Curriculum Structure & Detailed Syllabus

# Bachelor of Technology

in

# Electronics Engineering
# (VLSI Design & Technology)

(Four-Year Under-Graduate Program)

# Silicon University, Odisha

Silicon Hills, Patia, Bhubaneswar - 751024

https://silicon.ac.in

# Approval History

| ACM# | Date | Resolutions |
|------|------|-------------|
| SU-4 | 19/07/2025 | The curriculum structure of B. Tech. (EE-VLSI) and detailed syllabus of 1st Year has been approved by the Academic Council. |
| SU-5 | 07/02/2026 | The amendments to the curriculum structure and the detailed syllabus up to 2nd Year of B. Tech. (EE-VLSI) as recommended by the Board of Studies was approved by the Academic Council. |

# Knowledge and Attitude Profile (WK's)

Knowledge and Attitude Profile (WK's) are linked to the Graduates Attributes (GAs) which indicate a graduate's potential to acquire competence at the appropriate level. NBA has defined 9 (nine) Knowledge and Attitude Profile (WK's) aligned with the Washington Accord for UG Engineering programs.

WK1. A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.

WK2. Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.

WK3. A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.

WK4. Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.

WK5. Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.

WK6. Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.

WK7. Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.

WK8. Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.

WK9. Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

# Program Outcomes (PO's)

Graduates Attributes (GAs) form a set of individually assessable outcomes that are the components indicative of the graduate's potential to acquire competence to practice at the appropriate level. The Program Outcomes (POs) for UG Engineering programs as defined by NBA are:

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 (WK1 to WK4).

PO2. **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4).

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 (WK5).

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 (WK8).

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 (WK2 and WK6).

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 (WK1, WK5, and WK7).

PO7. **Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)

PO8. **Individual & 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. (WK8)

## Program Specific Outcomes (PSOs)

PSO1. Apply foundational knowledge of digital logic, CMOS circuit design, semiconductor device physics, and HDL-based modeling to design, simulate, verify, and implement efficient & optimized VLSI systems for a wide range of electronic, embedded, communication, and computational applications.

PSO2. Demonstrate proficiency in industry-standard VLSI design tools, design workflows, and low-power design methodologies in alignment with contemporary semiconductor industry practices to emerge as skilled professionals, entrepreneurs, or researchers with effective communication, strong ethics, and innovation-driven mindset.

PSO3. Appreciate and adapt to emerging and interdisciplinary technologies to robust, intelligent, and energy-efficient VLSI systems that address complex real-world challenges and contribute to future-ready electronic solutions.

## Program Educational Objectives (PEOs)

PEO1. *Core Knowledge & Technical Proficiency*: To establish a strong foundation in mathematics, semiconductor physics, digital and analog electronics, and VLSI system design, enabling graduates to solve complex engineering problems in chip design, verification, and fabrication domains.

PEO2. *Industry Readiness & Innovation*: To develop competence and expertise to analyze, design, simulate, and optimize VLSI-based systems using modern EDA tools and methods as per the evolving demands of semiconductor industries, embedded systems, and emerging computing architectures.

PEO3. *Leadership, Ethics & Social Responsibility*: To demonstrate leadership, teamwork, and effective communication skills, and to contribute meaningfully to society by practicing ethical engineering, understanding the environmental impact of chip manufacturing, and actively promoting sustainable VLSI development and community engagement.

PEO4. *Lifelong Learning & Professional Growth*: To pursue continuous learning through advanced degrees, professional certifications, and research in VLSI and allied interdisciplinary fields, and to grow as industry leaders, educators, or entrepreneurs staying current with evolving technological and management practices.

## Course Categories & Definitions

| | |
|---|---|
| L | Lecture |
| T | Tutorial |
| P | Practice / Hands-On / Practical / Laboratory / Sessional |
| WCH | Weekly Contact Hours |
| UCR | University Core Course |
| UMC | University Mandatory Course (0-Credit) |
| PCR | Program Core Course |
| PEL | Program Elective Course |
| OEL | Open Elective Course |
| HNS | Honours (Choice-based) Course |
| MNR | Minor (Choice-based) Course |
| OOC | Open Online Course (on NPTEL / Swayam / Other) |
| INT | Summer Internship |
| PSI | Practice School / Industry Internship |
| PRJ | Project Work |
| SEC | Skill Enhancement Course |
| VAC | Value Addition Course |

# Contents

# Part I

# Curriculum Structure

# Induction Program

In accordance with the guidelines issued by AICTE and NEP-2020, it is essential for newly admitted B.Tech. students to undergo a structured Student Induction Program (SIP). The program is designed to facilitate a smooth transition into higher technical education by enabling students to acclimatize to the institutional environment, develop a sense of belonging, and imbibe academic, ethical, and societal values. The primary objectives of the Student Induction Program are to:

- Help students adjust to the new academic and social environment
- Establish healthy bonding among students, faculty members, and the institution
- Familiarize students with the academic system, institutional culture, and discipline
- Promote communication skills, self-confidence, and teamwork
- Instill human values, professional ethics, and social responsibility
- Encourage holistic development in alignment with NEP-2020

**Mandatory Nature of the Program**
All students admitted to the B.Tech. programs shall undergo a mandatory Student Induction Program immediately after joining the institute and before the commencement of regular academic classes. As per AICTE guidelines, regular classes shall begin only after the successful completion of the induction program.

**Components of the Student Induction Program**
The Student Induction Program shall include, but not be limited to, the following components:

1. ***Institutional Orientation***
   - Rules and regulations of the university
   - Examination, evaluation, and academic progression systems
   - Departments, branches, and academic structure
   - Campus facilities, laboratories, libraries, and learning resources
   - Administrative processes and important officials
   - Curricular, co-curricular, and extra-curricular activity clubs
   - Innovation, research, entrepreneurship, and start-up initiatives

2. ***Universal Human Values and Ethics***
   - Sessions on human values, professional ethics, and responsible conduct
   - Social awareness, civic duties, and environmental consciousness
   - Motivation to contribute to societal development and nation building

3. ***Physical and Mental Well-being***
   - Individual and group physical activities, yoga, sports, or fitness sessions
   - Awareness on disciplined and healthy lifestyles

4. ***Creative Arts and Cultural Activities***
   - Learning, practicing, or exhibiting art forms, music, literature, or other creative expressions
   - Activities aimed at nurturing creativity, emotional expression, and cultural appreciation

5. ***Interaction and Mentoring***
   - Interaction with faculty advisors, mentors, and senior students
   - Sessions focused on career planning, emerging technologies, and professional pathways
   - Lectures and interactions with eminent academicians, professionals, and industry experts

6. *Community and Social Engagement*
   - Social service and community outreach activities
   - Visits to important places of the city or nearby areas of social, cultural, or historical significance
   - Any other activities deemed necessary by the institute in alignment with AICTE/NEP-2020 objectives

**Attendance and Participation**

Every newly admitted student must diligently attend and actively participate in all components of the Student Induction Program. Attendance for all activities shall be recorded. Students shall submit a daily report in the prescribed format to the concerned faculty advisor on the following working day.

**Assessment and Evaluation**

A computer-based multiple-choice test (MCQ) shall be conducted on a suitable date, generally about one week after the completion of the induction program. The evaluation of the Student Induction Program shall be carried out for a total of 100 marks, distributed as follows:

1. Attendance              : 25 marks
2. Daily Reports           : 25 marks
3. Computer-Based MCQ Test  : 50 marks

A student must secure a minimum of 50 marks in aggregate to successfully complete and pass the Student Induction Program.

In case a student fails to secure the minimum required marks, the student shall be required to undergo the Student Induction Program again in the subsequent academic year along with the newly admitted students, submit daily reports, and appear for the computer-based test to obtain the prescribed passing marks.

# Curriculum Structure

## 1st Year B.Tech. (Common)

| Category | Code | Course Title | WCH (L — T — P) | | | Credit |
|---|---|---|---|---|---|---|
| **Semester I** | | | | | | |
| | | | | | | |
| **THEORY** | | | | | | |
| UCR | MT1001 | ODE & Matrix Algebra | 3 | 0 | 0 | 3 |
| UCR | CH1003 / PH1002 | Engineering Chemistry / Engineering Physics | 3 | 0 | 0 | 3 |
| UCR | EC1001 / EE1001 | Basic Electronics Engineering / Basic Electrical Engineering | 3 | 0 | 0 | 3 |
| UCR | ME1004 / ME1002 | Engineering Mechanics / Engineering Thermodynamics | 2 | 0 | 0 | 2 |
| UCR | CS1001 | Computer Programming | 3 | 0 | 0 | 3 |
| UMC | HS0001 / CH0001 | Constitution of India & Professional Ethics / Environmental Science & Engineering | 3 | 0 | 0 | 0 |
| **PRACTICAL** | | | | | | |
| UCR | EC1002 / EE1002 | Basic Electronics Engineering Lab / Basic Electrical Engineering Lab | 0 | 0 | 2 | 1 |
| UCR | CS1002 | Computer Programming Lab | 0 | 0 | 4 | 2 |
| SEC | HS1001 | Communicative & Technical English | 0 | 0 | 4 | 2 |
| UCR | EE1003 / ME1003 | Workbench Practices / Engineering Graphics | 0 | 0 | 2 | 1 |
| | | | ***TOTAL*** | **29** | | **20** |

**Note**: For some courses, the subjects have been mentioned as Subject-1 / Subject-2, i.e., with an OR option. Every student has to study both the subjects, however allocation of these subjects shall alternate between Semesters I and II. For example, if a student has been allocated *Engineering Chemistry* in Semester-I, then he/she will be allocated *Engineering Physics* in Semester-II, and vice-versa. The laboratory courses (if any) will be as per the theory courses allocated in the applicable semester. The same applies to all other courses provided with an OR option.

