the semester for the courses he/she has taken.

8.0 CLASS COMMITTEE

a) Constitution of the Class Committee

For every class, a class committee shall be constituted by the Head of Department, as given below:

Chairman	A faculty member not teaching that particular class
Members	• Faculty of all the courses of study • Four student members from the class to be nominated by the Head of the Department.

b) Functions of the Class Committee

(i) The class committee shall meet thrice during the semester. The first meeting will be held within two weeks from the date of commencement of the semester in which the nature of the broad assessment procedure for the different courses will be discussed. The second and third meetings will be held six weeks and ten weeks respectively from the commencement of a semester to meaningfully interact and express opinions and suggestions to improve the effectiveness of teaching - learning process and analyze the performance of the students in the assessments. The chairperson of the class committee should send the minutes of the class committee meetings to the Dean through the Head of the Department, immediately after the meetings is over.

(ii) During the first meeting of the class committee, all the faculty members shall give their course plan to the class committee chairperson/chairman for approval and uploading into the ERP.

(iii) Any innovation in any course plan not agreed by the class committee or the HoD will be referred to the Dean for approval.

9.0 EXAMINATIONS AND ASSESSMENT

9.1 ASSESSMENTS

Continuous Internal Assessment

Continuous evaluation system is strengthened with 40-60 percentage weightage system in place for internal and external examinations. Three Continuous internal assessment will be conducted as per the academic calendar posted

in our institution website. Internal mark for every course is awarded based on the performance in Continuous Internal Assessment and the assignments submitted.

9.1.1 Theory Courses

- There will be a minimum of 2 Continuous Internal Assessments and 1 Model Test for each theory course.

DISTRIBUTION OF CONTINUOUS INTERNAL ASSESSMENT (CIA) MARKS FOR A THEORY COURSE			
Evaluation Component	**Syllabus coverage**	**Duration of the Test**	**Max. Weightage (40 Marks)**
CIA-1	First 1.5 Units of the syllabus	2.0 Hours	7.5 Marks
CIA-2	Second 1.5 Units of the syllabus	2.0 Hours	7.5 Marks
Model Test	Full syllabus	3 Hours	15 Marks
Assignment/ Mini Project (or) Group Presentation	Two written assignments for each course / Written quiz (or) Presentation of a written Report (or) Case study / Multiple choice Objective Type Test or Technical Project involving not more than 3 students (or) any other Group Presentation related to the course.		5 Marks
Attendance			5 Marks

- The continuous assessment marks obtained by the candidate in the first appearance shall be retained, considered and valid for all subsequent attempts, till the candidate secures a pass.

9.1.2 Practical Courses

S. No.	Category	Maximum Marks
1.	Record	15
2.	Observation work	10
3.	Model Examination	15
Total		40

- For practical courses, the student will be evaluated on a continuous basis for 25 Marks (which will include performing all experiments, submitting observation and record note book in scheduled format and time), 15 marks for model exam at the end of the semester.

- For practical courses, if a student has been absent for some practical classes or has performed poorly, then the student will have to get permission from the lab in-charge and year coordinator to do the experiments, so that he/she meets all the requirements for the course and thereby allowed to appear for model and end semester practical exams
- If a student has not done all the experiments assigned for that lab, before the scheduled date will not be allowed to appear for the model and end semester practical exam. Such students will have to register the course again by doing all the experiments in the next semester when the course is offered.

9.1.3 End Semester Examinations (ESE)

- The end semester examinations shall be conducted at the end of the odd and even semester of the Academic year.
- End semester examinations will be conducted for a maximum of 100 marks. The marks secured in end semester exams will be converted to 60 marks.
- The evaluation of training will be made by a three member committee constituted by Head of the Department in consultation with Faculty Advisor and respective Training Coordinator. A presentation should be made by the student before the Committee, based on the Industrial Training or Professional Enrichment undergone.

Pattern of Question Paper (Theory) for Model and ESE

Particulars	**Remarks**
Maximum Marks	60 Marks
Duration	3 Hours
Part – A (Q.No. 1 to 10)	MCQ (10x1=10)
Part – B (Q.No. 11 to 15)	Short Answers (Either or Type) (5x10=50)

9.1.4 Project Work/ Semester long Internship

The student shall register for Project Work-I in pre-final semester and Project Work-II in final semester. Project work may be allotted to a single student or to a group of students not exceeding 4 per group. Project Work-II may/may not be a continuation of Project Work-I. If Project Work II is not a continuation of Project Work I, then the topic and constitution of the project team members need not be the same.

- The project review would be conducted by a review committee where the student/ team shall make a presentation on the progress made, before the

committee. The Head of the department shall constitute the review committee for each branch in consultation with Director Academic, approved by CoE. The members of the review committee will evaluate the progress of the project and award marks.

- The guides would evaluate the students based on their performance and follow up.
- For Project work out of 100 marks, the maximum marks for Continuous Internal Assessment are fixed as 40 and the End Semester Examination (project report evaluation and viva-voce examination) carries 60 marks.

There shall be **Three Continuous Internal Assessments** (each 100 marks) during the semester by a review committee. The student shall make presentation on the progress made before the committee. The Head of the Department shall constitute a review committee for each programme. There shall be a minimum of three members in the review committee. The committee shall consist of the supervisor, expert member from the department and a project co-ordinator from another department. The total marks obtained in the three Reviews shall be reduced to 40 marks.

Continuous Internal Assessment (40 Marks)				**End Semester Examinations (60 Marks)**			
Review 0	**Review I**	**Review II**	**Review III**	**Project Report & Presentation**		**Viva-Voce Examination**	
10	10	10	10	Supervisor	External	Internal	External
				20	20	10	10

- A student is expected to attend all the project reviews conducted by the institution on the scheduled dates. It is mandatory for every student to attend the reviews, even if they are working on a project in an industry, which is outside Chennai city. If a student does not attend any of the project reviews, he / she shall not be allowed for the successive reviews and thereby not allowed to appear for the final viva voce.
- The candidate is expected to submit the project report as per the guidelines of the institution on or before the last day of submission. If a candidate fails to submit the project report on or before the specified deadline, he/she can be granted an extension of time up to a maximum limit of 5 days for the submission of project work, by the Head of the Department.

- If he/she fails to submit the project report, even beyond the extended time, then he/she is deemed to have failed in the project work and shall register for the same in the subsequent semester and re-do the project after obtaining permission from the HoD and the respective Deans.

9.1.5 Assessment for Summer internship:

The summer Industrial / Practical Training/ summer internship/ summer project shall carry 100 marks and shall be evaluated through continuous assessment only. At the end of the summer Industrial / Practical Training/ summer internship/ summer project, the student shall submit a certificate from the organization where the student has undergone training and a brief report about the training. The evaluation will be made based on this report, presentation and a Viva-Voce Examination conducted by a three-member Departmental Committee constituted by the Head of the Department consisting of one co-ordinator and two faculty members. Certificates (issued by the Organization) submitted by the student shall be attached to the mark list and sent to the Controller of Examinations by the Head of the Department. The evaluation shall be carried out as per the procedure shown below.

Internship / Industrial Training		
Evaluation Marks (60)		
Report	Presentation	Viva Voce
40	10	10

9.1.6 Assessment for Online Courses

Students may be permitted to credit two online courses (which are provided with certificate), subject to a maximum of six credits. The online course of 3 credits can be considered instead of one elective course. These online courses shall be chosen from the SWAYAM platform, provided the offering organization conducts regular examination and provides marks. The credits earned shall be transferred and the marks earned shall be converted into grades and transferred, provided the student has passed in the examination as per the norms of the offering organization. The details regarding online courses taken up by the student and marks/credits earned

and the approval for the course from Concerned Head of the Department shall be sent to the Controller of Examinations, in the subsequent semester(s) along with the details of the elective(s) to be dropped.

9.2 ASSESSMENT WEIGHTAGE:

There will be Continuous Internal Assessment and End Semester Examination for all courses of all programmes.

(i) Theory courses

Continuous Internal Assessment	: 40 Marks
End Semester Examination	: 60 Marks

(ii) Practical courses

Continuous Internal Assessment	: 40 Marks
End Semester Examination	: 60 Marks

(iii)Theory + Practical courses

Continuous Internal Assessment (Average of Theory and Practical)	: 40 Marks
End Semester Examination (Average of Theory and Practical)	: 60 Marks

10.0 EXAMINATIONS

10.1 RE-EXAMINATION

Re-examination requests shall be considered only for the Continuous Internal Assessment and the Examinations in the last instructional week of the semester based on medical reasons.

10.2 REVALUATION

A candidate can apply for revaluation of his/her End semester examination answer paper in a theory course, immediately after the declaration of results, on payment of a prescribed fee through the ERP. The Controller of Examinations will arrange for the revaluation and the result will be intimated to the candidate through website.

Revaluation is not permitted for practical courses and for project work.

10.3 SCRIBE FOR EXAMINATION

Divyangjan students or students with temporary physical disability or injury due to accident or illness can apply for a scribe (writer) with proof of disability as a medical certificate obtained from a Registered Medical Officer. The student shall be assigned a scribe by CoE to such student. The application for the scribe should be submitted in the CoE office well in advance or at least 2 days before the examination, to make necessary arrangements (Scriber, Separate Examination Hall etc.). The scribe assigned shall neither be a student nor a degree holder of any technical programme having similar competency.

Divyangjan students/ students with reading or writing disability, who can write at a slower speed as compared to a normal student would be allowed an extra time of 30 minutes to write the examination for each course. The proof of disability and application of extra time has to be submitted to the CoE office well in advance or 3 days before the start of the examination.

10.4 ACADEMIC MALPRACTICE

Academic malpractice would be strictly prohibited and any student who is found indulging in such activity would be penalized as per the recommendations of the Malpractice Committee constituted by the CoE with the approval of the Director Academic. The Committee would inquire and decide on the action based on the norms and policy listed in the Examination Manual.

10.5 SUPPLEMENTARY EXAMINATION

Supplementary examination will be conducted only for the final semester students within 10 days from the date of publication of revaluation results for students who have backlogs to complete the programme. Only such students shall apply with the prescribed fee to the Controller of Examinations within the stipulated time.

11.0 REQUIREMENTS FOR APPEARING FOR UNIVERSITY EXAMINATIONS

A student shall normally be permitted to appear for the University Examinations for all the courses registered in the current semester if he/she has satisfied the semester completion requirements. Further, examination registration by a student is mandatory for all the courses in the current semester and all arrear(s) course(s) for the University examinations failing which, the student will not be permitted to move to the higher semester. A student who has already appeared for any course in a semester and passed the examination is not entitled to reappear in the same subject for improvement of grades.

12.0 PASSING REQUIREMENTS FOR COMPLETION OF A COURSE

- A candidate who secures not less than 50% of total marks prescribed for the courses (Continuous Assessment + End semester examination) with a minimum of 40% of the marks prescribed for the end-semester Examination in theory, theory with practical components (40% individually in theory and laboratory) and practical courses (including Project work), shall be declared to have passed in the Examination. However, if a student fails in any integrated theory and practical course, he/she should register and appear for the End semester examination in both theory and practical components of this course.

- If a student fails to secure a pass in a theory course / theory with laboratory/laboratory course (except electives), the student shall register and appear only for the end semester examination in the subsequent semester. In such case, the continuous assessment marks obtained by the candidate in the first appearance shall be retained and considered valid for all subsequent attempts till the candidate secure a pass. However, from the third attempt (current semester's end semester examination is considered as the first attempt) onwards if a candidate fails to obtain pass marks (IA + End Semester Examination), then the candidate shall be declared to have passed the examination if he/she secure a minimum of 50% marks prescribed for the university end semester examinations alone.

- If a student has submitted the project report but absent in the end semester examination of project work, the student is deemed to be failed. In this case and also if a student attends and fails in the End semester examination of Project work of B.Tech, he/she shall attend end semester examination again within 60 days from the date of declaration of the results. The subsequent viva-voce examination will be considered as reappearance with payment of exam fee. In case, the student fails in the subsequent viva-voce examination also, the student shall redo the course again, when offered next.
- If a student is absent during the viva - voce examination, it would be considered as fail. If a student fails to secure a pass in Project Work-I, the student shall register for the course again in the subsequent semester and can-do Project Work-I and II together.
- The passing requirement for the courses which are assessed only through continuous assessment, shall be fixed as minimum 50%.

13.0 WITHDRAWAL FROM EXAMINATIONS

- A candidate may, for valid reasons, (medically unfit / unexpected family situations) be granted permission to withdraw from appearing for the examination in any course or courses in any one of the semester examination during the entire duration of the degree programme.
- Withdrawal application shall be valid only if the candidate is otherwise normally eligible (if he/she satisfies Attendance requirements and should not be involved in Disciplinary issues or Malpractice in Exams) to write the examination and if it is made within FIVE days before the commencement of the examination in that course or courses and also recommended by the Director Academic through HoD.
- Notwithstanding the requirement of mandatory FIVE days' notice, applications for withdrawal for special cases under extraordinary conditions will be considered based on the merit of the case.
- Withdrawal shall not be considered as an appearance for deciding the eligibility of a candidate for the purpose of Classification of Degree.
- Withdrawal is NOT permitted for arrears examinations of the previous semesters.

14.0 AUTHORIZED BREAK OF STUDY

- This shall be granted by the Institution, only once during the full duration of study, for valid reasons for a maximum of one year during the entire period of study of the degree programme.
- A candidate is normally not permitted to temporarily break the period of study. However, if a candidate would like to discontinue the programme temporarily in the middle of duration of study for valid reasons (such as accident or hospitalization due to prolonged ill health), he / she shall apply through the Director Academic in advance (Not later than the Reopening Day of that semester) through the Head of the Department stating the reasons. He /She should also mention clearly, the Joining date and Semester for Continuation of Studies after completion of break of Study. In such cases, he/she will attend classes along with the Junior Batches. A student who availed break of study has to rejoin only in the same semester from where he/she left.
- The total period for completion of the programme shall not exceed more than 10 consecutive semesters from the time of commencement of the course 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 not allowed to appear for End Semester Examinations for not satisfying Academic requirements and Disciplinary reasons, (Except due to Lack of Attendance), the period spent in that semester shall NOT be considered as permitted 'Break of Study' and is NOT applicable for Authorized Break of Study.
- In extraordinary situations, a candidate may apply for additional break of study not exceeding another one Semester by paying prescribed fee for break of study. Such extended break of study shall be counted for the purpose of classification of First Class Degree.
- If the candidate has not reported back to the department, even after the extended Break of Study, the name of the candidate shall be deleted permanently from the institution enrolment. Such candidates are not entitled to seek readmission under any circumstances.

- This shall be granted by the Institution, only once during the full duration of study, for valid reasons for a maximum of one year during the entire period of study of the degree programme.

15.0 PURSUING COURSES IN OTHER INDIAN INSTITUTIONS AND ABROAD

- A student can be selected, to get Professional Exposure in his/her area of Expertise in any Reputed Research Organization or Educational Institution of repute or any Universities in India andabroad.
- This is possible only with the List of Research Organizations, Educational Institutions in India and abroad approved by the Academic Council.
- The student can have the option of spending not more than three to Six months in the Final year or Pre - final year of his/her Degree. During this period, the student can do his/her Project work or register for courses which will be approved by the Class Committee and Director Academic, under the Guidance of a Project Supervisor who is employed in the Organization and Co-guided by a staff member from our Institution.
- Credit Transfer can be done by the CoE on submission of certificate through the HoD and Director Academic within 15 days of completion.
- The students who undergo training outside the Institution (either in India or Abroad) is expected to abide by all Rules and Regulations to be followed as per Indian and the respective Country Laws, and also should take care of Financial, Travel and Accommodation expenses.

16.0 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 course as detailed below:

RANGE OF MARKS FOR GRADES

Range of Marks	Letter Grade	Grade Point
90 -100	**O**	**10**
80 – 89	**A+**	**9**
70 – 79	**A**	**8**
60 – 69	**B+**	**7**
50 – 59	**B**	**6**
00-49 (Reappear)	**F**	**0**

ABSENT	**AAA**	**0**
Withdrawal	**W**	**0**
Authorised Break of Study	**ABS**	**0**

16.1 CUMULATIVE GRADE POINT AVERAGE CALCULATION

The CGPA calculation on a 10 Point scale is used to describe the overall performance of a student in all courses from first semester to the last semester. RA, AAA and W grades will be excluded for calculating GPA and CGPA.

$$GPA = \frac{\sum_{i=1}^{N} Ci\ GPi}{\sum_{i} Ci} \qquad CGPA = \frac{\sum_{i=1}^{N} Ci\ GPi}{\sum_{i} Ci}$$

Where

Ci – Credits for the course

GPi – Grade Point for the course

i – Sum of all courses successfully cleared during all the semesters

n - 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

16.2 GRADE SHEET

After revaluation results are declared in each semester, Grade Sheets will be issued to each student. At the end of programme a consolidated grade sheet also will be issued to each student. The grade sheet and consolidated grade sheet will contain the following details:

- The programme and degree in which the candidate has studied
- The list of courses enrolled during the semester and the grade secured
- The Grade Point Average (GPA) for the semester.

16.3 CLASSIFICATION OF DEGREE AWARDED

Final Degree is awarded based on the following

Range of CGPA	Classification of Degree
≥ 7.50	**First Class with Distinction**
≥ 6.00 <7.50	**First Class**
≥ 5.00 < 6.0	**Second Class**

Minimum requirements for award of Degree: A student should have obtained a minimum of 5.0 CGPA.

- A candidate who qualifies for the award of the Degree having passed the examination in all the courses of all the 8 semesters in his/her first appearance within a maximum of 10 consecutive semesters securing a overall CGPA of not less than 7.5 (Calculated from 1st semester) shall be declared to have passed the examination in **First Class with Distinction**. Authorized Break of Study vide Clause 14, will be considered as an Appearance for Examinations, for award of First Class with Distinction. Withdrawal shall not be considered as an appearance for deciding the eligibility of a candidate for First Class with Distinction

- A candidate who qualifies for the award of the Degree having passed the examination in all the courses of all the 8 semesters within a maximum period of 10 consecutive semesters after his/her commencement of study securing a overall CGPA of not less than 6.0 (Calculated from 1st semester), shall be declared to have passed the examination in **First Class.** Authorized break of study vides Clause 14 (if availed of) or prevention from writing End semester examination due to lack of attendance will not be considered as Appearance in Examinations. For award of First class, the extra number of semesters than can be provided (in addition to four years for Normal UG programme) will be equal to the Number of semesters availed for Authorized Break of Study or Lack of Attendance. Withdrawal shall not be considered as an appearance for deciding the eligibility of a candidate for First Class.
- All other candidates who qualify for the award of the Degree having passed the examination in all the courses of all the 8 semesters within a maximum period of 10 consecutive semesters after his/her commencement of study securing a overall CGPA of not less than 5.0, (Calculated from 1st semester) shall be declared to have passed the examination in **Second Class**.
- A candidate who is absent in semester examination in a course/project work after having registered for the same, shall be considered to have appeared in that examination for the purpose of classification.

17.0 ELIGIBILITY FOR THE AWARD OF DEGREE

A student shall be declared to be eligible for the award of the Certificate / Diploma / UG Degree / UG Honours degree, provided the student has successfully completed all the requirements of the programme, and has passed all the prescribed examinations in all the I/II/III/IV year respectively within the maximum period specified in clause 2.7.

i) Successfully gained the required number of total credits as specified in the curriculum corresponding to his/her programme within the stipulated time.

ii) Successfully completed the programme requirements and has passed all the courses prescribed in all the semesters within a maximum period of 5 years reckoned from the commencement of the first semester to which the candidate was admitted.

iii) Successfully completed any additional courses prescribed by the Institution.

iv) has earned a CGPA of not less than 5

v) has no dues to the Institution, Library, Hostels, etc.,

vi) has no disciplinary action pending against him / her.

18.0 RANKING

- A candidate who qualifies for the UG degree programme passing all the examinations in the first attempt, within the minimum period prescribed for the programme of study from semester I through semester VIII to the programme shall be eligible for ranking. Such ranking will be confirmed to 10 percent of the total number of candidates qualified in that particular programme of study subject to a maximum of 10 ranks.

19.0 DISCIPLINE

- Every student is required to observe disciplined and decorous behavior both inside and outside the Institution and not to indulge in any activity which will tend to bring down the prestige of the Institution. If a student indulges in malpractice in any of the end semester theory / practical examination, continuous assessment examinations he/she shall will be liable for disciplinary action as prescribed by the Institution from time to time.

20.0 STUDENT APPRAISAL

- It is mandatory for every student to submit the feedback on each and every course, he/she has undergone, at the end of every semester.

21.0 DECLARATION OF RESULTS

- The End Semester Examination results will be declared in institution website and the same is shared with the Head of the Department. In general, the results will be declared within 15 days from the date of last examination.

22.0 ACADEMIC BANK OF CREDITS (ABC)

- All the students who admitted in any one of the above programmes are mandatory to register in the Academic Bank of Credits (ABC) portal provided by the Ministry of Education (MoE), Government of India.

23.0 REVISION OF REGULATIONS / POWER TO MODIFY

- St. Peter's Institute of Higher Education and Research (Deemed to be University) may revise, amend, or modify the regulations, examination schemes, and syllabi as deemed necessary from time to time.

  Notwithstanding the provisions stated above, the Academic Council holds the authority to alter any or all of these regulations as required, subject to approval by the Executive Council.

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Dean Engg. Director Academic Registrar

VISION & MISSION OF THE DEPARTMENT

Vision

To become a Centre of excellence and to produce high quality, self-motivated, creative and ethical engineers and technologists, contributing effectively to Society and Science education.

Mission

1. To impart high quality Electronics and communication Engineering education and professional ethics to students
2. To adopt the best pedagogical methods in order to maximize knowledge transfer
3. To have adequate mechanisms to enhance understanding of implementation of theoretical concepts in practical Scenarios
4. To carry out high quality of research leading to the creation of knowledge and of intellectual property
5. To provide the best facility, infrastructure and environment to its students, researchers and faculty members, creating an ambience conducive for excellence in technical education and Research.

PROGRAM EDUCATIONAL OBJECTIVES (PEOS)

PEO1: To enable graduates to pursue research, or have a successful career in academia or industries associated with Electronics and Communication Engineering, or as entrepreneurs.

PEO2: To provide students with strong foundational concepts and also advanced techniques and tools in order to enable them to build solutions or systems of varying complexity.

PEO3: To prepare students to critically analyze existing literature in an area of specialization and ethically develop innovative and research oriented methodologies to solve the problems identified.

PROGRAM OUTCOMES (POS):

Engineering Graduates will be able to:

PO1: Engineering knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization to develop to the solution of complex engineering problems..

PO2: Problem analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development.

PO3: Design/development of solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required

PO4: Conduct investigations of complex problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions.

PO5: Engineering tool usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems.

PO6: The Engineer and the World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment..

PO7: Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws.

PO8: Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend

and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.

PO10: Project management and finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments

PO11: Life-long learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO 1: To analyze, design and develop solutions by applying foundational concepts of electronics and communication engineering.

PSO 2: To adapt the emerging information and communication technologies to innovate ideas and solutions to existing/novel problems.

Contribution 1: Reasonable **2: Significant** **3: Strong**

DEPARTMENT OF ELECTRONICS &COMMUNICATION ENGINEERING
FACULTY OF ----------

UG PROGRAM (CBCS) – B.Tech. Electronics and Communication Engineering
(2025–2026 Batch and onwards)

Semester I

Semester	Course Code	Title of the Course	Course Category	NCrF level	Objectives and outcomes		SDG Goal	Instruction Hours / week			Credit(s)	Marks		
					PEOs	POs		L	T	P		CIA	ESE	Total
I	25 MAU108	Engineering Mathematics- I	BSC	5.5	1,2	1-4	4	3	1	0	4	40	60	100
I	25PHU121	Engineering Physics	BSC	4.5	1,2	1,2, 3,5,	6	3	0	2	4	40	60	100
I	25EVSU001	Environmental Science	BSC	4.5	1,2	1-6	3, 13	2	0	0	2	40	60	100
I	25ENU121	Technical English	HSC	4.5	1,2	1-5	4,8	3	0	2	4	40	60	100
I	25EEU101	Basics of Engineering	BEC	4.5	1,2	1-5	7,9,11 ,12	3	0	0	3	40	60	100
I	25CSU121	Programming for Problem Solving	BEC	4.5	1,2	1-5	4,5 8,9, 10,17	2	0	4	4	40	60	100
I	25MEU101	Engineering Graphics	BEC	4.5	1,2	1,2, 3,5, 11	4,9,12	2	1	0	3	40	60	100
I	25MAC111	NCC/ YRC/ NSS/ Rotary Club	MAC	4.5	-	8,9	1-3, 5-7,10-15	0	0	2	0	-	-	-
	Semester Total											**280**	**420**	**700**

Semester II

Semester	Course Code	Title of the Course	Course Category	NCrF level	Objectives and outcomes		SDG Goal	Instruction Hours / week			Credit(s)	Marks		
					PEOs	POs		L	T	P		CIA	ESE	Total
II	25MAU208	Engineering Mathematics II	BSC	4.5	1,2	1-4	4	3	1	0	4	40	60	100
II	25CHU221	Engineering Chemistry	BSC	4.5	1,2	1-5	4,6	3	0	2	4	40	60	100
II	25ECU221	Electronics Devices	BEC	4.5	1,2	1-5	3,4,7,9,11	2	0	2	3	40	60	100
II	25ECU222	Circuit and Network Analysis	PCC	4.5	1,2	1-3	4,5,8,9,10,17	3	0	2	4	40	60	100
II	25CSU223	C Programming and Data Structures	PCC	4.5	2,3	1-5,11	4,8,9	3	0	2	4	40	60	100
II	25IKS001	Introduction to Indian Knowledge System	IKS	4.5	1,2	7,9	3-5,10,16	2	0	0	2	40	60	100
II	25MEU211	Design Thinking and Innovations Lab	BEC	4.5	1,2	1-6,11	4,8,9,11	0	0	4	2	40	60	100
II	25MAC201	Indian Constitution and Human Rights	MAC	4.5	1,2	7,8,9	4,16	2	0	0	2	40	60	100
	Semester Total											**320**	**480**	**800**

Semester III

Semester	Course Code	Title of the Course	Course Category	NCrF level	Objectives and outcome		SDG Goal	Instruction Hours / week			Credit(s)	Marks		
					PEOs	POs		L	T	P		CIA	ESE	Total
III	25MAU309	Probability and Random Process	BSC	5.0	2	1,2, 4	4,9	3	1	0	4	40	60	100
III	25UHV001	Universal Human Values and Ethics	HSC	5.0	1,2	7,8, 9,1 1	3,4, 5,10 ,16	2	0	0	2	40	60	100
III	25ECU321	Digital Electronics	PCC	5.0	1,2	1,2, 3,5, 11	4,9	3	0	2	4	40	60	100
III	25ECU301	Analog Electronic Circuits	PCC	5.0	1,2	1,2, 3,4	4,9	3	0	0	3	40	60	100
III	25ECU302	Signals and Systems	PCC	5.0	2	1,2, 4	4,9	3	0	0	3	40	60	100
III	25ECU303	Control Systems	PCC	5.0	1,2	1,2, 3,4,	4,9	3	0	0	3	40	60	100
III	25ECU311	Electronic Circuits Laboratory	PCC	5.0	2,3	1,3, 4,5	4,9	0	0	4	2	40	60	100
III	25MAC311	Yoga	MAC	5.0	1,2	7,8, 9,1 1	3,4, 5,10 ,16	0	0	1	0	-	-	-
	Semester Total											**280**	**420**	**700**

Semester IV

Semester	Course Code	Title of the Course	Course Category	NCrF level	Objectives and outcome		SDG Goal	Instruction Hours / week			Credit(s)	Marks		
					PEOs	POs		L	T	P		CIA	ESE	Total
IV	25ECU401	Analog and Digital Communication	PCC	5.0	1,2	1,2,3	4,9	3	0	0	3	40	60	100
IV	25ECU402	Linear Integrated Circuits and Applications	PCC	5.0	1,2	1,2,3,4	4,9	3	0	0	3	40	60	100
IV	25ECU421	Digital Signal Processing	PCC	5.0	1,2,3	1,2,3,4,5	4,9	3	0	2	4	40	60	100
IV	25ECU403	Electromagnetic Field Theory	PCC	5.0	1,2	1,2,3,4	4,9	3	1	0	4	40	60	100
IV	25ECU404	Communication Networks and Security	PCC	5.0	1,2,3	1,2,3,4	4,9,16	3	0	0	3	40	60	100
IV	25ECU411	Analog and Digital Communication Laboratory	PCC	5.0	1,2	1,2,3,4,5	4,9	0	0	4	2	40	60	100
IV	25ECU412	Analog Integrated Circuits Laboratory	PCC	5.0	1,2	1,2,3,4,5	4,9	0	0	4	2	40	60	100
IV	25ECU491	Mini Project	PRO	5.0	1,2,3	11-5,8-11	4,8,9,11,12,13,17	0	0	4	2	40	60	100
IV	25IKS002	Vedic Mathematics and Critical Thinking	IKS	5.0	1,2	1-4	4	2	0	0	2	40	60	100
	Semester Total											**360**	**540**	**900**

Semester V

Semester	Course Code	Title of the Course	Course Category	NCrF level	Objectives and outcome		SDG Goal	Instruction Hours / week			Credit(s)	Marks		
					PEOs	POs		L	T	P		CIA	ESE	Total
V	25ECU501	VLSI and Chip Design	PCC	5.5	1,2,3	1,2,3,4	4,9	3	0	0	3	40	60	100
V	25ECU521	Wireless Communication	PCC	5.5	1,2,3	1,2,3,4,5	4,9	3	0	2	4	40	60	100
V	25ECU502	Transmission Lines and RF systems	PCC	5.5	1,2,3	1,2,3,4	4,9	3	0	0	3	40	60	100
V	25ECU503	Optical Communication and Networks	PCC	5.5	1,2,3	1,2,3,4	4,9	3	0	0	3	40	60	100
V		Professional Elective-1	PEC	5.5				3	0	0	3	40	60	100
V		Open Elective-1	OEC	5.5				3	0	0	3	40	60	100
V	25ECU511	VLSI Laboratory	PCC	5.5	2,3	1,2,3,4,5	4,9	0	0	4	2	40	60	100
V	25ECU581	Internship-1	IAS	5.5		1-3,5,8-11	4,8,9,11,17	0	0	0	1	40	60	100
V	25MAC501	Entrepreneurship and Development	MAC	5.5	3	6,7,10	8,9	3	0	0	0	40	60	100
	Semester Total											**360**	**540**	**900**

Semester VI

Semester	Course Code	Title of the Course	Course Category	NCrF level	Objectives and outcome		SDG Goal	Instruction Hours / week			Credit(s)	Marks		
					PEOs	POs		L	T	P		CIA	ESE	Total
VI	25ECU621	Embedded Systems and IOT Design	PCC	5.5	1,2,3	1,2,3,4,5	4,9	3	0	2	4	40	60	100
VI	25ECU601	Antenna Design	PCC	5.5	1,2,3	1,2,3,4,5	4,9	3	0	0	3	40	60	100
VI	25ECU602	Microwave Engineering	PCC	5.5	1,2,3	1,2,3,4,	4,9	3	0	0	3	40	60	100
VI		Professional Elective-2	PEC	5.5				3	0	0	3	40	60	100
VI		Professional Elective-3	PEC	5.5				3	0	0	3	40	60	100
VI		Open Elective 2 (Online)	OEC	5.5				3	0	0	3	40	60	100
VI	25ECU611	Optical and Microwave Laboratory	PCC	5.5	2,3	1,2,3,4,5	4,9	0	0	4	2	40	60	100
	Semester Total											**280**	**420**	**700**

Semester VII

Semester	Course Code	Title of the Course	Course Category	NCrF level	Objectives and outcome		SDG Goal	Instruction Hours / week			Credit(s)	Marks		
					PEOs	POs		L	T	P		CIA	ESE	Total
VII	25ECU701	Multi-core architecture and Programming	PCC	6.0	1,2, 3	1,2, 3,4,	4, 9	3	0	0	3	40	60	100
VII		Professional Elective 4	PEC	6.0				3	0	0	3	40	60	100
VII		Professional Elective 5	PEC	6.0				3	0	0	3	40	60	100
VII		Open Elective 3 (online)	OEC	6.0				3	0	0	3	40	60	100
VII	25ECU791	Project Work - Phase I	PRO	6.0	1,2	1-11	4,8, 9,11 ,12, 13,1 6,17	0	0	12	6	40	60	100
VII	25ECU781	Internship-2	IAS	6.0	3	5,8	8	0	0	0	1	40	60	100
	Semester Total											**240**	**360**	**600**

Semester VIII

Semester	Course Code	Title of the Course	Course Category	NCrF level	Objectives and outcome		SDG Goal	Instruction Hours / week			Credit(s)	Marks		
					PEOs	POs		L	T	P		CIA	ESE	Total
VIII		Open Elective 4 (Online)	OEC	6.0				3	0	0	3	40	60	100
VIII	25ECU891	Project Work - Phase II	PRO	6.0	1,2, 3	1-11	4,8,9 ,11,1 2,13, 16,1 7	0	0	24	12	40	60	100
	Semester Total											**80**	**120**	**200**

Program Elective Courses (PE)

Programme Electives				
Sl. No.	**Course Code**	**Course Title**	**Prerequisite Courses**	**Credits**
Vertical 1- SEMICONDUCTOR CHIP DESIGN AND TESTING				
1	25ECU531A	Wide Bandgap Devices	Electronic Devices, Analog Electronic Circuits	3
2	25ECU532A	Validation and Testing Technology	Digital Electronics, VLSI and Chip Design	3
3	25ECU631A	Low Power IC Design	VLSI and Chip Design,	3
4	25ECU632A	VLSI Testing and Design For Testability	Digital Electronics, VLSI and Chip Design	3
5	25ECU731A	Mixed Signal IC Design Testing	Linear Integrated Circuits and Applications, Digital Electronics	3
6	25ECU732A	Analog IC Design	Analog Electronic Circuits, Electronic Devices	3
Vertical 2- SIGNAL PROCESSING				
7	25ECU531B	Advanced Digital Signal Processing	Signals and Systems, Digital Signal Processing	3
8	25ECU532B	Image Processing	Digital Signal Processing	3
9	25ECU631B	Speech Processing	Signals and Systems, Digital Signal Processing	3
10	25ECU632B	Software Defined Radio	Digital Communication, DSP	3
11	25ECU731B	DSP Architecture and Programming	Digital Signal Processing	3
12	25ECU732B	Computer Vision	Image Processing, Python/C++ Programming	3
Vertical 3 - High Speed Communications				
13	25ECU531C	Wireless Broad Band Networks	Analog and Digital Communication	3
14	25ECU532C	4G/5G Communication Networks	Wireless Communication, Digital	3

			Communication	
15	25ECU631C	Software Defined Networks	Communication Networks, Programming	3
16	25ECU632C	Green radio communication techniques	Wireless Communication	3
17	25ECU731C	Massive MIMO Networks	Wireless Communication	3
18	25ECU732C	Advanced Wireless Communication Techniques	Digital & Wireless Communication	
Vertical 4 - SENSOR TECHNOLOGIES AND IOT				
19	25ECU531D	IoT Processors	Microcontrollers	3
20	25ECU532D	IoT Based System Design	Embedded Systems, IoT Basics	3
21	25ECU631D	Wireless Sensor Network Design	Wireless Communication,	3
22	25ECU632D	Industrial IoT and Industry 4.0	IoT Processors, Embedded Systems	3
23	25ECU731D	MEMS Design	Physics	3
24	25ECU732D	Fundamentals of Nano electronics	Electronic Devices, Physics	3
Vertical 5 - SPACE TECHNOLOGIES				
25	25ECU531E	Radar Technologies	Electromagnetic Waves, Analog Communication	3
26	25ECU532E	Avionics Systems	Control Systems, Embedded Systems	3
27	25ECU631E	Positioning and Navigation Systems	RF Basics	3
28	25ECU632E	Satellite Communication	Analog/Digital Communication	3
29	25ECU731E	Remote Sensing	Satellite Communication, Antenna Theory	3
30	25ECU732E	Rocketry and Space Mechanics	Engineering Mechanics	3
Vertical 6 - ROBOTICS				
31	25ECU531F	Robotics and Automation	Control Systems	3
32	25ECU532F	Sensors and Instrumentation	Basic Electronics	3
33	25ECU631F	Sensors and Transducers	Sensors and Instrumentation	3
34	25ECU632F	Robot Kinematics	Control Systems,	3

			Engineering Mechanics	
35	25ECU731F	Programmable Logic Controllers	Digital Electronics	3
36	25ECU732F	Pattern Recognition and Image Vision	Digital Signal Processing	3

Open Elective Courses (OE)

Open Electives				
Sl. No.	**Course Code**	**Course Title**	**Prerequisite Courses**	**Credits**
1	25ECU041	Consumer Electronics	Basic Electronics	3
2	25ECU042	Robotics Process Automation	Programming Fundamentals	3
3	25ECU043	Drone Technology	Control Systems, Communication Systems	3
4	25ECU044	Sensors and Transducers	Basic Electronics	3
5	25ECU045	PCB designing and Fabrication	Electronic Devices, Circuit Theory	3

Semester – I

25MAU108 ENGINEERING MATHEMATICS -I 4H – 4C

Instruction Hours / week: L: 3 T: 1 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Develop the uses of matrix algebra techniques that engineers need for practical applications.
- Differentiate continuity and differentiability under differential calculus.
- Identify functions of several variables. This is required in many branches of engineering.
- Solve the problems under integral calculus.
- Acquaint the student with mathematical tools needed in evaluating multiple integrals and their applications.