# 1st Year B.Tech. (Common)

| Category | Code | Course Title | WCH (L — T — P) | | | Credit |
|---|---|---|---|---|---|---|
| **Semester II** | | | | | | |
| | | | | **WCH** (L — T — P) | | **Credit** |
| **THEORY** | | | | | | |
| UCR | MT1002 | Probability & Statistics | 3 | 0 | 0 | 3 |
| UCR | PH1002 / CH1003 | Engineering Physics / Engineering Chemistry | 3 | 0 | 0 | 3 |
| UCR | EE1001 / EC1001 | Basic Electrical Engineering / Basic Electronics Engineering | 3 | 0 | 0 | 3 |
| UCR | ME1002 / ME1004 | Engineering Thermodynamics / Engineering Mechanics | 2 | 0 | 0 | 2 |
| UCR | CS1003 | Data Structures & Algorithms | 3 | 0 | 0 | 3 |
| UMC | CH0001 / HS0001 | Environmental Science & Engineering / Constitution of India & Professional Ethics | 3 | 0 | 0 | 0 |
| **PRACTICAL** | | | | | | |
| UCR | EE1002 / EC1002 | Basic Electrical Engineering Lab / Basic Electronics Engineering Lab | 0 | 0 | 2 | 1 |
| UCR | CS1004 | Data Structures & Algorithms Lab | 0 | 0 | 4 | 2 |
| SEC | HS1002 | Corporate Communication Skills | 0 | 0 | 4 | 2 |
| UCR | ME1003 / EE1003 | Engineering Graphics / Workbench Practices | 0 | 0 | 2 | 1 |
| | | **TOTAL** | **29** | | | **20** |

**Note**: For some courses, the subjects have been mentioned as Subject-1 / Subject-2, i.e., with an OR option. Every student has to study both the subjects, however allocation of these subjects shall alternate between Semesters I and II. For example, if a student has been allocated *Engineering Chemistry* in Semester-I, then he/she will be allocated *Engineering Physics* in Semester-II, and vice-versa. The laboratory courses (if any) will be as per the theory courses allocated in the applicable semester. The same applies to all other courses provided with an OR option.

# 2nd Year B.Tech.(EE-VLSI)

| Semester III | | | | | | |
|---|---|---|---|---|---|---|
| Category | Code | Course Title | WCH (L — T — P) | | | Credit |
| THEORY | | | | | | |
| PCR | MT2003 | Vector Calculus & Fourier Analysis | 3 | 0 | 0 | 3 |
| UCR | CS2007 | Programming in Python | 3 | 0 | 0 | 3 |
| UCR | MG2001 / BL2001 | Management & Economics for Engineers / Biology for Engineers | 3 | 0 | 0 | 3 |
| PCR | EC2003 | Signals & Systems | 3 | 0 | 0 | 3 |
| PCR | EE2010 | Circuit Theory | 3 | 0 | 0 | 3 |
| PCR | EC2025 | Analog Circuit Design | 3 | 1 | 0 | 4 |
| PRACTICAL | | | | | | |
| UCR | CS2010 | Programming in Python Lab | 0 | 0 | 2 | 1 |
| PCR | EE2011 | Circuit Theory Lab | 0 | 0 | 2 | 1 |
| PCR | EC2026 | Analog Circuit Design Lab | 0 | 0 | 4 | 2 |
| INT | IP2001 | Summer Internship - I | 0 | 0 | 0 | 1 |
| | | TOTAL | 27 | | | 24 |

| Semester IV | | | | | | |
|---|---|---|---|---|---|---|
| Category | Code | Course Title | WCH (L — T — P) | | | Credit |
| THEORY | | | | | | |
| PCR | MT2004 | Complex Analysis & Numerical Methods | 3 | 0 | 0 | 3 |
| PCR | EC2010 | Solid State Devices | 3 | 0 | 0 | 3 |
| UCR | MG2001 / BL2001 | Management & Economics for Engineers / Biology for Engineers | 3 | 0 | 0 | 3 |
| PCR | EC2031 | Digital Circuit Design | 3 | 1 | 0 | 4 |
| PCR | EC3045 | Communication Systems Engineering | 3 | 0 | 0 | 3 |
| PEL | | Program Elective - I | 3 | 0 | 0 | 3 |
| HNS/MNR | | Honours / Minor - I | 3 | 0 | 0 | 3 |
| PRACTICAL | | | | | | |
| PCR | EC2029 | Linux & TCL for SSD Lab | 0 | 0 | 2 | 1 |
| PCR | EC2032 | Digital Circuit Design Lab | 0 | 0 | 4 | 2 |
| PCR | EC2030 | Communication Systems Engineering Lab | 0 | 0 | 2 | 1 |
| | | TOTAL | 27 | | | 23 |
| | | TOTAL (with Honours/Minor) | 30 | | | 26 |

# 3rd Year B.Tech.(EE-VLSI)

| Category | Code | Course Title | WCH (L — T — P) | | | Credit |
|---|---|---|---|---|---|---|
| **Semester V** | | | | | | |
| | | **THEORY** | | | | |
| PCR | EC3003 | Digital Signal Processing | 3 | 0 | 0 | 3 |
| PCR | EC3004 | Electromagnetic Waves | 3 | 1 | 0 | 4 |
| PCR | EC3059 | CMOS Integrated Circuits | 3 | 1 | 0 | 4 |
| PCR | EC3061 | Electronic System Design | 3 | 0 | 0 | 3 |
| PEL | | Program Elective - II | 3 | 0 | 0 | 3 |
| PEL | | Program Elective - III | 3 | 0 | 0 | 3 |
| HNS/MNR | | Honours / Minor - II | 3 | 0 | 0 | 3 |
| | | **PRACTICAL** | | | | |
| PCR | EC3007 | Digital Signal Processing Lab | 0 | 0 | 2 | 1 |
| PCR | EC3008 | Electromagnetic Waves Lab | 0 | 0 | 2 | 1 |
| PCR | EC3060 | CMOS Integrated Circuits Lab | 0 | 0 | 2 | 1 |
| PCR | EC3062 | Electronic System Design Lab | 0 | 0 | 2 | 1 |
| SEC | HS3001 | Soft Skills for Professionals | 0 | 0 | 2 | 1 |
| INT | IP3003 | Summer Internship - II | 0 | 0 | 0 | 1 |
| | | **TOTAL** | **30** | | | **26** |
| | | **TOTAL (with Honours/Minor)** | **33** | | | **29** |

| Category | Code | Course Title | WCH (L — T — P) | | | Credit |
|---|---|---|---|---|---|---|
| **Semester VI** | | | | | | |
| | | **THEORY** | | | | |
| PCR | EC3009 | Microprocessors & Microcontrollers | 3 | 0 | 0 | 3 |
| PCR | EC3020 | Analog VLSI Design | 3 | 0 | 0 | 3 |
| PCR | EE3001 | Control Systems Engineering | 3 | 0 | 0 | 3 |
| PEL | | Program Elective - IV | 3 | 0 | 0 | 3 |
| PEL | | Program Elective - V | 3 | 0 | 0 | 3 |
| PEL | | Program Elective - VI | 3 | 0 | 0 | 3 |
| HNS/MNR | | Honours / Minor - III | 3 | 0 | 1 | 4 |
| | | **PRACTICAL** | | | | |
| PCR | EC3011 | Microprocessors & Microcontrollers Lab | 0 | 0 | 2 | 1 |
| PCR | EC3063 | Analog VLSI Design Lab | 0 | 0 | 2 | 1 |
| SEC | IP3008 / IP3002 | Emerging Technologies Lab / Entrepreneurship & Innovation | 0 | 0 | 4 | 2 |
| SEC | HS3002 | Technical & Research Writing | 0 | 0 | 2 | 1 |
| VAC | VA0001 | Yoga / NSS / NCC / PES / CPA * | 0 | 0 | 2 | 0 |
| | | **TOTAL** | **30** | | | **23** |
| | | **TOTAL (with Honours/Minor)** | **34** | | | **27** |

**\*Value Addition Courses**: Yoga - Yoga & Meditation, NSS - National Service Scheme, NCC - National Cadet Corps, PES - Physical Education & Sports, CPA - Creative & Performing Arts. Every student must invest at least 2 hours per week in the chosen course in one semester.

# 4th Year B.Tech.(EE-VLSI)

## (Without Practice School Option)

| Semester VII | | | | | | |
|---|---|---|---|---|---|---|
| Category | Code | Course Title | WCH (L — T — P) | | | Credit |
| THEORY | | | | | | |
| OEL | | Open Elective - I | 3 | 0 | 0 | 3 |
| OOC | | MOOC - I | 0 | 0 | 0 | 3 |
| HNS/MNR | | Honours / Minor - IV | 3 | 0 | 1 | 4 |
| HNS/MNR | | Honours / Minor - V | 3 | 0 | 1 | 4 |
| PRACTICAL | | | | | | |
| PRJ | IP4013 | Skill Lab & Project - I | 0 | 0 | 4 | 2 |
| INT | IP4005 | Summer Internship - III | 0 | 0 | 0 | 1 |
| | | *TOTAL* | 7 | | | 9 |
| | | *TOTAL (with Honours/Minor)* | 15 | | | 17 |

| Semester VIII | | | | | | |
|---|---|---|---|---|---|---|
| Category | Code | Course Title | WCH (L — T — P) | | | Credit |
| THEORY | | | | | | |
| OEL | | Open Elective - II | 3 | 0 | 0 | 3 |
| OOC | | MOOC - II | 0 | 0 | 0 | 3 |
| PRACTICAL | | | | | | |
| UCR | IP4008 | Presentation Skills & Technical Seminar | 0 | 0 | 2 | 1 |
| PRJ | IP4009 | Project - II | 0 | 0 | 16 | 8 |
| | | *TOTAL* | 21 | | | 15 |

| | | | | |
|---|---|---|---|---|
| | | *GRAND TOTAL* | 200 | 160 |
| | | *GRAND TOTAL (with Honours/Minor)* | 220 | 178 |

**Note**:
1. Courses offered under each elective are given in "List of Electives" on Page 11.
2. Courses for Honours and Minor are given in "List of Tracks for Honours and Minor" on Page 12.
3. A 4-Credit Honours / Minor course may have L-T-P of 3-1-0 if the course does not require any practice or hands-on component. Refer to the detailed syllabus of the course for the allocated L-T-P.
4. MOOC - Massive Open Online Course (on NPTEL / Swayam / Other).
5. Approved list of courses for MOOC (self study) shall be published by the department. Students are advised to complete them before the end of 8th semester.

# 4th Year B.Tech.(EE-VLSI)

## (With Practice School Option in 7th Semester)

| | | | WCH | | | |
|---|---|---|---|---|---|---|
| **Category** | **Code** | **Course Title** | **(L — T — P)** | | | **Credit** |
| **PRACTICAL** | | | | | | |
| PSI | IP4006 | Practice School / Industry Internship | 0 | 0 | 0 | 15 |
| INT | IP4005 | Summer Internship - III | 0 | 0 | 0 | 1 |
| | | *TOTAL* | **0** | | | **16** |

| Semester VIII | | | | | | |
|---|---|---|---|---|---|---|
| | | | WCH | | | |
| **Category** | **Code** | **Course Title** | **(L — T — P)** | | | **Credit** |
| **THEORY** | | | | | | |
| OEL | | Open Elective - II | 3 | 0 | 0 | 3 |
| OOC | | MOOC - II | 0 | 0 | 0 | 3 |
| HNS/MNR | | Honours / Minor - IV | 3 | 0 | 1 | 4 |
| HNS/MNR | | Honours / Minor - V | 3 | 0 | 1 | 4 |
| **PRACTICAL** | | | | | | |
| PRJ | IP4013 | Skill Lab & Project - I | 0 | 0 | 4 | 2 |
| | | *TOTAL* | **7** | | | **8** |
| | | *TOTAL (with Honours/Minor)* | **15** | | | **16** |

| | | | | | |
|---|---|---|---|---|---|
| | | *GRAND TOTAL* | 179 | | 160 |
| | | *GRAND TOTAL (with Honours/Minor)* | 197 | | 178 |

**Note**:
1. Courses offered under each elective are given in "List of Electives" on Page 11.
2. Courses for Honours and Minor are given in "List of Tracks for Honours and Minor" on Page 12.
3. A 4-Credit Honours / Minor course may have L-T-P of 3-1-0 if the course does not require any practice or hands-on component. Refer to the detailed syllabus of the course for the allocated L-T-P.
4. MOOC - Massive Open Online Course (on NPTEL / Swayam / Other).
5. Approved list of courses for MOOC (self study) shall be published by the department. Students are advised to complete them before the end of 8th semester.

# 4th Year B.Tech.(EE-VLSI)

## (With Practice School Option in 8th Semester)

| Category | Code | Course Title | WCH (L — T — P) | | | Credit |
|---|---|---|---|---|---|---|
| **Semester VII** | | | | | | |
| **THEORY** | | | | | | |
| OEL | | Open Elective - I | 3 | 0 | 0 | 3 |
| OOC | | MOOC - I | 0 | 0 | 0 | 3 |
| HNS/MNR | | Honours / Minor - IV | 3 | 0 | 1 | 4 |
| HNS/MNR | | Honours / Minor - V | 3 | 0 | 1 | 4 |
| **PRACTICAL** | | | | | | |
| PRJ | IP4013 | Skill Lab & Project - I | 0 | 0 | 4 | 2 |
| INT | IP4005 | Summer Internship - III | 0 | 0 | 0 | 1 |
| | | **TOTAL** | **7** | | | **9** |
| | | **TOTAL (with Honours/Minor)** | **15** | | | **17** |

| Category | Code | Course Title | WCH (L — T — P) | | | Credit |
|---|---|---|---|---|---|---|
| **Semester VIII** | | | | | | |
| **PRACTICAL** | | | | | | |
| PSI | IP4006 | Practice School / Industry Internship | 0 | 0 | 0 | 15 |
| | | **TOTAL** | **0** | | | **15** |

| | | | | |
|---|---|---|---|---|
| | | **GRAND TOTAL** | **179** | **160** |
| | | **GRAND TOTAL (with Honours/Minor)** | **197** | **178** |

**Note**:

1. Courses offered under each elective are given in "List of Electives" on Page 11.
2. Courses for Honours and Minor are given in "List of Tracks for Honours and Minor" on Page 12.
3. A 4-Credit Honours / Minor course may have L-T-P of 3-1-0 if the course does not require any practice or hands-on component. Refer to the detailed syllabus of the course for the allocated L-T-P.
4. MOOC - Massive Open Online Course (on NPTEL / Swayam / Other).
5. Approved list of courses for MOOC (self study) shall be published by the department. Students are advised to complete them before the end of 8th semester.

# List of Electives

| Code | Elective # and Subjects |
|---|---|
| *Program Elective - I* | |
| EC3013 | IC Fabrication Technology |
| EC2027 | Electronic Design & Automation |
| EC2028 | Integrated Circuit Packaging |
| *Program Elective - II* | |
| EC4006 | Mixed Signal Design |
| EC3024 | Low Power VLSI Design |
| | Semiconductor Packaging Materials |
| *Program Elective - III* | |
| | SoC Design & Verification |
| EC2015 | Electronic Devices & Modeling |
| | Advanced Packaging Technologies |
| *Program Elective - IV* | |
| | SoC Physical Design for Tapeout |
| | Logic Synthesis |
| | Package Design & Simulation |
| *Program Elective - V* | |
| EC3028 | Design of Semiconductor Memories |
| | Formal Methods & Verification |
| | EMC & Signal Integrity |
| *Program Elective - VI* | |
| | Design for Testability |
| | AI & ML in CAD for VLSI |
| | On Chip Interfaces |
| *Open Elective - I & II (Basket)* | |
| MT4001 | Applied Linear Algebra |
| MT4002 | Stochastic Processes |
| MT4003 | Numerical Optimization |
| MT4004 | Simulation & Modelling |
| ME4001 | Fluid Mechanics |
| EE4001 | Power Plant Engineering |
| ME4002 | Project Management |
| HS4001 | Organizational Behaviour |
| HS4002 | Entrepreneurship Development |
| MG4001 | Securities Analysis, Investment & Trading |
| MG4002 | Circular Economy |

# List of Tracks for Honours / Minor

| Code | Honours / Minor # and Subjects |
|---|---|
| *Honours in Electronics Engineering (VLSI Design & Technology)* | |
| CS2008 | Computer Organization & Architecture |
| | Advanced Semiconductor Manufacturing |
| | MEMS & Sensor Design |
| | Emerging Memory Devices |
| | Compound Semiconductors |
| *Minor in "Sustainable Energy & E-Mobility"* | |
| EC2024 | Power Electronic Devices |
| EE2008 | Renewable Energy Systems |
| EE3022 | Basics of Power Systems |
| EE3024 | Smart Power Systems |
| EE4002 | Electric & Hybrid Vehicles |
| *Minor in "Information Technology"* | |
| CS2003 | Operating Systems |
| CS2008 | Computer Organization & Architecture |
| CS2002 | Design & Analysis of Algorithms |
| CS2009 | Database Management Systems |
| CS4001 | Internet Technology & Applications |
| *Minor in "Artificial Intelligence & Machine Learning"* | |
| CS3013 | Data Mining & Data Warehousing |
| CS2014 | Artificial Intelligence |
| CS3002 | Machine Learning |
| CS4003 | Human Language Processing |
| CS4004 | Advanced Machine Learning |
| *Minor in "Business Management"* | |
| MG2002 | Digital Marketing & SMO |
| MG3003 | Human Resource Information Systems |
| MG3004 | E-Commerce & Supply Chain Management |
| MG4005 | Financial Management |
| MG4006 | Business Strategy |
| *Minor in "Business Analytics"* | |
| MG2005 | Fundamentals of Business Analytics |
| MG3001 | Data Analytics with Python |
| MG3002 | Business Statistics & Predictive Modelling |
| MG4003 | Business Intelligence & Visualization |
| MG4004 | Business Analytics using Power of AI |

**Note:**
1. Choice for Honours or Minor must be submitted before the end of 3rd Semester.
2. A student can opt for either Honours or Minor, but not both.
3. Once opted for Honours or Minor, the same cannot be changed or converted.
4. Unless adequate number of students opt for Honours or Minor, it shall not be offered for the batch.

# Part II

# Detailed Syllabus

| Category | Code | ODE & Matrix Algebra | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| UCR | MT1001 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to study the concepts of solution of system of linear equations using matrix methods, Eigen values & Eigen vectors of matrices with application, ordinary differential equations with applications, and Laplace transform & its applications to ordinary differential and integral equations. |
| **Pre-Requisites** | Knowledge of elementary calculus, coordinate geometry of two & three dimensions and matrix algebra is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | Matrix algebra, System of linear equations, Rank, Vector space, Existence and uniqueness of solution of a system of linear equations. | **8 Hours** |
| **Module-2** | Eigen values and Eigen vectors, Complex matrices, Diagonalization of matrices, Positive definite matrix, Singular Value Decomposition (SVD) and pseudo inverse. | **8 Hours** |
| **Module-3** | Separable ordinary differential equation and modeling, Exact ODE and Integrating factor, Linear ODE, Bernoulli's Equation, Modeling electrical circuits, Homogeneous linear ODE of second order, Second order Linear ODE with constant coefficients. | **8 Hours** |
| **Module-4** | Non-homogeneous linear ODE, Solution of Non-homogeneous linear ODE using undetermined coefficients, Euler-Cauchy ODE and applications to electrical circuits, Laplace transform, Inverse Laplace transform. | **8 Hours** |
| **Module-5** | Shifting theorems, Transform of derivatives and integrals, Unit step function and Dirac delta function, Applications to derivatives, Differentiation and integration of transforms, Convolution, Integral equation, Solution of system of differential equations. | **10 Hours** |
| | Total | **42 Hours** |

**Text Books**:
  T1. E. Kreyszig, ***Advanced Engineering Mathematics***, 8th *Ed.*, Wiley India, 2015.
  T2. G. Strang, ***Linear Algebra and Its Applications***, 4th *Ed.*, Cengage Learning, 2015.

**Reference Books**:
  R1. S. Pal and S. C. Bhunia, ***Engineering Mathematics***, 1st *Ed.*, Oxford University Press, 2015.
  R2. B. V. Ramana, ***Higher Engineering Mathematics***, 1st *Ed.*, McGraw Hill, 2017.