Course Outcomes (COs)

At the completion of the course, the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Use the matrix algebra methods for solving practical problems	Apply
CO2	Use differential calculus ideas on several variable functions	Apply
CO3	Apply the concept of several variable functions in calculus	Understand
CO4	Apply the concept of integral calculus	Apply
CO5	Apply multiple integral ideas in solving areas, volumes, and other applications	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	--	--	--	--	--	--	--	--	--	2	--	--
CO2	3	2	--	--	--	--	--	--	--	--	--	2	--	--
CO3	3	2	--	--	--	--	--	--	--	--	--	2	--	--
CO4	3	2	--	--	--	--	--	--	--	--	--	2	--	--
CO5	3	2	--	--	--	--	--	--	--	--	--	2	--	--

1 - low, 2 - medium, 3 - high

Unit I – MATRICES

Eigenvalues and Eigenvectors of a real matrix – Characteristic equation – Properties of Eigen values and Eigen vectors – Cayley-Hamilton theorem – Diagonalization of matrices by orthogonal transformation – Reduction of a quadratic form to canonical form by orthogonal transformation – Nature of quadratic forms – Applications: Stretching of an elastic membrane.

Unit II – DIFFERENTIAL CALCULUS

Representation of functions – Limit of a function – Continuity – Derivatives – Differentiation rules (sum, product, quotient, chain rules) – Implicit differentiation – Logarithmic differentiation – Applications: Maxima and Minima of functions of one variable.

Unit III – FUNCTIONS OF SEVERAL VARIABLES

Partial differentiation – Homogeneous functions and Euler's theorem – Total derivative – Change of variables – Jacobians – Partial differentiation of implicit functions – Taylor's series for functions of two variables – Applications: Maxima and minima of functions of two variables, Lagrange's method of undetermined multipliers.

Unit IV –INTEGRAL CALCULUS

Definite and Indefinite integrals — Substitution rule — Techniques of Integration — Integration by parts, Trigonometric integrals, Trigonometric substitutions, Integration of rational functions by partial fraction, Integration of irrational functions — Improper integrals.

Unit V – MULTIPLE INTEGRALS

Double integrals – Change of order of integration – Double integrals in polar coordinates – Area enclosed by plane curves – Triple integrals – Volume of solids – Change of variables in double and triple integrals – Applications: Moments and centres of mass, moment of inertia.

SUGGESTED READINGS

1. Kreyszig, E. (2016). Advanced Engineering Mathematics. 10th Edition, John Wiley and Sons.
2. Grewal, B.S. (2018). Higher Engineering Mathematics. 44th Edition, Khanna Publishers.
3. Bali, N., Goyal, M., & Watkins, C. (2009). Advanced Engineering Mathematics. 7th Edition, Firewall Media.
4. Jain, R.K. & Iyengar, S.R.K. (2016). Advanced Engineering Mathematics. 5th Edition, Narosa Publications.
5. Narayanan, S. & Manicavachagom Pillai, T.K. (2009). Calculus, Volume I and II, S. Viswanathan Publishers.

Semester – I

25PHU121 EMGINEERING PHYSICS 5H – 4C

Instruction Hours / week: L: 3 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Provide a foundational understanding of the electrical properties of materials
- Introduce the fundamental concepts and behaviour of semiconductor materials
- Develop a conceptual and mathematical understanding of elasticity
- Explain the thermal properties of engineering materials
- Examine experimental evidence such as electron diffraction.

Course Outcomes (COs)
At the completion of the course, the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Discuss the basic electrical properties of materials and classify materials based on band theory.	Understand, Apply
CO2	Explain the properties of semiconductor materials and determine the band gap using appropriate experimental methods.	Understand, Apply
CO3	Calculate different moduli of elasticity and explain their applications in engineering and materials science.	Apply
CO4	Describe the thermal properties of materials and their applications, such as thermal expansion in joints and the functioning of heat exchangers.	Remember, Apply
CO5	Interpret the concept of wave-particle duality and describe experimental evidence, such as electron diffraction, that supports this duality.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	3	3	3	3	3	2	3	3	3	3	2
CO2	3	3	3	3	3	3	3	2	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2	3	3	3	3	2
CO4	3	3	3	3	3	3	3	2	3	3	3	3	2
CO5	3	3	3	3	3	3	3	2	1	2	3	3	2

1 - low, 2 - medium, 3 - high

Unit-I ELECTRICAL PROPERTIES OF MATERIALS

Classical free electron theory-Expression for Electrical conductivity-thermal conductivity-expression-Wiedmann Franz law- success and failure-electrons in metals-Particle in three dimensional box-degenerate state- Fermi Dirac Statistics-Density of Energy states-Electron in periodic potential-Bloch Theorem- Metals and Insulators-Energy bands in solids-Effective mass of electron- Concept of holes.

Unit II SEMICONDUCTORS AND TRANSPORT PHYSICS

Intrinsic semiconductors- Carrier concentration derivation– Fermi level – variation of Fermi level with temperature –electrical conductivity – band gap determination -extrinsic semiconductors - Carrier

concentration in N-type & P-type semiconductors – Variation of fermi level with temperature and impurity concentration.

Unit III PROPERTIES OF MATTER

Elasticity – Poisson's ratio and relationship between moduli (qualitative) - stress-strain diagram for ductile and brittle materials, uses - factors affecting elastic modulus and tensile strength - bending of beams - cantilever - bending moment - Young's modulus determination - theory and experiment - uniform and non-uniform bending - I shaped girders - twisting couple torsion pendulum - determination of rigidity modulus-moment of inertia of a body .

Unit IV THERMAL PHYSICS

Transfer of heat energy – thermal expansion of solids and liquids – expansion joints - bimetallic strips - thermal conduction, convection and radiation – heat conductions in solids – thermal conductivity - Forbe's and Lee's disc method: theory and experiment - conduction through compound media (series and parallel) – thermal insulation – applications: heat exchangers, refrigerators, ovens and solar water heaters.

Unit V QUANTUM PHYSICS

Black body radiation – Planck's theory (derivation) – Compton effect: theory and experimental verification – wave particle duality – electron diffraction – concept of wave function and its physical significance – Schrödinger's wave equation – time independent and time dependent equations – particle in a one-dimensional rigid box – tunnelling (qualitative) - scanning tunneling microscope.

SUGGESTED READINGS

1. Charles Kittel – Introduction to Solid State Physics, 8th Edition (2018) Publisher: Wiley
2. Brij Lal and N.Subramaniam, Properties of Matter S. Chand & Co., New Delhi (1994)
3. G. Aruldhas's Quantum Mechanics is the Second Edition, published by PHI Learning in 2008.
4. Donald A. Neamen's Semiconductor Physics and Devices: Basic Principles is the 4th Edition, published in 2012 by McGraw-Hill.
5. Halliday, D., Resnick, R. & Walker, J. "Principles of Physics". Wiley, 2015.
6. R. Shankar's Principles of Quantum Mechanics is the Second Edition, published in 1994 by Plenum Press
7. Dr. S. Stella Mary, 'Practical Engineering Physics' R. K. Publications, 2013
8. C.C. Ouseph, U.J. Rao, V. Vijayendran, 'Practical Physics and Electronics', S. Viswanathan Printers and Publishers Pvt. Ltd., 2011

Semester – I

25EVS001 **ENVIRONMENTAL SCIENCE** **2H – 2C**

Instruction Hours / week: L: 2 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Understand the scope and significance of the environment, raise public awareness about various environmental hazards and the structure and function of ecosystems
- Introduce the concept of biodiversity, its different types and the importance of its conservation at global, national, and local levels.
- Understand the causes, effects, and control measures of various environmental hazards, solid waste and disaster management, role of individuals in pollution prevention.
- Understand the need for new and renewable energy sources, focusing on energy management and conservation, and their applications.
- Understand the concepts of global and local environmental issues, various environmental protection laws

Course Outcomes (COs)

At the completion of the course, the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Define the environment and its significance, different environmental hazards, and the roles of producers, consumers, and decomposers in ecosystems, energy flow, and the structure of food chains, food webs, and ecological pyramids in various ecosystems.	Understand
CO2	Define biodiversity and its various levels, biodiversity hotspots, threats to biodiversity, and the importance of conserving endangered and endemic species in India using in-situ and ex-situ methods.	Understand
CO3	Identify the causes, effects control of different environmental hazards (air, water, marine, soil, noise, thermal, and nuclear pollution), importance of solid waste management and disaster management (floods, earthquakes, cyclones, and landslides), the role of individuals in preventing pollution, and pollution case studies.	Remember
CO4	Explore the role and potential of new and renewable energy sources, different types of renewable energy and their applications, particularly hydrogen, ocean, tidal, and geothermal energy, the concepts and technology behind energy management and conservation.	Understand
CO5	Identify key environmental issues and the role of environmental protection laws in safeguarding ecosystems, wildlife, and forests.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	3	1	2	2	2	1	1	1	1	2	2	2
CO2	3	2	3	1	2	2	2	1	1	1	1	3	2	3
CO3	2	2	3	1	2	1	2	1	1	1	1	2	3	2
CO4	3	1	2	1	2	2	2	1	1	1	1	3	2	3
CO5	3	2	3	1	1	1	2	1	1	1	1	2	3	3

1 - low, 2 - medium, 3 - high

Unit I – ENVIRONMENT AND ECOSYSTEM

Environment – Definition, scope and significance - Public awareness: Risk and hazards - Chemical hazards, Physical hazards, biological hazards in the environment. Ecosystem - concept -structure and function - producers, consumers and decomposers - Food chain - Food web - Ecological pyramids - Energy flow - Forest, Grassland, desert and aquatic ecosystem

Unit II – BIODIVERSITY AND ITS CONSERVATION

Introduction to Biodiversity - Definition - genetic, species and ecosystem diversity - Values and uses of biodiversity - biodiversity at global, national (India) and local levels - Hotspots, threats to biodiversity - Endangered and endemic species of India - conservation of biodiversity - In-situ & Ex-situ.

Unit III – ENVIRONMENTAL POLLUTION AND MANAGEMENT

Definition, Causes - Effects and control measures of Air, Water, Marine, soil, Noise, thermal and nuclear hazards, Solid waste Management: Causes, effects and control measures of urban and industrial wastes- Role of an individual in prevention of pollution- Pollution case studies- Disaster management: floods, earthquake, cyclone and landslides

Unit IV – RENEWABLE SOURCES OF ENERGY

Role and potential of new and renewable sources- Energy management and conservation, New Energy Sources: Need of new sources. Different types of new energy sources. Applications of - Hydrogen energy, Ocean energy resources, Tidal energy conversion. Concept, origin, and power plants of geothermal energy

Unit V – ENVIRONMENTAL PROTECTION

Climate change- Global, Regional and local environmental issues. Environmental Impact Assessment. Environment protection act, wildlife protection act., and Forest Conservation Act.

SUGGESTED READINGS

1. Gilbert M.Masters "Introduction to Environmental Engineering and Science", 2nd edition, Pearson Education (2004).
2. Benny Joseph, "Environmental Science and Engineering", Tata McGraw-Hill, New Delhi (2006).
3. Trivedi.R.K., "Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards", Vol. I and II, Enviro Media, 3rd edition, BPB publication (2010).
4. Anubha Kaushik and C. P. Kaushik's "Perspectives in Environmental Studies", 6th Edition, New Age International Publishers, 2018.
5. Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall.
6. Bradley. A.S; Adebayo, A.O., Maria, P. Engineering applications in sustainable design and development, Cengage learning
7. Environment Impact Assessment Guidelines, Notification of Government of India, 2006.
8. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998.
9. Dharmendra S. Sengar, 'Environmental law', Prentice hall of India PVT. LTD, New Delhi, 2007.
10. Rajagopalan, R, 'Environmental Studies-From Crisis to Cure', Oxford University Press, 2005
11. Erach Bharucha "Textbook of Environmental Studies for Undergraduate Courses" Orient Blackswan Pvt. Ltd. 2013

Semester – I

25ENU121 TECHNICAL ENGLISH 5H – 4C

Instruction Hours / week: L: 3 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Enhance the communicative competence of learners.
- Assist learners in using language effectively in academic/work contexts.
- Strengthen students' English language skills by engaging them in listening, speaking, and grammar learning activities that are relevant to authentic contexts.
- Develop analytical thinking skills for problem-solving in communicative contexts
- Equip them with writing skills needed for academic as well as workplace contexts.

Course Outcomes (COs)

At the completion of the course, the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Listen and comprehend complex academic texts.	Remember
CO2	Read and infer the denotative and connotative meanings of technical texts.	Apply
CO3	Write definitions, descriptions, narrations, and essays on various topics.	Apply
CO4	Speak fluently and accurately, and informal communicative contexts.	Apply
CO5	Express their opinions effectively in both oral and written medium of communication.	Create

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	3	3	3	3	3	2	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2	3	3	3	3	3
CO3	3	3	3	3	3	3	3	2	3	3	3	3	3
CO4	3	3	3	3	3	3	3	2	3	3	3	3	3
CO5	3	3	3	3	3	3	3	2	3	1	2	3	3

1 - low, 2 - medium, 3 - high

Unit I INTRODUCTION TO COMMUNICATION SKILLS

Listening–for general information, specific details, conversation: Introduction to classmates. Speaking - Self Introduction; Introducing a friend; Conversation - politeness strategies; Telephone conversation. Reading - Reading brochures (technical context). Writing-Writing emails/letters introducing oneself, Paragraph Writing, Reading Comprehension. Grammar – Parts of Speech, Sentence kinds. Wh-Questions forms and Tags. Vocabulary-Synonyms; One word substitution; Abbreviations &Acronyms (as used in technical contexts).

Unit II: REPORTING AND NARRATIONS

Listening- Listening to podcasts, anecdotes/stories/event narration; documentaries and interviews. Speaking- Narrating personal experiences/events; Interviewing a celebrity; Reporting and summarizing of documentaries/podcasts/interviews. Reading- Reading biographies, travelogues, newspaper reports,

Excerpts from literature, travel, and technical blogs. Writing – Report Writing - Short Report on an event. Grammar- Sentence Structures, Tenses. Vocabulary– Antonyms, Word Formation (prefixes & suffixes).

Unit III: ACADEMIC DEVELOPMENT AND COMMERCIAL REVIEWS

Listening- Listen to a classroom lecture. Speaking–Picture description; Instructing to use the product; Presenting a product and summarizing a lecture. Reading – Reading advertisements, gadget reviews, user manuals. Writing - Writing definitions; Instructions. Grammar-Active & Passive Voice, The Impersonal Passive., Subject-Verb Agreement; Infinitive and Gerunds. Vocabulary -Compound Words, Homonyms; and Homophones.

Unit IV: SCIENTIFIC REPORTS AND PRESENTATION TECHNIQUES

Listening – Listening to TED Talks; Scientific lectures and educational videos. Speaking – Small Talk; Mini presentations and making recommendations. Reading–Newspaper articles; Journal reports–and Non-Verbal Communication (tables, pie charts, etc,). Writing–Writing recommendations; Transferring information from non-verbal (chart, graph, etc), to verbal mode, Checklists. Grammar–Error correction; If conditional sentences., Vocabulary- Discourse markers, Connectives, Articles.

Unit V: POINT OF VIEW AND PLACEMENTS.

Listening–Listening to debates/discussions; different viewpoints on an issue; and panel discussions. Speaking–Group discussions, Debates, and Expressing opinions through Simulations & Role play. Reading – Reading Editorials and Opinion Blogs. Writing–Job/ application–Cover letter & Resume. Grammar–Numerical adjectives, Punctuation. Vocabulary- Cause & Effect Expressions

PRACTICAL EXERCISES

1. Group Discussion: Practical based on Accurate and Current Grammatical Patterns.
2. Conversational Skills for Interviews under suitable Professional Communication Lab conditions with emphasis on Kinesics
3. Communication Skills for Seminars/Conferences/Workshops with emphasis on Paralinguistics/ Kinesics. Presentation Skills for Technical Paper/Project Reports/ Professional Reports based on proper Stress and Intonation Mechanics.
4. Official/Public Speaking based on suitable Rhythmic Patterns.
5. Argumentative Skills/Role Play Presentation with Stress and Intonation

SUGGESTED READINGS

1. English for Engineers &Technologists Orient Blackswan Private Ltd. Department of English, Anna University, (2020 edition)
2. English for Science &Technology Cambridge University Press, 2021.
3. Technical Communication–Principles and Practices by Meenakshi Raman &Sangeeta Sharma
4. Dr.S.Uma Maheswari. English Workbook for Engineers and Technologists
5. Lakshmi Narayanan, Course Book on Technical English

Semester – I

25EEU101 BASICS OF ENGINEERING 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- To understand the basic calculations and measurements in DC circuits.
- To familiarize with working and characteristics of different DC and AC machines.
- To impart knowledge on the fundamentals of measuring electrical and electronic quantities, various sensors and transducers to measure non-electrical quantities.
- Demonstrate the fundamentals and scope of Mechanical Engineering, covering its core principles, key domains, and emerging technologies
- Identify basic and modern construction materials, explain their engineering properties,

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Perform the basic calculations in DC circuits and measure the various quantities associated with DC circuits.	Understand
CO2	Choose appropriate motor for specific applications based on the motor characteristics	Analyze
CO3	Analyze the functional blocks of a measurement system and the principles of various electrical and electronic instruments,	Analyze
CO4	Describe the scope of Civil Engineering and identify basic and modern construction materials along with their properties	Understand
CO5	Distinguish between different Steams of Mechanical Engineering and to gain foundational knowledge of mechanical systems, tools, and applications.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	–	2	2	–	–	–	–	–	2	3	1	3
CO2	3	3	–	2	2	–	–	–	–	–	2	3	1	3
CO3	3	3	–	3	3	–	–	–	–	–	2	3	2	3
CO4	2	1	–	–	–	2	2	–	–	–	1	–	3	2
CO5	2	1	–	–	–	–	2	–	–	–	1	–	3	2

1 - low, 2 - medium, 3 - high

Unit I: DC CIRCUITS AND MEASUREMENTS

The concept of voltage and current-Electric circuit elements: R, L, C – Independent and dependent sources – Ohm's law- Kirchhoff's law- series and parallel resistive circuits – Voltage and current division – Star-delta transformation - Mesh and nodal analysis of resistive circuits – simple problems - Measurement of voltage, current, and power in DC circuits.

Unit II: ELECTRICAL MACHINES

Construction, principle of operation, basic equations, characteristics and applications of DC generators, DC motors, single-phase transformers, and single-phase induction motors. Working principle of BLDC Motor and its applications in home appliances.

Unit III: ELECTRICAL AND ELECTRONIC INSTRUMENTATION

Functional blocks of a measurement system - types of measurements - Direct and indirect measurements – Classification of instruments – Induction type – dynamometer type wattmeters- Types of indicating Instruments Principles of Electrical Instruments – Multimeters, Oscilloscopes - Static and Dynamic characteristics of an instrumentation system – Errors in Measurement – Calibration and Standards. Classification of Transducers: Resistive, Inductive, Capacitive, Thermoelectric, piezoelectric, photoelectric, Hall Effect – electromagnetic flow transducers

Unit IV: INTRODUCTION TO CIVIL ENGINEERING AND MATERIALS

Introduction to Civil Engineering- Basic Construction Materials- Properties of Engineering Materials- Selection of Materials for Construction- Modern Materials in Construction

Unit V SCOPE AND CORE PRINCIPLES OF MECHANICAL ENGINEERING

Design, Manufacturing, Materials, Energy and Power Systems, Kinematics and Robotics, Instrumentation and Control, Emerging Trends, and Smart Applications.

SUGGESTED READINGS

1.D P Kothari and I.J Nagarath, “Basic Electrical and Electronics Engineering”, McGraw Hill Education (India) Private Limited, Third Reprint, 2016.
2.Giorgio Rizzoni, “Principles and Applications of Electrical Engineering”, McGraw Hill Education (India) Private Limited, 2010.
3.S.K.Bhattacharya, “Basic Electrical and Electronics Engineering”, Pearson India, 2011.
4.Del Toro, “Electrical Engineering Fundamentals”, Pearson Education, New Delhi, 2015.
5.Leonard S Bobrow, “Foundations of Electrical Engineering”, Oxford University Press, 2013.
6.Rajendra Prasad, “Fundamentals of Electrical engineering”, Prentice Hall of India, 2006.
7.Mittle N., “Basic Electrical Engineering”, Tata McGraw Hill Edition, 24th reprint 2016.
8.Sawhney, A. K., and Puneet Sawhney “A Course in Electrical and Electronic Measurements and Instrumentation” Dhanpat Rai & Company, 2016.
9. Jonathan Wickert & Kemper Lewis, An Introduction to Mechanical Engineering Cengage Learning Publication (Enhanced SI Edition, 4th Edition), 2021.
10. Author: S.K. Duggal Publication : New Age International Publishers Edition: 4th or 5th edition

Semester – I

25CSU121 PROGRAMMING FOR PROBLEM SOLVING 6H – 4C

Instruction Hours / week: L: 2 T: 0 P: 4 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Develop the foundational understanding of problem-solving techniques, algorithm design, and programming basics using C and Python.
- Apply conditional and iterative constructs effectively for developing logical, flow-controlled programs in both C and Python.
- Impart knowledge of function-based and modular programming approaches for creating structured, maintainable, and reusable code.
- Equip students with the ability to manipulate arrays, strings, and lists, and apply fundamental searching and sorting algorithms in C and Python.
- Introduce memory management concepts through pointers in C, and provide practical skills in file handling and understanding Python's memory model.

Course Outcomes (COs)

At the completion of the course, the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Construct basic programs using variables, operators, and input/output functions in C and Python	Remember
CO2	Execute decision-making and looping structures to solve common computational problems	Apply
CO3	Assemble modular programs by defining reusable functions with appropriate parameter usage and scope control	Analyze.
CO4	Implement basic searching and sorting algorithms to process structured data arrays, strings, and lists	Create
CO5	Demonstrate the use of pointers and dynamic memory in C, and operate file handling and memory reference concepts in C and Python	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	2	2	2	2	2	1	2	1	3	2
CO2	3	2	2	2	2	2	3	2	1	2	1	3	2
CO3	3	2	2	2	2	2	3	2	1	1	1	3	2
CO4	3	2	2	2	2	2	3	2	1	2	1	3	2
CO5	3	2	2	2	2	2	2	2	1	1	1	3	2

1 - low, 2 - medium, 3 - high

Unit I: INTRODUCTION TO PROGRAMMING

Introduction to problem solving, algorithms, and flowcharts, Programming structure in C and Python. Data types, variables, constants, Operators and expressions (arithmetic, relational, logical, assignment, Input/output functions: scanf, printf (C); input(), print() (Python). Type conversion and casting

Unit II: CONTROL FLOW AND ITERATIVE STATEMENTS

Decision-making: if, if-else, nested if, switch-case (C); if-elif-else (Python). Looping constructs: while, for, do-while (C); while, for-in (Python), Loop control: break, continue, pass. Problem-solving using loops (e.g., sum of digits, reverse number, pattern printing)

Unit III: FUNCTIONS AND MODULAR PROGRAMMING

Defining and calling functions in C and Python, Function parameters, return types, recursion, Python-specific: default arguments, keyword arguments, lambda functions, Variable scope and storage classes, Modular programming: creating reusable code blocks

Unit IV: ARRAYS, STRINGS, LISTS

Arrays in C: 1D and 2D, basic operations, Strings in C: declaration, input/output, string.h functions, Python lists: indexing, slicing, built-in methods, list comprehensions, Python strings: methods, slicing, immutability, Searching and sorting algorithms (linear, binary search; bubble, selection sort)

Unit V: POINTERS (C) AND FILE HANDLING IN C AND PYTHON

Pointers in C-declaration and initialization- Pointers and arrays-Pointers and functions (call by reference) Pointers and structures, Dynamic memory allocation: malloc(), calloc(), realloc(), free(), File Handling in C and Python, Python memory model, Mutable vs immutable objects, Function argument passing (by object reference) using id() to understand memory behavior

PRACTICAL EXERCISES (C and Python):

1. Write a Program to convert Celsius to Fahrenheit and vice versa. (Practice: I/O, arithmetic operators, conditionals)
2. Write a Program to simulate Simple Calculator that Perform addition, subtraction, multiplication, and division based on user input. (Practice: switch-case or if-elif-else.)
3. Write a program to check whether a given number is Odd or Even (Practice: conditionals, modulo operator).
4. Write a program to find Factorial of a Number using both iterative and recursive methods. (Practice: loops, recursion).
5. Write a program to Print Fibonacci series up to n terms. (Practice: loop/recursion logic.)
6. Write a program to find the GCD of two numbers. (Practice: functions, logic)
7. Write a program to check if a number is prime. (Practice: loops, conditionals, modularity.
8. Write a program to reverse a 1D array (C) or list (Python). (Practice: arrays/lists, loops)
9. Write a program to check if a given string is a palindrome. (Practice: string manipulation.)
10. Write a program to sort a list/array using bubble sort or selection sort. (Practice: sorting logic).
11. Write a program to define a structure for storing student data and display it. (Practice: structs, functions).
12. Write a program to implement a stack using List (Python). Implement push and pop operations. (Practice: lists, stack logic).
13. Write a program to read from and write to a text file. Practice: file I/O basics.
14. Write a program to read a file and count the number of words. (Practice: string handling, files)

SUGGESTED READINGS

1. Paul Deitel and Harvey Deitel, “C How to Program”, 9th Edition, Pearson Education, 2022
2. John Zelle, “Python Programming: An Introduction to Computer Science”, 3rd Edition, Franklin, Beedle & Associates, 2016. ISBN: 978-1590282755..
3. Mark Lutz, “Learning Python”, 5th Edition, O'Reilly Media, 2013.
4. Eric Matthes, “Python Crash Course”, 2nd Edition, No Starch Press, 2019.

Semester – I

25MEU101 ENGINEERING GRAPHICS 3H – 3C

Instruction Hours / week: L: 1 T: 2 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Communicate the concepts, ideas, and design of engineering products through graphic skills.
- Acquaint the national standards related to technical drawings.
- Comprehend Orthographic, Isometric, and perspective projection to represent the objects in two and three dimensions.

Course Outcomes (COs)

At the completion of the course, the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Sketch and distinguish between conic curves, cycloids, and involutes, and construct appropriate scales for engineering applications.	Apply
CO2	Identify and apply projection techniques to represent points, lines, and plane surfaces in first angle orthographic views.	Remember
CO3	Assemble and design accurate projections of solid geometries and truncated forms using appropriate methods.	Analysis
CO4	Prepare developments and sections of solids with holes and cut-outs, and evaluate the true shape of these sections.	Evaluate
CO5	Create isometric and perspective projections of simple and compound solids, and utilize CAD tools for visualization.	Create

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	1	2	1	1	1	2	2	2	2	2	3
CO2	3	2	2	1	2	1	1	1	2	2	2	2	2	3
CO3	3	2	2	1	2	1	1	1	2	2	2	2	2	3
CO4	3	2	2	1	2	1	1	1	2	2	2	2	2	3
CO5	3	2	2	1	2	1	1	1	2	2	2	2	2	3

1 - low, 2 - medium, 3 – high

Unit I PLANE CURVES AND FREE HAND SKETCHING

Basic Geometrical constructions, Curves used in engineering practices: Conics – Construction of ellipse, parabola and hyperbola by eccentricity method – Construction of cycloid – Construction of involutes of square and circle – Drawing of tangents and normal to the above curves, Scales: Construction of Diagonal and Vernier scales. Visualization concepts and Free Hand sketching: Visualization principles – Representation of Three Dimensional objects – Layout of views- Free hand sketching of multiple views from pictorial views of objects.

Unit II: PROJECTION OF POINTS, LINES AND PLANE SURFACES

Orthographic projection- principles-Principal planes-First angle projection-projection of points. Projection of straight lines (only First angle projections) inclined to both the principal planes - Determination of true lengths and true inclinations by rotating line method and traces. Projection of planes (polygonal and circular surfaces) inclined to both the principal planes by rotating object method.

Unit III: PROJECTION OF SOLIDS

Projection of simple solids like prisms, pyramids, cylinders, cones, and truncated solids when the axis is inclined to one of the principal planes by rotating object method and auxiliary plane method.

Unit IV: PROJECTION OF SECTIONED SOLIDS AND DEVELOPMENT OF SURFACES

Sectioning of above solids in simple vertical position when the cutting plane is inclined to the one of the principal planes and perpendicular to the other – obtaining true shape of section. Development of lateral surfaces of simple and sectioned solids – Prisms, pyramids cylinders and cones. Development of lateral surfaces of solids with cut-outs and holes.

Unit V: ISOMETRIC AND PERSPECTIVE PROJECTIONS

Principles of isometric projection – isometric scale –Isometric projections of simple solids and truncated solids - Prisms, pyramids, cylinders, cones- combination of two solid objects in simple vertical positions and miscellaneous problems. Perspective projection of simple solids-Prisms, pyramids and cylinders by visual ray method.

COMPUTER AIDED DRAFTING (Demonstration Only)
Introduction to drafting packages and demonstration of their use.

SUGGESTED READINGS

1.Parthasarathy, N.S.and Vela Murali, “Engineering Drawing”, Oxford University Press, 2015.
2.Bhatt N.D. and Panchal V.M., “Engineering Drawing”, Charotar Publishing House, 53rd Edition,2014.
3.Gopalakrishna K.R., “Engineering Drawing” (Vol. I&II combined), Subhas Stores, Bangalore,(2017).
4.Venugopal K. and Prabhu Raja V., “Engineering graphics”, New Age International (P) Limited,(2008).
5.Natrajan K.V., “A text book of Engineering Graphics”, Dhanalakshmi Publishers, Chennai, (2012).

Semester – II

25MAU208 ENGINEERING MATHEMATICS -II 4H – 4C

Instruction Hours / week: L: 3 T: 1 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Define and differentiate the Linear partial differential equations of second and higher order with constant coefficients of both homogeneous and non-homogeneous types.
- Identify Fourier and half range Fourier transform techniques used in wide variety of situations.
- Apply the effective mathematical tools for the solutions of partial differential equations that model several physical processes.
- Evaluate Fourier transform techniques for different functions.
- Identify Z-transforms and Elementary properties of several functions

Course Outcomes (COs)

At the completion of the course the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Solve the methods of solving Partial differential equations.	Apply
CO2	Apply the concepts in Fourier series.	Apply
CO3	Apply the Partial derivative one-two dimensional concept in solving the Heat flow equations.	Apply
CO4	Solve the problems under Fourier transforms.	Apply
CO5	Identify and apply Z-transform concepts in Problem solving.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	--	--	--	--	--	--	--	--	2	--	--	3
CO2	3	2	--	--	--	--	--	--	--	--	2	--	--	3
CO3	3	2	--	--	--	--	--	--	--	--	2	--	--	3
CO4	3	2	--	--	--	--	--	--	--	--	2	--	--	3
CO5	3	2	--	--	--	--	--	--	--	--	2	--	--	3

1 - low, 2 - medium, 3 - high

Unit I -PARTIAL DIFFERENTIAL EQUATIONS

Formation of partial differential equations. Solutions of standard types of first-order partial differential equations – Lagrange's linear equation. Linear partial differential equations of second and higher order with constant coefficients of both homogeneous and non-homogeneous types.

Unit II FOURIER SERIES

Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series – Half range cosine series – Root mean square value – Parseval's identity – Harmonic analysis

Unit III APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS

Classification of PDE – Method of separation of variables – Fourier Series – Solutions of one-dimensional wave equation – One-dimensional equation of heat conduction – Steady state solution of two-dimensional equation of heat conduction (excluding insulated edges).

Unit IV FOURIER TRANSFORMS

Statement of Fourier integral theorem – Fourier transform pair – Fourier sine and cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity.

Unit V- Z TRANSFORMS

Z-transforms – Elementary properties – Convergence of Z-transform – Initial and final value theorem – Inverse Z-transform using partial fraction and residues – Formation of difference equations.