**Online Resources**:
  1. https://nptel.ac.in/courses/111105035: by Prof. P. D. Srivastava, IIT Kharagpur
  2. https://nptel.ac.in/courses/122104017: by Prof. S. K. Ray, IIT Kanpur
  3. https://nptel.ac.in/courses/122102009: by Prof. S. R. K. Iyengar, IIT Delhi
  4. https://nptel.ac.in/courses/111107063: by Dr. S. Gakkhar, IIT Roorkee
  5. https://www.coursera.org/learn/linearalgebra2

6. https://www.coursera.org/learn/differentiation-calculus
7. https://www.coursera.org/learn/single-variable-calculus
8. https://alison.com/courses/Algebra-Functions-Expressions-and-Equations

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Solve a system of linear equations by applying the appropriate method. |
|-----|------------------------------------------------------------------------|
| CO2 | Apply Eigen values and Eigen vector techniques to find SVD and pseudo inverse of a matrix. |
| CO3 | Apply first order ordinary differential equations to solve real-world problems. |
| CO4 | Apply second order ordinary differential equations to solve problems of electrical circuits. |
| CO5 | Apply the concept of Laplace transforms to solve differential and integral equations. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|-----|----------------------------------------------------------------------------------------------------|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Engineering Chemistry | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| UCR | CH1003 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The purpose of this course is to understand the fundamentals and applications of chemical sciences in the field of engineering. The course addresses the principles of general and engineering chemistry, so that the students can apply the knowledge in their areas of expertise. |
| **Pre-Requisites** | Preliminary knowledge of mole concept, oxidation and reduction, combustion, electromagnetic wave, and nano-materials is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on examples and applications. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | **Water Treatments**: Types of hardness-Units, Alkalinity of water and its significance, Softening methods and Numerical problems based on these methods; Membrane-based processes; Dissolved Oxygen, Problems with Boiler feed water and its treatments. | **8 Hours** |
| **Module-2** | **Corrosion Science**: Definition and scope of corrosion, Dry and wet corrosion, Direct chemical corrosion, Electro-chemical corrosion and its mechanisms, Types of electro-chemical corrosion (Differential aeration, Galvanic, Concentration cell), Typical Electro-chemical corrosion like Pitting, Soil, Waterline, Factors affecting corrosion, Protection from corrosion. | **8 Hours** |
| **Module-3** | **Instrumental Techniques**: Fundamentals of Spectroscopy, Principles and applications of molecular spectroscopy such as UV-visible, IR, Elementary idea about XRD, SEM & TEM. | **8 Hours** |
| **Module-4** | **Electrochemical Devices**: Battery Technology — Fundamentals of primary & secondary cells, Rechargeable batteries – Lead acid storage battery, Lithium ion battery, Fuel cells – Principles, Applications, Solar Cells – Principles & applications; Potentiostat – Introduction, Instrumentation and working principle, Voltammetry, Cyclic voltammetry (principle, role of scan rate, potential range and current response), Analysis of cyclic voltammograms - peak currents, redox potentials, and reversibility, Applications of potentiostat. | **10 Hours** |
| **Module-5** | **Nanochemistry**: Nanomaterials, Classification of nanomaterials, Synthesis and characterization of noble metal nanoparticles (Gold and oxide-based nanoparticles) using Green Synthetic route, Stabilization of nanoparticles using capping agents, Applications of nanomaterials, Carbon based nanomaterials and their applications, Brief on Graphene and Fullerene. | **8 Hours** |
| | Total | 42 Hours |

**Text Books**:
T1. Jain & Jain, **Engineering Chemistry**, 16th *Ed.*, Dhanpat Rai Publishing Company, 2015.
T2. Wiley-India Editorial Team, **Engineering Chemistry**, 2nd *Ed.*, Wiley India, 2011.
T3. C. N. Banwell, **Fundamentals of Molecular Spectroscopy**, 4th *Ed.*, McGraw-Hill Education, 2017.
T4. Willard, Merritt, Dean, and Settle, **Instrumental Methods of Analysis**, 7th *Ed.*, CBS Publishers, 2004.

**Reference Books**:

R1. S. S. Dara, *Engineering Chemistry*, 12th *Ed.*, S. Chand Publisher, 2014.

R2. G. A. Ozin & A. C Arsenault, *Nanochemistry - A Chemical Approach to Nanomaterials*, 2nd *Ed.*, RSC Publishing, 2008.

R3. J. M. Lehn, L. Cademartiri, *Concepts of Nanochemistry*, 1st *Ed.*, Wiley-VCH, 2009.

R4. Y. R. Sharma, *Elementary Organic Spectroscopy*, S Chand & Co Ltd., 2013.

**Online Resources**:
1. https://nptel.ac.in/courses/105104102/
2. https://nptel.ac.in/courses/113104082/
3. https://nptel.ac.in/courses/104106122/
4. https://nptel.ac.in/courses/103102015/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| | |
|---|---|
| CO1 | Determine the hardness of water and apply difference processes to soften hard water. |
| CO2 | Utilize the knowledge of electro-chemistry and corrosion science for prevention of corrosion. |
| CO3 | Apply molecular spectroscopy to analyze organic compounds using spectrophotometer. |
| CO4 | Understand different technologies for storing energy and the working principles of electrochemical devices & their industrial applications. |
| CO5 | Explore synthesis & characterization of nanoparticles through green synthetic route. |

**Program Outcomes Relevant to the Course**:

| | |
|---|---|
| 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 (WK1 to WK4). |
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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 (WK1, WK5, and WK7). |
| PO7 | **Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9) |
| PO8 | **Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams. |
| 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. (WK8) |

P.T.O

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

|     | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 | PSO3 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|
| CO1 | 2   | 2   | 2   | 1   | 1   | 1   | 1   |     |     |      | 1    | 1    | 2    | 1    |
| CO2 | 2   | 2   | 2   | 1   | 1   | 1   | 1   | 1   |     |      | 1    | 2    | 1    | 2    |
| CO3 | 2   | 2   | 1   | 2   | 1   | 1   | 1   | 1   |     |      | 1    | 2    | 1    | 1    |
| CO4 | 2   | 2   | 2   | 1   | 1   | 1   | 1   | 1   |     |      | 1    | 1    | 1    | 1    |
| CO5 | 2   | 2   | 1   | 1   | 1   | 1   | 1   |     |     |      | 1    | 2    | 1    | 2    |

| Category | Code | Engineering Physics | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| UCR | PH1002 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to study various laws of physics and understand different phenomena using these principles which are necessary to understand the working of instruments & technologies, and solving various engineering problems. |
| **Pre-Requisites** | Basic knowledge on waves, electrostatics, magnetism and mathematics is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | **Wave Optics**: Wave and wave equation, Superposition of waves, Huygen's principle, Concept of Interference and Diffraction, Polarization, Types of polarization, Brewster's law, Malus's Law, Nicol Prism, Wave plate and types, Applications of polarization. | 9 Hours |
| **Module-2** | **Electrostatics and Magnetostatics**: Introduction to Gauss's law, Faraday's law, Ampere's Circuital law and Biot-Savarat's law, Application of the laws to derive the constituent relations of the fundamental passive elements: Resistor, Capacitor and Inductor. | 8 Hours |
| **Module-3** | **Electromagnetic Waves**: Gradient of scalar field, Divergence and curl of vector field, Displacement current and modified Ampere's circuital law, Maxwell's electromagnetic equations, Wave equations in free space, dielectric and conducting medium, Poynting's theorem. | 8 Hours |
| **Module-4** | **Basics of Quantum Physics**: Need of Quantum Physics, Particle nature of radiation, Planck's Quantum Theory, Photoelectric effect, Compton's effect, Pair production, Matter waves, Heisenberg's uncertainty principle, Schrödinger's wave equation, Particle in a box. | 9 Hours |
| **Module-5** | **Laser and Fiber Optics**: Radiation-matter interaction, Stimulated emission, Population inversion, Types of Laser – Solid State Laser and Gas Laser, Optical Fiber – Structure and Principle, Types of optical fiber, Numerical aperture, Applications of laser and optical fiber. | 8 Hours |
| | Total | 42 Hours |

**Text Books**:
T1. D. R. Joshi, ***Engineering Physics***, 1st *Ed.*, Tata McGraw-Hill Publication, 2017.
T2. Md. M. Khan and S. Panigrahi, ***Principle of Physics***, Vol. I & II, Cambridge Univ. Press.

**Reference Books**:
R1. A. Ghatak, ***Optics***, 7th *Ed.*, McGraw-Hill Education, 2020.
R2. D. J. Griffith, ***Introduction to Electrodynamics***, 4th *Ed.*, Pearson Education, 2015.
R3. A. Beiser, ***Concept of Modern Physics***, 6th *Ed.*, McGraw-Hill Education, 2009.

<div align="right">P.T.O</div>

**Online Resources**:
1. https://nptel.ac.in/courses/122101002: by Prof. Prof. D. K. Ghosh, IIT Bombay
2. https://nptel.ac.in/courses/122107035: by Prof. G. D. Verma et. al., IIT Roorkee
3. https://nptel.ac.in/courses/115101107: by Prof. Ramadevi, IIT Bombay
4. https://ocw.mit.edu/courses/physics/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| | |
|---|---|
| CO1 | Analyze & apply waves and polarized light in different fields and engineering applications. |
| CO2 | Understand basic laws in electromagnetism and apply them to solve problems involving electromagnetic fields and their interaction with circuit analysis. |
| CO3 | Develop and apply Maxwell's equations to understand the properties of electromagnetic waves. |
| CO4 | Analyze wave particle duality to understand radiation-matter interaction and apply Schrödinger's equations to fields like bound particle, potential barrier etc. |
| CO5 | Investigate the basic principle, properties, operations and applications of laser & optical fiber in different domains of engineering. |

**Program Outcomes Relevant to the Course**:

| | |
|---|---|
| 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 (WK1 to WK4). |
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Basic Electronics Engineering | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| UCR | EC1001 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objectives of this course is to study the concepts and functionalities of electronic devices, tools and instruments, general specifications and deployability of the electronic devices, and assemblies in engineering applications. |
| **Pre-Requisites** | Knowledge of physics, chemistry, and introductory idea of semiconductors studied at the higher secondary level is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, and planned lectures to make the sessions interactive with problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | **Semiconductor & Diodes**: Types of semiconductors, Majority and minority charge carriers, Energy Band diagram, Transport phenomena, Law of Mass Action, Drift and Diffusion Current; Semiconductor Diode – Ideal vs. Practical, Diode equivalent circuits, Diode Applications – Rectifiers, Clipper, Clamper, and Switch, Zener Diode – Operation and Applications. | 9 Hours |
| **Module-2** | **Transistors**: Bipolar Junction Transistor (BJT) – Construction, Operation, Amplifying action, CB, CE, and CC configurations, Load line analysis, Fundamentals of biasing, Fixed biasing; Field Effect Transistor (FET) – Construction, Working principles, Characteristics of JFET & MOSFET. | 9 Hours |
| **Module-3** | **Op-Amps, Oscillators, and Measuring Instruments**: Introduction, Characteristics of ideal Op-Amp, Virtual Ground Concept, Pin Configuration, Applications of Op-Amp – Inverting & Non Inverting Amplifier, Summing Amplifier, Differentiator, Integrator; Oscillators – Barkhausen's Criteria, RC phase shift oscillator, Wien bridge oscillator; Measuring Instruments – Construction & working of CRO, DSO, and Multimeter. | 8 Hours |
| **Module-4** | **Digital Logic**: Number systems and its conversion, Signed & unsigned numbers, Binary arithmetic, 1's and 2's complement arithmetic, Basic & universal Logic gates, Boolean algebra and identities, Algebraic reduction using postulates of boolean algebra, Realization of boolean functions using universal logic gates. | 8 Hours |
| **Module-5** | **Signals & Communication Systems**: Signals – Continuous & Discrete-time, Analog & Digital, Energy & Power, Spectrum of a signal, Fourier Transform (Exponential, Sine and Cosine); Communication Systems – Block diagram, Modulation, Time & Frequency domain representation of AM, Carrier & side-band power calculation, Generation (Square law modulator), Demodulation (Synchronous demodulator). | 8 Hours |
| | Total | 42 Hours |

**Text Books**:

T1. R. L. Boylestad and L. Nashelsky, *Electronic Devices and Circuit Theory*, 11<sup>th</sup> *Ed.*, Pearson Education, 2015.

T2. A. Agarwal and J. Lang, *Foundations of Analog and Digital Electronic Circuits*, 1st *Ed.*, Morgan Kaufmann, 2005.

T3. R. P. Singh and S. D. Sapre, *Communication Systems: Analog and Digital*, 3rd *Ed.*, McGraw-Hill Education, 2014.

**Reference Books**:

R1. A. S. Sedra and K. C. Smith, *Microelectronic Circuits*, 7th *Ed.*, Oxford University Press, 2009.

R2. V. K. Mehta and R. Mehta, *Principles of Electronics*, 10th *Rev. Ed.*, S. Chand Publishing, 2006.

R3. A. Kumar, *Fundamentals of Digital Circuits*, 3rd *Ed.*, PHI Learning, 2014.

**Online Resources**:

1. https://nptel.ac.in/courses/117103063/: by Prof. G. Barua, IIT Guwahati
2. https://nptel.ac.in/courses/108101091/: By Prof. M. B. Patil, IIT Bombay
3. https://nptel.ac.in/courses/122106025/: By Prof. T. S. Natarajan, IIT Madras
4. https://nptel.ac.in/courses/117107095/: Web Content by IIT Roorkee
5. https://nptel.ac.in/courses/122104013/: Web Content by IIT Kanpur
6. https://nptel.ac.in/courses/117106086/: By Prof S.Srinivasan, IIT Madras
7. https://nptel.ac.in/courses/117103064/: By Prof A. Mahanta, IIT Guwahati

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Understand basic principles of semiconductor diodes and their applications. |
|---|---|
| CO2 | Understand the construction, characteristics, configurations, and applications of transistors. |
| CO3 | Analyze the characteristics of Op-Amps & use them to design circuits for various applications. |
| CO4 | Convert numbers using different number systems and apply boolean algebra on them. |
| CO5 | Explain different types of signals and their characteristics using Fourier analysis tools. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|---|---|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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. (WK8) |

P.T.O

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Basic Electrical Engineering | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| UCR | EE1001 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to introduce the basic concepts of electricity and magnetism, DC & AC networks, principles of different electrical machines and measuring instruments, protection systems and safety requirements. |
| **Pre-Requisites** | Basic knowledge of intermediate physics and mathematics such as calculus, ordinary differential equations, matrices etc. is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | **Electric Circuits**: Charge & current, Ideal & practical sources, Source conversion, Characteristics of circuit elements, Kirchhoff's current and voltage laws, Current & voltage division rule; Resistive Network Analysis – Node voltage & Mesh current (controlled & uncontrolled sources), Thevenin's theorem, Norton's theorem, Superposition theorem, Maximum power transfer theorem; Transient Analysis – Introduction, Differential equations, Time-domain analysis of first-order RL & RC circuits, Time constant. | **12 Hours** |
| **Module-2** | **Single-phase AC Circuit Analysis**: Representation of sinusoidal waveforms, Peak and RMS values, Phasor representation, AC power analysis, Power factor, Improvement of power factor, Analysis of series & parallel AC circuits (R, L, C, RL, RC, RLC circuits), Series resonance, Q-factor. | **8 Hours** |
| **Module-3** | **Three-phase AC Circuit Analysis**: Representation of 3-phase AC voltage, Phase sequence, Balanced load and source, Voltage and current relationship in star and delta connections, AC power analysis; Introduction to generation, transmission, and distribution of power system network, Residential wiring, Earthing, Electrical safety. | **7 Hours** |
| **Module-4** | **Electromagnetism**: Magnetic flux, Reluctance, Series & parallel magnetic circuits, Magnetic materials, Hysteresis loop; Single-phase Transformer – Construction & working, Ideal and practical transformer, EMF equation, Equivalent circuit & phasor diagram of transformer on load and no-load, Shifting of impedances. | **8 Hours** |
| **Module-5** | **DC Machine**: Construction, Working of generator and motor, EMF equation of generator, Back EMF of Motor, Classification based on excitation system; **AC Machine**: Construction and working of a 3-phase induction motor, Synchronous speed, Concept of slip, Construction, working, and types of single-phase induction motor. | **7 Hours** |
| | Total | **42 Hours** |

**Text Books**:
T1.  C. K. Alexander and M. N. O. Sadiku, *Fundamentals of Electric Circuits*, 6th *Ed.*, McGraw-Hill, 2017.
T2.  E. Hughes, *Electrical & Electronic Technology*, 9th *Ed.*, Pearson, 2004.
T3.  G. Rizzoni, *Principles and Applications of Electrical Engineering*, 5th *Ed.*, McGraw Hill, 2006.

**Reference Books**:
R1. A. E. Fitzgerald, D. E. Higginbotham, and A. Grabel, *Basic Electrical Engineering*, 5<sup>th</sup> *Ed.*, Tata McGraw Hill.
R2. B. L. Theraja and A. K. Theraja, *Textbook of Electrical Technology (Vol-I)*, 23<sup>rd</sup> *Ed.*, S. Chand & Co.Ltd., 2002.
R3. L. S. Bobrow, *Foundations of Electrical Engineering*, Asian Edition, Oxford Univ. Press, 2013.

**Online Resources**:
1. https://nptel.ac.in/courses/108/105/108105053/: by Prof. G. D. Roy, Prof. N. K. De, and Prof. T. K. Bhattacharya, IIT Kharagpur
2. https://nptel.ac.in/courses/108/108/108108076/: By Prof. L. Umanand, IISc Bangalore
3. https://www.electrical4u.com/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| | |
|---|---|
| CO1 | Understand and analyze basic electrical network with direct current source. |
| CO2 | Measure current, voltage, and power of series RLC circuit excited by single-phase AC circuit. |
| CO3 | Analyze 3-phase electrical systems and explore the engineering of practical power systems. |
| CO4 | Explain different concepts of magnetic fields and apply them to single-phase transformers. |
| CO5 | Describe the working principles of rotating electrical machines. |

**Program Outcomes Relevant to the Course**:

| | |
|---|---|
| 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 (WK1 to WK4). |
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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 (WK1, WK5, and WK7). |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Engineering Mechanics | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| UCR | ME1004 | | 2-0-0 | 2 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to provide knowledge of statics with focus on force equilibrium, free body diagrams, concepts of mass moment of inertia, and elementary idea of kinematics of a particle and forces in nature including curvilinear motion, which are required for solving various engineering problems. |
| **Pre-Requisites** | Knowledge of physics & mathematics and basic analytical skills is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

### Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

### Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | **Introduction**: Basic concepts of vector analysis, equilibrium of forces in two and three dimensions, Basic principles of Equivalent Force system, Equations of equilibrium, Free body diagram, Moment of forces and its application; Description and applications of friction. | **7 Hours** |
| **Module-2** | **Virtual Work & Moment of Inertia**: Virtual Work, Centroid and Center of Gravity, Centroid of simple and composite sections; Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Area moment of inertia of standard and composite sections, Mass moment inertia of circular plate, Elementary concepts of stresses, and Stress-Strain behaviour. | **7 Hours** |
| **Module-3** | **Kinematics of Particles**: Rectilinear motion, Curvilinear motion; Use of cartesian & polar coordinate systems, Relative and constrained motion, Space curvilinear motion, Extension to cylindrical & spherical coordinate systems. | **7 Hours** |
| **Module-4** | **Dynamics of a Particle & Forces in Nature**: Newton's laws in describing particle motion, D'Alembert's Principle; Work and Energy, Impulse, Momentum and Angular Momentum; Solving Newton's equations of motion in polar coordinates; Kepler's Laws and satellite motion. | **7 Hours** |
| | Total | 28 Hours |

**Text Books**:
  T1. S. Timoshenko, D. H. Young, S. Pati, and J. V. Rao, *Engineering Mechanics*, 5th *Ed.*, McGraw-Hill Education, 2013.
  T2. M. K. Harbola, *Engineering Mechanics*, 2nd *Ed.*, Cengage Learning, 2018.
  T3. J. L. Meriam and L. G. Kraige, *Engineering Mechanics: Statics*, 8th *Ed.*, Wiley India, 2014.

**Reference Books**:
  R1. F. Beer, E. Johnston, D. Mazurek, P. Cornwell, and B. Self, *Vector Mechanics for Engineers: Statics and Dynamics*, 10th *Ed.*, McGraw Hill, 2019.
  R2. G. H. Ryder, *Strength of Materials*, 3rd *Ed.*, Macmillan Press, 1969.
  R3. D. Kleppner and R. Kolenkow, *An Introduction to Mechanics*, 1st *Ed.*, McGraw Hill, 2017.