SUGGESTED READINGS

1. Kreyszig, E., 'Advanced Engineering Mathematics', John Wiley and Sons, 10th Edition, New Delhi, 2016.
2. Grewal, B.S., 'Higher Engineering Mathematics', Khanna Publishers, New Delhi, 44th Edition, 2018.
3. Bali, N., Goyal, M., and Watkins, C., 'Advanced Engineering Mathematics', Firewall Media, New Delhi, 7th Edition, 2009.
4. L.C. Andrews and B. Shivamoggi, 'Integral Transforms for Engineers', SPIE Press, 1999.
5. Narayanan, S., Manicavachagom Pillay, T.K., and Ramanaiah, G., 'Advanced Mathematics for Engineering Students', Vol. II & III, S. Viswanathan Publishers Pvt. Ltd, Chennai, 1998

Semester – II

25CHU221 ENGINEERING CHEMISTRY 5H – 4C

Instruction Hours / week: L: 3 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- To inculcate a sound understanding of water quality parameters and water treatment techniques.
- To impart knowledge on the basic principles and preparatory methods of nanomaterials.
- To introduce the basic concepts and applications of the phase rule and composites.
- To facilitate the understanding of different types of fuels, their preparation, properties, and combustion characteristics.
- To familiarize the students with the operating principles, working processes, and applications of energy conversion and storage devices.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Interpret water quality parameters and treatment methods for domestic and industrial use.	Understand
CO2	Differentiate nanomaterials based on their properties, types, and synthesis techniques.	Analyse
CO3	Analyze phase diagrams and composite material systems with respect to their components and applications.	Apply
CO4	Evaluate fuel types, combustion characteristics, and emission parameter for energy efficiency.	Evaluate
CO5	Compare various energy sources and storage systems based on their principles and applications.	Assess

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	2	1	-	-	-	-	-	-	1	-	2	3	2
CO2	2	2	1	-	-	-	-	-	-	-	-	2	3	2
CO3	2	2	1	-	-	-	-	-	-	3	-	2	3	2
CO4	2	2	1	-	-	-	-	-	-	-	-	2	3	2
CO5	2	2	1	-	-	-	-	-	-	-	-	2	3	2

1 - low, 2 - medium, 3 - high

Unit I – WATER AND ITS TREATMENT

Water: Sources and impurities, Water quality parameters: Definition and significance of color, odour, turbidity, pH, hardness, alkalinity, TDS, COD and BOD, fluoride and arsenic. Domestic water treatment: Steps involved -primary treatment and disinfection (UV, Ozonation, breakpoint chlorination). Desalination of brackish water: Electro dialysis- Reverse Osmosis. Boiler troubles: Scale and sludge, Boiler corrosion, Caustic embrittlement, Priming and foaming. Treatment of boiler feed water: Internal treatment (phosphate, colloidal, sodium aluminate, and Calgon conditioning) and External treatment – Ion exchange demineralization process and zeolite process.

Unit II – NANOCHEMISTRY

Basics: Distinction between molecules, nanomaterials and bulk materials; Size-dependent properties (optical, electrical, mechanical and magnetic); Types of nanomaterials: Definition, properties and uses of – nanoparticle, nanocluster, nanorod, nanowire and nanotube-Single walled and Multiwalled Nanotubes-Preparation of nanomaterials: sol-gel, solvothermal, laser ablation, chemical vapour deposition, electrochemical deposition and electro spinning. Applications of nanomaterials in medicine, agriculture, energy, electronics, and catalysis.

Unit III – PHASE RULE AND COMPOSITES

Phase rule: Introduction, definition of terms with examples. One component system – water system; Reduced phase rule; Construction of a simple eutectic phase diagram – Thermal analysis; Two component system: lead-silver system – Pattinson process.
Composites: Introduction: Definition & Need for composites; Constitution: Matrix materials (Polymer matrix, metal matrix, and ceramic matrix) and Reinforcement (fiber, particulates, flakes, and whiskers). Properties and applications of Metal matrix composites (MMC), Ceramic matrix composites (CMC), and Polymer matrix composites (PMC). Hybrid composites – definition and examples.

Unit IV – FUELS AND COMBUSTION

Fuels: Introduction: Classification of fuels; Coal and coke: Analysis of coal (proximate and ultimate), Carbonization, Manufacture of metallurgical coke (Otto Hoffmann method). Petroleum and Diesel: Fractional distillation of Petroleum- Manufacture of synthetic petrol (Fischer–Tropsch and Bergius process), Knocking – octane number, diesel oil – cetane number; Power alcohol and biodiesel. Combustion of fuels: Introduction: Calorific value – higher and lower calorific values, Theoretical calculation of calorific value; Ignition temperature: spontaneous ignition temperature, Explosive range; Flue gas analysis – ORSAT Method. CO_2 emission and carbon footprint.

Unit V – ENERGY SOURCES AND STORAGE DEVICES

Stability of nucleus: mass defect (problems), binding energy; Nuclear energy: light water nuclear power plant, breeder reactor. Solar energy conversion: Principle, working, and applications of solar cells; Recent developments in solar cell materials. Wind energy; Geothermal energy; Batteries: Types of batteries, Primary battery – dry cell, Secondary battery – NICAD battery, lead acid battery, and lithium-ion battery; Electric vehicles – working principles; Fuel cells: H_2-O_2 fuel cell, microbial fuel cell; Super capacitors: Storage principle, types and examples.

SUGGESTED READINGS

1. P. C. Jain and Monica Jain. (2018). Engineering Chemistry, 17th Edition, Dhanpat Rai Publishing Company (P) Ltd, New Delhi.
2. Sivasankar B. (2008). Engineering Chemistry, Tata McGraw-Hill Publishing Company Ltd, New Delhi
3. S.S. Dara. (2018). A Textbook of Engineering Chemistry, S. Chand Publishing, 12th Edition.
4. Dr. Sayeeda Sultana (2016). Engineering Chemistry, R.K. Publishers, Coimbatore.
5. B. S. Murty, P. Shankar, Baldev Raj, B. B. Rath and James Murday. (2018). Textbook of Nanoscience and Nanotechnology, Universities Press-IIM Series in Metallurgy and Materials Science.
6. Dr. Sayeeda Sultana, (2016). Practical Engineering Chemistry laboratory manual, R.K. Publishers, Coimbatore.

Semester – II

25ECU221 ELECTRONIC DEVICES 5H – 4C

Instruction Hours / week: L: 3 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To teach fundamental concepts of semiconductors and electronic components.
- To discuss about various semiconductor devices and its applications.
- To introduce different types of power control devices in an appropriate application.
- To provide an overview of the characteristics of optoelectronic and nano electronic devices.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the characteristics, the applications of PN junction and special diodes.	Understand
CO2	Apply PCB design principles to create schematics and layout designs	Apply
CO3	Analyze the operation and characteristics of BJTs & FETs.	Analyze
CO4	Analyze circuits utilizing power devices for efficient control applications	Create
CO5	Explain Optoelectronic and Nanoelectronics Devices	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	1	1	2	1	1	1	1	1	1	1	1	3	2
CO2	3	1	1	2	1	1	1	1	1	1	1	1	3	2
CO3	3	1	1	2	1	1	1	1	1	1	1	1	3	2
CO4	3	1	1	2	1	1	1	1	1	1	1	1	3	2
CO5	3	1	1	2	1	1	1	1	1	1	1	1	3	2

UNIT 1: INTRODUCTION TO DIODES AND PCB DESIGN 9

Overview of Electronic components- Semiconductors – Construction, Characteristics and applications of PN junction diode: Rectifiers - Construction, Characteristics and applications of Special purpose diodes: Zener Diode, Varactor Diode, Tunnel Diode, Schottky Diode -Process of PCB design: Schematic and Layout.

UNIT 2: BIPOLAR JUNCTION TRANSISTORS 9

Construction, Configurations and Characteristics of BJT - Current components - Hybrid Model - Biasing of BJT - Transistor switching times -Applications of BJT.

UNIT 3: FIELD EFFECT TRANSISTORS 9

Construction, Configuration and Characteristics of JFET - JFET biasing - Applications of JFET. Construction, Configuration and Characteristics of MOSFET - MOSFET biasing –Types of FET - Applications of MOSFET.

UNIT 4: POWER CONTROL DEVICES 9

Construction, characteristics, and applications: UJT, SCR, TRIAC and DIAC - IGBT – Power MOSFET.

UNIT 5: OPTOELECTRONIC AND NANOELECTRONICS DEVICES 9

Optoelectronic devices- Laser diodes, Photoresistors, Photo diodes, Solar cell, Display Devices: Liquid Crystal Display, LED, OLED, AMOLED – Nano electronic Devices.

45 PERIODS

PRACTICAL EXERCISES 15 PERIODS

1. Study of Electronic Components, Data Sheet and Equipment.
2. PN junction diode characteristics
3. Half wave and Full Wave Rectifier
4. Zener Diode characteristics
5. Series and Shunt Regulator
6. Characteristics of Bipolar Junction Transistor (BJT)
7. Frequency response of Common Emitter Amplifier
8. Characteristics of Field Effect Transistor (FET)
9. Characteristics of MOSFET
10. Characteristics of LDR, SCR, UJT, Triac and Diac.
11. PCB Design Process - Schematic capture, Simulation, Schematic to layout transfer.

SUGGESTED READINGS

1. J.Millman, C.C.Halkias, and Satyabratha Jit, “Electronic Devices and Circuits” Tata McGraw Hill, 2nd Ed., 2010.

2. Thomas L. Floyd,”Electronic Devices”, Global Edition, Pearson Education, 2017.

3. Pallab Bhattacharya, “Semiconductor Optoelectronic Devices”, 2017, 2nd Edition, Pearson Education, India.

4. William Liu, “Fundamentals of III-V Devices: HBTs, MESFETs, and HFETs/ HEMTs”, Wiley-Interscience; 1st edition, 1999.

5. Byung-Gook Park, Sung Woo Hwang, Young June Park,” Nano electronic devices”, Stanford publishing, 2012

Semester –II

25ECU222 CIRCUIT AND NETWORK ANALYSIS 5H – 4C

Instruction Hours / week: L: 3 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- To teach the fundamental theorems of electrical circuit and network
- To discuss the concepts of steady state and transient analysis in RL,RC and RLC circuits.
- To impart knowledge on the significance of two port networks
- To design and analyze the circuits using simulation tools.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Apply various theorems to electrical circuits and simplify the network	Apply
CO2	Analysis First and second order circuits using transforms	Apply
CO3	Use phasor representation for carrying out AC circuit analysis	Apply
CO4	Apply Laplace transform for solving time domain circuits	Apply
CO5	Evaluate two-port network parameters.	Analyze
CO6	Use simulation tools for the analysis of circuits	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	2	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	2	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	2	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	2	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	2	1	1	1	1	1	1	1	1	3	2

UNIT 1: CIRCUIT THEOREMS AND KIRCHOFF'S LAWS 9

Analysis with dependent current and voltage sources. Node and Mesh Analysis, Current and Voltage Divider Rules, Superposition theorem, Thevenin theorem, Norton theorem, Maximum power transfer theorem, Reciprocity theorem, Compensation theorem. Concept of duality and dual networks.

UNIT 2: SOLUTION OF FIRST AND SECOND ORDER NETWORKS 9

Solution of first and second order differential equations, Review of Laplace Transform, Representation of sine function as rotating phasor, phasor diagrams. Series and parallel R-L, R-C, RLC circuits, initial and final conditions in network elements, forced and free response, time constants, steady state and transient state response

UNIT 3: SINUSOIDAL STEADY STATE ANALYSIS 9

Impedances and admittances, AC circuit analysis, effective or RMS values, average power and complex power. Three-phase circuits. Mutual coupled circuits, Dot Convention in coupled circuits, Ideal Transformer.

UNIT 4: ELECTRICAL CIRCUIT ANALYSIS USING LAPLACE TRANSFORMS 9

Analysis of electrical circuits using Laplace Transform for standard inputs, convolution integral, inverse Laplace transform, transformed network with initial conditions. Transfer function representation. Poles and Zeros. Frequency response (magnitude and phase plots), series and parallel resonances

UNIT 5: TWO PORT NETWORK 9

Two Port Networks, terminal pairs, relationship of two port variables, impedance parameters, admittance parameters, transmission parameters and hybrid parameters, interconnections of two port networks.

45 PERIODS

PRACTICAL EXERCISES: 15 PERIODS

1. Verification of KVL & KCL.
2. Verification of Thevenin & Norton theorem.
3. Verification of Superposition Theorem.
4. Verification of maximum power transfer Theorem.
5. Resonance Frequency of Series & Parallel RLC Circuits.
6. Transient analysis of RL and RC circuits
7. Z and Y parameters
8. Simulation of DC circuits
9. Mesh and Nodal analysis using SPICE
10. Determination of transmission and hybrid parameters of two port networks.

SUGGESTED READINGS

1. William H.Hayt, Jr, J.E.Kemmerly& Steven M.Durban, "Engineering Circuit Analysis" 9th Edition, Mc Graw Hill, 2020
2. K.S.Suresh Kumar, “Electric Circuit Analysis”, Pearson Publications, 2013
3. M. E. Van Valkenburg, “Network Analysis”, Prentice Hall, 2006.
4. A. A. Nimje and D. P. Kothari, “Electrical Circuit Analysis and synthesis”, New Age International Publications, 2017
5. C. K. Alexander and M. N. O. Sadiku, “Electric Circuits”, McGraw Hill Education, 2004

OPEN SOURCE SOFTWARE/LEARNING WEBSITE

1. Falstad Circuit Simulator Applet : https://www.falstad.com/circuit/
2. CircuitLab: Online circuit simulator & schematic editor: https://www.circuitlab.com/
3. https://openlibrary.org/search?q=circuit+analysis&mode=everything

Semester – II

25CSU223 C PROGRAMMING AND DATA STRUCTURES 4H – 3C

Instruction Hours / week: L: 2 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To introduce the basics of C programming language.
- To learn the concepts of advanced features of C
- To understand the concepts of ADTs and linear data structures
- To know the concepts of non-linear data structure and hashing.
- To familiarize the concepts of sorting and searching techniques.

Course Outcomes (COs)

At the completion of the course, the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Develop C programs for any real world/technical application	Remembering
CO2	Apply advanced features of C in solving problems.	Understanding
CO3	Write functions to implement linear and non–linear data structure operations and use appropriate linear/non–linear data structure operations for solving a given problem	Applying
CO4	Apply appropriate hash functions that result in a collision free scenario for data storage and retrieval	Analyzing
CO5	Appropriately use sort and search algorithms for a given application	Evaluating

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	2	3	1	2	1	-	-	-	-	-	1	1	1
CO2	1	2	1	1	2	-	-	-	-	-	1	2	1
CO3	2	3	1	2	2	-	-	-	-	-	1	1	2
CO4	2	1	-	3	2	-	-	-	-	-	1	2	2
CO5	1	2	1	2	3	-	-	-	-	-	1	3	3

1 - low, 2 - medium, 3 - high

Unit I: C PROGRAMMING FUNDAMENTALS

Data Types – Variables – Operations – Expressions and Statements – Conditional Statements – Functions – Recursive Functions – Arrays – Single and Multi-Dimensional Arrays.

Unit II: C PROGRAMMING - ADVANCED FEATURES

Structures – Union – Enumerated Data Types – Pointers: Pointers to Variables, Arrays and Functions – File Handling – Preprocessor Directives.

Unit III: LINEAR DATA STRUCTURES

Abstract Data Types (ADTs) – List ADT – Array-Based Implementation – Linked List – Doubly Linked Lists – Circular Linked List – Stack ADT – Implementation of Stack – Applications – Queue ADT – Priority Queues – Queue Implementation – Applications

Unit IV: NON-LINEAR DATA STRUCTURES

Trees – Binary Trees – Tree Traversals – Expression Trees – Binary Search Tree – Hashing - Hash Functions – Separate Chaining – Open Addressing – Linear Probing– Quadratic Probing – Double Hashing – Rehashing.

Unit V: SORTING AND SEARCHING TECHNIQUES

Insertion Sort – Quick Sort – Heap Sort – Merge Sort –Linear Search – Binary Search.

PRACTICAL EXERCISES: 15 PERIODS

1. Practice of C programming using statements, expressions, decision making and iterative statements
2. Practice of C programming using Functions and Arrays
3. Implement C programs using Files, Pointers and Structures
4. Development of real time C applications
5. Array implementation of List ADT
6. Array implementation of Stack and Queue ADTs
7. Linked list implementation of List, Stack and Queue ADTs
8. Applications of List, Stack and Queue ADTs
9. Implementation of Binary Trees and operations of Binary Trees
10. Implementation of Binary Search Trees
11. Implementation of searching techniques
12. Implementation of Sorting algorithms : Insertion Sort, Quick Sort, Merge Sort
13. Implementation of Hashing – any two collision techniques

SUGGESTED READINGS

1. Mark Allen Weiss, “Data Structures and Algorithm Analysis in C”, Second Edition, Pearson Education, 1997.
2. ReemaThareja, “Programming in C”, Second Edition, Oxford University Press, 2016.
3. Brian W. Kernighan, Rob Pike, “The Practice of Programming”, Pearson Education, 1999
4. Paul J. Deitel, Harvey Deitel, “C How to Program”, Seventh Edition, Pearson Education, 2013
5. Alfred V. Aho, John E. Hopcroft, Jeffrey D. Ullman, “Data Structures and Algorithms”, Pearson Education,1983
6. https://www.coursera.org/specializations/data-structures-algorithms
7. https://nptel.ac.in/courses/112107243
8. https://nptel.ac.in/courses/112105598

Semester – II

25IKS001 INTRODUCTION TO INDIAN KNOWLEDGE SYSTEM 2H – 2C

Instruction Hours / week: L: 2 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To introduce students to the foundational concepts of the Indian Knowledge System (IKS)
- To explore the relevance and applications of IKS in contemporary times.
- To promote interdisciplinary learning through the integration of traditional Indian knowledge and modern education.

Course Outcomes (COs)
At the completion of the course, the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Describe the meaning, scope, and philosophical foundations of IKS	Remembering
CO2	Summarize the features of Indian education, language, and literary contributions	Understanding
CO3	Illustrate traditional Indian scientific and technological advancements	Applying
CO4	Examine the impact of Indian art, aesthetics, and socio-cultural practices	Analyzing
CO5	Evaluate the relevance and application of IKS in contemporary society	Evaluating

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	2	1	1	2	0	0	0	0	1	1
CO2	2	3	2	1	2	0	1	0	0	0	0	2	1
CO3	2	2	3	2	2	1	2	1	0	0	0	1	2
CO4	1	1	2	3	2	2	2	1	0	0	0	2	2
CO5	1	1	1	2	3	3	2	2	0	0	0	3	3

1 - low, 2 - medium, 3 - high

Unit I: FOUNDATIONS OF INDIAN KNOWLEDGE SYSTEM

Meaning and Scope of IKS-Historical evolution and literary sources: Vedas, Upanishads, Puranas-Philosophical foundations: Darshanas (Nyaya, Vaisheshika, Samkhya, Yoga, Mimamsa, Vedanta)-Interdisciplinary nature of IKS.

Unit II: EDUCATION, LANGUAGE, AND LITERATURE

Traditional education systems: Gurukula, Pathashalas-Higher education: Nalanda, Takshashila-Role of Sanskrit and regional languages-Contributions of Panini, Bhartrihari-Epics and classical literature.

Unit III: SCIENCE AND TECHNOLOGY IN IKS

Mathematics: Sulbasutras, Aryabhata, Bhaskara-Astronomy: Surya Siddhanta-Ayurveda: Tridosha, healing systems-Metallurgy, Vastu Shastra, water management-

Unit IV: INDIAN ART, CULTURE, AND SOCIETY

Music, dance, painting, sculpture-Rasa theory, Natya Shastra-Festivals, rituals, socio-cultural life-Dharma, Purusharthas, social organization.

Unit V: CONTEMPORARY RELEVANCE AND APPLICATIONS OF IKS

IKS in modern education and research-Sustainable practices in agriculture, ecology, lifestyle-Yoga and meditation in wellness- Role of IKS in national identity and global relevance.

SUGGESTED READINGS

1. Kapil Kapoor (Ed.) – Encyclopedia of Hinduism, Rupa Publications, Comprehensive overview of philosophical and literary foundations of IKS.
2. Michel Danino – The Indian Mind: A Cultural and Philosophical Perspective, DK Printworld-Offers insight into Indian civilization's unique philosophical frameworks and relevance today.
3. V. Sivaramakrishnan (Ed.) – Cultural Heritage of India, Ramakrishna Mission Institute of Culture-Multi-volume work covering various aspects of Indian science, arts, literature, and education.
4. Subhash Kak, David Frawley & N.S. Rajaram – In Search of the Cradle of Civilization, Motilal Banarsidass-Discusses early Indian contributions to science, mathematics, and cosmology.
5. Bharatiya Vidya Bhavan Series – History and Culture of Indian P*eople*-A classic multi-volume series offering a deep dive into ancient Indian education, society, arts, and sciences.
6. Debroy, Bibek – The Bhagavad Gita, Upanishads, and the Vedas (Translations*)*-For primary source reading and understanding scriptural references in IKS.
7. R. Balasubramanian (Ed.) – The Bloomsbury Research Handbook of Indian Epistemology *and Metaphysics*
8. Yoga Sutras of Patanjali (Various commentaries) – for insights into yoga, wellness, and consciousness studies.

Semester – II

25MEU211 DESIGN THINKING AND INNOVATIONS LAB 4H – 2C

Instruction Hours / week: L: 0 T: 0 P: 4 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Demonstrate the significance of design thinking and contrast it with traditional problem-solving techniques.
- Manipulate each phase of the design thinking process to solve human-centered problems.
- Equip students with essential tools and techniques for user-centered design, creative idea generation, and rapid prototyping
- Understand innovation types, overcome barriers, analyze success stories, and effectively pitch ideas.
- Build innovative models through ideation and prototyping tools and strategies**.**

Course Outcomes (COs)

At the completion of the course, the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Distinguish between traditional and design thinking approaches through hands-on comparisons.	Understand
CO2	Apply the five phases of design thinking to solve a user-focused problem.	Apply
CO3	Create and use empathy-based design tools to develop human-centric solutions.	Create
CO4	Analyze innovation types, strategies, case studies, and confidently pitch ideas to stakeholders**.**	Analyze
CO5	Develop sustainable, impactful solutions through design thinking and prototyping**.**	Create

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	2	2	3	3	3	2	2	2	3	2
CO2	3	3	2	2	3	2	3	2	3	2	3	3	3	3
CO3	3	3	3	2	3	2	2	2	2	1	3	3	3	3
CO4	2	2	2	2	2	2	2	2	3	2	2	2	2	2
CO5	3	2	2	2	2	3	3	3	3	2	3	3	3	2

1 - low, 2 - medium, 3 – high

Unit I: INTRODUCTION TO DESIGN THINKING

Definition and importance of design thinking - Comparison with traditional problem-solving approaches - Key principles: Empathy, experimentation, and iteration. Problem Reframing Techniques.

Unit II: PHASES OF DESIGN THINKING

Empathize: Understanding users and their needs - Define: Framing the right problem to solve.
Ideate: Generating a wide range of ideas - Prototype: Building representations of ideas - Test: Gathering feedback to refine solutions.

Unit III: TOOLS AND TECHNIQUES

Empathy maps, user personas, journey mapping - Brainstorming, SCAMPER, mind mapping - Rapid prototyping techniques: sketches, models, digital tools. Rapid idea generation tools for expanding creative thinking.

Unit IV: INNOVATION STRATEGIES

Types of innovation: product, process, business model - Barriers to innovation and how to overcome them - Case studies of successful innovations- Presenting and pitching ideas to stakeholders

Unit V: SUSTAINABLE DESIGN AND PROTOTYPING

Design thinking for sustainability and social Impact. Tangible outcomes in terms of design and prototype development.

SUGGESTED READINGS

1.Jeanne Liedtka, Randy Salzman, Daisy Azer, Experiencing Design: The Innovator's Journey, Columbia Business School Publishing, 2021
2.Arne van Oosterom, Marcel Zwiers, This is Design Thinking. This is Service Design Doing, BIS Publishers, 2020
3.Nigel Cross, Design Thinking: Understanding How Designers Think and Work, Bloomsbury Academic, 2nd Edition, 2022
4.Michael Lewrick, Patrick Link, Larry Leifer, The Design Thinking Toolbox: A Guide to Mastering the Most Popular and Valuable Innovation Methods, Wiley, 2020
5.Robert Curedale, Design Thinking Process and Methods 5th Edition, Design Community College Inc., 2021.

Semester – II

25MAC201 INDIAN CONSTITUTION AND HUMAN RIGHTS 2H – 2C

Instruction Hours / week: L: 0 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To create the basic philosophical tenets of Indian Constitution and Human Rights.
- To underline the significance of our Constitution as Fundamental Law of the land and its features.
- To respect human rights, rule of law and democracy.
- To gain In-depth insight into the constitutional, statutory and institutional aspects of human rights protection in India.
- To identify the constitutional provisions dealing with human rights and special legislations dealing with protection of vulnerable and marginalized groups.

Course Outcomes (COs)
At the completion of the course, the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Demonstrate the provisions under the Constitution of India dealing with human rights	Remember
CO2	Display the nature and scope of special legislations dealing with protection of human rights of marginalized and vulnerable sections.	Understand
CO3	Apply practically human rights law to specific human rights problems in India	Apply
CO4	Analyze complex human rights problems and apply relevant provisions of human rights law in India to a hypothetical situation/case study..	Analyze
CO5	Acquainted with the theoretical knowledge of the underpinnings of the human rights framework in India, its operation and issues associated with its implementation.	Create

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	3	3	3	3	3	3	3	2	3	2	2
CO2	3	3	3	3	3	3	3	3	2	2	3	3	2	3
CO3	3	3	2	2	1	3	3	3	3	3	2	3	2	3
CO4	3	2	3	3	3	2	3	2	3	3	3	3	2	3
CO5	2	3	1	3	2	3	2	3	2	3	3	2	1	2

1 - low, 2 - medium, 3 - high

Unit I THE CONSTITUTION

Definition and Principles of the Constitution – Socio-Economic and Political Conditions in India at the time of Independence – Contents and Amendments to the Constitution.

Unit II FUNDAMENTAL RIGHTS

Historical Perspectives on Rights in India – Fundamental Rights in India – Provisions in Articles 14 to 32 and its implications on Human Rights – Right against unlawful detention.

Unit III - DUTIES, DIRECTIVE PRINCIPLES AND AFFIRMATIVE ACTIONS

Fundamental Duties of a Citizen in India - Directive Principles - Policy and Practices in Reservation Affirmative Actions: Special Provisions for SCs and STs.

Unit IV- PROTECTION OF WEAKER SECTIONS OF SOCIETY

Constitutional Provisions for the Protection of women and children - Safeguard for the Labours – Minorities – Tribals.

Unit V - ENFORCEMENT MECHANISM AND EVALUATION

Protection of Human Rights Act 1993 – National and State Human Rights Commissions – Role of Judiciary in Human Rights Protection – Critical Appraisal of the Current Status of Human Rights in India – AFSPA.

SUGGESTED READINGS

1. Desai, A.R. (ed.) (1986), Violations of Democratic Rights in India, Bombay: Popular Prakashan.
2. Meghraj Kapurderiya (2013) Indian Philosophical Foundation of Human Rights, New Delhi: R.P. Publications.
3. Mishra, P.K. (2012) Human Rights: Human Rights: Acts, Statues and Constitutional Provisions, Jaipur: Ritu Publications.
4. Satish Chandra (1995) Minorities in National And International Laws, New Delhi: Deep and Deep Publications.

Semester – III

25MAU309 PROBABILITY AND RANDOM PROCESS 4H – 4C

Instruction Hours / week: L: 3 T: 1 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- Apply the fundamental concepts of probability and random variables and their distributions.
- Analyze joint distributions, correlation, and regression of two-dimensional random variables.
- Classify and describe various types of random processes including Markov and Poisson processes
- Evaluate autocorrelation and spectral density functions in the context of signals.
- Explore applications of special polynomials in engineering domains such as signal processing and control systems.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Apply probability theory and standard distributions to model and analyze random phenomena.	Apply
CO2	Analyze joint, marginal, and conditional distributions and determine correlation and regression.	Analyze
CO3	Classify and apply concepts of different types of random processes..	Understand
CO4	Evaluate correlation functions and spectral densities in signal analysis.	Evaluate
CO5	Apply orthogonal polynomials to solve problems in signal processing and control.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	--	2	--	--	--	--	--	--	--	2	3	--	--
CO2	3	3	2	2	--	--	--	--	--	--	--	2	3	--	--
CO3	3	2	--	2	--	--	--	--	--	--	--	2	3	--	--
CO4	3	3	2	2	--	--	--	--	--	--	--	2	3	--	--
CO5	3	2	2	2	--	--	--	--	--	--	--	2	3	--	--

Unit I – PROBABILITY AND RANDOM VARIABLES

Probability - The axioms of probability - Conditional probability - Baye's theorem -Discrete and continuous random variables - Moments - Moment generating functions -Binomial, Poisson, Geometric, Uniform, Exponential and Normal distributions

Unit II – TWO – DIMENSIONAL RANDOM VARIABLES

Joint distributions – Marginal and conditional distributions – Covariance – Correlation and linear regression.

Unit III – RANDOM PROCESSES

Classification – Stationary process – Markov process - Poisson process – Random telegraph process.

Unit IV – CORRELATION AND SPECTRAL DENSITIES

Auto correlation functions – Cross correlation functions – Properties – Power spectral density – Cross spectral density – Properties.

Unit V – APPLICATIONS IN ENGINEERING

Definitions and properties of Orthogonal, Legendre and Butterworth polynomials- Engineering applications in signal processing and control systems.

SUGGESTED READINGS

1. Ibe.O.C., "Fundamentals of Applied Probability and Random Processes", Elsevier, 1st Indian Reprint, 2007
2. Peebles. P.Z., "Probability, Random Variables and Random Signal Principles", Tata Mc Graw Hill, 4th Edition, New Delhi, 2002.
3. Stark. H., and Woods. J.W., "Probability and Random Processes with Applications to Signal Processing", 3rd Edition, Pearson Education, Asia, 2002.
4. Miller. S.L. and Childers. D.G., "Probability and Random Processes with Applications to Signal Processing and Communications", Academic Press, 2004.
5. Kreyszig. E, "Advanced Engineering Mathematics", John Wiley and Sons, 10th Edition, New Delhi, 2016

Semester – III

25UHV001 UNIVERSAL HUMAN VALUES AND ETHICS 2H – 2C

Instruction Hours / week: L: 2 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To create an awareness on Engineering Ethics and Human Values.
- To instill Moral and Social Values and Loyalty.
- To appreciate the rights of others.
- To create awareness on assessment of safety and risk.
- To provide knowledge on Intellectual Property Rights

Course Outcomes (COs)

At the completion of the course, the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Identify and analyze an ethical issue in the subject matter under investigation or in a relevant field.	Remember
CO2	Identify the multiple ethical interests at stake in a real-world situation or practice.	Understand
CO3	Articulate what makes a particular course of action ethically defensible	Apply
CO4	Assess their own ethical values and the social context of problems	Analyze
CO5	Demonstrate knowledge of ethical values in non-classroom activities, such as service learning, internships, and field work integrate, synthesize, and apply knowledge of ethical dilemmas and resolutions in academic settings.	Create

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	1	1	1	1	1	1	2	1	2	2	2
CO2	3	1	3	1	1	1	1	1	1	2	1	2	3	2
CO3	3	2	3	1	1	1	1	1	1	2	1	3	2	3
CO4	3	2	3	1	1	1	1	1	1	2	1	2	3	2
CO5	3	2	3	1	1	1	1	1	1	2	1	3	2	3

1 - low, 2 - medium, 3 – high

UNIT 1 - Introduction to Human Values

Meaning and Nature of Human Values – Significance of Human Values in life – Relation between values and Ethics – relevance of Human values. Theory of Naya(Jainism) – Deontology, virtue ethics – Utilitarianism.

UNIT 2 - Integrated Personality and well-being

Relationship among self, Identity and Personality – Understanding integrated personality with 3 Gunas theory of Sankhya, the four Antah – Karanas (inner instruments) in Yoga and Panchkosha (5 sheaths) in Upanishad.

UNIT 3 - Ethics and Global citizenship

Nature, characteristics and scope of Professional Ethics – Types of Professional Ethics – Trusteeship, Inclusiveness, Commitment, Sustainability, Accountability, Transparency, Impartiality. Values for Global citizenship – Equality, Justice and Human Dignity.

UNIT 4 - Safety, Responsibilities and Rights

Safety and Risk – Assessment of safety and risk – Risk Benefit Analysis and reducing risk – Collective Bargaining – Confidentiality – Conflicts of interest – Occupational crime – Professional Rights – Employee rights - -Intellectual Property rights (IPR) discrimination.

UNIT 5 - Ethics in public affairs and profession

Ethical standards for elected representatives of the people – Ethics for the bureaucracy, police and other institutions of coercive authority – basic values in the civil services – dedication to public service and empathy for weaker sections and groups in society and non-corruptibility. Ethics at the workplace: Cybercrime, Plagiarism, fraudulent use of institutional resources.

SUGGESTED READINGS

1. Mike W. Martin and Roland Schinzinger “Ethics in Engineering” Tata McGraw- Hill–2003.
2. Prof. A.R. Aryasri, Dharanikota Suyodhana “Professional Ethics and Morals” Maruthi Publications.
3. A. Alavudeen, R. KalilRahman and M. Jayakumaran “Professional Ethics and Human Values” - LaxmiPublications.
4. Prof. D.R. Kiran “Professional Ethics and Human Values”.
5. PSR Murthy “Indian Culture, Values and Professional Ethics”, BS Publication.

Semester -III

25ECU321 DIGITAL ELECTRONICS 5H – 4C

Instruction Hours / week: L: 3 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To teach about different types of binary logic.
- To simplify the Boolean expression using Karnaugh Map and Tabulation method.
- To design a binary logic circuit for an arithmetic expression
- To understand the usage of registers and counters used in various digital circuits
- To learn about logic families and programmable logic devices

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Minimize Boolean functions for computationally less complex implementations.	Apply
CO2	Apply K map and tabulation method for minimization of Boolean functions.	Apply
CO3	Design and Implement combinational logic circuits.	Apply
CO4	Design and Implement sequential logic circuits	Apply
CO5	Analyze the performance of various logic families and Implement memory units with Programmable logic devices	Analyze

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	2	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	2	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	2	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	2	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	2	1	1	1	1	1	1	1	1	3	2

UNIT 1: NUMBER SYSTEMS, LOGIC FUNCTIONS AND BOOLEAN ALGEBRA 9

Number systems – Number systems conversions - Binary arithmetic – Binary codes – Logic functions Universal gate functions - Boolean algebra – Functionally complete operation sets, Reduction of switching equations using Boolean algebra, Realization of switching function.

UNIT 2: DESIGN OF COMBINATIONAL LOGIC 9

Design procedure of Combinational Logic – Design of two level gate networks - Sum of Products (SOP) - Product of Sums(POS) - Canonical SOP - Canonical POS - Karnaugh Map – Simplifications of Boolean functions using Karnaugh Map and implementation using Logic function – Advantages and limitations of K-Map –Tabulation method.

UNIT 3: COMBINATIONAL CIRCUITS 9

Introduction to Combinational circuits – Half Adder, Full Adder - Half Subtractor, Full Subtractor - Parallel binary Adder, Parallel binary Subtractor - Carry look ahead Adder- BCD Adder- Decoders, Encoders - Multiplexers- Demultiplexers- Code convertors- Magnitude Comparator.

UNIT 4: SEQUENTIAL CIRCUITS 9

Introduction to Sequential circuits – Flip flops – SR, JK, D and T flip flops, Master-Slave flip flop, Characteristic and excitation table –Registers – Shift registers – Counters – Synchronous and Asynchronous counters – Modulus counters –State diagram, State table, State minimization – Hazards.

UNIT 5: DIGITAL LOGIC FAMILIES AND PROGRAMMABLE LOGIC DEVICES 9

Classification and characteristics of logic family – Bipolar logic family – Saturated logic family – Non saturated family – Unipolar family – TTL, MOS and CMOS logic families. Programmable Logic Devices– Programmable Logic Array (PLA) – Programmable Array Logic (PAL) – Field Programmable Gate Arrays (FPGA)

45 PERIODS

PRACTICAL EXERCISES: 15 PERIODS

1. Verification of Logic Gates.
2. Design and Experimental verification of Boolean function
3. Design of adders and subtractors
4. Design of Multiplexers & Demultiplexers.
5. Design of Encoders and Decoders.
6. Design of Magnitude Comparators
7. Design of code converters.
8. Verification of FlipFlops
9. Design and implementation of counters using flip-flops
10. Design and implementation of shift registers.