**Online Resources**:
  1. https://nptel.ac.in/courses/122104015/: by Prof. M. Harbola, IIT Kanpur.
  2. https://nptel.ac.in/courses/112106286/: by Prof. K. Ramesh, IIT Madras

**Course Outcomes**: *At the end of this course, the students will be able to:*

| | |
|---|---|
| CO1 | Apply the principles of mechanics to solve problems in statics. |
| CO2 | Compute virtual work, area & mass moment of inertia, and explain stress-strain behaviour. |
| CO3 | Use appropriate coordinate systems to explain and analyze motion of particles. |
| CO4 | Describe the mechanics of deformable bodies and mechanical properties of materials. |

**Program Outcomes Relevant to the Course**:

| | |
|---|---|
| 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 (WK1 to WK4). |
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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 (WK1, WK5, and WK7). |
| PO7 | **Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9) |
| PO8 | **Individual & 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 2 | 1 | | | | 2 | 3 | 2 | | | |
| CO2 | 3 | 3 | 3 | 3 | 2 | | | | 2 | 3 | 2 | | | |
| CO3 | 2 | 2 | 2 | 2 | 3 | 1 | 1 | 1 | 2 | 3 | 2 | 3 | 3 | |
| CO4 | 1 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 3 | 3 | 2 | 2 | 2 | 1 |

| Category | Code | Engineering Thermodynamics | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| UCR | ME1002 | | 2-0-0 | 2 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to introduce laws of thermodynamics with emphasis on various equilibrium processes and their applications in practical domains like power plants, refrigerators and internal combustion engines. |
| **Pre-Requisites** | Knowledge of physics & mathematics and basic analytical skills is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | Introduction, Basic concepts, System, Control volume, Surrounding, Boundaries, Universe, Types of systems, Macroscopic and microscopic viewpoints, Concept of continuum, Thermodynamic equilibrium, State, Property, Process, Exact & inexact differentials, Point & path functions, Cycle, Quasi-static process, Reversibility and irreversibility, Pressure measurement, Zeroth law of thermodynamics, Temperature, Principles of thermometry, Constant volume gas thermometer, Temperature scale. | 7 Hours |
| **Module-2** | Pure Substances, p-v, T-v, T-s and h-s diagrams, Phase Transformations, Triple point and critical state, properties during change of phase, Dryness Fraction, Property tables. Brief discussionon the First law for cycle, closed system and open system (steady flow energy equation, SFEE), Perpetual Motion Machines, PMM1. | 7 Hours |
| **Module-3** | Introduction to Second Law of Thermodynamics, Kelvin-Planck and Clausius' Statements and their Equivalence, Corollaries, PMM2, Carnot's Principle and Cycle, Entropy, Clausius' Inequality, Principle of Entropy and its application, T-s plot. | 7 Hours |
| **Module-4** | Applications of Thermodynamics, Brief description and working principles of Steam Power Plant, Refrigerators and Heat pump, I.C. Engines (two-stroke and four-stroke, petrol and diesel) and Aircraft Propulsion Engines, Brayton Cycle, Rankine Cycle, Comparison. | 7 Hours |
| | Total | 28 Hours |

**Text Books**:
 T1. R. E. Sonntag and C. Borgnakke, *Fundamentals of Thermodynamics*, 7th *Ed.*, John Wiley, 2014.
 T2. Y. A. Cengel and M. A. Boles, *Thermodynamics – An Engineering Approach*, 7th *Ed.*, McGraw-Hill Education,2011.

**Reference Books**:
 R1. P. K. Nag, *Engineering Thermodynamics*, 5th *Ed.*, McGraw-Hill Education, 2013.
 R2. Y. V. C. Rao, *An Introduction to Thermodynamics*, 2nd *Ed.*, University Press, 2004.

P.T.O

**Online Resources**:
1. https://nptel.ac.in/courses/112105123/: by Prof. S. Chakraborty, IIT Kharagpur
2. https://www3.nd.edu/~powers/ame.20231/notes.pdf
3. https://ocw.mit.edu/courses/chemistry/5-60-thermodynamics-kinetics-spring-2008/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| | |
|---|---|
| CO1 | Articulate the concepts of thermodynamic properties, equilibrium, temperature and pressure. |
| CO2 | Apply first laws of thermodynamics to analyze turbine, compressors, heat exchangers and nozzles by using steam table and ideal gas equation. |
| CO3 | Analyze the limitations of the First law and evaluate the available energy and irreversibility. |
| CO4 | Analyze power cycles and refrigeration cycles and their applications in the real world. |

**Program Outcomes Relevant to the Course**:

| | |
|---|---|
| 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 (WK1 to WK4). |
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 1 | 2 | | | | | | 2 | 2 | 2 | 2 |
| CO2 | 3 | 3 | 2 | 2 | 1 | | | | | | 2 | 3 | 3 | 2 |
| CO3 | 3 | 3 | 3 | 3 | 2 | | | | | | 3 | 2 | 3 | 2 |
| CO4 | 3 | 3 | 3 | 2 | 2 | | | | | | 2 | 3 | 2 | 1 |

| Category | Code | Computer Programming | L-T-P | Credit | Marks |
|----------|------|------------------------|-------|--------|-------|
| UCR | CS1001 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to introduce fundamentals of computer programming using the C programming language starting with simple programs to advanced topics like structures, pointers, file processing and pre-processor directives for solving various engineering problems through computer programming. |
| **Pre-Requisites** | Basic analytical and logical understanding including basic knowledge and usage of computers is required for this course. Prior experience with any other programming language will be beneficial. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|------------|----------------------|----------|----------|-------|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|----------|--------|-------|
| **Module-1** | Introduction to computers and programming, operating system, compilers, interpreters, algorithm, flowchart, pseudocode etc., structure of C program, character set, identifier, keywords, constants, variables, data types, operators, expressions, statements, operator precedence and associativity, type conversion, input/output statements. | **8 Hours** |
| **Module-2** | Decision making and branching: if, if-else, nested if-else, else-if ladder and switch constructs, iterative execution of code using loops: while, for, do-while, nested loops, controlling loop behavior using jump statements (break, continue, goto) and exit statements. | **8 Hours** |
| **Module-3** | Arrays (1-D & 2-D), declaration and initialization of arrays, accessing array elements, operations on arrays - insertion, deletion, searching, sorting (selection sort), merging etc., character arrays and strings, initialization, input & output of strings, operations on strings, array of strings, string handling functions. | **9 Hours** |
| **Module-4** | User-defined functions, declaration and definition, parameter passing by value, functions returning values, idea on call by reference, passing arrays to functions, recursion, storage classes - auto, register, static, extern, Structures and Unions - definition, initialization, accessing members, array of structures, arrays within structures, structures and functions, self-referential structures. | **9 Hours** |
| **Module-5** | Understanding pointers, declaration, initialization, accessing variables using pointers, pointer expressions, scale factor, chain of pointers, using pointers with arrays, strings, functions and structures, dynamic memory management, pre-processor directives, command line arguments, basics of file handling. | **8 Hours** |
| | Total | 42 Hours |

**Text Books**:
T1. E. Balagurusamy, ***Programming in ANSI C***, 7th *Ed.*, McGraw-Hill Education, 2017.
T2. Y. Kanetker, ***Let Us C***, 16th *Ed.*, BPB Publications, 2018.

**Reference Books**:

R1. B. W. Kernighan and D. M. Ritchie, **The C Programming Language**, 2nd *Ed.*, Pearson Education, 2015.
R2. H. Schildt, **C: The Complete Reference**, 4th *Ed.*, McGraw-Hill, 2017.
R3. A. Kelley and I. Pohl, **A Book on C**, 4th *Ed.*, Pearson Education, 2008.
R4. B. Gottfried, **Schaum's Outline of Programming with C**, 3rd *Ed.*, McGraw-Hill, 2017.

**Online Resources**:

1. https://nptel.ac.in/courses/106104128: by Prof. S. Nandakumar, IIT Kanpur
2. https://nptel.ac.in/courses/106105171: Prof. A. Basu, IIT Kharagpur
3. https://nptel.ac.in/courses/106106210: by Prof. J. Viraraghavan, IIT Madras
4. http://www.stat.cmu.edu/~hseltman/c/CTips.html
5. http://www.c-faq.com/
6. https://www.learn-c.org/
7. http://www2.its.strath.ac.uk/courses/c/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Formulate logic of a problem and write C programs using variables, expressions and I/O. |
|---|---|
| CO2 | Develop structured C programs involving decision making using different control constructs. |
| CO3 | Solve problems involving similar set of data items and write C programs using arrays. |
| CO4 | Design modular C programs and handle heterogeneous data items using structures & unions. |
| CO5 | Develop complex C programs with file processing using advanced features of C programming. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|---|---|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Constitution of India & Professional Ethics | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| UMC | HS0001 | | 3-0-0 | 0 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this mandatory course is to provide understanding of basic concepts of Indian Constitution and various organs created by the constitution including their functions. This course also introduces a holistic perspective towards life by understanding of the human reality and the rest of existence. |
| **Pre-Requisites** | Basic knowledge of Indian history, overall idea on India's political system, a positive bent of mind, zeal to know the essence of human existence and nature. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required and each session is planned to be interactive. |

### Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

### Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | Introduction to Indian Constitution, Preamble, Salient Features, Fundamental Rights, Fundamental Duties, Features of Federal Structure, The Union Legislature – The Parliament, The Lok Sabha and Rajya Sabha, Composition, Powers and Functions. | 9 Hours |
| **Module-2** | Union Executive, President of India (with powers and functions), Vice-President, The Council of Ministers and the Prime Minister – Powers and Functions; State Government, The State Legislature -– Composition, Powers and Functions, State Executive – Governor, Chief Minister, and State Council of Ministers. | 9 Hours |
| **Module-3** | Professional Ethics, Basic terms – Moral, Ethics, Ethical Dilemma, Emotional Intelligence, View on Ethics by Aristotle, Governing Factors of an Individual's Value System, Personal and Professional Ethics. | 7 Hours |
| **Module-4** | Profession, Professional, Professionalism, Professional Accountability, Professional Risks, Profession and Craftsmanship, Conflict of Interest, Ethics in Engineering – Purpose and Concept of Engineering Ethics, Engineering as Social Experimentation, Issues in Engineering Ethics, Engineers' Responsibility – Safety & Risk, Risk-Benefit Analysis, Causes of an Accident, Preventive Measures. | 9 Hours |
| **Module-5** | Value Education, Self-exploration as the Process for Value Education, Basic Human Aspirations – Continuous Happiness and Prosperity, Current Scenario, Method to Fulfill the Basic Human Aspirations, Harmony in the Human Being, Family, Society and Nature or Existence. | 8 Hours |
| | Total | 42 Hours |

**Text Books**:
- T1. D. D. Basu, *Introduction of Constitution of India*, 22nd *Ed.*, LexisNexis, 2015.
- T2. R. Subramanian, *Professional Ethics*, 2nd *Ed.*, Oxford University Press, 2017.
- T3. R. R. Gaur, R. Asthana, and G. P. Bagaria, *A Foundation Course in Human Values and Professional Ethics*, 2nd *Ed.*, Excel Books, 2019..

**Reference Books**:
- R1. M. Laxmikanth, *Indian Polity*, 5th *Ed.*, McGraw Hill, 2011.

R2.  K. Subas, *An Introduction to India's Constitution and Constitutional Law*, 5<sup>th</sup> *Ed.*, National Book Trust India, 2011.

R3.  C. E. Harris, M. S. Pritchard, and M. J. Robins, *Engineering Ethics – Concepts and Cases*, 4<sup>th</sup> *Ed.*, Cengage Learning, 2012.

R4.  A. N. Tripathi, *Human Values*, 3<sup>rd</sup> *Ed.*, New Age International, 2019.

**Online Resources**:

1. https://nptel.ac.in/courses/129106411: by Prof. S. Bhat, IIT Madras
2. https://www.india.gov.in/sites/upload_files/npi/files/coi_part_full.pdf
3. https://www.india.gov.in/my-government/constitution-india/constitution-india-full-text

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Describe basics of Indian constitution, fundamental laws and rights of Indian citizen. |
|-----|-----|
| CO2 | Articulate the union executive system and constitutional institutions of center and state. |
| CO3 | Understand basic purpose of profession, professional ethics and various moral and social issues. |
| CO4 | Realize the rights, responsibilities, and ethical principles of an Engineer at various levels. |
| CO5 | Understand importance of human values and live with harmony in family, society, and nature. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1, WK5, and WK7). |
|-----|-----|
| PO7 | **Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9) |
| PO8 | **Individual & 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Environmental Science & Engineering | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| UMC | CH0001 | | 3-0-0 | 0 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to introduce essential aspects of environmental science for engineering students. The course covers ecology, ecosystems, air and water pollution, management of municipal solid wastes, hazardous wastes and e-waste, along with environmental laws and UN conferences. |
| **Pre-Requisites** | Basic knowledge of physics, chemistry and biology is required for this course. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required with focus on importance of environment, examples and case studies. |

### Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

### Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | Ecology, Ecosystems and Biogeochemical Cycles: Introduction to environmental science and engineering, Ecological perspective, Ecosystems and processes, Trophic pyramids, Biodiversity of species, Water, Oxygen, Nitrogen and Carbon cycle, Environmental gradient and tolerance levels of environmental factors. | **9 Hours** |
| **Module-2** | Water and Wastewater Treatment: Water quality standards and parameters, water table, aquifer, pre-treatment, conventional treatment processes of water, DO, BOD, COD and microbial wastewater treatment. | **9 Hours** |
| **Module-3** | Atmospheric Chemistry, Soil Chemistry and Noise Abatement: Atmospheric chemistry, air pollution and associated control equipment, climate change, soil chemistry, noise standards, noise measurement and noise abatement. | **8 Hours** |
| **Module-4** | Waste Management: Types and management of MSW (Municipal Solid Waste), hazardous waste and e-waste, Introduction to LCA (Life Cycle Assessment). | **8 Hours** |
| **Module-5** | EIA, EIS, Environmental Laws and Human Health: Environmental Audit, EIA (Environmental Impact Assessment), EIS (Environmental Impact Statement), Indian environmental laws, UN Conferences, Human population and the environment. | **8 Hours** |
| | Total | **42 Hours** |

**Text Books**:
  T1. G. M. Masters and W. P. Ela, *An Introduction to Environmental Engineering and Science*, 3rd *Ed.*, PHI Learning, 2015.
  T2. G. Kiely, *Environmental Engineering*, Spl. Indian Edition, McGraw Hill, 2007.

**Reference Books**:
  R1. M. L. Davis and S. J. Masten, *Principles of Environmental Engineering and Science*, 2nd *Ed.*, McGraw-Hill, 2017.
  R2. H. D. Kumar and U. N. Dash, *Environmental Studies*, 2nd *Ed.*, IndiaTech Publishers, 2017.

**Online Resources**:
  1. http://nptel.ac.in/courses/120108002/: Aquatic Biodiversity and Environmental Pollution.
  2. http://nptel.ac.in/courses/120108004/: Environment Management.

3. http://nptel.ac.in/courses/120108005/: Municipal Solid Waste Management.
4. https://www.epa.gov/environmental-topics/: All Current Environmental Issues.

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Describe the concepts of ecology, ecosystems, and biogeochemical cycles in the environment. |
|-----|---------------------------------------------------------------------------------------------|
| CO2 | Explain the process of water and wastewater treatment for prevention of water pollution. |
| CO3 | Understand the pollutants in the environment and explore the principles for their eradication. |
| CO4 | Explore waste minimization and management of different types of wastes generated. |
| CO5 | Understand EIA, EIS, and other environmental laws for prevention of pollution. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|-----|-------------------------------------------------------------------------------------------|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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 (WK1, WK5, and WK7). |
| PO7 | **Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9) |
| PO8 | **Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams. |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Probability & Statistics | L-T-P | Credit | Marks |
|----------|------|--------------------------|-------|--------|-------|
| UCR | MT1002 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to familiarize the perspective engineers with the knowledge and concepts of probability and statistics which are essential to study non-deterministic systems. |
| **Pre-Requisites** | Basics of sets, counting techniques, differential and integral calculus of one variable and coordinate geometry of two and three dimensions. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

### Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|------------|----------------------|----------|----------|-------|
| 10 | 20 | 20 | 50 | 100 |

### Detailed Syllabus

| Module-# | Topics | Hours |
|----------|--------|-------|
| **Module-1** | Measures of central tendencies, Elementary probability, Conditional probability, Bayes' Rule (related problems only), Random variable, Binomial & Hypergeometric distribution, Mean and variance. | **8 Hours** |
| **Module-2** | The Poisson approximation to Binomial Distribution, Poisson Process, Geometric Distribution & Multinomial Distribution, Continuous random variables, Normal Distribution, Normal Approximation to the Binomial Distribution, Uniform Distribution, Exponential Distribution, Joint Discrete Distribution. | **9 Hours** |
| **Module-3** | Populations and Samples, Sampling Distribution of Mean ($\sigma$ known), Sampling Distribution of Mean ($\sigma$ unknown) & Sampling Distribution of Variance; Point Estimation of mean, Interval Estimation of mean, Tests of hypotheses and errors involved, Hypotheses concerning one mean, Inference concerning two mean, Estimation of variance, Hypotheses concerning one variance, Hypotheses concerning two variances. | **10 Hours** |
| **Module-4** | Estimation of Proportions, Hypotheses Concerning proportion (one & several), Analysis of $r \times c$ table (Contingency table), Goodness of fit. | **7 Hours** |
| **Module-5** | The method of least squares, Inferences based on the least square estimation, Curvilinear Regression, Checking the adequacy of the model, Correlation, Analysis of Variance, General principle, Completely Randomized Design, Randomized Block Design. | **8 Hours** |
| | Total | **42 Hours** |

**Text Books**:
  T1. R. A. Johnson, **Miller & Freund's - Probability and Statistics for Engineers**, 8<sup>th</sup> *Ed.*, PHI Learning, 2011.

**Reference Books**:
  R1. W. Mendenhall, R. J. Beaver, and B. M. Beaver, **Probability and Statistics**, 14<sup>th</sup> *Ed.*, Cengage Learning, 2014.
  R2. R. E. Walpole, R. H. Myers, S. L. Myers, and K. E. Ye, **Probability & Statistics for Engineers & Scientists**, 9<sup>th</sup> *Ed.*, PHI Learning, 2012.

**Online Resources**:
1. https://nptel.ac.in/courses/111/105/111105041/: by Prof. S. Kumar, IIT Kharagpur
2. https://ocw.mit.edu/courses/mathematics/18-440-probability-and-random-variables-spring-2014/lecture-notes/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Apply the concepts of probability and random variables to evaluate probabilities of events. |
|-----|---------------------------------------------------------------------------------------------|
| CO2 | Apply different discrete and continuous probability models to solve real life problems. |
| CO3 | Apply the concepts of sampling to estimate population parameters and test hypothesis. |
| CO4 | Test the goodness of a model and apply it to real life problems. |
| CO5 | Apply regression model and ANOVA to study the characteristics of data sets. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|-----|------|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Data Structures & Algorithms | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| UCR | CS1003 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | To understand the abstract data types and to solve problems using data structures such as stacks, queues, linked lists, hash tables, binary trees, heaps, binary search trees, graphs and writing programs for these solutions. |
| **Pre-Requisites** | Knowledge of programming in C, specifically on structures, pointers, functions, recursion etc., are required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

### Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

### Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | Introduction to data structures, classification of data structures, algorithmic notation, complexity of algorithms, asymptotic notations, abstract data types. Arrays - introduction, representation of arrays (row and column major representation), basic operations on array (traverse, insert, delete, search), sparse matrix, representation of sparse matrix using triplet form, operations on sparse matrix (addition, transpose) | **8 Hours** |
| **Module-2** | ADT Stack - stack model, representation of stack using array, basic operations with analysis, applications- recursion, and conversion of infix to post fix expression, evaluation of postfix expression. ADT Queue - queue model, representation using array, basic operations with analysis, circular queue, introduction to priority queue and double ended queue. | **8 Hours** |
| **Module-3** | Linked list - introduction, types of linked list (single, double, circular), representation in memory, operations on linked list (traverse, search, insert, delete, sort, merge) in each type with analysis. Representation of polynomial and its operations (addition, multiplication), implementation of stack and queue using linked list. | **9 Hours** |
| **Module-4** | Tree - terminology, representation, binary tree - tree traversal algorithms with and without recursion. Binary search tree, Operations on Binary Search Tree with analysis, threaded binary tree, general tree, Height balanced tree (AVL tree), m-way search trees, B-trees. Graph - terminology, representation (adjacency matrix, incidence matrix, path matrix, linked representation), graph traversal (BFS, DFS), Dijkstra's single source shortest path algorithm, Warshall's all pair shortest path algorithm, topological sort. | **9 Hours** |
| **Module-5** | Sorting algorithms - bubble sort, selection sort, insertion sort, quick sort, merge sort, radix sort, heap sort. Hashing- hash functions and hashing techniques. collision resolution techniques- linear probing, quadratic probing, chaining. | **8 Hours** |
| | Total | **42 Hours** |

**Text Books**:

T1.  M. A. Weiss, *Data Structures and Algorithm Analysis in C*, 2nd *Ed.*, Pearson Education, 2002.

T2.  E. Horowitz, S. Sahni, S. A-Freed, *Fundamentals of Data Structures in C*, 2nd *Ed.*, Univ. Press, 2008.

**Reference Books**:

R1. A. M. Tenenbaum, Y. Langsam, and M. J. Augenstein, *Data Structures Using C*, 3rd *Ed.*, Pearson Education, 2007.