SUGGESTED READINGS

1. Morris Mano, “Digital design”, 5 th Edition, Prentice Hall of India, 2016.
2. Milos Ercegovac, Tomas Lang, “Introduction to Digital Systems”, Wiley publications, 2013.
3. John M. Yarbrough, “Digital logic: Applications and Design”, Thomas – Vikas Publishing House, 2002
4. R.P.Jain, “Modern digital Electronics”, 3rd Edition, TMH, 2003
5. William H. Gothmann, “Digital Electronics”, Prentice Hall, 2001
6. David A Bell, “Electronic Devices and Circuits”, 5th edition, Oxford University Press, 2008.

Semester -III

25ECU301 ANALOG ELECTRONIC CIRCUITS 4H – 4C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- To teach small signal amplifiers of BJT and FET amplifiers
- To provide the fundamentals of the feedback amplifiers and oscillators.
- To teach the principle of operation of tuned amplifiers and power amplifiers..
- To analyze the concepts of Multivibrator circuits.
- To give an overview of blocking oscillator & Time base generating circuits.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Perform small signal analysis of the BJT and FET amplifiers	Understand
CO2	Design the feedback amplifiers and oscillators.	Apply
CO3	Design and analysis of tuned amplifiers and power amplifiers	Apply
CO4	Design and develop circuits to generate non-sinusoidal waveforms	Apply
CO5	Design the circuits to generate Time base waveforms.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	1	1	2	1	1	1	1	1	1	1	1	3	2
CO2	3	1	1	2	1	1	1	1	1	1	1	1	3	2
CO3	3	1	1	2	1	1	1	1	1	1	1	1	3	2
CO4	3	1	1	2	1	1	1	1	1	1	1	1	3	2
CO5	3	1	1	2	1	1	1	1	1	1	1	1	3	2

UNIT 1: SMALL SIGNAL ANALYSIS AND FREQUENCY RESPONSE OF AMPLIFIERS **9**

Small signal models of BJT and MOSFET, Small signal Analysis of Common Emitter, Common Collector and common Base amplifiers. Small signal analysis of FET amplifiers, Differential amplifiers. Low frequency response of BJT and FET amplifiers-high frequency response of BJT and FET amplifiers.

UNIT 2: FEEDBACK AMPLIFIERS AND OSCILLATORS **9**

Basic feedback concepts - Properties of Negative feedback -Four feedback topologies with amplifier circuit - Analysis of series - shunt feedback amplifiers. Oscillators: Barkhausen criteria for oscillator - Analysis of RC oscillators - LC oscillators - Crystal Oscillator

UNIT 3: POWER AMPLIFIERS AND TUNED AMPLIFIERS **9**

Classification of large signal amplifiers – Class A amplifier– Class B amplifier – Class AB amplifier– Class C amplifier and Efficiency – Analysis of Single tuned amplifier - Double tuned amplifier - Synchronously tuned amplifiers.

UNIT 4: MULTIVIBRATOR CIRCUITS **9**

Collector coupled and Emitter coupled Astable multivibrator – Monostable multivibrator- Bistable multivibrators. Triggering methods: Storage delay and calculation of switching times - Speed up capacitors - Schmitt trigger circuit.

UNIT 5: BLOCKING OSCILLATORS AND TIME BASE GENERATORS **9**

Pulse transformers - Monostable Blocking Oscillators using Emitter and base timing - Astable blocking oscillator - Voltage sweep generators - Current sweep generators.

SUGGESTED READINGS

1. Boylested and Nashlesky, Electronic Devices and Circuit theory, 11 th edition, Prentice Hall of India, 2015
2. Donald .A.Neamen, Electronic Circuit Analysis and Design, 2 nd edition, Tata McGraw Hill, 2009
3. Millman .J. and Halkias C.C, Integrated Electronics, McGraw Hill, 2 nd Edition, 2017
4. Robert Boylestad , Introductory Circuit Analysis, Pearson; 13th edition, 2015.
5. Adel.S.Sedra, Kenneth C. Smith, Micro Electronic circuits, 8th Edition, Oxford University Press, 2020.
6. David A. Bell,Electronic Devices and Circuits, Oxford Higher Education press, 5th Edition, 2010

Semester -III

25ECU301 SIGNALS AND SYSTEMS 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To categorize the various types of CT and DT signals.
- To analyze the spectral characteristics of CT periodic and aperiodic signals
- To determine the response of CT LTI system.
- To analyze system properties based on impulse response, Fourier analysis and Z transform.
- To apply mathematical tools for analysis of various real time signals and systems.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Apply various signal operations on different types of CT and DT signals.	Apply
CO2	Analyze the characteristics of continuous-time periodic and aperiodic signal using suitable transforms.	Apply
CO3	Evaluate the input and output relationships of LTI system.	Analyse
CO4	Analyze the response of DT systems using various transforms.	Apply
CO5	Analyze the characteristics of various real time signals.	Analyse

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	1	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	1	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	1	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	1	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	1	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: INTRODUCTION TO SIGNALS 9

Signals- Continuous time signals (CT signals) and Discrete time signals (DT signals) -Step, Ramp, Pulse, Impulse, Exponential and Sinusoidal Signal – Basic Operations on signals -Amplitude Scaling, Time Scaling, Time Reversal, Time Shifting, Signal Addition, Subtraction-classification of CT and DT signals- Deterministic and Non- deterministic Signals, Even and Odd Signals, Periodic and Aperiodic Signals, Energy and Power Signals, Real and Imaginary Signals.

UNIT 2: ANALYSIS OF CONTINUOUS TIME SIGNALS 9

Continuous Time Fourier Transform -Properties of CTFT- Inverse Fourier transform- unilateral and bilateral Laplace Transform analysis with examples - Basic properties -Correlation-Auto correlation, Cross Correlation, Inverse Laplace transform using partial fraction expansion method - Relation between Fourier transform and Laplace transform.

UNIT 3: LINEAR TIME INVARIANT CONTINUOUS TIME SYSTEMS AND DISCRETE TIME SYSTEMS **9**

Classification of CT and DT systems - Static and dynamic, Linear and non-linear, Time-variant and time-invariant, Causal and non-causal, Stable and unstable -Linear time Invariant System- Frequency response of LTI systems - Analysis and characterization of LTI systems using Laplace transform - Differential equation- Computation of impulse response, step response, natural response - forced response and transfer function using Laplace transform - Convolution integral.

UNIT 4: ANALYSIS OF DISCRETE TIME SIGNALS AND LTI DISCRETE TIME SYSTEMS **9**

Discrete Time Fourier Transform (DTFT)- z-transform -Basic properties of Z transform Properties of ROC - Inverse z- transform, Long division and Partial fraction expansion- Difference equation - Computation of Impulse response, Frequency response, step response, natural response, forced response and Transfer function using Z Transform, Convolution Sum using matrix, graphical and tabulation method.

UNIT 5: REAL TIME APPLICATIONS OF SIGALS AND SYSTEMS **9**

Mathematical tools for the analysis of deterministic and random signals –Sampling theorem- Speech and audio processing- Underwater acoustic- Biological signal analysis- Multimedia processing-image and Video- Analysis and modeling of Systems- Systems that manipulate signals-analysis and synthesis of signals and their interaction with systems.

SUGGESTED READINGS

1. Alan v Oppenheim Alan s Willsky with S Hamid Nawab, “Signals and systems”, 2nd edition, Pearson Education, March 2016
2. P.Ramesh Babu, R. Anandanataragan, “Signals and Systems”, 5th Edition, Scitech Publishers, 2018.
3. Rodger E. Ziemer , William H Tranter, D. R. Fannin,”Signals and Systems: Continuous and Discrete”, 4th Edition, Pearson Education India, 2014.
4. Rodger E. Ziemer , William H Tranter, D. R. Fannin,”Signals and Systems: Continuous and Discrete”, 4th Edition, Pearson Education India, 2014.
5. H.P. Hsu, "Signals and Systems", 2nd Edition, Tata McGraw Hill, 2017.

Semester -III

25ECU303 CONTROL SYSTEM 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks: Internal: 40 External: 60 Total: 100**

End Semester Exam: 3 Hours

Course Objectives

- To introduce the components and their representation of control systems
- To teach various methods for analyzing the time response, frequency response and stability of the systems.
- To teach the various approach for the state variable analysis.
- To introduce the concepts of stability analysis and state variable methods.

Course Outcomes (Cos)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Use the mathematical concepts to model of the physical systems.	Apply
CO2	Analyze the response of the closed and open loop systems.	Analyse
CO3	Illustrate the frequency response characteristics of open loop and closed loop system response.	Apply
CO4	Analyse the stability using Routh and root locus techniques.	Analyse
CO5	Illustrate the state space model of a physical system and discuss the concepts of sampled data control system.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	1	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	1	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	1	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	1	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	1	1	1	1	1	1	1	1	1	1	1	3	2

UNIT1: SYSTEMS COMPONENTS AND THEIR REPRESENTATION 9

Control System: Terminology and Basic Structure-Feed forward and Feedback control theory - Electrical and Mechanical Transfer Function Models-Block diagram Models-Signal flow graphs models-DC and AC servo Systems-Synchronous -Multivariable control system

UNIT2: TIME RESPONSE ANALYSIS 9

Transient response-steady state response-Measures of performance of the standard first order and second order system-effect on an additional zero and an additional pole-steady error constant and system- type number-PID control-Analytical design for PD, PI,PID control systems

UNIT3: FREQUENCY RESPONSE AND SYSTEM ANALYSIS 9

Closed loop frequency response-Performance specification in frequency domain-Frequency response of standard second order system- Bode Plot - Polar Plot- Nyquist plots-Design of compensators using Bode plots-Cascade lead compensation-Cascade lag compensation-Cascade lag-lead compensation

UNIT4: CONCEPTS OF STABILITY ANALYSIS 9

Concept of stability-Bounded - Input Bounded - Output stability-Routh stability criterion-Relative stability-Root locus concept-Guidelines for sketching root locus-Nyquist stability criterion.

UNIT5: CONTROL SYSTEM ANALYSIS USING STATE VARIABLE METHODS 9

State variable representation-Conversion of state variable models to transfer functions-Conversion of transfer functions to state variable models-Solution of state equations-Concepts of Controllability and Observability- Stability of linear systems-Equivalence between transfer function and state variable representations-State variable analysis of digital control system-Digital control design using state feedback.

45 PERIODS

SUGGESTED READINGS

1. M.Gopal,"Control System – Principles and Design", Tata McGraw Hill, 4th Edition, 2012.
2. J.Nagrath and M.Gopal, "Control System Engineering", New Age International Publishers, 5th Edition, 2007.
3. K.Ogata, "Modern Control Engineering", PHI, 5th Edition, 2012.
4. S.K.Bhattacharya, "Control System Engineering", Pearson, 3rd Edition, 2013.
5. Benjamin.C.Kuo, "Automatic Control Systems", Prentice Hall of India, 7th Edition,1995.

Semester -III

25ECU311 ELECTRONIC CIRCUITS LABORATORY 4H – 2C

Instruction Hours / week: L: 0 T: 0 P: 4 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To give hands on experience in designing and implementing electronic circuits
- To learn simulation software used in circuit design

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Design and Analyze various types of electronic circuits	Evaluate
CO2	Design and simulate feedback amplifiers and wave- shaping circuits and Multivibrators, filters using SPICE Tool	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	1	1	2	1	1	1	1	1	1	1	1	3	2
CO2	3	1	1	2	1	1	1	1	1	1	1	1	3	2

PRACTICAL EXERCISES: 30 PERIODS

1. Series and Shunt feedback amplifiers-Frequency response, Input and output impedance.
2. RC Phase shift oscillator
3. Wien Bridge Oscillator
4. Hartley Oscillator
5. Colpitts Oscillator
6. RC Integrator and Differentiator circuits
7. Clippers and Clampers
8. Astable Multivibrator
9. Class A & B Power Amplifier
10. Single Tuned Amplifier

SIMULATION USING SPICE

11. Wein Bridge Oscillator
12. Double and Stagger tuned Amplifiers
13. Monostable multivibrator
14. Schmitt Trigger
15. Bistable multivibrator

Semester -III

25MAC311	**YOGA**	**1H – C**

Instruction Hours / week: L: 0 T: 0 P: 1

Marks: Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Semester – IV

25ECU401 Analog and Digital Communication 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To provide understanding on the needs of analog and digital communication systems
- To teach various analog and digital modulation and demodulation techniques.
- To impart basic knowledge of AM, FM transmitters and receivers.
- To familiarize the concepts of sampling, quantization & the various band pass signaling schemes.
- To know the fundamentals of spread spectrum modeling and speech coding.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain various continuous wave Amplitude modulation and demodulation techniques	Understand
CO2	Describe the concept of Angle modulation and demodulation, and the effect of noise on it.	Understand
CO3	Discuss about the different AM, FM Transmitters and Receivers	Apply
CO4	Explain various digital modulation and demodulation techniques	Understand
CO5	Explain Multiple access techniques and speech coding	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	2	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	2	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	2	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	2	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: AMPLITUDE MODULATION AND DEMODULATION 9

Model of communication systems – Communication system classification - Need for modulation – Representation of AM – Modulation index and power calculation – Types of AM and its Generation - Comparison of various AM schemes – AM Demodulation, Envelope detector and Square law detector.

UNIT 2: FREQUENCY AND PHASE MODULATION AND DEMODULATION 9

FM Generation: Direct method using Varactor diode and indirect method - FM Detector: Balanced slope detector, Foster seeley frequency discriminator and Ratio detector. PM Generation and Detections - FM to PM and PM to FM – Comparison of AM, FM and PM – Pre-emphasis and Deemphasis - characteristics. Design and Experimental Verification AM Modulation, frequency modulation and Phase modulation.

UNIT 3: ANALOG TO DIGITAL CONVERSION 9

Sampling theorem - Sampling and signal reconstruction – Aliasing - Types of sampling - Concepts of PAM, PWM, PPM – Quantization – Companding - PCM - DPCM – ADPCM - Delta modulation - Adaptive delta modulation – Non theoretical comparison of Pulse modulation Techniques.

UNIT 4: DIGITAL MODULATION TECHNIQUES 9

ASK - Modulator, Coherent and Non-Coherent Detector, FSK - Modulator, Coherent and Non-Coherent FSK Detector, BPSK - Modulator, Coherent BPSK Detection - Principles of QPSK - Differential PSK and QAM. A Baseband Signal Optimum Receiver - Probability of Error – ISI - Eye Diagrams - Observe the performance of Digital carrier system ASK, PSK, FSK.

UNIT 5: SPREAD SPECTRUM TECHNIQUES 9

Pseudo-noise sequence - DS Spread Spectrum with coherent binary PSK - Processing gain - FH Spread Spectrum -Multiple access techniques: TDMA, FDMA, CDMA - Speech encoding for wireless Communication.

SUGGESTED READINGS

1. Wilson K and Walker J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. 7th edition, Cambridge University Press.
2. Brown B, and Aaron M (2001). The politics of nature. In: Smith J (ed) The rise of modern genomics, 3rd edition. Wiley, New York, pp 230-257
3. Gamelin FX, Baquet G, Berthoin S, Thevenet D, Nourry C, Nottin S, and Bosquet L (2009). Effect of high intensity intermittent training on heart rate variability in prepubescent children. Eur J ApplPhysiol 105:731-738

Semester – IV

25ECU402 Linear Integrated Circuits and Applications 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To provide an understanding of Op-Amp Characteristics and its applications.
- To teach the design of filters and oscillators using Op-amp.
- To impart knowledge on different types of Analog to Digital Converter and Digital to Analog Converters.
- To introduce the basic principles & applications of PLL and Instrumentation amplifier.
- To teach the design of waveform generators using Timers.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the performance characteristics of Op-amp and its applications.	Understand
CO2	Design filters and oscillators using Op-amp	Analyse
CO3	Explain various types of A/D and D/A converters using Op-amp	Understand
CO4	basic principles & applications of PLL and Instrumentation amplifier	Apply
CO5	Design various waveform generators using timers	

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	2	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	2	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	2	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	2	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: OP- AMP AND ITS APPLICATIONS 9

OP-AMP- DC and AC Characteristics- Input offset voltage- Input bias current-Input offset current- Total output offset voltage- Thermal drift- Slew rate- CMRR -Inverting amplifier- non-inverting amplifier Voltage follower- Summing and differential amplifier- Integrator- Differentiator- Logarithmic and Anti logarithmic amplifiers-Comparator and Schmitt trigger.

UNIT 2: FILTERS AND SIGNAL GENERATORS 9

First order and Second order Butterworth filters- low pass, high pass, band pass and band reject filters - RC phase shift, Wein's bridge oscillator- Astable and Monostable Multivibrator-Precision half wave and full wave rectifiers.

UNIT 3: A/D AND D/A CONVERTERS 9

Sample and Hold circuit - Digital to analog converters: R-2R ladder network and Binary weighted Characteristics of D/A converters - Analog to digital converters: Flash converter – Successive approximation converter - Dual slope ADC-Weighted Capacitor DACs- Oversampling Converters.

UNIT 4: PLL AND INSTRUMENTATION AMPLIFIER 9

Phase Locked Loop IC 565- Block schematic - Applications of PLL: FM demodulator and Frequency synthesizers Demodulator - AD623 Instrumentation Amplifier and its application as load cell weight measurement.

UNIT 5: WAVEFORM GENERATOR 9

Square wave generators: 555Timer, Crystal controlled Oscillator Ramp Generator: Triangle generator, Saw tooth generator Sine wave generator: Requirement for sinusoidal oscillations, Wien-bridge and twin-T oscillators. Function Generators: Multi op-amp function generators

45 PERIODS

SUGGESTED READINGS

1. D.Roy Choudary, Shail Jain, “Linear Integrated Circuits”, New Age International Pvt. Ltd., 2022.
2. James M . Fiore, Operational amplifier and linear Integrated circuits: Theory and applications, 2020
3. Ramakant A.Gayakwad, “OP-AMP and Linear ICs”, 4th Edition, Prentice Hall / Pearson Education, 2015
4. S. Salivahanan, V.S. Kanchana Bhaaskaran, “Linear integrated circuits”, 3rd Edition, McGrawHill, 2011.

Semester – IV

25ECU421 Digital Signal Processing 5H – 4C

Instruction Hours / week: L: 3 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To teach discrete Fourier transform, properties of DFT and its application to linear filtering
- To impart knowledge on characteristics of digital filters and design digital IIR and FIR filters.
- To provide an understanding on the effects of finite precision representation on digital filters.
- To teach the fundamental concepts of multi rate signal processing and its applications
- To introduce the concepts of adaptive filters and its application to communication engineering.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Apply DFT to discrete time sequences and obtain the frequency response.	Apply
CO2	Design digital IIR and FIR filters	Apply
CO3	Explain the effects of finite precision representation on digital filters	Analyse
CO4	Discuss multi rate signal processing and its applications	Understand
CO5	Explain the architecture of DSP Processors.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	2	2	1	1	1	1	1	1	1	3	3
CO2	3	2	2	2	2	1	1	1	1	1	1	1	3	3
CO3	3	2	2	2	2	1	1	1	1	1	1	1	3	3
CO4	3	2	2	2	2	1	1	1	1	1	1	1	3	3
CO5	3	2	2	2	2	1	1	1	1	1	1	1	3	3

UNIT 1: DISCRETE FOURIER TRANSFORM 9

Sampling Theorem, concept of frequency in discrete-time signals, summary of analysis & synthesis equations for FT & DTFT, frequency domain sampling, Discrete Fourier transform (DFT) - deriving DFT from DTFT, properties of DFT - periodicity, symmetry, circular convolution. Linear filtering using DFT. Filtering long data sequences - overlap save and overlap add method. Fast computation of DFT - Radix-2 Decimation-in- time (DIT) Fast Fourier transform (FFT), Decimation-in-frequency (DIF) Fast Fourier transform (FFT). Linear filtering using FFT.

UNIT 2: INFINITE IMPULSE RESPONSE FILTERS 9

Characteristics of practical frequency selective filters. Characteristics of commonly used analog filters - Butterworth filters, Chebyshev filters. Design of IIR filters from analog filters (LPF, HPF, BPF, BRF) - Approximation of derivatives, Impulse invariance method, Bilinear transformation. Frequency 81 transformation in the analog domain. Structure of IIR filter - direct form I, direct form II, Cascade, parallel realizations.

UNIT 3: FINITE IMPULSE RESPONSE FILTERS 9

Design of FIR filters - symmetric and Anti-symmetric FIR filters - design of linear phase FIR filters using Fourier series method - FIR filter design using windows (Rectangular, Hamming and Hanning window), Frequency sampling method. FIR filter structures - linear phase structure, direct form realizations

UNIT 4: FINITE WORD LENGTH EFFECTS 9

Fixed point and floating point number representation - ADC - quantization - truncation and rounding - quantization noise - input / output quantization - coefficient quantization error - product quantization error - overflow error - limit cycle oscillations due to product quantization and summation - scaling to prevent overflow.

UNIT 5: DSP APPLICATIONS 9

Multirate signal processing: Decimation, Interpolation, Sampling rate conversion by a rational factor – Adaptive Filters: Introduction, Applications of adaptive filtering to equalization-DSP Architecture Fixed and Floating point architecture principles.

45 PERIODS

PRACTICAL EXERCISES: 15 PERIODS

1. Generation of elementary Discrete-Time sequences.
2. Linear and Circular convolutions.
3. Auto correlation and Cross Correlation.
4. Frequency Analysis using DFT and FFT.
5. Design of FIR filters (LPF/HPF/BPF/BSF) and demonstrates the filtering operation
6. Design of Butterworth and Chebyshev IIR filters (LPF/HPF/BPF/BSF) and demonstrate the filtering operations
7. Decimation and Interpolation.
8. Finite word length Effects
9. Study of architecture of Digital Signal Processor.
10. Wave form generation..

TOTAL PERIODS :60

SUGGESTED READINGS

1. John G. Proakis and Dimitris G.Manolakis, Digital Signal Processing – Principles, Algorithms and Applications, Fourth Edition, Pearson Education / Prentice Hall, 2007.
2. V. Oppenheim, R.W. Schafer and J.R. Buck, ―Discrete-Time Signal Processing", 8th Indian Reprint, Pearson, 2004.
3. Emmanuel C. Ifeachor& Barrie. W. Jervis, "Digital Signal Processing", Second Edition, Pearson Education / Prentice Hall, 2002.
4. Sanjit K. Mitra, "Digital Signal Processing – A Computer Based Approach", Tata Mc Graw Hill, 2007.
5. Andreas Antoniou, "Digital Signal Processing", Tata Mc Graw Hill, 2006

Semester – IV

25ECU403 Electromagnetic Field Theory 4H – 4C

Instruction Hours / week: L: 3 T: 1 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To familiarize elementary phenomena and concepts in field theory
- To provide knowledge on the concepts of Electro-magnetic field which is essential for understanding the working principle, design and analysis of Electrical machines.
- To derive, formulate and solve field problems with the help of static and dynamic fields and potentials and use them for electrical systems.
- To provide understanding on the interaction of electric and magnetic fields in various media.
- To teach the concepts the electromagnetic wave propagation using Maxwell's equations, derive Poynting theorem and interpret the physical meaning.

Course Outcomes (COs)
At the completion of the course the student will be able to

CO	Course Outcomes	Blooms Level
CO1	Select suitable laws for specific applications in electromagnetic fields.	Analyse
CO2	Analyze electrostatic fields in free space and material media using Gauss's law and boundary conditions..	Apply
CO3	Apply various theorems and laws in solving magnetic field circuits.	Remember
CO4	Analyze self and mutual inductance in solenoid, toroid, transmission lines and cables.	Understand
CO5	Design electrical system using Maxwell's equation.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	2	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	2	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	2	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	2	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: ELECTRIC FILEDS 9

Introduction - Concepts of Different Co-Ordinate Systems, Vector algebra, Vector calculus, Sources and effects of electromagnetic fields - Coulomb's Law, Electric Field Intensity, Electric Field due to Point Charge, Line Charge, Surface Charge and Volume Charge Distributions - Electric Flux Density - Gauss Law - Application of Gauss Law - Electric Potential - Potential Gradient - Divergence and Divergence Theorem - Poisson's and Laplace equation.

UNIT 2: CONDUCTORS AND DIELECTRICS 9

Electric potential – Electric field and equipotential plots, Uniform and Non-Uniform field - Field due to Dipoles - Dipole Moment - Boundary Conditions at Dielectric and Conductor Surfaces - Capacitor and

Capacitance of a System of Conductors - Energy Stored and Energy Density - Capacitance due to Spherical Shell, Coaxial cable and Two Wire Transmission Line - Electrostatic Potential Energy Associated with Different Charges.

UNIT 3: MAGNETIC FIELDS 9

Current and Current Density - Conduction and Convection Current - Force on a Current Element - Lorentz force - Biot- Savart's law - Force between Current Carrying Conductors - Torque on Closed Conductors - Ampere's Law- Magnetic Flux Density - Curl and Stokes Theorem - Magnetic Vector Potential - Boundary Condition at the Magnetic surfaces.

UNIT 4: FARADAY'S LAW OF ELECTROMAGNETIC INDUCTION 9

Faradays' Laws - Self and Mutual Inductance - Inductance of Solenoids, Toroids, Transmission Lines and Cables - Energy Stored and Density in Magnetic Circuits - Relation between field theory and circuit theory, Applications.

UNIT 5: MAXWELL'S EQUATION AND ELECTRO MAGNETIC WAVES 9

Wave parameters; velocity, intrinsic impedance, propagation constant - Concept of Displacement and Conduction Current - Modified Ampere's Circuital Law - Maxwell's Equations in point and Integral Forms - Wave Equations - Plane Waves in Free Space - Polarization - Poynting's Theorem and Poynting Vector and its Significance - Energy in Electromagnetic Field - Plane wave reflection and refraction – Standing Wave, Applications.

45 PERIODS

SUGGESTED READINGS

1. K A Gangadhar, 'Electromagnetic Field Theory', Khanna Publishers; Sixteenth Edition Eighth Reprint :2015.
2. V.V.Sarwate, 'Electromagnetic fields and waves', Second Edition, Newage Publishers,2018.
3. Joseph. A.Edminister, 'Schaum's Outline of Electromagnetics, Fifth Edition (Schaum's Outline Series), McGraw Hill, 2018.
4. Karl.E.Lonngren, Sava.V.Savov, "Fundamentals of Electromagnetics with MATLAB", PHI,2005.
5. William H. Hayt and John A. Buck, 'Engineering Electromagnetics', McGraw Hill Special Indian edition, 2014.
6. R.Meenakumari&R.Subasri, "Electromagnetic Felds", New Age International Publishers, 2ndEdition, 2007.
7. E.C.Jordan&K.G.Balmain, "Electromagnetic Waves & Radiating Systems", Prentice Hall, 2006.

Semester – IV

25ECU404 Communication Networks and Security 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40**External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To impart knowledge on the Network Models and datalink layer functions
- To teach the fundamental concepts of routing in the Network Layer
- To explore methods of communication and congestion control by the Transport Layer.
- To introduce the Network Security architectures, algorithm and Mechanisms.
- To create awareness of various hardware security attacks and their countermeasures.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the various types of Network Models, layers and functions.	Understand
CO2	Categorize and classify the routing protocols.	Apply
CO3	List the functions of the transport and application layer	Understand
CO4	Evaluate and choose the network security mechanisms	Analyse
CO5	Discuss the hardware security attacks and countermeasures	Analyse

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	1	1	1	1	1	1	1	1	1	3	3
CO2	3	2	2	1	1	1	1	1	1	1	1	1	3	3
CO3	3	2	2	1	1	1	1	1	1	1	1	1	3	3
CO4	3	2	2	1	1	1	1	1	1	1	1	1	3	3
CO5	3	2	2	1	1	1	1	1	1	1	1	1	3	3

UNIT 1: NETWORK MODELS AND DATALINK LAYER 9

Overview of Networks and its Attributes – Network Models – OSI, TCP/IP, Addressing – Introduction to Datalink Layer – Error Detection and Correction – Ethernet(802.3)- Wireless LAN – IEEE 802.11, Bluetooth – Flow and Error Control Protocols – HDLC – PPP.

UNIT 2: NETWORK LAYER PROTOCOLS 9

Network Layer – IPv4 Addressing – Network Layer Protocols(IP,ICMP and Mobile IP) Unicast and Multicast Routing – Intradomain and Interdomain Routing Protocols – IPv6 Addresses – IPv6 – Datagram Format - Transition from IPv4 to IPv6.

UNIT 3: TRANSPORT AND APPLICATION LAYERS 9

Transport Layer Protocols – UDP and TCP Connection and State Transition Diagram - Congestion Control and Avoidance(DEC bit, RED)- QoS - Application Layer Paradigms – Client – Server Programming – Domain Name System – World Wide Web, HTTP, Electronic Mail.

UNIT 4: NETWORK SECURITY 9

OSI Security Architecture – Attacks – Security Services and Mechanisms – Encryption –Advanced Encryption Standard – Public Key Cryptosystems – RSA Algorithm – Hash Functions – Secure Hash Algorithm – Digital Signature Algorithm.

UNIT 5: HARDWARE SECURITY 9

Introduction to hardware security, Hardware Trojans, Side – Channel Attacks – Physical Attacks and Countermeasures – Design for Security. Introduction to Blockchain Technology

45 PERIODS

SUGGESTED READINGS

1. Behrouz.A.Forouzan, Data Communication and Networking, Fifth Edition, TMH, 2017.(Unit – I,II,III)
2. William Stallings, Cryptography and Network Security, Seventh Edition, Pearson Education, 2017(Unit-IV)
3. Bhunia Swarup, Hardware Security –A Hands On Approach,Morgan Kaufmann, First edition, 2018. (Unit – V).
4. James.F.Kurose and Keith.W.Ross, Computer Networking – A Top – Down Approach, Sixth Edition, Pearson, 2017
5. Doughlas .E.Comer, Computer Networks and Internets with Internet Applications, Fourth Edition, Pearson Education, 2008.

25ECU411 Analog and Digital Communication Laboratory **Semester – IV** **4H – 2C**

Instruction Hours / week: L: 0 T: 0 P: 4 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- The goal of this course is to introduce basic principles of Continuous wave (CW) Modulation, Pulse Modulation, as required for Electronics engineering students
- The course aims to make the student familiar with Digital Modulation and Demodulation techniques, Digital transmission, reception etc.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Analyze and compare different analog modulation schemes like AM, FM for their efficiency and bandwidth.	Evaluate
CO2	Analyze and compare various analog and digital modulation and demodulation techniques	Evaluate
CO3	Evaluate the performance of pulse modulation systems and their performance	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	3	1	1	1	1	1	1	1	1	3	3
CO2	3	2	1	3	1	1	1	1	1	1	1	1	3	3
CO3	3	2	1	3	1	1	1	1	1	1	1	1	3	3

LIST OF EXPERIMENTS

1. Amplitude Modulation and Demodulation
2. Frequency Modulation and Demodulation
3. Pre-Emphasis/ De-Emphasis Circuits
4. Sampling
5. Pulse Amplitude Modulation (PAM)
6. Pulse Width Modulation (PWM), Pulse Position Modulation (PPM)
7. Pulse Code Modulation (PCM).
8. Time Division Multiplexing.
9. Delta Modulation
10. Digital Modulation &Demodulation-ASK (Hardware & MATLAB) Pulse Code Modulation (PCM).
11. Digital Modulation & Demodulation-FSK (Hardware &MATLAB) Time Division Multiplexing.

12. Digital Modulation & Demodulation-PSK (Hardware &MATLAB)

13. Digital Modulation & Demodulation-QPSK (Hardware &MATLAB)

14. PLL and Frequency Synthesizer

15. Error Control Coding using MATLAB

TOTAL :30 PERIODS

		Semester – IV
25ECU412	Analog Integrated Circuits Laboratory	**4H – 2C**

Instruction Hours / week: L: 0 T: 0 P: 4

Marks: Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To enable the students to design and test of analog circuits using op-amp and Timer ICs.
- To expose the students to a variety of practical circuits using various analog ICs.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Design and analyze the analog circuits like filters, waveform generators, etc. using Op-amps	Analyse
CO2	Design and analyze waveform generators using Timers.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	3	1	1	1	1	1	1	1	1	3	3
CO2	3	2	1	3	1	1	1	1	1	1	1	1	3	3

LIST OF EXPERIMENTS

1. Inverting, Non Inverting amplifier
2. Integrator and Differentiator.
3. Precision Rectifiers (HW & FW)..
4. Comparators.
5. Filters (LPF & HPF).
6. Astable Multivibrator Using IC 741.
7. Monostable Multivibrator Using IC 741.
8. Schmitt Trigger Using IC 741.
9. Instrumentation Amplifier
10. A/D Converters
11. D/A Converters
12. Wein's Bridge Oscillator
13. RC Phase Shift Oscillator
14. Astable Multivibrator using IC 555.
15. Monostable Multivibrator using IC 555.

		Semester – V
25IKS002	**Vedic Mathematics**	**2H – 02**

Instruction Hours / week: L: 2 T: 0 P: 0

Marks: Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

		Semester – V
25ECU501	VLSI and Chip Design	**3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0

Marks: Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To impart fundamental knowledge on the characteristics of MOSFET under ideal, nonideal, static and dynamic conditions
- To teach the design of combinational logic circuits using various logic families and low power design in CMOS circuits
- To teach sequential logic circuits and clocking strategies.
- To teach about Interconnects, Arithmetic circuits, Logic Implementation using Programmable Devices and Memory Architecture.
- To teach the fundamentals of ASIC Design flow and Testing

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the characteristics of MOSFET under ideal, nonideal, static and dynamic conditions.	Analyse
CO2	Design of combinational logic circuits using various logic families and discuss the types of power dissipation in CMOS circuits	Apply
CO3	Describe sequential logic circuits and clocking strategies.	Remember
CO4	Discuss the various types of Interconnects, Arithmetic circuits, Logic Implementation using Programmable Devices and Memory Architecture	Understand
CO5	Explain ASIC Design flow and various types of Testing	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	2	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	2	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	2	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	2	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	2	3	2

UNIT 1: MOS TRANSISTOR PRINCIPLES **9**

MOS logic families (NMOS and CMOS), MOS(FET) Transistor Characteristic under Static and Dynamic Conditions, Ideal and Non-Ideal IV Characteristics, CMOS devices., Technology Scaling, power dissipation.

UNIT 2: COMBINATIONAL LOGIC CIRCUITS **9**

Propagation Delays, stick diagram, Layout diagrams, Examples of combinational logic design, Elmore's constant, Static Logic Gates, Dynamic Logic Gates, Pass Transistor Logic, Low Power Design principles.

UNIT 3: SEQUENTIAL LOGIC CIRCUITS AND CLOCKING STRATEGIES 9

Static Latches and Registers, Dynamic Latches and Registers, Pipelines, Non bistable Sequential Circuits. Timing classification of Digital Systems, Synchronous Design, Self-Timed Circuit Design.

UNIT 4: INTERCONNECT, MEMORY ARCHITECTURE AND ARITHMETIC CIRCUITS 9

Interconnect Parameters – Capacitance, Resistance, and Inductance, Electrical WireModels, Sequential digital circuits: adders, multipliers, comparators, shift registers. Logic Implementation using Programmable Devices (ROM, PLA, FPGA), Memory Architecture and Building Blocks,Memory Core and Memory Peripherals Circuitry.

UNIT 5: ASIC DESIGN AND TESTING 9

Introduction to wafer to chip fabrication process flow. Microchip design process & issues in test and verification of complex chips, embedded cores and SOCs, Fault models, Test coding. ASIC Design Flow, Introduction to ASICs, Introduction to test benches, Writing test benches in Verilog HDL, Automatic test pattern generation, Design for testability, Scan design: Test interface and boundary scan.

45 PERIODS

SUGGESTED READINGS

1. Jan D Rabaey, Anantha Chandrakasan, “Digital Integrated Circuits: A Design Perspective”, PHI, 2016.
2. Neil H E Weste, Kamran Eshranghian, “Principles of CMOS VLSI Design: A System Perspective,” Addison Wesley, 2009.
3. M J Smith, “Application Specific Integrated Circuits”, Addison Wesley, January 2002.
4. Parag K.Lala,” Digital Circuit Testing and Testability”, Academic Press, 1997,

Semester – V

25ECU521 Wireless Communication **5H – 4C**

Instruction Hours / week: L: 3 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To introduce the concepts and design of a Cellular System
- To teach the types of Mobile Radio Propagation and Digital Modulation Techniques.
- To provide fundamental knowledge on Multiple Access Techniques and Wireless Networks

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain channel assignment strategies, interference, coverage and capacity of cellular systems.	Understand Analyse
CO2	Describe Mobile Radio Propagation and Various Digital Modulation Techniques	Apply
CO3	Enumerate the Concepts of Multiple Access Techniques and Wireless Networks	Understand
CO4	Characterize a wireless channel and evolve the system design specifications	Apply
CO5	Design a cellular system based on resource availability and traffic demands.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	2	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	2	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	2	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	2	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	2	1	1	1	1	1	1	1	1	3	2

UNIT 1: THE CELLULAR CONCEPT-SYSTEM DESIGN FUNDAMENTALS 9

Introduction-Frequency Reuse-Channel Assignment Strategies-Handoff Strategies: Prioritizing Handoffs, Practical Handoff Considerations. Interference And System Capacity: Co-Channel Interference and System Capacity-Channel Planning for Wireless Systems, Adjacent Channel Interference, Power Control For Reducing Interference, Trunking and Grade Of Service. Improving Coverage and Capacity in Cellular Systems: Cell Splitting, Sectoring

UNIT 2: MOBILE RADIO PROPAGATION 9

Large Scale Path Loss: Introduction to Radio Wave Propagation - Free Space Propagation Model – Three Basic Propagation Mechanism: Reflection – Brewster Angle- Diffraction Scattering. Small Scale Fading and Multipath: Small Scale Multipath Propagation, Factors Influencing Small-Scale Fading, Doppler Shift, Coherence Bandwidth, Doppler Spread and Coherence Time. Types Of Small- Scale Fading: Fading Effects Due To Multipath Time Delay Spread, Fading Effects Due To Doppler Spread

UNIT 3: MODULATION TECHNIQUES AND EQUALIZATION AND DIVERSITY 9

Digital Modulation – An Overview: Factors That Influence The Choice Of Digital Modulation, Linear Modulation Techniques: Minimum Shift Keying (MSK), Gaussian Minimum Shift Keying(GMSK), Spread Spectrum Modulation Techniques: Pseudo- Noise (PN) Sequences, Direct Sequence Spread Spectrum (DS-SS)- Modulation Performance In Fading And Multipath Channels- Equalization, Diversity And Channel Coding: Introduction-Fundamentals Of Equalization- Diversity Techniques: Practical Space Diversity Considerations, Polarization Diversity, Frequency Diversity, Time Diversity.

UNIT 4: MULTIPLE ACCESS TECHNIQUES 9

Introduction: Introduction To Multiple Access- Frequency Division Multiple Access(FDMA)- Time Division Multiple Access(TDMA)- Spread Spectrum Multiple Access-Code Division Multiple Access(CDMA)- Space Division Multiple Access(SDMA)- Capacity Of Cellular Systems: Capacity Of Cellular CDMA, Capacity of CDMA With Multiple Cells..

UNIT 5: WIRELESS NETWORKING 9

Introduction: Difference Between Wireless And Fixed Telephone Networks, The Public Switched Telephone Network(PSTN), Development Of Wireless Networks: First Generation Wireless Networks, Second Generation Wireless Networks, Third Generation Wireless Networks, Fixed Network Transmission Hierarchy, Traffic Routing In Wireless Networks: Circuit Switching, Packet Switching- Personal Communication Services/ Networks(PCS/PCNs):Packet Vs Circuit Switching For PCN, Cellular Packet- Switched Architecture- Packet Reservation Multiple Access(PRMA)- Network Databases: Distributed Database For Mobility Management- Universal Mobile Telecommunication Systems(UMTS).

45 PERIODS

PRACTICAL EXERCISES: 15 PERIODS

1. Modeling and simulation of Two ray multipath propagation channel using matlab.
2. Modeling and simulation of free-space propagation model using matlab
3. Modeling and simulation of Rayleigh and Rician multipath fading channel using matlab
4. Analyze the BER performance of wireless standards for 64bit QAM.
5. Performance measurements such as BER, PER, BLER for 4G and 5G using Matlab
6. Performance measurements such as throughput, capacity, ACLR, EVM for 4G and 5G using Matlab
7. Spread Spectrum – DSSS Modulation & Demodulation
8. Modeling and simulation of TDMA and FDMA for wireless communication
9. Modeling and simulation of CDMA and SDMA for wireless communication
10. Wireless Channel equalization: Zero-Forcing Equalizer (ZFE), MMSE Equalizer(MMSEE)
11. Wireless Channel equalization: Adaptive Equalizer (ADE), Decision Feedback Equalizer (DFE)

SUGGESTED READINGS

1. Rappaport,T.S.,-Wireless communications", Pearson Education, Second Edition, 2010
2. Wireless Communication –Andrea Goldsmith, Cambridge University Press, 2011
3. Van Nee, R. and Ramji Prasad, —OFDM for wireless multimedia communications, Artech House, 2000
4. David Tse and Pramod Viswanath, —Fundamentals of Wireless Communication, Cambridge University Press, 2005
5. Upena Dalal, —Wireless Communication", Oxford University Press, 2009
6. Andreas.F. Molisch, —Wireless Communications", John Wiley – India, 2006.
7. Wireless Communication and Networks –William Stallings ,Pearson Education, Second Edition 2002

Semester – V

25ECU502 Transmission Lines and RF systems **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To introduce various types of transmission lines and their characteristics.
- To give thorough understanding about high frequency line, power and impedance measurements
- To impart technical knowledge in impedance matching using smith chart
- To introduce passive filters and basic knowledge of active RF components
- To teach the design of RF system transceiver design

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the characteristics of transmission lines and its losses	Understand
CO2	Derive the standing wave ratio and input impedance in high frequency transmission lines	Apply
CO3	Analyze impedance matching by stubs using smith charts	Analyse
CO4	Analyze the characteristics of TE and TM waves in different types of waveguides	Analyse
CO5	Explain the design concepts of a RF transceiver system used for wireless communication	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: TRANSMISSION LINE THEORY **9**

General theory of Transmission lines - the transmission line - general solution - The infinite line - Wavelength, velocity of propagation - Waveform distortion - the distortion-less line - Loading and different methods of loading - Line not terminated in Z0 - Reflection coefficient - calculation of current, voltage, power delivered and efficiency of transmission - Input and transfer impedance - Open and short circuited lines - reflection factor and reflection loss.

UNIT 2: HIGH FREQUENCY TRANSMISSION LINES **9**

Transmission line equations at radio frequencies - Line of Zero dissipation - Voltage and current on the dissipation-less line, Standing Waves, Nodes, Standing Wave Ratio - Input impedance of the dissipation-less line - Open and short circuited lines - Power and impedance measurement on lines - Reflection losses - Measurement of VSWR and wavelength.

UNIT 3: IMPEDANCE MATCHING IN HIGH FREQUENCY LINES 9

Impedance matching: Quarter wave transformer - Impedance matching by stubs - Single stub and double stub matching - Smith chart - Solutions of problems using Smith chart - Single and double stub matching using Smith chart.

UNIT 4: WAVEGUIDES 9

General Wave behavior along uniform guiding structures – Transverse Electromagnetic Waves, Transverse Magnetic Waves, Transverse Electric Waves – TM and TE Waves between parallel plates. Field Equations in rectangular waveguides, TM and TE waves in rectangular waveguides, Bessel Functions, TM and TE waves in Circular waveguides

UNIT 5: RF SYSTEM DESIGN CONCEPTS 9

Active RF components: Semiconductor basics in RF, bipolar junction transistors, RF field effect transistors, High electron mobility transistors Basic concepts of RF design, Mixers, Low noise amplifiers, voltage control oscillators, Power amplifiers, transducer power gain and stability considerations.

45 PERIODS

SUGGESTED READINGS

1. John D Ryder, ―Networks, lines and fields‖, 2nd Edition, Prentice Hall India, 2015. (UNIT I-IV)
2. Mathew M. Radmanesh, ―Radio Frequency &Microwave Electronics‖, Pearson Education Asia, Second Edition,2002. (UNIT V)
3. Reinhold Ludwig and Powel Bretchko,‖ RF Circuit Design – Theory and Applications‖, Pearson Education Asia, First Edition,2001
4. D. K. Misra, ―Radio Frequency and Microwave Communication Circuits- Analysis and Design‖, John Wiley & Sons, 2004.
5. E.C.Jordan and K.G. Balmain, ―Electromagnetic Waves and Radiating Systems Prentice Hall of India, 2006.
6. G.S.N Raju, "Electromagnetic Field Theory and Transmission Lines Pearson Education, First edition 2005.

Semester – V

25ECU503 Optical Communication and Networks **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To introduce the types of Optical Fiber Modes, Configuration of Optical Fibers
- To provide an understanding of the Transmission Characteristics of Optical Fibers.
- To teach about the various Optical Sources, Detectors and Transmission Techniques.
- To explore different types of Optical Fiber Measurements and Coupling Techniques.
- To teach about Optical Communication Systems and Networks.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the basic elements in optical Fibers, different Modes and Configurations.	Analyse
CO2	Explain the types of attenuation, scattering, dispersion losses in optical fibers.	Apply
CO3	Describe the types of Optical Sources and Detectors and their use in optical Communication System.	Remember
CO4	Discuss fiber optic attenuation, dispersion, wavelength measurement techniques.	Understand
CO5	Explain Optical Communication Networks and their applications.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: INTRODUCTION TO OPTICAL FIBER COMMUNICATION 9

Introduction - The General Systems - Advantages of Optical Fiber Communication- Ray Theory Transmission: Total Internal Reflection, Acceptance Angle, Numerical Aperture, Skew Rays - Electromagnetic Mode Theory for Optical Propagation: Modes in a Planar Guide, Phase and group velocity - Cylindrical Fiber: Step index fibers, Graded index fibers - Single mode fibers: Cutoff wavelength.

UNIT 2: TRANSMISSION CHARACTERISTICS OF OPTICAL FIBERS 9

Attenuation - Material absorption losses in silica glass fibers: Intrinsic absorption, Extrinsic absorption - Linear scattering losses: Rayleigh Scattering, Mie Scattering -Nonlinear scattering losses: Stimulated Brillouin Scattering, Stimulated Raman Scattering – Fiber Bend Loss – Dispersion- Chromatic dispersion: Material dispersion, Waveguide dispersion- Intermodal dispersion: Multimode step index fiber, Multimode graded index fiber.

UNIT 3: OPTICAL SOURCES AND OPTICAL DETECTORS 9

The laser: Introduction - Basic concepts: Absorption and emission of radiation, Population inversion , Optical feedback and laser oscillation, Threshold condition for laser oscillation- Optical emission from semiconductors: The PN junction, Spontaneous emission, Carrier recombination, Stimulated emission and lasing, Hetero junctions- LED: Introduction- Power and Efficiency - LED structures: Planar LED, Dome LED, Surface emitter LED, Edge emitter LED- LED Characteristics. Optical Detectors: Introduction, Optical Detection Principles, Quantum Efficiency, Resposivity, P-N Photodiode, P-I-N Photo Diode and Avalanche Photodiode.

UNIT 4: OPTICAL FIBER MEASUREMENTS 9

Introduction- Total Fiber Attenuation Measurement, Fiber Dispersion Measurements in Time Domain and Frequency Domain, Fiber Cut off Wavelength Measurements, Numerical Aperture Measurements. Fiber Diameter Measurements, Reflectance And Optical Return Loss, Field Measurements.

UNIT 5: OPTICAL NETWORKS 9

Introduction- Optical Network Concepts: Optical Networking Terminology, Optical Network Node And Switching Elements, Wavelength Division Multiplexed Networks, Public Telecommunications Network Overview- Optical Network Transmission Modes, Layers And Protocols: Synchronous Networks, Asynchronous Transfer Mode, Open System Interconnection Reference Model, Optical Transport Network, Internet Protocol- Wavelength Routing Networks: Routing And Wavelength Assignment- Optical Switching Networks: Optical Circuit Switched Networks, Optical Packet Switched Networks, Multiprotocol Label Switching, Optical Burst Switching Networks- Optical Network Deployment : Long Haul Networks, Metropolitan area networks, Access networks, Local Area Networks- Optical Ethernet: Network protection, restoration and survivability.

45 PERIODS

SUGGESTED READINGS

1. Gred Keiser,"Optical Fiber Communication", McGraw Hill Education (India) Private Limited. Fifth Edition, Reprint 2013.
2. Govind P. Agrawal, "Fiber-Optic Communication Systems", Third Edition, John Wiley & Sons, 2004.
3. J.Gower, "Optical Communication System", Prentice Hall Of India, 2001
4. Rajiv Ramaswami, "Optical Networks " , Second Edition, Elsevier , 2004.
5. P Chakrabarti, "Optical Fiber Communication", McGraw Hill Education (India)Private Limited, 2016.

Semester – V

25ECU511 **VLSI Laboratory** **4H – 2C**

Instruction Hours / week: L: 0 T: 0 P: 4 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To teach combinational and sequential circuit deisgn using Hardware Descriptive Language (Verilog)
- To familiarize implementation of logical modules on FPGAs.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Write Verilog code for combinational circuits and sequential circuits and simulate it using Xilinx ISE	Analyse
CO2	Synthesize and Implement the designed digital circuits using Spartan FPGA kits.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	3	1	1	1	1	1	1	1	1	3	3
CO2	3	2	1	3	1	1	1	1	1	1	1	1	3	3

LIST OF EXPERIMENTS

1. Realization of Logic Gates using behavioral modelling
2. Synthesis of Half adder and Full adder
3. Synthesis of Ripple Carry Adder
4. Synthesis of multiplier
5. Synthesis of MUX/ DEMUX
6. Synthesis of Encoder/Decoder
7. Synthesis of Binary to Gray code counters
8. Synthesis of Flip Flops
9. Synthesis of Pseudo Random Binary Sequence
10. Synthesis of up-down counter
11. Synthesis of Shift register
12. Design of Sequence Detector
13. Design and Implementation of adder circuit
14. Design and Implementation of multiplier circuit
15. Design and Implementation of ALU

TOTAL :30 PERIODS

25MAC501	Entrepreneurship and Development	Semester – V 3H – 0C

Instruction Hours / week: L: 3 T: 0 P: 0

Semester – VI

25ECU621 Embedded Systems and IOT Design 5H – 4C

Instruction Hours / week: L: 3 T: 0 P: 2 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To teach the architecture and features of 8051
- To introduce the design process of an embedded system
- To provide basic understanding on the real – time processing in an embedded system
- To teach the architecture and design flow of IoT
- To teach design of IoT based system for simple real time application.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the architecture and features of 8051 microcontroller	Analyse
CO2	Describe embedded system design process.	Apply
CO3	Explain different types of operating systems used in embedded systems and Distributed Embedded Systems	Remember
CO4	Explain the architecture and protocols of IoT.	Understand
CO5	Design an IoT based system for simple real time application.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	2	2	1	1	1	1	1	1	1	3	3
CO2	3	2	2	2	2	1	1	1	1	1	1	1	3	3
CO3	3	2	2	2	2	1	1	1	1	1	1	1	3	3
CO4	3	2	2	2	2	1	1	1	1	1	1	1	3	3
CO5	3	2	2	2	2	1	1	1	1	1	1	1	3	3

UNIT 1: 8051 MICROCONTROLLER 9

Microcontrollers for an Embedded System – 8051 – Architecture – Addressing Modes – Instruction Set – Program and Data Memory – Stacks – Interrupts – Timers/Counters – Serial Ports – Programming.

UNIT 2: EMBEDDED SYSTEMS 9

Embedded System Design Process – Model Train Controller – ARM Processor – Instruction Set Preliminaries – CPU – Programming Input and Output – Supervisor Mode – Exceptions and Trap – Models for programs – Assembly, Linking and Loading – Compilation Techniques – Program Level Performance Analysis.

UNIT 3: PROCESSES AND OPERATING SYSTEMS 9

Structure of a real – time system – Task Assignment and Scheduling – Multiple Tasks and Multiple Processes – Multirate Systems – Pre emptive real – time Operating systems – Priority based scheduling – Interprocess Communication Mechanisms – Distributed Embedded Systems – MPSoCs and Shared

Memory Multiprocessors – Design Example – Audio Player, Engine Control Unit and Video Accelerator

UNIT 4: IOT ARCHITECTURE AND PROTOCOLS 9

Internet – of – Things – Physical Design, Logical Design – IoT Enabling Technologies – Domain Specific IoTs – IoT and M2M – IoT System Management with NETCONF – YANG – IoT Platform Design – Methodology – IoT Reference Model – Domain Model – Communication Model – IoT Reference Architecture – IoT Protocols - MQTT, XMPP, Modbus, CANBUS and BACNet.

UNIT 5: IOT SYSTEM DESIGN 9

Basic building blocks of an IoT device – Raspberry Pi – Board – Linux on Raspberry Pi – Interfaces – Programming with Python – Case Studies: Home Automation, Smart Cities, Environment and Agriculture.

45 PERIODS

Experiments using 8051:

1. Programming Arithmetic and Logical Operations in 8051
2. Generation of Square waveform using 8051.
3. Design of a Digital Clock using Timers/Counters in 8051

Experiments using ARM

4. Interfacing ADC and DAC
5. Blinking of LEDs and LCD
6. Interfacing keyboard and Stepper Motor

Miniprojects for IoT

7. Garbage Segregator and Bin Level Indicator
8. Colour based Product Sorting
9. Image Processing based Fire Detection / Vehicle Number Plate Detection
10. Smart Lock System

SUGGESTED READINGS

1. S. Misra, A. Mukherjee, and A. Roy, 2020. Introduction to IoT. Cambridge University Press. Availability: https://www.amazon.in/Introduction-IoT-Sudip Misra/dp/1108959741/ref=sr_1_1?dchild=1&keywords=sudip+misra&qid=1627359928&sr= 8-1.
2. S. Misra, C. Roy, and A. Mukherjee, 2020. Introduction to Industrial Internet of Things and Industry 4.0. CRC Press. Availability:https://www.amazon.in/dp/1032146753/ref=sr_1_3?dchild=1&keywords=sudip+misra&qid=1627 359971&sr=8-3
3. Klaus Schwab, “Fourth Industrial Revolution”, Random House USA Inc, New York, USA, 2017
4. Oliver Grunow, ”SMART FACTORY AND INDUSTRY 4.0. The current state of Application Technologies”, Studylab Publications, 2016
5. Alasdair Gilchrist, “INDUSTRY 4.0: Industrial Internet of Things”, Apress, 2016

Semester – VI

25ECU601 **Antenna Design** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

To emphasize antenna array concepts and beamforming techniques
To provide foundational knowledge of random processes and their classification
To familiarize students with various AoA estimation algorithms and methods
To enable analysis and design of fixed beamforming architecture
To introduce the fundamentals of smart antennas and the motivation for adaptive beamforming

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Describe the basics of phased array antennas	Understand
CO2	Use random process and its application in Smart antennas	Apply
CO3	Estimate the weights of the antenna array based on the angle of arrival	Apply
CO4	Analyze the fixed weight beam forming in smart antennas	Understand
CO5	Analyze adaptive beamforming in smart antennas	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: ANTENNA ARRAY FUNDAMENTALS 9

Linear arrays: Two element and Uniform N element array – Array weighting: Beam steered and weighted arrays – Circular arrays – Rectangular planar arrays – Fixed beam arrays – Butler Matrices – Fixed sidelobe cancelling – Retrodirective arrays: Passive and active retrodirective arrays.

UNIT 2: PRINCIPLES OF RANDOM VARIABLES AND PROCESSES 9

Definition of Random Variables – Probability Density Functions – Expectation and Moment -Common Probability Density Functions – Stationarity and Ergodicity – Autocorrelation and Power Spectral Density – Correlation Matrix

UNIT 3: ANGLE OF ARRIVAL ESTIMATION 9

Fundamentals of Matrix Algebra: Vector basics – Matrix basics – Array Correlation Matrix – AOA Estimation Methods: Bartlett AOA estimate, Capon AOA estimate, Linear prediction AOA estimate, Maximum entropy AOA estimate, Pisarenko harmonic decomposition AOA estimate, Min-norm AOA estimate, MUSIC AOA estimate, Root-MUSIC AOA estimate, ESPRIT AOA estimate

UNIT 4: SMART ANTENNAS: FIXED WEIGHT BEAMFORMING 9

Introduction – Historical Development of Smart Antennas – Fixed Weight Beamforming Basics: Maximum signal-to-interference ratio, Minimum mean-square error, Maximum likelihood, Minimum variance.

UNIT 5: SMART ANTENNAS: ADAPTIVE BEAMFORMING 9

Adaptive Beamforming: Least mean squares, Sample matrix inversion, Recursive least squares, Constant modulus, Least squares constant modulus, Conjugate gradient method, Spreading sequence array weights, Description of the new SDMA receiver.

45 PERIODS

SUGGESTED READINGS

1. Frank Gross, Smart antennas for wireless communications, McGra-Hill, 2006.
2. S. Chandran, Adaptive antenna arrays, trends and applications, Springer, 2009.
3. T. S. Rappaport, Smart antennas: Adaptive arrays, algorithms and wireless position location, IEEE Press, 1998.
4. Robert A.Monzingo, Randy L. Haupt and Thomas W.Miller, Introduction to Adaptive arrays, 2nd Edition, IET, 2011.
5. Thomas Kaiser, Smart Antennas: State of the Art, Hindawi, 2005.

Semester – VI

25ECU622 **Microwave Engineering** **5H – 4C**

Instruction Hours / week: L: 3 T: 0 P: 20 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To analyze microwave frequencies and perform Scattering parameter analysis of RF networks
- To analyze microwave systems and assess the impact of microwave component performances on overall system performance.
- To describe the operation and analyze the performance of microwave sources and solid state semiconductor devices
- To analyze, assess qualitatively and quantitatively the role of optical fiber communication and signal degradation.
- To familiarize on the principle of operation of optical sources and detectors and optical networks.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Select suitable microwave components for high frequency applications.	Understand
CO2	Analyze the performance characteristics of various microwave sources and solid state devices	Apply
CO3	Measure S parameters of microwave components	Apply
CO4	Analyze the performance of analog and digital optical communication system	Understand
CO5	Select suitable optical sources, detectors and optical amplifiers for various applications and examine the characteristics of optical Networks.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	2	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	2	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	2	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	2	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	2	1	1	1	1	1	1	1	3	2

UNIT 1: RECTANGULAR WAVE GUIDE 9

Field Components, TE, TM Modes, Dominant TE10 mode, Field Distribution, Power, Attenuation. Circular Waveguides: TE, TM modes. Wave Velocities, Microstrip Transmission line (TL), Coupled TL, Strip TL, Coupled Strip Line, Coplanar TL, Microwave Cavities

UNIT 2: SCATTERING MATRIX, PASSIVE MICROWAVE DEVICES 9

Microwave Hybrid Circuits, Terminations, Attenuators, Phase Shifters, Directional Couplers: Two Hole directional couplers, S Matrix of a Directional coupler, Hybrid Couplers, Microwave Propagation in ferrites, Faraday Rotation, Isolators, Circulators. Spara meter analysis of all components.

UNIT 3: MICROWAVE TUBES 9

Limitation of Conventional Active Devices at Microwave frequency, Two Cavity Klystron, Reflex Klystron, Magnetron, Traveling Wave Tube, Backward Wave Oscillators: Their Schematic, Principle of Operation, Performance Characteristic and their applications.

UNIT 4: SOLID STATE AMPLIFIERS AND OSCILLATORS 9

Microwave Bipolar Transistor, Microwave tunnel diode, Microwave Field-effect Transistor, Transferred electron devices, Avalanche Transit -time devices: IMPATT Diode, TRAPPAT Diode.

UNIT 5: MICROWAVE MEASUREMENTS 9

General setup of a microwave testbench, Slotted line carriage, VSWR Meter, microwave power measurements techniques, Crystal Detector, frequency measurement, wavelength measurements, Impedance and Refection coefficient, VSWR, Insertion and attenuation loss measurements, measurement of antenna characteristics, microwave link design.

45 PERIODS

SUGGESTED READINGS

1. Samuel Y. Liao, "Microwave Devices and Circuits", Pearson Education Publication.
2. Das and S.K. Das," Microwave Engineering", Tata McGraw Hill Publication.
3. R.E Collin, "Foundation for Microwave Engineering", John Wiley India Publication

Semester – IV

25ECU611 **Optical and Microwave Laboratory** **4H – 2C**

Instruction Hours / week: L: 0 T: 0 P: 4 **Marks:** Internal: **40** External:**60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To understand the working principle of optical sources, detector, fibers and microwave components
- To develop understanding of simple optical communication link.
- To learn about the characteristics and measurements in optical fiber
- To know about the behavior of microwave components.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Analyze the performance of simple optical link.	Analyze
CO2	Test microwave and optical components.	Apply
CO3	Analyse the mode characteristics of fiber	Analyse
CO4	Demonstrate the structure and operation of various antennas and to describe their parameters.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	2	2	1	1	1	1	1	1	1	3	3
CO2	3	2	2	2	2	1	1	1	1	1	1	1	3	3
CO3	3	2	2	2	2	1	1	1	1	1	1	1	3	3
CO4	3	2	2	2	2	1	1	1	1	1	1	1	3	3
CO5	3	2	2	2	2	1	1	1	1	1	1	1	3	3

PRACTICAL EXERCISES:

1. DC Characteristics of LED and PIN Photo diode
2. Mode Characteristics of Fibers
3. Measurement of connector and bending losses
4. Fiber optic Analog and Digital Link- frequency response(analog) and eye diagram (digital)
5. Numerical Aperture determination for Fibers
6. Attenuation Measurement in optical Fibers

7. Reflex klystron characteristics and basic microwave measurement such as VSWR, frequency, wavelength
8. Gunn diode characteristics and basic microwave parameter measurement such as VSWR, frequency, wavelength.
9. Directional Coupler Characteristics.
10. Radiation Pattern of Horn Antenna.
11. S-parameter Measurement of the microwave components such as Isolator and Circulators
12. S-parameter Measurement of E plane Tee, H Plane Tee
13. S-parameter Measurement of Magic Tee
14. Attenuation and Power Measurement of reflex klystron
15. Attenuation and Power Measurement of gun diode oscillator

TOTAL PERIODS :30

Semester – VII

25ECU701 Multi-core architecture and Programming 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To provide fundamental knowledge on the need for multi-core processors, and their architecture.
- To teach the challenges in parallel and multithreaded programming.
- To introduce various parallel programming paradigms.
- To develop multicore programs and design parallel solutions.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Describe multicore architectures and identify their characteristics and challenges.	Understand
CO2	Identify the issues in programming Parallel Processors.	Apply
CO3	Write programs using OpenMP and MPI.	Apply
CO4	Design parallel programming solutions to common problems.	Apply
CO5	Compare programming for serial processors and programming for parallel professors	Analyse

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	1	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	1	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	1	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	1	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	1	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: MULTI-CORE PROCESSORS 9

Single core to Multi-core architectures – SIMD and MIMD systems – Interconnection networks – Symmetric and Distributed Shared Memory Architectures – Cache coherence – Performance Issues – Parallel program design.

UNIT 2: PARALLEL PROGRAM CHALLENGES 9

Performance – Scalability – Synchronization and data sharing – Data races – Synchronization primitives (mutexes, locks, semaphores, barriers) – deadlocks and livelocks – communication between threads (condition variables, signals, message queues and pipes)

UNIT 3: SHARED MEMORY PROGRAMMING WITH OpenMP 9

OpenMP Execution Model – Memory Model – OpenMP Directives – Work-sharing Constructs – Library functions – Handling Data and Functional Parallelism – Handling Loops – Performance Considerations

UNIT 4: DISTRIBUTED MEMORY PROGRAMMING WITH MPI 9

MPI program execution – MPI constructs – libraries – MPI send and receive – Point-to-point and Collective communication – MPI derived datatypes – Performance evaluation

UNIT 5: PARALLEL PROGRAM DEVELOPMENT 9

Case studies – n-Body solvers – Tree Search – OpenMP and MPI implementations and comparison.

45 PERIODS

SUGGESTED READINGS

1. Peter S. Pacheco, “An Introduction to Parallel Programming, Morgan-Kauffman/Elsevier, 2021.
2. Michael J Quinn, “Parallel programming in C with MPI and OpenMP, Tata McGraw Hill,2003
3. Darryl Gove, “Multicore Application Programming for Windows, Linux, and Oracle Solaris,
4. Victor Alessandrini, Shared Memory Application Programming, 1st Edition, Concepts and Strategies in Multicore Application Programming, Morgan Kaufmann, 2015.
5. Yan Solihin, Fundamentals of Parallel Multicore Architecture, CRC Press, 2015

Vertical 1

Semiconductor Chip Design and Testing

25ECU531A WIDE BANDGAP DEVICES 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To introduce the concept of wide band gap (WBG) devices and its application in real world
- To teach advantages and disadvantages of WBG devices.
- To provide an introduction to basic operation of WBG power devices.
- To teach design principles of modern power devices
- To ability to deal high frequency design complexity

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the characteristics of wide band gap semiconductor devices	Understand
CO2	Discuss the switching characteristics reliability issues and testing methods	Understand
CO3	Describe the drivers of wide band gap semiconductor devices	Apply
CO4	Discuss about the high frequency design complexity and pcb designing	Apply
CO5	Explain the applications of Wide Band gap (WBG) technology.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: WBG DEVICES AND THEIR APPLICATION IN REAL WORLD 9

Review of semiconductor basics, Operation and characteristics of the SiC Schottky Barrier Diode, SiC DMOSFET and GaN HEMT, Review of Wide bandgap semiconductor technology -Advantages and disadvantages

UNIT 2: SWITCHING CHARACTERIZATION OF WBG 9

Turn-on and Turn-off characteristics of the device, Hard switching loss analysis, Double pulse test set-up

UNIT 3: DRIVERS FOR WIDE BAND GAP DEVICES 9

Gate driver, Impact of gate resistance, Gate drivers for wide bandgap power devices , Transient immunity integrated gate drivers

UNIT 4: HIGH FREQUENCY DESIGN COMPLEXITY AND PCB DESIGNING 9

Effects of parasitic inductance, Effects of parasitic capacitance , EMI filter design for high frequency power converters High frequency PCB design, Conventional power loop design, High frequency power loop optimization, Separation of power from signal PCB

UNIT 5: APPLICATIONS OF WIDE BANDGAP DEVICES 9

Consumer electronics applications, Wireless power transfer applications, Electric vehicle applications , Renewable energy sources applications

SUGGESTED READINGS

1. A. Lidow, J. Strydom, M. D. Rooij, D. Reusch, GaN Transistors for Efficient Power Convertion, Wiley, 2014, ISBN-13: 978-1118844762.
2. G. Meneghesso, M. Meneghini, E. Zanoni, “Gallium Nitride-enabled High Frequency and High Efficiency Power Conversion,” Springer International Publishing, 2018, ISBN: 978-3- 319-77993-5
3. F. Wang, Z. Zhang and E. A. Jones, Characterization of Wide Bandgap Power Semiconductor Devices, IET, ISBN-13: 978-1785614910 (2018).
4. B.J.Baliga, “Gallium Nitride and Silicon Carbide Power Devices,” World Scientific Publishing Company (3 Feb. 2017).
5. L. Corradini, D. Maksimovic, P. Mattavelli, R. Zane, “Digital Control of HighFrequency Switched-Mode Power Converters”, Wiley, ISBN-13: 978-1118935101 (9th June, 2015)

25ECU532A VALIDATION AND TESTING TECHNOLOGY 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To introduce various IC technologies
- To teach MOS theory and testing
- To teach CMOS circuit theory and testing.
- To give insight on CMOS characterization.
- To explore circuit and device level testing methods.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the CMOS fabrication process.	Understand
CO2	Analyse the characteristics of MOS devices.	Analyze
CO3	Analyze CMOS performance through testing and estimation techniques.	Analyze
CO4	Explain the basics of Testing and Fault Modeling	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: TECHNOLOGY INTRODUCTION 9

Introduction to IC Technology – MOS, PMOS, NMOS, CMOS & BiCMOS Technologies. VLSI Fabrication, Oxidation, Lithography, Diffusion, Ion Implantation, Metallization, Integrated Resistors and Capacitors.

UNIT 2: MOS THEORY ANALYSIS-I 9

Basic Electrical Properties of MOS Circuits: Ids-Vds Relationships, MOS Transistor Threshold Voltage Vth, gm, gds, Figure of Merit ωo, Short Channel and Narrow Channel Width Effects.

UNIT 3: MOS THEORY ANALYSIS- II 9

Pass Transistor, Transmission Gate, NMOS Inverter, Various Pull-ups, CMOS Inverter Analysis and Design, Bi-CMOS Inverters, Latch up in CMOS Circuits.

UNIT 4: CMOS CIRCUIT CHARACTERISATION AND PERFORMANCE ESTIMATION **9**

Sheet Resistance RS, conductivity and its Concept to MOS, Area Capacitance Units, Calculations - Delays, Driving Large Capacitive Loads, Delay Estimation, Logical Effort and Transistor Sizing, Power Dissipation, Reliability.

UNIT 5: BASIC OF SILICON VALIDATION **9**

Need for Testing, Testing at Various Levels, Objectives of Testing - VLSI Test process and Test Equipment - Types of Testing: Functionality Tests, Silicon Debug, Manufacturing Tests, Defect during manufacturing - Fault Modelling, Observability and Controllability, Fault Coverage, Fault Sampling - ATE, Test economics

45 PERIODS

SUGGESTED READINGS

1. Kamran Ehraghian, Dauglas A. Pucknell and Sholeh Eshraghiam, “Essentials of VLSI Circuits and Systems” – PHI, EEE, 2005 Edition
2. Neil H. E. Weste and David. Harris Ayan Banerjee,, “CMOS VLSI Design” - Pearson Education, 1999
3. M.L. Bushnell and V.D. Agrawal, “Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits”, Kluwer Academic Publishers, 2004
4. N.K. Jha and S.G. Gupta, “Testing of Digital Systems”, Cambridge University Press, 2003
5. Etienne Sicard, Sonia Delmas Bendhia, “Basics of CMOS Cell Design”, TMH, EEE, 2005

25ECU631A LOW POWER IC DESIGN 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To teach the fundamentals of low power low voltage VLSI design.
- To provide insight on the impact of power on system performances
- To provide the fundamentals of different design approaches.
- To develop the low power low voltage memories

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the fundamentals of low-power circuit design.	Understand
CO2	Describe the architectural approaches for low-power design.	Understand
CO3	Analyze and design low-voltage, low-power combinational circuits.	Apply
CO4	Design low-voltage, low-power memory circuits	Apply
CO5	Design and develop low-power, low-voltage circuits for real-world applications.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: FUNDAMENTALS OF LOW POWER CIRCUITS 9

Need for Low Power Circuit Design, Sources of Power Dissipation – Switching Power Dissipation, Short Circuit Power Dissipation, Leakage Power Dissipation, Glitching Power Dissipation, Short Channel Effects –Drain Induced Barrier Lowering and Punch Through, Surface Scattering, Velocity Saturation, Impact Ionization, Hot Electron Effect.

UNIT 2: LOW-POWER DESIGN APPROACHES 9

Low-Power Design through Voltage Scaling: VTCMOS circuits, MTCMOS circuits, Architectural Level Approach –Pipelining and Parallel Processing Approaches. Switched Capacitance Minimization Approaches: System Level Measures, Circuit Level Measures, Mask level Measures.

UNIT 3: LOW VOLTAGE LOW-POWER MULTIPLIERS 9

Introduction, Standard Adder Cells, CMOS Adder's Architectures – Ripple Carry Adders, Carry Look-Ahead Adders, Carry Select Adders, Carry Save Adders, LowVoltage Low Power Design Techniques –Trends of Technology and Power Supply Voltage, LowVoltage Low-Power Logic Styles.

UNIT 4: LOW-VOLTAGE LOW-POWER MULTIPLIERS 9

Introduction, Overview of Multiplication, Types of Multiplier Architectures, Braun Multiplier, BaughWooley Multiplier, Booth Multiplier, Introduction to Wallace Tree Multiplier

UNIT 5: LOW-VOLTAGE LOW-POWER MEMORIES 9

Basics of ROM, Low-Power ROM Technology, Future Trend and Development of ROMs, Basics of SRAM, Memory Cell, Precharge and Equalization Circuit, LowPower SRAM Technologies, Basics of DRAM, Self-Refres Circuit, Future Trend and Development of DRAM

45 PERIODS

SUGGESTED READINGS

1. Sung-Mo Kang, Yusuf Leblebici, “CMOS Digital Integrated Circuits – Analysis and Design”, TMH, 2011.
2. Kiat-Seng Yeo, Kaushik Roy, “Low-Voltage, Low-Power VLSI Subsystems”, TMH Professional Engineering, 2004.
3. Ming-BO Lin, “Introduction to VLSI Systems: A Logic, Circuit and System Perspective”, CRC Press, 2012
4. Anantha Chandrakasan, “Low Power CMOS Design”, IEEE Press, /Wiley International, 1998
5. Kaushik Roy, Sharat C. Prasad, “Low Power CMOS VLSI Circuit Design”, John Wiley, & Sons, 2000

25ECU632A VLSI TESTING AND DESIGN FOR TESTABILITY 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**

End Semester Exam: 3 Hours

Course Objectives

- To introduce logic and fault simulation and testability measures.
- To impart knowledge on the design for testability
- To provide the fundamentals of interfacing and testing of memory
- To introduce power management techniques in testing
- To teach testability in analog circuits

Course Outcomes (COs)

At the completion of the course the student will be able to

CO	Course Outcomes	Blooms Level
CO1	Explain logic and fault simulation requirements and testability measures	Understand
CO2	Explain the Design for Testability.	Understand
CO3	Develop interfacing and memory testing.	Apply
CO4	Perform testing with power management techniques.	Analyze
CO5	Carry-out fault Detection in analog circuits.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: TEST REQUIREMENTS AND METRICS 9

Validation platforms- SOC design methodology, IP components, Integration, Clocking, I/Os and interfaces, Device modes, Logic, memories, analog, I/Os, power management; Test requirements Test handoffs, Testers Where DUT and DFT fit into design / framework; Test- ATPG, DFT, BIST, COF, TTR; Test cost metrics and test economics; Logic fault models- SAF, TDF, PDF, Iddq, StBDG, Dy-BDG, SDD; Basics of test generation and fault simulation- Combinational circuits, Sequential; Specific algorithmic approaches, CAD framework, Optimisations..

UNIT 2: SCAN DESIGN AND BIST 9

Scan Design- Scan design requirements, Types of scan and control mechanisms, Test pattern construction for scan, Managing scan in IPs and SOCs, Scan design optimisations, Partitioning, Clocking requirements for scan and delay fault testing, Speed of operation; BIST – Framework, Controller configurations, FSMs, LFSRs, STUMPS architecture, Scan compression and bounds, Test per cycle, Test per scan, Self-testing and self-checking circuits, Online test

UNIT 3: MEMORY TEST AND TEST INTERFACES 9

Memory Test -Memory fault models, Functional architecture as applicable to test, Test of memories, Test of logic around memories, BIST controller configuration, Test of logic around memories, DFT and architecture enhancements, Algorithmic optimisations; Test Interfaces-Test control requirements, Test interfaces - 1500, JTAG, Hierarchical, serial control, Module / IP test, SOC test, Board test,

System test, Boundary scan

UNIT 4: DESIGN CONSIDERATIONS AND POWER MANAGEMENT DURING TEST **9**

Design Considerations- Design considerations, Physical design congestion, Partitioning, Clocks, Test modes, Pins, Test scheduling, Embedded test, Architecture improvements, Test in presence of security; Power management during test- Methods for low power test, ATPG methods, DFT methods, Scan methods, Low power compression, Test of power management, Implications of power excursions, Optimisations

UNIT 5: ANALOG TEST **9**

Test requirements. DFT methods. BIST methods. Test versus measurement. Defect tests versus performance tests. Tests for specific modules - PLL, I/Os, ADC, DAC, SerDes, etc. RF test requirements.

45 PERIODS

SUGGESTED READINGS

1. Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits,Vishwani Agrawal and Michael Bushnell, Springer, 2002.

25ECU731A MIXED SIGNAL IC DESIGN TESTING 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To teach about mixed-signal devices and the need for testing these devices
- To provide overview of various techniques for testing.
- To give insight about ADC and DAC based testing.
- To teach about the Clock and Serial Data Communications Channels
- To impart knowledge on the general purpose measuring devices.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain mixed signal circuits and its testing.	Understand
CO2	Define the various measurement terminologies.	Understand
CO3	Acquire knowledge of Analog to Digital Converters.	Understand
CO4	Learn testing of Analog to Digital Converters	Apply
CO5	Comprehend the attributes of a clock signal	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: MIXED – SIGNAL TESTING 9

Common Types of Analog and Mixed- Signal Circuits – Applications of Mixed-Signal Circuits – Post Silicon Production Flow - Test and Packing – Characterization versus Production Testing - Test and Diagnostic Equipment - Automated Test Equipments – Wafer Probers – Handlers – E-Beam Probers – Focused Ion Beam Equipments – Forced –Temperature

UNIT 2: YIELD, MEASUREMENT ACCURACY, AND TEST TIME 9

Yield - Measurement Terminology - Repeatability, Bias, and Accuracy - Calibrations and Checkers - Tester Specifications - Reducing Measurement Error with Greater Measurement Time – Guardbands - Effects of Measurement Variability on Test Yield - Effects of Reproducibilty and Process Variation on Yield - Statistical Process Control

UNIT 3: DAC TESTING 9

Basics of Data Converters -Principles of DAC and ADC Conversion, Data Formats, Comparison of DACs and ADCs, DAC Failure Mechanisms - Basic DC Tests - Transfer Curve Tests - Dynamic DAC Tests - Tests for Common DAC Applications

UNIT 4: ADC TESTING 9

ADC Testing Versus DAC Testing - ADC Code Edge Measurements - Edge Code Testing Versus Center Code Testing, Step Search and Binary Search Methods, Servo Method, Linear Ramp Histogram Method, Histograms to Code Edge Transfer Curves, Rising Ramps Versus Falling Ramps, Sinusoidal Histogram Method - DC Tests and Transfer Curve Tests - Dynamic ADC Tests - Tests for

Common ADC Applications

UNIT 5: CLOCK AND SERIAL DATA COMMUNICATIONS CHANNEL MEASUREME **9**

Synchronous and Asynchronous Communications - Time-Domain Attributes of a Clock Signal - Frequency-Domain Attributes of a Clock Signal - Communicating Serially Over a Channel - Bit Error Rate Measurement - Methods to Speed Up BER Tests in Production - Deterministic Jitter Decomposition - Jitter Transmission Tests.

45 PERIODS

SUGGESTED READINGS

1. Gordon W.Roberts, Friedrich Taenzler, Mark Burns, “An Introduction to Mixed-signal IC Test and Measurement” Oxford University Press, Inc.2012 (Unit I - V)
2. M.L.Bushnell and V.D.Agrawal, “Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits”, Kluwer Academic Publishers, 2002. (Unit - III)
3. Bapiraju Vinnakota, “Analog and mixed-signal test”, Prentice Hall, 1998.(Unit - II)
4. Digital and Analogue Instrumentation: Testing and Measurement by NihalKularatna

25ECU732A ANALOG IC DESIGN 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To provide fundamental knowledge on the basics of MOS Circuits.
- To analyse the noise characteristics of amplifiers
- To analyse the performance parameters of amplifiers
- To comprehend the compensation techniques
- To teach the detection and testing of faults.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Design amplifiers to meet user specifications	Analyze
CO2	Analyse the frequency and noise performance of amplifiers	Analyze
CO3	Design and analyse feedback amplifiers and one stage op amps .	Create / Analyze
CO4	Analyze the stability of operational amplifiers.	Analyze
CO5	Testing experience of logic circuits.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: SINGLE STAGE AMPLIFIERS 9

Basic MOS physics and equivalent circuits and models, CS, CG and Source Follower, differential amplifier with active load, Cascode and Folded Cascode configurations with active load, design of Differential and Cascode Amplifiers – to meet specified SR, noise, gain, BW, ICMR and power dissipation, voltage swing, high gain amplifier structures

UNIT 2: HIGH FREQUENCY AND NOISE CHARACTERISTICS OF AMPLIFIERS 9

Miller effect, association of poles with nodes, frequency response of CS, CG and Source Follower, Cascode and Differential Amplifier stages, statistical characteristics of noise, noise in Single Stage amplifiers, noise in Differential Amplifiers

UNIT 3: FEEDBACK AND SINGLE STAGE OPERATIONAL AMPLIFIERS 9

Properties and types of negative feedback circuits, effect of loading in feedback networks, operational amplifier performance parameters, single stage Op Amps, two-stage Op Amps, input range limitations, gain boosting, slew rate, power supply rejection, noise in Op Amps.

UNIT 4: STABILITY , FREQUENCY COMPENSATION 9

Multipole Systems, Phase Margin, Frequency Compensation, Compensation Of Two Stage Op Amps, Slewing In Two Stage Op Amps, Other Compensation Techniques.

UNIT 5: LOGIC CIRCUIT TESTING 9

Faults in Logic Circuits- Basic Concepts of Fault Detection- Design for Testability- Ad Hoc Techniques, Level-Sensitive Scan Design, Partial Scan, Built-in Self-Test

45 PERIODS

SUGGESTED READINGS

1. Behzad Razavi, “Design Of Analog Cmos Integrated Circuits”, Tata Mcgraw Hill, 2001.(Unit – I,II,III,IV)
2. Parag K.Lala, “An Introduction to Logic Circuit Testing”,Morgan & Claypool Publishers,2009.(Unit V)
3. Grebene, “Bipolar And Mos Analog Integrated Circuit Design”, John Wiley & Sons,Inc.,2003. Phillip E.Allen, Douglas R .Holberg, “Cmos Analog Circuit Design”, Oxford University Press, 2nd Edition, 2002
4. Recorded Lecture Available at http://www.ee.iitm.ac.in/vlsi/courses/ee5320_2021/start

Verticals -2
Signal Processing

25ECU531B ADVANCED DIGITAL SIGNAL PROCESSING 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To impart knowledge about multirate signal processing and its applications
- To teach the concepts of discrete time random signal processing
- To provide understanding on the concepts of prediction theory and filtering.
- To teach the concepts of adaptive filtering
- To introduce the spectrum estimation techniques

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain Multirate signal processing and discuss its applications	Understand
CO2	Derive of the power spectral density and apply to discrete random signals and systems	Apply
CO3	Apply linear prediction and filtering techniques to discrete random signals for signal detection and estimation.	Apply
CO4	Analyze adaptive filtering problems and demonstrate its application	Apply
CO5	Apply power spectrum estimation techniques to random signals	Analyse

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: MULTIRATE SIGNAL PROCESSING 9

Review of Convolution, DFT and ZT, Multirate Signal Processing - Decimation, Interpolation, Sampling Rate Conversion by a rational factor – digital filter banks, sub band coding, Quadrature Mirror Filter.

UNIT 2: DISCRETE TIME RANDOM PROCESSES 9

Stationary random processes, Autocorrelation, Rational Power Spectra, Filters for generating random Processes from white noise and inverse filter – AR, MA and ARMA processes – relationship between autocorrelation and the filter parameters.

UNIT 3: LINEAR PREDICTION AND FILTERING 9

Linear Prediction – Forward and Backward - Wiener filters for filtering and prediction – FIR Wiener Filter – IIR Wiener Filter – Kalman Filter.

UNIT 4: ADAPTIVE FILTERING 9

FIR adaptive filters – adaptive filters based on steepest descent method – LMS algorithm – Variants of LMS algorithm – adaptive echo cancellation – adaptive channel equalization – RLS Algorithm.

UNIT 5: SPECTRUM ESTIMATION 9

Estimation of power spectra from finite duration observations of signals – Non parametric methods of spectrum estimation – the Bartlett and the Welch method – Parametric spectrum estimation – AR, MA and ARMA

45 PERIODS

SUGGESTED READINGS

1. John G. Proakis & Dimitris G.Manolakis, —Digital Signal Processing – Principles, Algorithms & Applications, Fourth Edition, Pearson Education / Prentice Hall, 2007.
2. P. Vaidyanathan, "Multirate systems and filter banks", Prentice Hall Inc. 1993.
3. Monson H. Hayes, "Statistical digital signal processing and modeling", John Wiley and Sons Inc. New York, Indian reprint 2008.
4. Haykin, Adaptive Filter Theory, 4th Edition, Pearson Education, New Delhi, 2006.
5. Sophoncles J. Orfanidis, “Optimum Signal Processing “, McGraw Hill, 2000.

25ECU532B **IMAGE PROCESSING** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40**External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To familiarize with digital image fundamentals
- To provide exposure to simple image enhancement techniques in Spatial and Frequency domain.
- To teach concepts of degradation function and restoration techniques.
- To introduce the image segmentation and representation techniques
- To familiarize image compression and recognition methods.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain digitization, sampling, quantization, and 2D-transforms	Analyse
CO2	Operate on images using the techniques of smoothing, sharpening and enhancement.	Apply
CO3	Apply the restoration concepts and filtering techniques	Remember
CO4	Use segmentation, features extraction, compression and recognition methods for color models.	Understand
CO5	Explain image compression concepts.	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: DIGITAL IMAGE FUNDAMENTALS **9**

Steps in Digital Image Processing – Components – Elements of Visual Perception – Image Sensing and Acquisition – Image Sampling and Quantization – Relationships between pixels - Color image fundamentals - RGB, HSI models, Two-dimensional mathematical preliminaries, 2D transforms - DFT, DCT.

UNIT 2: IMAGE ENHANCEMENT **9**

Spatial Domain: Gray level transformations – Histogram processing – Basics of Spatial Filtering– Smoothing and Sharpening Spatial Filtering, Frequency Domain: Introduction to Fourier Transform– Smoothing and Sharpening frequency domain filters – Ideal, Butterworth and Gaussian filters, Homomorphic filtering, Color image enhancement.

UNIT 3: IMAGE RESTORATION **9**

Image Restoration - degradation model, Properties, Noise models – Mean Filters – Order Statistics – Adaptive filters – Band reject Filters – Band pass Filters – Notch Filters – Optimum Notch Filtering – Inverse Filtering – Wiener filtering

UNIT 4: IMAGE SEGMENTATION 9

Edge detection, Edge linking via Hough transform – Thresholding - Region based segmentation – Region growing – Region splitting and merging – Morphological processing- erosion and dilation, Segmentation by morphological watersheds – basic concepts – Dam construction – Watershed segmentation algorithm.

UNIT 5: IMAGE COMPRESSION AND RECOGNITION 9

Need for data compression, Huffman, Run Length Encoding, Shift codes, Arithmetic coding, JPEG standard, MPEG. Boundary representation, Boundary description, Fourier Descriptor, Regional Descriptors – Topological feature, Texture - Patterns and Pattern classes - Recognition based on matching.

45 PERIODS

SUGGESTED READINGS

1. Rafael C. Gonzalez, Richard E. Woods, 'Digital Image Processing', Pearson, Third Edition,2010.
2. Anil K. Jain, 'Fundamentals of Digital Image Processing', Pearson, 2002.
3. Kenneth R. Castleman, 'Digital Image Processing', Pearson, 2006.
4. Rafael C. Gonzalez, Richard E. Woods, Steven Eddins, 'Digital Image Processing using MATLAB', Pearson Education, Inc., 2011.
5. D,E. Dudgeon and RM. Mersereau, 'Multidimensional Digital Signal Processing', Prentice Hall Professional Technical Reference, 1990.
6. William K. Pratt, 'Digital Image Processing', John Wiley, New York, 2002
7. Milan Sonka et al 'Image processing, analysis and machine vision', Brookes/Cole, Vikas Publishing House, 2nd edition, 1999...

25ECU631B **SPEECH PROCESSING** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Teach the fundamentals of speech signal and extract various speech features
- To provide basic understanding on different speech coding techniques for speech compression applications
- Introduce speech enhancement techniques and text-to-speech synthesis system.

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the fundamentals of speech and features of speech	Understand
CO2	Extract various speech features for speech related applications	Apply
CO3	Describe an appropriate speech coder for a given application.	Apply
CO4	Explain a speech enhancement techniques.	Understand
CO5	Discuss a text-to-speech synthesis system for various applications	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: FUNDAMENTALS OF SPEECH **9**

The Human speech production mechanism, Discrete-Time model of speech production, Speech perception - human auditory system, Phonetics - articulatory phonetics, acoustic phonetics, and auditory phonetics, Categorization of speech sounds, Spectrographic analysis of speech sounds, Pitch frequency, Pitch period measurement using spectral and cepstral domain, Formants, Evaluation of Formants for voiced and unvoiced speech.

UNIT 2: SPEECH FEATURES AND DISTORTION MEASURES **9**

Significance of speech features in speech-based applications, Speech Features – Cepstral Coefficients, Mel Frequency Cepstral Coefficients (MFCCs), Perceptual Linear Prediction (PLP), Log Frequency Power Coefficients (LFPCs), Speech distortion measures–Simplified distance measure, LPC-based distance measure, Spectral distortion measure, Perceptual distortion measure

UNIT 3: SPEECH CODING 9

Need for speech coding, Waveform coding of speech – PCM, Adaptive PCM, DPCM, ADPCM, Delta Modulation, Adaptive Delta Modulation, G.726 Standard for ADPCM, Parametric Speech Coding – Channel Vocoders, Linear Prediction Based Vocoders, Code Excited Linear Prediction (CELP) based Vocoders, Sinusoidal speech coding techniques, Hybrid coder, Transform domain coding of speech

UNIT 4: SPEECH ENHANCEMENT 9

Classes of Speech Enhancement Algorithms, Spectral-Subtractive Algorithms - Multiband Spectral Subtraction, MMSE Spectral Subtraction Algorithm, Spectral Subtraction Based on Perceptual Properties, Wiener Filtering - Wiener Filters in the Time Domain, Wiener Filters in the Frequency Domain, Wiener Filters for Noise Reduction, Maximum-Likelihood Estimators, Bayesian Estimators, MMSE and Log-MMSE Estimator, Subspace Algorithms.

UNIT 5: SPEECH SYNTHESIS AND APPLICATION 9

A Text-to-Speech systems (TTS), Synthesizers technologies – Concatenative synthesis, Use of Formants for concatenative synthesis, Use of LPC for concatenative synthesis, HMM-based synthesis, Sinewave synthesis, Speech transformations, Watermarking for authentication of a speech, Emotion recognition from speech.

45 PERIODS

SUGGESTED READINGS

1. Shaila D. Apte, Speech and Audio Processing, Wiley India (P) Ltd, New Delhi, 2012.
2. Philipos C. Loizou, Speech Enhancement Theory and Practice, Second Edition, CRC Press, Inc., United States, 2013.
3. Rabiner L. R. and Juang B. H, Fundamentals of speech recognition, Pearson Education, 2003
4. Thomas F. Quatieri, Discrete-time speech signal processing - Principles and practice, Pearson, 2012.

25ECU632B **SOFTWARE DEFINED RADIO** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40**External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To introduce the concepts of software radios
- To teach about RF implementation challenges for software defined radios
- To provide insights on the digital generation of signals
- To familiarise the software and hardware requirements for software defined radios

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain Software defined radio technology and its implementation	Understand
CO2	Analyse Radio frequency implementation issues	Analyse
CO3	Implement Smart antenna techniques for software defined radio	Apply
CO4	Compare various digital synthesis procedures	Understand
CO5	Comprehend various hardware and software requirements for software defined radios	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	3

UNIT 1: INTRODUCTION TO SOFTWARE RADIO **9**

The Need for Software Radios. Characteristics and Benefits of a Software Radio. Design Principles of a Software Radio

UNIT 2: RF IMPLEMENTATION **9**

Purpose of RF front – end, Dynamic range, RF receiver front – end topologies, Enhanced flexibility of the RF chain with software radios, Importance of the components to overall performance, Transmitter architectures and their issues, Noise and distortion in the RF chain, Hybrid DDS – PLL systems, Applications of Direct Digital Synthesis

UNIT 3: DIGITAL GENERATION OF SIGNALS **9**

Comparison of direct digital synthesis with analog signal synthesis, Approaches to direct digital synthesis, Analysis of spurious signals, Performance of direct digital synthesis systems, Applications of

direct digital synthesis.

UNIT 4: SMART ANTENNAS 9

Benefits of smart antennas, Structures for beamforming systems, Smart antenna algorithms, Hardware implementation of smart antennas, Digital Hardware Choices-Key hardware elements.

UNIT 5: HARDWARE AND SOFTWARE FOR SDR & CASE STUDIES 9

DSP Processors, FPGA, ASICs. Trade-offs, Object oriented programming, Object Brokers, GNU Radio-USRP. Case Studies: SPEAK easy, JRTS, SDR-3000.

45 PERIODS

SUGGESTED READINGS

1. Jeffrey Hugh Reed, “Software Radio: A Modern Approach to Radio Engineering,” Prentice Hall Professional, 2002
2. Tony J Rouphael, “RF and DSP for SDR,” Elsevier Newnes Press, 2008
3. P. Kenington, “RF and Baseband Techniques for Software Defined Radio,” Artech House, 2005
4. Paul Burns, “Software Defined Radio for 3G,” Artech House, 2002.
5. Behrouz. F. Bourjney“ Signal Processing for Software defined Radios”, Lulu 2008.

25ECU731B DSP ARCHITECTURE AND PROGRAMMING 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To teach the architecture of programmable DSP processors
- To implement various standard DSP algorithms in DSP Processors
- Use the Programmable DSP Processors to build real-time DSP systems

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Describe the architectural features of DSP Processors.	Understand
CO2	Explain the organization of TMS320C54xx DSP processors	Apply
CO3	Build solutions using TMS320C6x DSP Processor	Apply
CO4	Implement DSP Algorithms using DSP processors.	Apply
CO5	Explain the applications of DSP Processors	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: ARCHITECTURES FOR PROGRAMMABLE DSP PROCESSORS 9

Basic Architectural features, DSP Computational building blocks, Bus architecture and memory, Data addressing capabilities, Address generation Unit, Programmability and program execution, Speed issues, Features for external interfacing

UNIT 2: TMS320C5X PROGRAMMABLE DSP PROCESSOR 9

Architecture of TMS320C54xx DSP processors, Addressing modes – Assembly language Instructions - Memory space, interrupts, and pipeline operation of TMS320C54xx DSP Processor, On-Chip peripherals, Block Diagram of TMS320C54xx DSP starter kit

UNIT 3: TMS320C6X PROGRAMMABLE DSP PROCESSOR 9

Commercial TI DSP processors, Architecture of TMS320C6x DSP Processor, Linear and Circular addressing modes, TMS320C6x Instruction Set, Assembler directives, Linear Assembly, Interrupts, Multichannel buffered serial ports, Block diagram of TMS320C67xx DSP Starter Kit and Support Tools

UNIT 4: IMPLEMENTATION OF DSP ALGORITHMS 9

DSP Development system, On-chip, and On-board peripherals of C54xx and C67xx DSP development boards, Code Composer Studio (CCS) and support files, Implementation of Conventional FIR, IIR, and Adaptive filters in TMS320C54xx/TMS320C67xx DSP processors for real-time DSP applications, Implementation of FFT algorithm for frequency analysis in real-time

UNIT 5: APPLICATIONS OF DSP PROCESSORS 9

Voice scrambling using filtering and modulation, Voice detection and reverse playback, Audio effects, Graphic Equalizer, Adaptive noise cancellation, DTMF signal detection, Speech thesis using LPC, Automatic speaker recognition

45 PERIODS

SUGGESTED READINGS

1. Avtar Singh and S. Srinivasan, Digital Signal Processing – Implementations using DSP Microprocessors with Examples from TMS320C54xx, Cengage Learning India Private Limited, Delhi 2012
2. RulphChassaing and Donald Reay, Digital Signal Processing and Applications with the TMS320C6713 and TMS320C6416 DSK, Second Edition, Wiley India (P) Ltd, New Delhi, 2008
3. B.Venkataramani and M.Bhaskar, “Digital Signal Processors – Architecture, Programming and Applications”, Tata McGraw – Hill Publishing Company Limited. New Delhi, 2003.
4. TMS320C5416/6713 DSK user manual at https://www.ti.com.

25ECU732B **COMPUTER VISION** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Teach the fundamental concepts related to Image formation and processing.
- Introduce the feature detection, matching and detection teachniques
- Familiarize with feature based alignment and motion estimation
- Develop skills on 3D reconstruction
- Teach image based rendering and recognition techniques

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the basic knowledge, theories and methods in image processing and computer vision	Understand
CO2	Implement basic and some advanced image processing techniques in OpenCV.	Apply
CO3	Apply 2D feature-based based image alignment, segmentation and motion estimations.	Apply
CO4	Apply 3D image reconstruction techniques	Apply
CO5	Explain image rendering and rendering for computer vision applications.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	3

UNIT 1: INTRODUCTION TO IMAGE FORMATION AND PROCESSING 9

Computer Vision - Geometric primitives and transformations - Photometric image formation - The digital camera - Point operators - Linear filtering - More neighborhood operators - Fourier transforms - Pyramids and wavelets - Geometric transformations - Global optimization.

UNIT 2: FEATURE DETECTION, MATCHING AND SEGMENTATION 9

Points and patches - Edges - Lines - Segmentation - Active contours - Split and merge - Mean shift and mode finding - Normalized cuts - Graph cuts and energy-based methods

UNIT 3: FEATURE-BASED ALIGNMENT & MOTION ESTIMATION 9

2D and 3D feature-based alignment - Pose estimation - Geometric intrinsic calibration - Triangulation - Two-frame structure from motion - Factorization - Bundle adjustment - Constrained structure and motion - Translational alignment - Parametric motion - Spline-based motion - Optical flow - Layered motion.

UNIT 4: 3D RECONSTRUCTION 9

Shape from X - Active range finding - Surface representations - Point-based representations Volumetric representations - Model-based reconstruction - Recovering texture maps and albedo sos.

UNIT 5: IMAGE-BASED RENDERING AND RECOGNITION 9

View interpolation Layered depth images - Light fields and Lumigraphs - Environment mattes - Video-based rendering-Object detection - Face recognition - Instance recognition - Category recognition - Context and scene understanding- Recognition databases and test sets

45 PERIODS

SUGGESTED READINGS

1. Richard Szeliski, “Computer Vision: Algorithms and Applications”, Springer- Texts in Computer Science, Second Edition, 2022.
2. Computer Vision: A Modern Approach, D. A. Forsyth, J. Ponce, Pearson Education, Second Edition, 2015
3. Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, March 2004.
4. Christopher M. Bishop; Pattern Recognition and Machine Learning, Springer, 2006
5. E. R. Davies, Computer and Machine Vision, Fourth Edition, Academic Press, 2012.

Vertical 3

High Speed Communications

25ECU531C **Wireless Broadband Networks** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To provide insight on the evolution of wireless networks
- To impart knowledge on the fundamentals of 5G networks.
- To introduce the networ architecture.
- To teach the concepts of spectrum sharing and spectrum trading.
- To give overview of the security features in 5G networks.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the various protocols in wireless networks.	Understand
CO2	Analyze the architecture of 3G network standards.	Analyze
CO3	Analyze the difference of LTE-A network design from 4G standard.	Analyze
CO4	Design the interconnecting network functionalities by layer level functions.	Apply
CO5	Explore the current generation (5G) network architecture.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	3

UNIT 1: WIRELESS PROTOCOLS **9**

Mobile network layer - Fundamentals of Mobile IP, data forwarding procedures in mobile IP, IPv4, IPv6, IP mobility management, IP addressing - DHCP, Mobile transport layer - Traditional TCP, congestion control, slow start, fast recovery / fast retransmission, classical TCP improvements - Indirect TCP, snooping TCP, Mobile TCP.

UNIT 2: 3G EVOLUTION **9**

IMT - 2000 - W - CDMA, CDMA 2000 - radio & network components, network structure, packet -data transport process flow, Channel Allocation, core network, interference - mitigation techniques, UMTS - services, air interface, network architecture of 3GPP, UTRAN - architecture, High Speed Packet Data - HSDPA, HSUPA.

UNIT 3: NETWORK ARCHITECTURE AND THE PROCESSES **9**

Introduction to LTE - A - Requirements and Challenges, network architectures - EPC, E - UTRAN architecture - mobility management, resource management, services, channel - logical and transport channel mapping, downlink / uplink data transfer, MAC control element, PDU packet formats, scheduling services, random access procedure.

UNIT 4: LAYER-LEVEL FUNCTIONS 9

Characteristics of wireless channels - downlink physical layer, uplink physical layer, MAC scheme - frame structure, resource structure, mapping, synchronization, reference signals and channel estimation, SC-FDMA, interference cancellation - CoMP, Carrier aggregation, Services - multimedia broadcast / multicast, location-based services.

UNIT 5: 5G EVOLUTION 9

5G Roadmap - Pillars of 5G - 5G Architecture, The 5G internet - IoT and context awareness - Networking reconfiguration and virtualization support - Mobility QoS control - emerging approach for resource over provisioning, Small cells for 5G mobile networks - capacity limits and achievable gains with densification - Mobile data demand, Demand Vs Capacity, Small cell challenges, conclusion and future directions.

SUGGESTED READINGS

1. Vijay K.Garg, “Wireless Network Evolution – 2G & 3G”. Prentice Hall, 2008.
2. Clint Smith,P.E, Dannel Collins, “3G Wireless Networks” Tata McGraw- Hill, 2nd Edition, 2011.
3. Sassan Ahmadi, “LTE-Advanced – A practical systems approach to understanding the 3GPP LTE Releases 10 and 11 radio access technologies”, Elsevier, 2014.
4. Jonathan Rodriguez, “Fundamentals of 5G Mobile networks”, John Wiley, 2015.

25ECU532C 4G / 5G Communication Networks **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To teach the evolution of wireless networks
- To provide the fundamentals of 5G networks.
- To impart knowledge on the processes associated with 5G architecture.
- To teach spectrum sharing and spectrum trading.
- To teach the security features in 5G networks.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the evolution of mobile communication systems from 1G to 5G, identifying the key enabling technologies.	Understand
CO2	Analyze the architecture, protocol stack, and operation of LTE (4G) networks including the Evolved Packet Core (EPC).	Analyse
CO3	Evaluate the key features and performance metrics of 4G LTE, such as OFDMA, MIMO, and QoS support.	Analyse
CO4	Describe the design principles of spectrum management mechanisms in 5G radios.	Understand
CO5	Explain the security features in 5G networks mitigating the threats in 5G.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	3

UNIT 1: EVOLUTION OF WIRELESS NETWORKS **9**

Networks evolution: 2G,3G,4G, evolution of radio access networks, need for 5G. 4G versus 5G,Next Generation core (NG-core), visualized Evolved Packet core(vEPC).

UNIT 2: 5G CONCEPTS AND CHALLENGES **9**

Fundamentals of 5G technologies, overview of 5G core network architecture,5G new radio and cloud technologies, Radio Access Technologies (RATs), EPC for 5G

UNIT 3: NETWORK ARCHITECTURE AND THE PROCESSES **9**

5G architecture and core, network slicing, multi access edge computing (MEC)visualization of 5G components, end-to-end system architecture, service continuity, relation to EPC, and edge computing. 5G protocols: 5G NAS, NGAP, GTP-U, IPsec and GRE

UNIT 4: DYNAMIC SPECTRUM MANAGEMENT AND MM-WAVES 9

Mobility management, Command and control, spectrum sharing and spectrum trading, cognitive radio based on 5G, millimetre waves.

UNIT 5: SECURITY IN 5G NETWORKS 9

Security features in 5G networks, network domain security, user domain security, flow based QoS framework, mitigating the threats in 5G

45 PERIODS

SUGGESTED READINGS

1. 5G Core networks: Powering Digitalization, Stephen Rommer, Academic Press,2019
2. An Introduction to 5G Wireless Networks : Technology, Concepts and Use cases, Saro Velrajan,First Edition, 2020.
3. 5G Simplified: ABCs of Advanced Mobile Communications Jyrki. T. J. Penttinen, Copyrighted Material.
4. 5G system Design: An end to end Perspective , Wan Lee Anthony, Springer Publications,2019

25ECU631C Software Defined Networks 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To develop knowledge in networking fundamentals
- To gain conceptual understanding of Software Defined Networks (SDN)
- To study industrial deployment use-cases of SDN

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the challenges and opportunities associated with adopting SDN compared to traditional approaches to networking	Understand
CO2	Analyse the functions and components of the SDN architecture	Analyse
CO3	Discuss the major requirements of the design of an SDN protocol.	Understand
CO4	Design and create an SDN network consisting of SDN switches and a centralized controller.	Apply
CO5	Analyze the performance of the SDN network by using verification and troubleshooting techniques.	Analyse

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	3

UNIT 1: INTRODUCTION TO SDN 9

Overview; History and evolution of SDN; Architecture of SDN; SDN Flavours; Scalability (Data Centres, Service provider networks, ISP Automation); Reliability (QoS, and Service Availability); Consistency (Configuration management, and Access Control Violations); Opportunities and Challenges

UNIT 2: ARCHITECTURE 9

Network Operating System (NOS). SDN Architecture. Planes - data, management and control. Interfaces - northbound and southbound.

UNIT 3: PROTOCOLS 9

Languages and functions available for programming SDNs, northbound API. Mininet. Software vs. Hardware SDN switch implementations - Open vSwitch, WhiteBox, ONL. Controller implementations - POX, NOX, Beacon, Floodlight. Special Purpose controllers - Flowvisor, RouteFlow.

UNIT 4: DESIGN AND DEVELOPMENT 9

Network Programmability - Network Function Virtualization - NetApp Development, Network Slicing, SDX; Northbound Application Programming Interface, Current Languages and Tools, Composition of

SDNs.

UNIT 5: PROGRAMMING **9**

Network Virtualization, Network Topology and Topological Information Abstraction, Data Centric Traffic Management, Wide Area Traffic Management, Wireless networks

45 PERIODS

SUGGESTED READINGS

1. Goransson, Paul, Chuck Black, and Timothy Culver. Software defined networks: a comprehensive approach, 1st edition, Morgan Kaufmann, 2016.
2. Oswald Coker, Siamak Azodolmolky. Software-Defined Networking with OpenFlow - Second Edition, Packt Publishing, 2017
3. Stallings, William. Foundations of modern networking: SDN, NFV, QoE, IoT, and Cloud, 1st edition, Addison-Wesley Professional, 2015.

25ECU632C Green Radio Communication Techniques 3H – 3C

Instruction Hours / week: L: 3 T: 1 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To introduce the fundamentals of energy consumption in wireless communication systems, including power usage in devices, base stations, and network infrastructure.
- To explore the principles and challenges of designing energy-efficient wireless networks, considering trade-offs between energy, spectral efficiency, and quality of service (QoS)
- To examine the base station power management techniques
- To provide a foundational understanding of wireless access methods used in modern communication systems, including time, frequency, code, and spatial domain techniques.

Course Outcomes (COs)

At the completion of the course the student will be able to

CO	Course Outcomes	Blooms Level
CO1	Design green radio communication networks with energy efficient techniques.	Apply
CO2	Analyze the energy efficiency metrics for wireless networks	Analyze
CO3	Explain the base station power management techniques	Understand
CO4	Identify the different types of wireless access techniques	Analyze
CO5	Simulate green communication networks	Create

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	3

UNIT 1: INTRODUCTION 9

Fundamental tradeoffs on the design of green radio networks: Insight from Shannon's capacity formula - impact of practical constraints - algorithms for energy harvesting wireless networks: Energy harvesting technologies - PHY and MAC layer optimization for energy harvesting wireless networks – Vertical Handoff and its types.

UNIT 2: GREEN MODULATION AND CO-OPERATIVE TECHNIQUES 9

Modulation and coding schemes with energy optimized techniques for wireless networks - cooperative techniques for energy efficient wireless communications: Energy efficiency metrics for wireless networks - co-operative networks - optimizing the energy efficiency performance of cooperative networks - energy efficiency in co-operative base stations.

UNIT 3: BASE STATION POWER MANAGEMENT TECHNIQUES 9

Base station power management techniques: Opportunistic spectrum and load management - energy saving techniques in cellular wireless base stations - power management for base stations in a smart grid environment.

UNIT 4: WIRELESS ACCESS TECHNIQUES 9

Cross layer design: Adaptive packet scheduling for green radio networks - energy efficient relaying for cooperative cellular wireless networks - energy performance in TDD CDMA multihop cellular networks - resource allocation for green communication in relay based cellular networks.

UNIT 5: INSTRUCTIONAL ACTIVITIES 9

Survey about minimum of four green communication networks and carry out simulation of those networks.

45 PERIODS

SUGGESTED READINGS

1. EkramHossain, Vijay Bhargava K and Gerhard Fettweis P, “Green Radio Communication Networks”, Cambridge University Press, New York, 2012.
2. Richard Yu F, Zhang Xi and Victor Leung C M, “Green Communications and Networking”, 1 st Edition, CRC press, 2012.
3. Mazin Al Noor, “Green Radio Communication Networks Applying Radio-Over-Fibre Technology for Wireless Access”, GRINVerlag, 2012.
4. Mohammad Obaidat S, AlaganAnpalagan and Isaac Woungang, “Handbook of Green Information and Communication Systems”, 1st Edition, Academic Press, 2012.

25ECU731C **Massive MIMO Networks** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To explain the architecture and operational principles of massive MIMO networks, including base station array configurations and user multiplexing.
- To explore the channel modeling, estimation, and state acquisition techniques specific to large-scale antenna systems.
- To explain resource allocation techniques within a single-cell, including power control, channel assignment, and scheduling.
- To introduce the architecture and fundamentals of multicell wireless communication systems, including the concepts of frequency reuse, cell planning, and network topology.

Course Outcomes (COs)

At the completion of the course the student will be able to

COs	Course Outcomes	Blooms Level
CO1	Analyze and explain massive MIMO networks.	Understand
CO2	Analyze massive MIMO propagation channels and their capacity bounds	Analyze
CO3	Examine channel estimation techniques for single cell system.	Understand
CO4	Analyze channel estimation techniques for multi cell system.	Analyse
CO5	Explain the concepts underlining the deployment of single and multicell massive MIMO systems.	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	3

UNIT 1: MASSIVE MIMO NETWORKS **9**

Definition of Massive MIMO, Correlated Rayleigh Fading, System Model for Uplink and Downlink, Basic Impact of Spatial Channel Correlation, Channel Hardening and Favourable Propagation, Local Scattering Spatial Correlation Model

UNIT 2: THE MASSIVE MIMO PROPAGATION CHANNEL **9**

Favorable Propagation and Deterministic Channels-Capacity Upper Bound-Distance from Favorable Propagation-Favorable Propagation and Linear Processing-Singular Values and Favorable Propagation, Favorable Propagation and Random Channels-Independent Rayleigh Fading-Uniformly Random Line-of-Sight (UR-LoS)-Independent Rayleigh Fading versus UR-LoS – FiniteDimensional Channels

UNIT 3: SINGLE-CELL SYSTEMS **9**

Uplink Pilots and Channel Estimation – Orthogonal Pilots- De-Spreading of the Received Pilot Signal-MMSE Channel Estimation, Uplink Data Transmission – Zero-Forcing -Maximum-Ratio, Downlink Data Transmission-Linear Precoding-Zero-Forcing-Maximum-Ratio, Discussion Interpretation of the

Effective SINR Expressions-Implications for Power Control-Scaling Laws and Upper Bounds on the SINR – Near-Optimality of Linear Processing when M >> K – Net Spectral Efficiency – Limiting Factors: Number of Antennas and Mobility

UNIT 4: MULTI-CELL SYSTEMS 9

Uplink Pilots and Channel Estimation, Uplink Data Transmission – Zero-Forcing -Maximum-Ratio, Downlink Data Transmission -Zero-Forcing – Maximum-Ratio, Discussion -Asymptotic Limits with Infinite Numbers of Base Station Antennas – The Effects of Pilot Contamination – Non-Synchronous Pilot Interference

UNIT 5: CASE STUDIES 9

Single-Cell Deployment Example: Fixed Broadband Access in Rural Area, Multi-Cell Deployment: Preliminaries and Algorithms, Multi-Cell Deployment Examples: Mobile Access – Dense Urban 171 Scenario – Suburban Scenario – Minimum Per-Terminal Throughput Performance -Additional Observations – Comparison of Power Control Policies

45 PERIODS

SUGGESTED READINGS

1. Thomas L. Marzetta, Erik G. Larsson, Hong Yang, Hien Quoc Ngo, “Fundamentals of Massive MIMO”, Cambridge University Press 2016
2. Emil Bjornson, Jakob Hoydis and Luca Sanguinetti (2017), “Massive MIMO Networks: Spectral, Energy, and Hardware Efficiency”, Foundations and Trends, Now, 2017.

25ECU732C Advanced Wireless Communication Techniques 3H –3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To provide understanding the evolving paradigm of cooperative communication
- To provide understanding concepts related to green wireless communication
- To enable the student to understand the different power saving strategies and energy efficient signal, system and network design.
- To expose the student to the energy saving techniques adopted in existing wireless components
- To provide understanding on protocols and networks related to green future wireless communication technologies.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the necessity and the design aspects of cooperative communication	Analyze
CO2	Discuss the necessity and the design aspects of green wireless communication	Analyze
CO3	Explain Relay-Based Cooperative Cellular Networks	Evaluate
CO4	Demonstrate the feasibility of using mathematical models using simulation tools.	Analyze
CO5	Demonstrate the impact of the green engineering solutions in a global, economic, environmental and societal context.	Understand & Analyze

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	3

UNIT 1: COOPERATIVE COMMUNICATIONS AND GREEN CONCEPTS 9

Network architectures and research issues in cooperative cellular wireless networks ; Cooperative communications in OFDM and MIMO cellular relay networks: issues and approaches; Fundamental trade-offs on the design of green radio networks, Green modulation and coding schemes.

UNIT 2: COOPERATIVE TECHNIQUES 9

Cooperative techniques for energy efficiency, Cooperative base station techniques for cellular wireless networks; Turbo base stations; Antenna architectures for cooperation; Cooperative communications in 3GPP LTE-Advanced, Partial information relaying and Coordinated multi-point transmission in LTE-Advanced.

UNIT 3: RELAY-BASED COOPERATIVE CELLULAR NETWORKS 9

Distributed space-time block codes, Collaborative relaying in downlink cellular systems; Radio resource optimization; Adaptive resource allocation; Cross-layer scheduling design for cooperative wireless two-way relay networks; Network coding in relay-based networks

UNIT 4: GREEN RADIO NETWORKS 9

Base Station Power-Management Techniques- Opportunistic spectrum and load management, Energy-saving techniques in cellular wireless base stations , Power-management for base stations in smart grid environment, Cooperative multi cell processing techniques for energy-efficient cellular wireless communications.

UNIT 5: ASIC DESIGN AND TESTING 9

Cross-layer design of adaptive packet scheduling for green radio networks; Energy-efficient relaying for cooperative cellular wireless networks ; Energy performance in TDD-CDMA multihop cellular networks ; Resource allocation for green communication in relay-based cellular networks ; Green Radio Test-Beds and Standardization Activities.

45 PERIODS

SUGGESTED READINGS

1. Ekram Hossain, Dong In Kim, Vijay K. Bhargava , “Cooperative Cellular Wireless Networks”,Cambridge University Press, 2011.
2. Ekram Hossain, Vijay K. Bhargava (Editor), Gerhard P. Fettweis (Editor), “Green Radio Communication Networks”, Cambridge University Press, 2012.
3. F. Richard Yu, Yu, Zhang and Victor C. M. Leung “Green Communications and Networking”, CRC press, 2012.
4. Ramjee Prasad and Shingo Ohmori, Dina Simunic, “Towards Green ICT”, River Publishers,2010.

Vertical 4
PE-Sensor Technologies and IoT

25ECU531D **IoT Processors** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To teach the architecture and features of ARM.
- To introduce the concepts of exception handling and interrupts in CORTEX M3.
- To teach programming of CORTEX M3.
- To provide an overview of the architecture of STM 32L15XXX ARM CORTEX M3/M4 microcontroller.
- To introduce the concepts of System – On – Chip (SoC).

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the architecture and features of ARM.	Understanding
CO2	List the concepts of exception handling.	Understanding
CO3	Write a program using ARM CORTEX M3/M4.	Apply
CO4	Explain the architecture of STM32L15XXX ARM CORTEX M3/M4.	Apply
CO5	Discuss the design steps an SoC for various application.	Analyze

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO2	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO3	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO4	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO5	3	2	2	1	1	1	1	1	1	1	1	2	3	3

UNIT 1: OVERVIEW OF ARM AND CORTEX-M3 **9**

ARM Architecture – Versions, Instruction Set Development, Thumb 2 and Instruction Set Architecture, Cortex M3 Basics: Registers, Stack Pointer, Link Register, Program Counter, Special Registers, Operation Mode, Exceptions and Interrupts, Vector Tables, Stack Memory Operations, Reset Sequence, CORTEX M3 Instruction Sets: Assembly Basics, Instruction List, Instruction Descriptions, CORTEX M3 – Implementation Overview: Pipeline, Block Diagram. Bus Interfaces, I – Code Bus, D – Code Bus, System Bus- External PPB and DAP Bus.

UNIT 2: CORTEX EXCEPTION HANDLING AND INTERRUPTS **9**

Exception Types, Priority, Vector Tables, Interrupt Inputs and Pending behaviour, Fault Exceptions, Supervisor Call and Pendable Service Call, NVIC: Nested Vector Interrupt Controller, Overview, Basic Interrupts, SYSTICK Time, Interrupt Behaviour Interrupt/Exception Sequences, Exception Exits, Nested Interrupts, Tail – Chaining Interrupts, Late Arrivals and Interrupt Latency.

UNIT 3: CORTEX M3/M4 PROGRAMMING 9

Cortex M3/M4 Programming: Overview, Typical Development Flow, Using C, CMSIS Using Assembly, Exception Programming Using Interrupts, Exception/Interrupt Handlers, Software Interrupts, Vector Table Relocation, Memory Protection Unit and other CORTEX M3 Features, MPU Registers, Setting up the MPU, Power Management, Multiprocessor Configuration.

UNIT 4: STM32L15XXX ARMCORTEX M3/M4 MICROCONTROLLER AND DEBUGGING TOOLS 9

STM32L15XXX ARM CORTEX M3/M4 Microcontroller: Memory and Bus Architecture, Power Control, Reset and Clock Control, STM32L15XXX Peripherals: GPIOs, System Configuration Controller, NVIC, ADC, Comparators, GP Timers, USART Development and Debugging Tools: Software and Hardware tools like Cross Assembler Compiler, Debugger, Simulator, In – Circuit Emulator(ICE), Logic Analyser.

UNIT 5: INTRODUCTION TO SYSTEM – ON – CHIP 9

System Architecture: An Overview, Components of the System Processors, Memories and Interconnects, Processor Architectures, Memory and Addressing, System Level Interconnection – An Approach for SOC Design – Chip basics – Cycle Time – Die Area – Power and Cost – Area, Power and Time Trade – Offs in Processor Design – Reliability and Configurability – SOC Design Approach – Application Studies – AES, 3D Graphics Processor. Image Compression and Video Compression.

SUGGESTED READINGS

1. Joseph Yiu, The Definitive Guide to the ARM CORTEX M3/M4, Second Edition, Elsevier, 2010. (Unit – I, II).
2. Andrew N Sloss, Dominic Symes, Chris Wright, ARM System Developers Guide Designing and Optimising System Software, Elsevier, 2006 (Unit – III, IV).
3. Michael J Flynn and Wayne Luk, Computer System Design, System On Chip, Wiley India 2011.(Unit – V).
4. Steve Furber, ARM System – on – Chip Architecture, 2nd Edition, Pearson, 2015.
5. CORTEX M3 Technical Reference Manual
6. CORTEX M Series ARM Reference Manual

25ECU532D IoT Based System Design 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To impart knowledge on the basics of IoT.
- To provide knowledge about the various services provided by IoT.
- To introduce various communication techniques and networking.
- To teach the implementation of IoT with different tools.
- To outline the various applications in IoT.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Articulate the main concepts, key technologies, strength and limitations of IoT.	Understand
CO2	Explain the architecture, infrastructure models of IoT.	Understand
CO3	Analyze the networking and how the sensors are communicated in IoT.	Analyse
CO4	Analyze different models for IoT implementation.	Analyse
CO5	Discuss the applications of IoT	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO2	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO3	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO4	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO5	3	2	2	1	1	1	1	1	1	1	1	2	3	3

UNIT 1: INTRODUCTION TO INTERNET OF THINGS 9

Rise of the machines – Evolution of IoT – Web 3.0 view of IoT – Definition and characteristics of IoT – IoT Enabling Technologies – IoT Architecture –– Fog, Edge and Cloud in IoT – Functional blocks of an IoT ecosystem – Sensors, Actuators, Smart Objects and Connecting Smart Objects - IoT levels and deployment templates – A panaromic view of IoT applications.

UNIT 2: MIDDLEWARE AND PROTOCOLS OF IOT 9

Middleware technologies for IoT system (IoT Ecosystem Overview – Horizontal Architecture Approach for IoT Systems – SOA based IoT Middleware) Middleware architecture of RFID,WSN,SCADA,M2M – Interoperability challenges of IoT-Protocols for RFID,WSN,SCADA,M2M- Zigbee, KNX,BACNet,MODBUS - Challenges Introduced by 5G in IoT Middleware(Technological Requirements of 5G Systems - Perspectives and a Middleware Approach Toward 5G (COMPaaS Middleware) – Resource management in IoT.

UNIT 3: COMMUNICATION AND NETWORKING 9

IoT Access Technologies: Physical and MAC layers, topology and Security of IEEE 802.15.4, 802.15.4g, 802.15.4e, 1901.2a, 802.11ah and LoRaWAN – Network Layer: IP versions, Constrained Nodes and Constrained Networks – Optimizing IP for IoT: From 6LoWPAN to 6Lo, Routing over Low Power and Lossy Networks – Application Transport Methods: Supervisory Control and Data Acquisition –Application Layer Protocols: CoAP and MQTT- Data aggregation & dissemination.

UNIT 4: IOT IMPLEMENTATION TOOLS 9

Introduction to Python, Introduction to different IoTtools, Developing applications through IoT tools, Developing sensor based application through embedded system platform, Implementing IoT concepts with python, Implementation of IoT with Raspberry Pi.

UNIT 5: APPLICATIONS AND CASE STUDIES 9

Home automations - Smart cities – Environment – Energy – Retail – Logistics – Agriculture – Industry - Health and life style – Case study.

45 PERIODS

SUGGESTED READINGS

1. Honbo Zhou, “Internet of Things in the cloud: A middleware perspective”, CRC press, 2012.
2. Vijay Madisetti and Arshdeep Bahga, “Internet of Things (A Hands-on Approach)”, VPT, 1st Edition, 2014.
3. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press, 2017.
4. Constandinos X. Mavromoustakis, George Mastorakis, Jordi MongayBatalla, “Internet of Things (IoT) in 5G Mobile Technologies” Springer International Publishing Switzerland 2016

25ECU631D Wireless Sensor Network Design 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To introduce the fundamentals of wireless sensor network
- To provide knowledge on the MAC and Routing Protocols of WSN
- To provide exposure to 6LOWPAN technology
- To impart knowledge on the protocols required for developing real time applications using WSN and 6LOWPAN.
- To teach about operating system related to WSN and 6LOWPAN.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the Node architecture, Network architecture of WSN	Understand
CO2	Describe different types of MAC and Routing Protocols	Apply
CO3	Explain the different layers of 6LOWPAN networks	Apply
CO4	Discuss the various paradigms and protocols of WSN	Apply
CO5	Describe Tiny OS and Contiki OS in WSNs and 6LOWPAN applications	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	2	3	3
CO2	3	2	1	1	1	1	1	1	1	1	1	2	3	3
CO3	3	2	1	1	1	1	1	1	1	1	1	2	3	3
CO4	3	2	1	1	1	1	1	1	1	1	1	2	3	3
CO5	3	2	1	1	1	1	1	1	1	1	1	2	3	3

UNIT 1: INTRODUCTION 9

Principle of Wireless Sensor Network -Introduction to wireless sensor networks- Challenges, Comparison with ad hoc network, Node architecture and Network architecture, design principles, Service interfaces, Gateway, Short range radio communication standards-IEEE 802.15.4, Zigbee and Bluetooth. Physical layer and transceiver design considerations.

UNIT 2: MAC AND ROUTING PROTOCOLS 9

MAC protocols – fundamentals, low duty cycle protocols and wakeup concepts, contention and Schedule-based protocols - SMAC, BMAC, TRAMA, Routing protocols – Requirements, Classification-SPIN, Directed Diffusion, COUGAR, ACQUIRE, LEACH, PEGASIS.

UNIT 3: 6LOWPAN 9

6LoWPAN Architecture - protocol stack, Adaptation Layer, Link layers – Addressing, Routing - Mesh-Under - Route-Over, Header Compression - Stateless header compression - Context- based header compression, Fragmentation and Reassembly , Mobility – types, Mobile IPv6, Proxy Home Agent, Proxy MIPv6, NEMO –Routing – MANET, ROLL, Border routing.

UNIT 4: APPLICATION 9

Design Issues, Protocol Paradigms - End -to- end, Real – time streaming and sessions, Publish/subscribe, Web service paradigms, Common Protocols -Web service protocols, MQ telemetry transport for sensor networks (MQTT-S), ZigBee compact application protocol (CAP),Service discovery, Simple network management protocol (SNMP), Real-time transport and sessions, Industry-Specific protocols.

UNIT 5: TOOLS 9

TinyOS – Introduction, NesC, Interfaces, modules, configuration, Programming in TinyOS using NesC, TOSSIM, Contiki – Structure, Communication Stack, Simulation environment – Cooja simulator, Programming.

45 PERIODS

SUGGESTED READINGS

1. Kazem Sohraby, Daniel Minoli, Taieb Znati"Wireless Sensor Networks: Technology, Protocols, and Applications",2007.
2. Cuno Pfister “Getting Started with the Internet of Things”,2011.
3. Holger Karl , Andreas willig, “Protocol and Architecture for Wireless Sensor Networks”, John Wiley Publication, 2006.
4. Zach Shelby Sensinode and Carsten Bormann, “ 6LoWPAN: The Wireless Embedded Internet” John Wiley and Sons, Ltd, Publication, 2009.
5. Philip Levis, “TinyOS Programming”, 2006 –www.tinyos.net

25ECU632D Industrial IoT and Industry 4.0 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To discuss IoT Nodes & Sensors
- To explore the IoT Gateways
- To explore IoT Cloud Systems
- To explore IoT Cloud Dashboards
- To discuss Challenges in IoT system Design – Hardware & Software

Course Outcomes (COs)

At the completion of the course the student will be able to

CO	Course Outcomes	Blooms Level
CO1	Explain the building blocks of IoT technology and explore the vast spectrum of IoT applications	Understand
CO2	Use processors & peripherals to design & build IoT hardware.	Analyze
CO3	Assess, select and customize technologies for IoT applications.	Understand
CO4	Connect numerous IOT applications with the physical world of humans and real life problem solving.	Analyze
CO5	Design and implement IOT applications that manage big data.	Analyze

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO2	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO3	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO4	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO5	3	2	2	1	1	1	1	1	1	1	1	2	3	3

UNIT 1: UNDERSTANDING IOT CONCEPT AND DEVELOPMENT PLATFORM 9

IOT Definition, Importance of IoT, Applications of IOT, IoT architecture, Understanding working of Sensors, Actuators, Sensor calibration, Study of Different sensors and their characteristics.

UNIT 2: ANALYZING & DECODING OF COMMUNICATION PROTOCOL USED IN IOT DEVELOPMENT PLATFORM 9

UART Communication Protocol, I2C Protocol device interfacing and decoding of signal, SPI Protocol device interfacing and decoding of signal, WIFI and Router interfacing, Ethernet Configuration, Bluetooth study and analysis of data flow, Zigbee Interfacing and study of signal flow.

UNIT 3: IOT PHYSICAL DEVICES AND ENDPOINTS AND CONTROLLING HARDWARE AND SENSORS 9

IoT Physical Devices and Endpoints- Introduction to Arduino and Raspberry Pi- Installation, Interfaces (serial, SPI, I2C), Programming – Python program with Raspberry PI with focus on interfacing external gadgets, controlling output, reading input from pins.

Controlling Hardware- Connecting LED, Buzzer, Switching High Power devices with transistors, Controlling AC Power devices with Relays, Controlling servo motor, speed control of DC Motor, unipolar and bipolar Stepper motors;
Sensors- Light sensor, temperature sensor with thermistor, voltage sensor, ADC and DAC, Temperature and Humidity Sensor DHT11, Motion Detection Sensors, Wireless Bluetooth Sensors, Level Sensors, USB Sensors, Embedded Sensors, Distance Measurement with ultrasound sensor.

UNIT 4: CLOUD SERVICES USED IN IOT DEVELOPMENT PLATFORM 9

Configuration of the cloud platform, Sending data from the IOT nodes to the gateways using different communication options; Transferring data from gateway to the cloud; Exploring the web services like mail, Messaging (SMS) and Twitter etc.-Tracking of cloud data as per the requirement; Google Cloud service architect; AWS clod Services architect; Microsoft Azure cloud services Architect; OEN source Cloud Services; Initial State Iot Dashboard & Cloud Services.

UNIT 5: CHALLENGES IN IOT SYSTEM DESIGN – HARDWARE & SOFTWARE 9

Antenna design and placement, Chip-package system development, Power electronics, electromagnetic interference/compatibility (EMI/EMC), Electronics reliability; Battery simulation.

45 PERIODS

SUGGESTED READINGS

1. Internet of Things - A Hands-on Approach, Arshdeep Bahga and Vijay Madisetti, Universities Press, 2015, ISBN: 9788173719547
2. Getting Started with Raspberry Pi, Matt Richardson & Shawn Wallace, O'Reilly (SPD), 2014, ISBN: 9789350239759
3. Raspberry Pi Cookbook, Software and Hardware Problems and solutions, Simon Monk, O'Reilly (SPD), 2016, ISBN 7989352133895
4. N. Ida, Sensors, Actuators and Their Interfaces, SciTech Publishers, 2014.

25ECU731D **MEMS Design** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To provide the basic electrical and mechanical concepts of MEMS design.
- To introduce the design aspects of electrostatic sensors and actuators.
- To introduce the design aspects of thermal sensors and actuators
- To introduce the design aspects of piezoelectric sensors and actuators.
- To introduce the design aspects of magnetic sensors and actuators

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the electrical and mechanical properties of MEMS.	Understand
CO2	Describe the operation and characteristics of electro static sensors and actuators.	Apply
CO3	Discuss the operation and characteristics of thermal sensors and actuators.	Apply
CO4	Explain the operation and characteristics of piezoelectric sensors and actuators.	Apply
CO5	Explain the operation and characteristics of magnetic sensors and actuators.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO2	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO3	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO4	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO5	3	2	2	1	1	1	1	1	1	1	1	2	3	3

UNIT 1: ESSENTIAL ELECTRIC AND MECHANICAL CONCEPTS 9

Conductivity of semiconductors, Crystal planes and orientations, stress and strain, flexural beam bending analysis under simple loading conditions, Dynamic system, resonant frequency and quality factor.

UNIT 2: ELECTRO STATIC SESNING AND ACTUATION 9

Parallel plate capacitor, Applications of parallel plate capacitors- inertial sensor, pressure sensor, flow sensor, tactile sensor, parallel plate actuators, interdigitated finger capacitors, applications of comb drive devices.

UNIT 3: THERMAL SENSING AND ACTUATION 9

Fundamentals of thermal transfer, Sensors and actuators based on thermal expansion, Themal couples, Thermal resistors, Applications- Infrared sensors, flow sensors, Inertial sensors, other sensors.

UNIT 4: PIEZOELECTRIC SENSING AND ACTUATION 9

Mathematical description of piezoelectric effects, Cantilever piezoelectric actuator model, properties of piezoelectric materials –Quartz, PZT,PVDF, ZnO , Applications – Acoustic sensors, Tactile sensors.

UNIT 5: CASE STUDIES 9

Concepts and principles- magnetization and nomenclatures, principles of micromagnetic actuators, fabrication of micro magnetic components- deposition, design and fabrication of magnetic coil, MEMS magnetic actuators.

45 PERIODS

SUGGESTED READINGS

1. Chang Liu, “Foundations of MEMS”, Pearson education India limited, 2006
2. Murty B.S, Shankar P, Raj B, Rath, B.B, Murday J, Textbook of Nanoscience and Nanotechnology, Springer publishing, 2013
3. Sergey Edward Lyshevski, “MEMS and NEMS: Systems, Devices, and Structures”, CRC Press, 2002.
4. Tai Ran Hsu, MEMS and Microsystems Design and Manufacture, Tata Mcgraw Hill, 2002

25ECU732D **Fundamentals of Nanoelectronics** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To introduce the concepts of nano electronics and quantum electronics
- To impart knowledge on nano electronic devices, transistors, tunneling devices and superconducting devices
- To teach the basics of nanotube devices
- To provide insight on the role of tunneling and superconducting phenomena
- To introduce carbon nanostructures such as carbon nanotubes (CNTs) and fullerenes.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the basics of nano electronics including quantum wires, dots and wells	Understand
CO2	Describe the mechanism behind quantum electronic devices	Apply
CO3	Analyze the key performance aspects of tunneling and superconducting nano electronic devices	Analyze
CO4	Explain the operation and characteristics of nanotubes and nanostructure devices	Apply
CO5	Analyze the electronic properties of carbon nanotubes.	Analyze

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO2	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO3	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO4	3	2	2	1	1	1	1	1	1	1	1	2	3	3
CO5	3	2	2	1	1	1	1	1	1	1	1	2	3	3

UNIT 1: INTRODUCTION TO NANO ELECTRONICS **9**

Scaling to nano - Light as a wave and particle- Electrons as waves and particles- origin of quantum mechanics - General postulates of quantum mechanics - Time independent Schrodinger wave equation- Electron confinement - Quantum dots, wires and well-Spin and angular momentum.

UNIT 2: QUANTUM ELECTRONICS **9**

Quantum electronic devices - Short channel MOS transistor - Split gate transistor - Electron wave transistor - Electron wave transistor - Electron spin transistor - Quantum cellular automata - Quantum dot array, Quantum memory.

UNIT 3: NANO ELECTRONIC TRANSISTORS 9

Coulomb blockade - Coulomb blockade in Nano capacitors - Coulomb blockade in tunnel junctions - Single electron transistors, Semiconductor nanowire FETs and SETs, Molecular SETs and molecular electronics - Memory cell.

UNIT 4: NANO ELECTRONIC TUNNELING AND SUPER CONDUCTING DEVICES 9

Tunnel effect -Tunneling element -Tunneling diode - Resonant tunneling diode - Three terminal resonant tunneling devices- Superconducting switching devices- Cryotron- Josephson tunneling device.

UNIT 5: NANOTUBES AND NANOSTRUCTURE DEVICES 9

Carbon Nanotube - Fullerenes - Types of nanotubes – Formation of nanotubes –Assemblies – Purification of carbon nanotubes – Electronic properties – Synthesis of carbon nanotubes – Carbon nanotube interconnects – Carbon nanotube FETs and SETs –Nanotube for memory applications- Nano structures and nano structured devices.

45 PERIODS

SUGGESTED READINGS

1. Hanson, Fundamentals of Nanoelectronics, Pearson education, 2009.
2. Jan Dienstuhl, Karl Goser, and Peter Glösekötter, Nanoelectronics and Nanosystems: From Transistors to Molecular and Quantum Devices, Springer-Verlag, 2004.
3. Mircea Dragoman and Daniela Dragoman, Nanoelectronics: Principles and Devices, Artech House, 2009.
4. Brajesh Kumar Kaushik, Nanoelectronics: Devices, Circuits and Systems, Elsevier science, 2018.

Verticals -5
Space Technologies

25ECU531E **RADAR TECHNOLOGIES** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- Teach the basics of Radar, Radar equation and significance of signal to noise ratio
- Introduce the CW, MTI AND Pulse Doppler Radar.
- Impart the fundamental concepts of tracking with Radar
- Introduce the types of signal processing in Radar
- Teach the Subsystems in Radar transmitter and receiver.

Course Outcomes (COs)
At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the Radar principle, parameters and derive the radar equation and SNR	Understand
CO2	Differentiate CW, MTI AND Pulse Doppler Radar	Apply
CO3	Evaluate different tracking and filtering schemes of Radar	Apply
CO4	Apply signal processing in target detection	Apply
CO5	Explain different types of Radar transmitter, receiver , displays and antennas	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: INTRODUCTION TO RADAR EQUATION 9

The Origins of Radar ,Radar principles, Basic Block Diagram, Radar classifications based on Frequencies, Wave form and application, Radar Fundamentals: Detection, Range, velocity, The simple form of the Radar Equation, Pulsed Radar equation, Detection of Signals in Noise- Receiver Noise, Signal-to-Noise Ratio, Probabilities of Detection and False Alarm, Integration of Radar Pulses, Radar Cross Section of Targets, Transmitter Power, Pulse Repetition Frequency, Antenna Parameters, System losses

UNIT 2: CW, MTI AND PULSE DOPPLER RADAR 9

CW and Frequency Modulated Radar, Doppler and MTI Radar- Delay Line Cancellers, Staggered Pulse Repetition Frequencies, Doppler Filter Banks, Digital MTI Processing, Moving Target 163 Detector, Limitations to MTI Performance, MTI from a Moving Platform (AMIT), Pulse Doppler Rada.

UNIT 3: TRACKING RADAR 9

Tracking with Radar, Monopulse Tracking, Conical Scan, Sequential Lobing, Limitations to Tracking Accuracy, Low-Angle Tracking - Comparison of Trackers, Track while Scan (TWS) Radar- Target prediction, state estimation, Measurement models, alpha – beta tracker, Kalman Filtering, Extended Kalman filtering.

UNIT 4: RADAR SIGNAL PROCESSING 9

Radar Signal Processing Fundamentals, Detection strategies, Optimal detection, Threshold detection, Constant False alarm rate detectors, Adaptive CFAR, pulse compression waveforms, compression gain, LFM waveforms matched filtering, radar ambiguity functions, radar resolution, Detection of radar signals in Noise and clutter, detection of non-fluctuating target in noise, Doppler spectrum of fluctuating targets, Range Doppler spectrum of stationary and moving radar

UNIT 5: RADAR TRANSMITTERS AND RECEIVERS 9

Radar Transmitter, Linear Beam Power Tubes, Solid State RF Power Sources, Magnetron, Crossed Field Amplifiers, Other RF Power Sources. The Radar Receiver, Receiver noise power, Super heterodyne Receiver, Duplexers and Receiver Protectors- Radar Displays. Radar Antenna - Reflector Antennas - Electronically Steered Phased Array Antennas – Phase Shifters

45 PERIODS

SUGGESTED READINGS

1. Habibur Rahman, Fundamental Principles of Radar, CRC press, Taylor and Francis, 2019.
2. M. R. Richards, J. A. Scheer, W. A. Holm, Editors “Principles of Modern Radar, Basic Principles”, SciTech Publishing, 2012
3. Nathansan, “Radar design principles-Signal processing and environment”, PHI, 2nd Edition,2007. 2. 2.M.I.Skolnik , “Introduction to Radar Systems”, Tata McGraw Hill 2006.
4. Mark A. Richards, “Fundamentals of Radar Signal Processing”, McGraw-Hill, 2005.

25ECU532E **AVIONICS SYSTEMS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0

Marks: Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To provide understanding on the needs for avionics for both Civil and military aircraft.
- To impart knowledge on avionics architecture and Avionics data bus.
- To impart knowledge on the various cockpit displays and human interfaces.
- To introduce the concepts of flight control systems, FMS and their importance
- To introduce basics of different navigation aids and need for certification.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the different of Avionics Systems and its need for civil and military aircrafts considering the reliability and safety aspects	Understand
CO2	Select a suitable architecture and data bus based on the requirements	Apply
CO3	Compare the different display technologies used in cockpit	Apply
CO4	Explain the principles of flight control systems and the importance of FMS	Understand
CO5	Explain the communication and navigation techniques used in aircrafts	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: INTRODUCTION TO AVIONICS **9**

Basics of Avionics-Basics of Cockpits – Need for Avionics in civil and military aircraft and space systems – Integrated Avionics Architecture –Military and Civil system – Typical avionics System and Sub systems – Design and Technologies – Requirements and Importance of illities of Avionic Systems

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UNIT 2: DIGITAL AVIONICS BUS ARCHITECTURE **9**

Evolution of Avionics architecture– Avionics Data buses MIL-STD-1553, MIL-STD-1773, ARINC429, ARINC-629, AFDX/ARINC-664, ARINC-818 – Aircraft system Interface

UNIT 3: COCKPIT DISPLAYS AND MAN-MACHINE INTERACTION **9**

Trends in display technology- CRT, LED, LCD, EL and plasma panel - Touch screen - Direct voice input

(DVI) –-Civil cockpit and military cockpit: MFD, MFK, HUD, HDD, HMD, HOTAS – Glass cockpit.

UNIT 4: FLIGHT CONTROL SYSTEMS 9

Introduction to Flight control systems and FMS– Longitudinal control – Lateral Control –Autopilot – Flight planning – Radar Electronic Warfare - Certification-Military and civil aircrafts

UNIT 5: NAVIGATION SYSTEMS 9

Overview of navigation systems - Communication Systems – Radio navigation – Types & Principles – Fundamentals of Inertial Sensors – INS – GNSS -- GPS – Approach and Landing Aids – ILS & MLS – Hybrid Navigation

45 PERIODS

SUGGESTED READINGS

1. R.P.G. Collinson, “Introduction to Avionics”, Springer Publications, Third Edition, 2011.
2. Cary R .Spitzer, “The Avionics Handbook”, CRC Press, 2000. 2. Middleton, D.H. “Avionics Systems”, Longman Scientific and Technical, Longman Group UK Ltd., England, 1989. 165
3. Spitzer, C.R. “Digital Avionics Systems”, Prentice Hall, Englewood Cliffs, N.J., U.S.A., 1987.
4. Myron Kayton , Walter R. Fried “Avionics Navigation Systems” 2nd Edition, Wiley Publication, 2008.
5. Jim Curren, “Trend in Advanced Avionics”, IOWA State University,

25ECU631E POSITIONING AND NAVIGATION SYSTEMS 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To teach the fundamentals of navigation systems.
- To impart knowledge in the inertial navigation systems
- To introduce various types of radio navigation and traffic management.
- To provide an overview of global positioning systems
- To teach the hybrid navigation systems.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Describe the advanced concepts of Positioning and Navigation systems and exposure on various Navigation systems	Analyse
CO2	Explain Gyroscopes and accelerometers and Inertial Navigation systems and its types and Mechanisation	Apply
CO3	Explain the different Radio Navigation aids and its usage for civil and military aircrafts and satellites	Remember
CO4	Explain the Satellite Navigation – GPS and its usage in aircraft and spacecraft applications	Understand
CO5	Analyse hybrid navigation systems and Relative navigation in a spacecraft	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: NAVIGATION CONCEPTS 9

Fundamentals of navigation systems and Position Fixing – Categories of navigation – Geometric concepts of Navigation – The Earth in inertial space - Different Coordinate Systems – Coordinate Transformation - Euler angle formulations - Direction cosine matrices formulation – Quaternion formulation.

UNIT 2: INERTIAL NAVIGATION SYSTEMS 9

Inertial sensors - Gyroscopes -Types - Mechanical - Electromechanical-Optical Gyro -Ring Laser gyro- Fiber optic gyro- Accelerometers – Pendulous type – Force Balance type – MEMs - Basic Principles of Inertial Navigation – Types - Platform and Strap down - Mechanization INS system - Rate Corrections -

Acceleration errors – Schuler Tuning

UNIT 3: RADIO NAVIGATION & AIR TRAFFIC MANAGEMENT 9

Different types of radio navigation- ADF, VOR, DME, TACAN,VORTAC - Doppler – Hyperbolic Navigations – Air Traffic Management – RADAR Surveillance - Airborne Collision Avoidance Systems

UNIT 4: GLOBAL POSITIONING SYSTEM 9

Overview of GPS: Basic concept, system architecture, , GPS Signals Signal structure, anti-spoofing (AS), selective availability, GPS for position and velocity determination, GPS aided Geo-augmented navigation (GAGAN) architecture -GPS error sources-clock error, ionospheric error, tropospheric error, multipath, ionospheric error estimation using dual frequency GPS receiver

UNIT 5: HYBRID NAVIGATION & RELATIVE NAVIGATION SYSTEMS 9

Hybrid Navigation - Introduction to Kalman filtering – Case Studies -Integration of GPS and INS using Kalman Filter - Relative Navigation – fundamentals – Equations of Relative Motion for circular orbits (Clohessy_Wiltshire Equations) - Sensors for Rendezvous Navigation - Relative positioning - Point positioning and differential positioning - Differential GPS (DGPS) and Space based Augmentation system (SBAS)- Concepts - Relative GPS -Formation Flying - Figure of Merit (FOM)

45 PERIODS

SUGGESTED READINGS

1. Myron Kyton, Walfred Fried, 'Avionics Navigation Systems', John Wiley & Sons,2 edition,1997.
2. Nagaraja, N.S. "Elements of Electronic Navigation", Tata McGraw-Hill Pub. Co., New Delhi, 2nd edition, 1975
3. George M Siouris, 'Aerospace Avionics System; A Modern Synthesis', Academic Press Inc., 1993.
4. Albert Helfrick, 'Practical Aircraft Electronic Systems', Prentice Hall Education, Career & Technology, 1995.
5. Albert D. Helfrick, 'Modern Aviation Electronics', Second Edition, Prentice Hall Career & Technology, 1994.
6. Paul. D. Groves. 'Principles of GNSS, Inertial, and Multisensor Integrated Navigation Systems', Artech House, 2013.

25ECU632E **SATELLITE COMMUNICATION** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To provide an overview on the basics of satellite orbits ,the satellite segment and earth segment
- To teach Link Power budget calculation
- To impart knowledge on the various satellite access and coding technology , the applications of satellite

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain laws, parameters, launching procedures and launch vehicles of the satellite orbits	Analyse
CO2	Explain the satellite subsystems in the space segment.	Apply
CO3	Calculate the satellite link power budget	Remember
CO4	Describe satellite access technology and coding techniques.	Understand
CO5	Discuss about the various satellite applications	Evaluate

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	3
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	3

UNIT 1: SATELLITE ORBITS **9**

Kepler's Laws, Newton's law, orbital parameters, orbital perturbations, station keeping, geo stationary and non Geo-stationary orbits – Look Angle Determination- Limits of visibility – eclipse Sub satellite point –Sun transit outage-Launching Procedures - launch vehicles and propulsion

UNIT 2: SPACE SEGMENT **9**

Spacecraft Technology- Structure, Primary power, Attitude and Orbit control, Thermal control and Propulsion, communication Payload and supporting subsystems, Telemetry, Tracking and command- Transponders Antenna Subsystem

UNIT 3: SATELLITE LINK DESIGN **9**

Basic link analysis, Uplink and Downlink Design equation, Free space loss-Atmospheric effects, Ionospheric scintillation, Rain induced attenuation and interference, system noise temperature, Link

Design with and without frequency reuse.

UNIT 4: SATELLITE ACCESS AND CODING TECHNIQUES 9

Modulation and Multiplexing: Voice, Data, Video, Analog – digital transmission system, Digital video Broadcast, multiple access: FDMA, TDMA, CDMA, PAMA and DAMA Assignment Methods, compression – encryption, Coding Schemes.

UNIT 5: SATELLITE APPLICATIONS 9

INTELSAT Series, INSAT, VSAT, Mobile satellite services: GSM, GPS, LEO, MEO, Satellite Navigational System. GPS-Position Location Principles, Differential GPS, Direct Broadcast satellites (DBS/DTH).

45 PERIODS

SUGGESTED READINGS

1. Dennis Roddy, “Satellite Communication”, 4th Edition, Mc Graw Hill International, 2017.
2. Timothy Pratt, Charles, W.Bostain,Jeremy E.Allnutt,"SatelliteCommunication”,3rd Edition, Wiley Publications,2021
3. Tri T. Ha, “Digital Satellite Communications”, 2nd edition, Mc Graw Hill education, 2017. 168
4. Wilbur L.Pritchard, Hendri G. Suyderhoud, Robert A. Nelson, “Satellite Communications Systems Engineering”, 2nd edition , Prentice Hall/Pearson , 2013.
5. M.Richharia, “Satellite Communication Systems-Design Principles”, Macmillan, 1999.
6. Brian Ackroyd, “World Satellite Communication and earth station Design”, BSP professional Books, 1990.
7. Bruce R. Elbert, “The Satellite Communication Applications”, Hand Book, Artech House Bostan London, 2003.

25ECU731E **REMOTE SENSING** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To teach the principles of remote sensing and electromagnetic radiation.
- To introduce the fundamentals of the atmospheric radiation interactions, laws of planetary motion.
- To provide insight on the different types of sensing techniques.
- To teach the concepts of digital interpretation

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain the principles of electromagnetic radiation and remote sensing	Understand
CO2	Analyze the atmospheric radiation interactions with atmosphere and earth	Apply
CO3	Derive the laws of planetary motion and explain the types of orbits & platforms	Apply
CO4	Explain the different types of sensing techniques.	Understand
CO5	Describe the concepts of digital interpretation	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: REMOTE SENSING AND ELECTROMAGNETIC RADIATION 9

Definition – components of RS – History of Remote Sensing – Merits and demerits of Data Collation between conventional and remote sensing methods - Electromagnetic Spectrum – Radiation principles - Wave theory, Planck‘s law, Wien’s Displacement Law, Stefan’s Boltzmann law, Kirchoff‘s law – Radiation sources: active & passive – Radiation Quantities

UNIT 2: EMR INTERACTION WITH ATMOSPHERE AND EARTH MATERIAL 9

Standard atmospheric profile – main atmospheric regions and its characteristics – interaction of radiation with atmosphere – Scattering, absorption and refraction – Atmospheric windows – Energy balance equation – Specular and diffuse reflectors – Spectral reflectance & emittance– Spectroradiometer – Spectral Signature concepts – Typical spectral reflectance curves for vegetation,

soil and water – solid surface scattering in microwave region

UNIT 3: ORBITS AND PLATFORMS 9

Motions of planets and satellites – Newton 's law of gravitation – Gravitational field and potential - Escape velocity - Kepler 's law of planetary motion - Orbit elements and types – Orbital perturbations and maneuvers – Types of remote sensing platforms - Ground based, Air borne platforms and Space borne platforms – Classification of satellites – Sun synchronous and Geosynchronous satellites – Legrange Orbit

UNIT 4: SENSING TECHNIQUES 9

Classification of remote sensors – Resolution concept: spatial, spectral, radiometric and temporal resolutions - Scanners - Along and across track scanners – Optical-infrared sensors – Thermal sensors – microwave sensors – Calibration of sensors – High Resolution Sensors - LIDAR, UAV – Orbital and sensor characteristics of live Indian earth observation satellites.

UNIT 5: DATA PRODUCTS AND INTERPRETATION 9

Photographic and digital products – Types, levels and open-source satellite data products – selection and procurement of data – Visual interpretation: basic elements and interpretation keys - Digital interpretation – Concepts of Image rectification, Image enhancement and Image classification.

45 PERIODS

SUGGESTED READINGS

1. Thomas M. Lillesand, Ralph W. Kieferand Jonathan W. Chipman, Remote Sensing and Image interpretation, John Wiley and Sons, Inc., New York, 2015.
2. George Joseph and C Jeganathan, Fundamentals of Remote Sensing, Third Edition Universities Press (India) Private limited, Hyderabad, 2018
3. Stanley A Morain; Amelia M Budge; Michael S Renslow. Manual of Remote Sensing. Vol. I, American Society for Photogrammetry and Remote Sensing, Virginia, USA,2019, 4th edition
4. Verbyla, David, Satellite Remote Sensing of Natural Resources. CRC Press,2022 first edition.
5. Paul Curran P. J. Principles of Remote Sensing Longman, RLBS, 1996.
6. Introduction to Physics and Techniques of Remote Sensing, Charles Elachi and Jacob Van Zyl, 2021 Edition3, Wiley Publication.
7. BasudebBhatta, Remote Sensing and GIS, Oxford University Press, 2020 third edition

25ECU732E **ROCKETRY AND SPACE MECHANICS** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0

Marks: Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To present the fundamental aspects of rocket motion along with detailed estimation of rocket trajectories.
- To impart knowledge on optimization of multistage rockets.
- To provide the basics of space mechanics required for an aeronautical student 170
- To provide with the basics of orbit transfer of satellites.
- To introduce various control methods of rockets

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Explain on the fundamental laws of orbital mechanics with particular emphasis on interplanetary trajectories	Understand
CO2	Calculate orbital parameters and perform conceptual trajectory designs for geocentric or interplanetary missions	Apply
CO3	Analyze themselves with trajectory calculations for planar motion of rockets.	Apply
CO4	Determine forces and moments acting on airframe of a missile	Apply
CO5	Describe on the need for staging and stage separation dynamics of rocket vehicles	Understand

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO2	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO3	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO4	3	2	1	1	1	1	1	1	1	1	1	1	3	2
CO5	3	2	1	1	1	1	1	1	1	1	1	1	3	2

UNIT 1: ORBITAL MECHANICS **9**

Description of solar system – Kepler's Laws of planetary motion – Newton's Law of Universal gravitation – Two body and Three-body problems – Jacobi's Integral, Librations points – Estimation of orbital and escape velocities.

UNIT 2: SATELLITE DYNAMICS **9**

Geosynchronous and geostationary satellites- factors determining life time of satellites – satellite perturbations – orbit transfer and examples –Hohmann orbits – calculation of orbit parameters– Determination of satellite rectangular coordinates from orbital elements

UNIT 3: ROCKET MOTION 9

Principle of operation of rocket motor – thrust equation – one dimensional and two dimensional rocket motions in free space and homogeneous gravitational fields – Description of vertical, inclined and gravity turn trajectories – determinations of range and altitude – simple approximations to burnout velocity.

UNIT 4: ROCKET AERODYNAMICS 9

Description of various loads experienced by a rocket passing through atmosphere – drag estimation – wave drag, skin friction drag, form drag and base pressure drag – Boat-tailing in missiles – performance at various altitudes – rocket stability – rocket dispersion – launching problems.

UNIT 5: STAGING AND CONTROL OF ROCKET VEHICLES 9

Need for multi staging of rocket vehicles – multistage vehicle optimization – stage separation dynamics and separation techniques- aerodynamic and jet control methods of rocket vehicles – SITVC

45 PERIODS

SUGGESTED READINGS

1. Cornelisse,JW, “Rocket Propulsion and Space Dynamics”, J.W. Freeman & Co., Ltd., London, 1982.
2. Parker,ER, “Materials for Missiles and Spacecraft”, McGraw-Hill Book Co., Inc., 1982.
3. Suresh. B N & Sivan. K, “Integrated Design for Space Transportation System”, Springer India, 2015.
4. Sutton,GP, “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 8th Edition, 2010.
5. Van de Kamp, “Elements of Astro-mechanics”, Pitman Publishing Co., Ltd., London, 1980..

Verticals -6- ROBOTICS

25ECU531F **Robotics and Automation** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To study the fundamental concepts of robotics and automation.
- To impart knowledge on various drive system, sensors & machine vision system.
- To learn the various manipulators, grippers as well as the various dynamic process.
- To acquire the concept of kinematics and inverse kinematics.
- To understand the programming and specific industrial applications and applications in Machine Learning.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Summarize knowledge of basic concepts of robotic system	Understanding
CO2	Analyze the function of sensors and machine vision system in the robot.	Understanding
CO3	Categorize the drives, manipulators and grippers.	Understanding
CO4	Develop the qualitative knowledge of. Robot dynamics and kinematics.	Understanding
CO5	Evaluate the recent trends and application of robotics in various fields and its applications of Machine Learning in Robotics	Understanding

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	3	2	2	2	-	-	-	-	-	3	3	3
CO2	3	3	3	3	2	2	-	-	-	-	-	2	3	3
CO3	3	3	3	3	2	2	-	-	-	-	-	2	2	3
CO4	3	3	2	2	2	2	-	-	-	-	-	2	2	3
CO5	3	3	2	2	2	1	-	-	-	-	-	3	2	3

UNIT 1: BASIC CONCEPTS **9**

Origin & various generation of Robots - Robot definition - Robotics system components - Robot classification Coordinate frames - Asimov's laws of robotics - degree of freedom - dynamic stabilization of robots. Work volume. Need for Automation - types of automation - fixed, programmable and flexible automation.

UNIT 2: DRIVES, SENSORS AND MACHINE VISION **9**

Hydraulic, Pneumatic and Electric drives - Machine vision - Sensing - Range, Proximity, Position, Velocity, Acceleration, Tactile, Acoustic, Force, Torque, Optical & laser sensors. Machine vision - Introduction, Image acquisition, Illumination Techniques, Image conversion, Cameras, Image processing and analysis – Image data reduction – Segmentation feature extraction – Object recognition- Case study on choice of sensors and actuators for maze solving robot and self-driving cars.

UNIT 3: ANIPULATORS, GRIPPERS AND ROBOT DYNAMICS AND KINEMATICS 9

Construction of manipulators - Manipulator dynamics and force control - Electronic and Pneumatic manipulator control circuits - End effectors - Various types of grippers - Design considerations. Introduction to Robot Dynamics - Lagrange formulation - Newton Euler formulation - Properties of robot dynamic equations. Forward Kinematics - Denavit Hartenberg Representation. Multiple solution jacobian work envelop, Inverse Kinematics - Geometric approach. Hill climbing techniques.

UNIT 4: PROGRAMMING LANGUAGES 9

Robot programming - Fixed instruction, sequence control, General programming language, Specific programming languages. Implementation of Robots in industries-Robots for welding, painting and assembly - Remote Controlled robots - robots in manufacturing and non-manufacturing applications - Robots for nuclear and chemical plants.

UNIT 5: APPLICATIONS OF MACHINE LEARNING 9

Application of Machine learning - AI, Expert systems; Tele-robotics and Virtual Reality, Micro & Nanorobots, Unmanned vehicles, Cognitive robotics, Evolutionary robotics, Humanoids.

45 PERIODS

SUGGESTED READINGS

1. Mikell P. Weiss G.M., Nagel R.N., Odraj N.G., “Industrial Robotics”, McGraw-Hill Singapore, 1996.
2. Ghosh, “Control in Robotics and Automation: Sensor Based Integration”, Allied Publishers, Chennai, 1998.
3. Asfahl C.R., “Robots and Manufacturing Automation”, John Wiley, USA 1992.
4. Klafter R.D., Chimielewski T.A., Negin M., “Robotic Engineering - An integrated approach”, Prentice Hall of India, New Delhi, 1994.
5. M.P.Groover, “Industrial Robotics – Technology, Programming and Applications”, TATA McGrawHill Publishing Company, New Delhi,2008.

25ECU532F **Sensors and Instrumentation** **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To emphasize the basic concepts of Sensors and Transducers
- To introduce LabVIEW and its graphical programming techniques.
- To acquire knowledge about software-based instruments.
- To outline the prescribed methods of Data acquisition.
- To implement these ideas and tools in real time applications using Arduino.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Apply sensors for measurement of displacement, force and pressure.	Apply
CO2	Employ commonly used sensors in industries for measurement of temperature, position, accelerometer, vibration sensor, flow and level.	Understand
CO3	Demonstrate the practice of virtual instrumentation in industrial automation.	Analyse
CO4	Identify and use various data acquisition methods.	Analyse
CO5	Realize intelligent instrumentation in automation process.	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	2	2	1	3	-	-	-	-	2	3	3	3
CO2	3	3	2	2	1	-	-	-	-	-	1	2	3	3
CO3	3	3	3	2	1	2	-	-	-	-	3	2	2	3
CO4	3	3	2	2	3	-	-	-	-	-	-	1	3	2
CO5	3	2	3	3	2	1	-	-	-	-	2	1	2	2

UNIT 1: SENSORS **9**

Introduction to sensors: Definition, Difference between sensors and transducers, Classification and selection of sensors, temperature sensors, pressure sensors, humidity sensors, current sensors, sensors for the measurement of motion and position, GPS, INS, Doppler, SONAR, Thermo-EMF Sensors, NQR thermometry and heat flux sensor.

UNIT 2: TRANSDUCERS **9**

Introduction to transducers: Definition, Classification of transducers based on quantity to be measured, based on principle of operation, Measurement of displacement using potentiometer, LVDT and optical encoder, Measurement of force using strain gauge, Measurement of pressure using LVDT based diaphragm and piezoelectric transducers.

UNIT 3: SMART SENSORS **9**

Introduction to Smart Sensors and Semiconductor sensors, MEMS, MOEMS, Nano-sensors, SQUID Sensors, Thick and Thin Film sensors (Bio sensor and Chemical sensor), Environmental Monitoring sensors (Water Quality and Air Pollution), Basics of fabrication, Sensor Interface Systems.

UNIT 4: VIRTUAL INSTRUMENTATION 9

Virtual Instrumentation: Overview of LabVIEW, Graphical programming techniques, Data types, Advantage of Virtual Instrumentation techniques, Concept of WHILE and FOR loops, Arrays, Clusters and graphs Structures: Case, Sequence and Formula nodes, need of software-based instruments for industrial automation.

UNIT 5: APPLICATIONS AND CASE STUDIES 9

Data Acquisition Methods: Basic block diagram, Analog and Digital Inputs/Outputs, Counters, Timers, Types of ADC: Successive Approximation (SAR) ADC, Delta-sigma (ΔΣ) ADC, Pipelined ADC Types of DAC: Binary Weighted Resistor D/A Converter, R–2R ladder D/A ConverterSegmented DAC, Use of Data Sockets for Networked Communication. Programming with Arduino: Arduino Platform Boards Anatomy, Arduino IDE, coding, using emulator, using libraries, additions in Arduino, programming Arduino for IoT applications.

45 PERIODS

SUGGESTED READINGS

1. DVS Murthy, 'Transducers and Instrumentation', PHI 2nd Edition 2013.
2. D Patranabis, 'Sensors and Transducers', PHI 2nd Edition 2013.
3. S. Gupta, J.P. Gupta,'PC interfacing for Data Acquisition & Process Control', 2nd ED/Instrument Society of America, 1994.
4. A.D. Helfrick and W.D. Cooper,' Modern Electronic Instrumentation and Measurement Techniques', PHI-2001

25ECU631F Sensors and Transducers 3H – 3C

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To categorize the sensors and transducers according to its applications
- To introduce virtual instrumentation and LabVIEW
- To focus on the advanced features of smart sensors
- To summarize the characteristics and operating principles of various types of transducers.
- To familiarize with Arduino programming

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Infer the needs of sensors and transducers in industrial automation.	Understand
CO2	Evaluate the unique characteristics of Resistive, Capacitive and Inductive transducers.	Apply
CO3	Investigate different types of advanced sensors and its principles of operation.	Apply
CO4	Apply virtual instrumentation techniques for complicated process handling.	Apply
CO5	Monitor the environmental parameter variations using smart sensors.	Analyse

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	2	2	2	1	-	-	-	-	2	2	1	3
CO2	3	3	2	2	2	1	-	-	-	-	-	2	2	3
CO3	3	3	3	2	2	1	-	-	-	-	-	3	2	3
CO4	3	3	3	3	2	2	-	-	-	-	-	2	1	3
CO5	2	-	1	1	3	2	-	-	-	-	-	2	2	2

UNIT 1: BASIC SENSORS 9

Introduction, Difference between Sensors and Transducers, Classification, Active and Passive transducers, Characteristics, Basic Requirements and Selection of Sensors and Transducers, Sensor for Motion and Position Measurement, GPS, INS, Doppler, SONAR, Thermal Sensors, Gas Thermometric Sensors, Acoustic Temperature Sensor, Thermo-EMF Sensors, NQR Thermometry, Heat Flux Sensor. Basics of Virtual Instrumentation, Introduction to LabVIEW, Graphical programming techniques.

UNIT 2: RESISTIVE TRANSDUCERS 9

Resistive Transducers: Principle of operation, construction details, characteristics and applications of potentiometer, strain gauge, resistance thermometer, hot-wire anemometer, piezo-resistive sensor and humidity sensor.

UNIT 3: CAPACITIVE TRANSDUCERS 9

Capacitive Transducers: Principle of operation, construction details, characteristics of capacitive transducers, Capacitor microphone, Capacitive pressure sensor, Proximity sensor, Ultrasonic sensors, IR sensors.

UNIT 4: INDUCTIVE TRANSDUCERS 9

Inductive transducers: Self inductive transducers, Mutual inductive transducer, Principle of operation, construction details, characteristics and applications of LVDT, Induction potentiometer, Variable reluctance transducers, Synchros, Microsyn, Hall Effect transducer, Magneto elastic sensor, Digital transducers, Fibre optic sensors, Sensors used in Robotics, Vision Sensor, velocity sensors and optical encoder.

UNIT 5: SMART SENSORS 9

Introduction to Smart Sensors and Semiconductor sensors, MEMS, MOEMS, Nano-sensors, SQUID Sensors, Thick and Thin Film sensors, Environmental Monitoring sensors (Water Quality and Air Pollution), Basics of fabrication, Sensor Interface Systems. Air quality detection sensors, motion sensors, smart smog and Carbon monoxide detector, smart plant sensors and smart climate sensors Simple programming techniques with Arduino, Arduino IDE, coding and emulator.

45 PERIODS

SUGGESTED READINGS

1. Sawhney A.K., 'Electrical & Electronic Measurements and Instrumentation', Dhanpat Rai & Sons,18th Edition., 2010.
2. Doeblin E.O., 'Measurement System Applications and Design', TMH, Sch Edition, 2004.
3. Renganathan S., 'Transducer Engineering', Allied Publishers Limited, 2003.
4. Murthy D.V.S., 'Transducer and Instrumentation', PHI, 1st Edition, 2008.
5. Jacob Fraden, 'Handbook of modern sensors physics, designs and applications", 5th edition, Springer, 2015.

25ECU632F Robot Kinematics **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60 Total**: **100**
End Semester Exam: 3 Hours

Course Objectives

- To Control both the position and orientation of the tool in 3D Space.
- To Plan trajectories for the tools to follow on order to perform meaningful task.
- To precisely control high speed motion of the system.

Course Outcomes (COs)

At the completion of the course the student will be able to

CO	Course Outcomes	Blooms Level
CO1	Demonstrate knowledge of industrial robots, characteristics, end effectors and actuators.	Apply
CO2	Apply spatial transformation to obtain direct kinematics	Apply
CO3	Apply spatial transformation to obtain inverse kinematics	Apply
CO4	Describe working principle of various sensors and program different operations	Understand
CO5	Analyze applications of robots in industry	Analyze

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	2	2	1	2	-	-	-	-	-	3	2
CO2	3	2	2	2	1	2	-	-	-	-	-	3	3
CO3	3	2	2	2	2	2	-	-	-	-	-	3	3
CO4	3	2	3	2	3	2	-	-	-	-	-	3	3
CO5	3	3	3	3	3	3	-	-	-	-	-	3	2

UNIT 1: INTRODUCTION 9

Introduction, Rigid-body, Degrees of Freedom, position and orientation of objects, objects coordinate frame Rotation matrix, Euler angles Roll, pitch and yaw angles coordinate Transformations, Joint variables and position of end effector, Dot and cross products, coordinate frames, Rotations, Homogeneous coordinates.

UNIT 2: DIRECT KINEMATICS 9

Link coordinates D-H Representation, The ARM equation. Direct kinematic analysis for Four axis, SCARA Robot and three, five and six axis Articulated Robots.

UNIT 3: INVERSE KINEMATICS 9

The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics of four axis SCARA robot and three and five axis, articulated robot.

UNIT 4: WORKSPACE ANALYSIS AND TRAJECTORY PLANNING 9

Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, Joint space technique – continuous path motion, Interpolated motion, straight line motion and Cartesian space technique in trajectory planning.

UNIT 5: MANUPLATOR DYNAMICS 9

Introduction, Lagrange's equation kinetic and potential energy. Link inertia Tensor, link Jacobian Manipulator inertia tensor. Gravity, Generalized forces, Lagrange-Euler Dynamic model, Dynamic model of a Two-axis planar robot, Newton Euler formulation, Lagrange Euler formulation, problems.

45 PERIODS

SUGGESTED READINGS

1. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, PHI Learning, 2009
2. Richard D. Klafter, Thomas .A, Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Phi Learning., 2009.
3. P.A. Janaki Raman, Robotics and Image Processing An Introduction, Tata Me Graw Hill Publishing company Ltd., 1995.
4. Bijay K. Ghosh, Ning Xi, T.J. Tam, Control in Robotics and Automation Sensor – Based integration, Academic Press, 1999.
5. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, MIT Press., 2003.

25ECU731F Programmable Logic Controllers **3H – 3C**

Instruction Hours / week: L: 3 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To provide the Fundamentals of PLC, PLC programming concepts, PLC applications.
- To provide in-depth understanding PID Control and HMI which are used in automation of various machines, processes and systems in industries.

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Differentiate between PLC and computer controlled systems.	Understand
CO2	Use counters, timers, algebraic and boolean operations, memory, subroutines etc. of PLC to do a certain task	Understand
CO3	Choose different PLC for specific application	Understand
CO4	Design PLC based automated industrial applications like starter, level controller, lift etc.,	Apply
CO5	Incorporate a PLC in a simple SCADA and perform simulations using different PLC software	Apply

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	2	2	2	2	-	-	-	-	-	1	2	2
CO2	3	3	3	2	2	2	-	-	-	-	-	2	2	2
CO3	3	3	3	2	2	2	-	-	-	-	-	2	2	2
CO4	3	3	3	2	2	2	-	-	-	-	-	2	2	2
CO5	3	3	3	2	2	2	-	-	-	-	-	2	2	2

UNIT 1: PROGRAMMABLE LOGIC CONTROLLERS **9**

Programmable Logic Controllers (PLCs) – architecture-Types- features -Programming a PLC using ladder/connected Component workbench-Input & Output Modules- Bit Instructions- Timer & Counter Instructions- Comparison & Data Handling Instructions- Program Control Instructions- Sequencing Instructions- PLC Programming Exercises for Industrial Applications DOL starter- Star Delta starter Automatic water level controller- Conveyor-Lift-Bottle filling and process control applications-Analog I/Os -High speed counter-PTO PWM and RTC.

UNIT 2: PNEUMATIC COMPONENTS **9**

Pneumatic Components A. Development of Relay Logic Ladder Diagram, Introduction to PLC Programming, Programming devices and languages as per IEC 61131-3 like IL, ST, FBD, CFC, SFC, PLC Timers and Counters, PLC Selection, Installation and Troubleshooting.

UNIT 3: SCADA **9**

B.PLC Documentation. Role of Computers in Measurement and Control- PC based data acquisition System – Direct digital Control - software - Velocity algorithm & Position algorithm.

UNIT 4: ADVANCE PLC **9**

Advanced PLC instructions A. Advanced PLC instructions like, Program control, comparison, mathematical, logical, communication, shift registers, sequencers, data handling, advanced mathematical, PID Control using PLC, PID instruction, PID for temperature control loop. PLC programming for industrial applications using advanced instructions.

UNIT 5: HUMAN MACHINE INTERFACE **9**

Human-Machine Interface A.HMI programming. Need, working principle, functions and types of HMI. Programming techniques for Text display, Variable parameter display and setting alarm messages, Pages Generation, Sequence of pages, Graphic display, and PLC-HMI communication.

45 PERIODS

SUGGESTED READINGS

1. Programmable Logic Controllers: Principles and Applications , J.Webb, Prentice Hall of India, 2002
2. Introduction to Programmable Logic Controllers, Gary Dunning Delmar Thomson Learning, 2005
3. Technician's guide to programmable controllers, Richard Terry, ,Delmar/Thomson learning, 2007
4. Instrument engineer’s handbook , Bela G. Liptak, 2012.

25ECU732F Pattern Recognition and Image Vision 3H – 3C

Instruction Hours / week: L: 0 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

Course Objectives

- To impart knowledge in the area of image processing and pattern recognition
- To understand fundamentals of digital image processing
- perform and apply compression and coding techniques used for image data
- To learn the fundamentals of Pattern recognition and to choose an appropriate feature
- To classify algorithm for a pattern recognition problem and apply them applications using modern computing tools such as MATLAB, C/C++

Course Outcomes (COs)

At the completion of the course the student will be able to

Cos	Course Outcomes	Blooms Level
CO1	Infer Basics of Image formation and transformation using sampling and quantization.	Understand
CO2	Interpret different types signal processing techniques used for image sharpening and smoothing.	Apply
CO3	Apply compression and coding techniques used for image data understand the nature and inherent difficulties of the pattern recognition problems.	Apply
CO4	Categorize the nature and inherent difficulties of the pattern recognition problems.	Apply
CO5	Design and verify suitable classification process, features, and proper classifier to address a desired pattern recognition problem.	Analyze

CO-PO Mapping

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	2	2	2	1	-	-	-	-	-	2	1	3
CO2	3	3	3	2	2	2	-	-	-	-	-	2	1	3
CO3	3	3	3	2	2	2	-	-	-	-	-	2	1	3
CO4	3	3	2	2	2	2	-	-	-	-	-	2	1	3
CO5	3	3	3	3	3	3	-	-	-	-	-	2	1	3

UNIT 1: INTRODUCTION TO IMAGE PROCESSING 9

Image formation, image geometry perspective and other transformation, stereo imaging elements of visual perception. Digital Image-sampling and quantization serial & parallel Image processing.

UNIT 2: IMAGE RESTORATION 9

Image Restoration-Constrained and unconstrained restoration Wiener filter , motion blur remover, geometric and radiometric correction Image data compression-Huffman and other codes transform compression, predictive compression two tone Image compression, block coding, run length coding, and contour coding.

UNIT 3: SEGMENTATION TECHNIQUES 9

Tasks- Functions -systems tasks and functions - Verification - Modeling a test bench – timing and Segmentation Techniques-thresh holding approaches, region growing, relaxation, line and edge detection approaches, edge linking, supervised and unsupervised classification techniques, remotely sensed image analysis and applications, Shape Analysis – Gestalt principles, shape number, moment Fourier and other shape descriptors, Skelton detection, Hough trans-form, topological and texture analysis, shape matching.

UNIT 4: PATTERN RECOGNITION 9

Basics of pattern recognition, Design principles of pattern recognition system, Learning and adaptation, Pattern recognition approaches, Mathematical foundations – Linear algebra, Probability Theory, Expectation, mean and covariance, Normal distribution, multivariate normal densities, Chi squared test.

UNIT 5: STATISTICAL PATTEN RECOGNITION 9

Bayesian Decision Theory, Classifiers, Normal density and discriminant functions, Parameter estimation methods: Maximum-Likelihood estimation, Bayesian Parameter estimation, Dimension reduction methods – Principal Component Analysis (PCA), Fisher Linear discriminant analysis, Expectation maximization (EM), Hidden Markov Models (HMM),Gaussian mixture models.

45 PERIODS

SUGGESTED READINGS

1. Digital Image Processing – Ganzalez and Wood, Addison Wesley, 2018.
2. Fundamental of Image Processing – Anil K.Jain, Prentice Hall of India.
3. Pattern Classification – R.O. Duda, P.E. Hart and D.G. Stork, Second Edition John Wiley, 2006
4. Digital Picture Processing – Rosenfeld and Kak, vol.I & vol.II, Academic,1982
5. Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, “Digital Image Processing Using MATLAB”, Third Edition Tata Mc Graw Hill Pvt. Ltd., 2011.
6. Anil Jain K. “Fundamentals of Digital Image Processing”, PHI Learning Pvt. Ltd., 2011.
7. Malay K. Pakhira, “Digital Image Processing and Pattern Recognition”, First Edition, PHI Learning Pvt. Ltd.,2011