R2. J. P. Tremblay and P. G. Sorenson, *An Introduction to Data Structures with Applications*, 2nd *Ed.*, McGraw Education, 2017.

R3. S. Lipschutz, *Data Structures*, 1st *Revised Ed.*, McGraw Education, 2014.

**Online Resources**:

1. https://nptel.ac.in/courses/106/106/106106127/: By Prof. H. A. Murthy, Prof. S. Balachandran, and Dr. N. S. Narayanaswamy, IIT Madras
2. https://nptel.ac.in/courses/106/102/106102064/: By Prof. N. Garg, IIT Delhi
3. https://nptel.ac.in/courses/106/106/106106130/: By Dr. N. S. Narayanaswamy, IIT Madras
4. https://www.geeksforgeeks.org/data-structures/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Analyze performance of algorithms and implement operations on arrays and sparse matrices. |
|-----|-----|
| CO2 | Apply the basic operations of stacks and queues to solve real world problems. |
| CO3 | Implement different types of linked list operations and their applications. |
| CO4 | Represent data using trees & graphs to use them in various real life applications. |
| CO5 | Analyze various sorting algorithms and explore different hashing techniques. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|-----|-----|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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 (WK1, WK5, and WK7). |
| 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. (WK8) |

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**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Basic Electronics Engineering Lab | L-T-P | Credit | Marks |
|----------|------|-----------------------------------|-------|--------|-------|
| UCR | EC1002 | | 0-0-2 | 1 | 100 |

| Objectives | The objective of this practical course if to learn the concepts and functionalities of the electronic devices, tools and instruments. Students will understand general specifications and deployability of the electronic devices and assemblies, and also develop confidence in handling and usage of electronic devices, tools and instruments in engineering applications. |
|------------|---|
| Pre-Requisites | Knowledge on intrinsic and extrinsic Semiconductors, Physics and Chemistry of Higher Secondary Science level. |
| Teaching Scheme | Regular laboratory experiments to be conducted under the supervision of teachers and demonstrators with the help of ICT, as and when required along with pre-lab session and demonstration for each experiment. |

## Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test / Mini Project | Viva-voce | Total |
|------------|-------------------|------------|-------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

## Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|-----------------------|
| 1 | Identification of electronic components and devices (Testing of semiconductor diodes and transistors using digital multi-meter). |
| 2 | Understand and use oscilloscope, signal generator to view waveforms and measure amplitude and frequency of a given waveform. |
| 3 | Generate V-I characteristics of semiconductor diode and determine its DC and AC resistances. |
| 4 | Implement clipper circuits (positive clipper and negative clippers) and observe its output waveforms and compare them with theoretically analyzed results. |
| 5 | Design half-wave and full-wave rectifier circuits without and with capacitor filter, record the waveforms and measure average & RMS values of the rectified output. |
| 6 | Generate and analyze the static characteristics of BJT in CE configuration. |
| 7 | Design the DC biasing (Fixed) circuit of transistor in CE configuration and determine its operating point. |
| 8 | Analyze the static characteristics of FET in CS configuration. |
| 9 | Apply Op-Amp in inverting, non-inverting, integrating and differentiating configurations & record their input-output waveforms. |
| 10 | Understand and verify truth tables of various logic gates. |
| 11 | Apply NAND and NOR as Universal logic gates. |
| 12 | Analyze and implement of R.C phase shift Oscillator using Op-AMP. |
| 13 | Design and simulate BJT and FET I/O characteristics using OrCAD PSpice/ Multisim. |
| 14 | Design and analysis of AM modulator and demodulator. |

**Text Books**:
  T1. R. L. Boylestad and L. Nashelsky, *Electronic Devices and Circuit Theory*, 11th *Ed.*, Pearson Education.
  T2. A. S. Sedra and K. C. Smith, *Microelectronic Circuits*, 7th *Ed.*, Oxford University Press.

**Reference Books**:

R1. V. K. Mehta and R. Mehta, *Principles of Electronics*, 3$^{rd}$ *Ed.*, S. Chand Publishing, 1980.

**Online Resources**:

1. http://vlab.co.in/ba_labs_all.php?id=1
2. http://iitg.vlab.co.in/?sub=59&brch=165

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Recognize electronic components, measuring instruments, semiconductor diodes and their use. |
|-----|-----------------------------------------------------------------------------------------------|
| CO2 | Determine the characteristics of transistors and use them in various electronic circuits. |
| CO3 | Explore design and testing of Op-Amp and design circuits for various applications using them. |
| CO4 | Design and test digital circuits using logic gates for different applications. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|-----|------------------------------------------------------------------------------------------------------------|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

|     | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 | PSO3 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|
| CO1 | 2 | 2 | 1 | | | | | | | | | 2 | 2 | 2 |
| CO2 | 3 | 3 | 2 | 1 | | | | | | | | 3 | 3 | 2 |
| CO3 | 2 | 2 | 2 | 1 | | | | | | | 2 | 3 | 2 | 2 |
| CO4 | 2 | 2 | 3 | | | | | | | | 2 | 3 | 3 | 2 |

| Category | Code | Basic Electrical Engineering Lab | L-T-P | Credit | Marks |
|----------|------|----------------------------------|-------|--------|-------|
| UCR | EE1002 | | 0-0-2 | 1 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this practical course is to expose the students to different electrical components and basic safety rules and regulations, give hands on practice about different measuring and protection equipment and their operations to understand and verify the concept of electrical & magnetic circuits and electric machines. |
| **Pre-Requisites** | Basic knowledge of different electrical components and different analysis techniques of electrical and magnetic circuits. Topics taught in Basic Electrical Engineering theory class are essential to conduct the experiments. |
| **Teaching Scheme** | Regular laboratory experiments conducted under supervision of the teacher. Demonstration will be given for each experiment. |

## Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test / Mini Project | Viva-voce | Total |
|-----------|-------------------|------------|-------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

## Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|------------------------|
| 1 | Measurement of power consumption & power factor of a fluorescent lamp and its power factor improvement. |
| 2 | Measurement of winding resistances of a DC compound machine. |
| 3 | Power & power factor measurement of three-phase load by two-wattmeter method. |
| 4 | Connection and testing of a single-phase energy meter. |
| 5 | Determination of open circuit characteristics (OCC) of a DC shunt generator. |
| 6 | Calculation of power & power factor in series R-L-C circuit excited by single-phase supply. |
| 7 | Determination of no-load parameters through OC Test of single-phase transformer. |
| 8 | Study of capacitor start and run single-phase induction motor/fan motor. |
| 9 | Study and verification of Thevenin's Theorem and Norton's Theorem. |
| 10 | Draw the B-H curve of a magnetic Specimen. |
| 11 | Starting of three-phase induction motor. |
| 12 | Voltage Regulation & efficiency of single-phase transformer by direct loading. |

**Text Books:**
 T1.  A. Husain, *Fundamentals of Electrical Engineering*, 4th *Ed.*, Dhanpat Rai & Co., 2016.
 T2.  B. L. Thereja & A. K. Thereja, *A Textbook of Electrical Technology*, 23rd *Ed.*, S. Chand & Co.

**Reference Books**:
 R1.  J. B. Gupta, *A Textbook of Electrical Science*, S. K. Kataria & Sons, 2013.
 R2.  B. R. Gupta and V. Singhal, *Electrical Science*, S. Chand & Co, 2005.

**Online Resources**:
 1.  https://nptel.ac.in/courses/108/105/108105053/: by Prof. G. D. Roy, Prof. N. K. De, and Prof. T. K. Bhattacharya, IIT Kharagpur
 2.  https://nptel.ac.in/courses/108/108/108108076/: By Prof. L. Umanand, IISc Bangalore
 3.  https://www.electrical4u.com/
 4.  www.electronics-tutorials.ws/dc-circuits

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Get an exposure to common electrical components and their ratings. |
|---|---|
| CO2 | Develop electrical circuits and measure its characteristics using different measuring instruments and deploy different protective devices of appropriate ratings. |
| CO3 | Understand the usage of common electrical measuring instruments. |
| CO4 | Understand the basic characteristics of transformers and electrical machines. |
| CO5 | Verify different network theorems and magnetic properties. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|---|---|
| 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 (WK8). |
| 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 (WK1, WK5, and WK7). |
| PO8 | **Individual & 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Computer Programming Lab | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| UCR | CS1002 | | 0-0-4 | 2 | 100 |

| | |
|---|---|
| **Objectives** | To enable the students to analyze problems, formulate and implement solutions using the C programming language. The students will write C programs using proper logic to solve a problem and execute them on a computer. |
| **Pre-Requisites** | Basic analytical and logical understanding including basic knowledge and usage of computers is required for this course. |
| **Teaching Scheme** | Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of programming assignments. |

## Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test / Mini Project | Viva-voce | Total |
|---|---|---|---|---|---|
| 10 | 30 | 15 | 30 | 15 | 100 |

## Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|---|---|
| 1 | Introduction to computers and Linux operating system. |
| 2, 3 | Get acquainted with the programming environment - Linux commands and VI-editor. |
| 4 | Editing, compiling, executing, and debugging of simple C programs. |
| 5 | Programs using operators and formatted input/output statements. |
| 6 | Decision making using `if`, `if-else`, `else-if` ladder, nested `if`. |
| 7 | Decision making using `switch-case` construct. |
| 8, 9 | Loop control structure (`while`, `do-while`, `for`) with jump statements. |
| 10 | Nested loops (printing various formats) |
| 11, 12 | 1-D arrays including operation like searching, sorting, merging etc. |
| 13 | Handling 2-D arrays such as matrix operations. |
| 14, 15 | Programs on strings using various string handling functions (library functions) |
| 16, 17 | Designing user-defined functions. |
| 18, 19 | Programs on recursion. |
| 20 | Designing user defined functions for string manipulation. |
| 21 | Passing arrays (both 1D and 2D) to functions. |
| 22, 23 | Structure, array of structure, nested structure. |
| 24 | Dynamic memory management. |
| 25 | Self-referential structure (create and display operation of single linked list) |
| 26, 27 | File handling - reading from and writing to files. |
| 28 | Command-line argument, pre-processor directives. |

**Text Books**:

T1. E. Balagurusamy, **Programming in ANSI C**, 7th *Ed.*, McGraw-Hill Education, 2017.

T2. Y. Kanetker, **Let Us C**, 16th *Ed.*, BPB Publications, 2018.

**Reference Books**:

R1. B. W. Kernighan and D. M. Ritchie, **The C Programming Language**, 2nd *Ed.*, Pearson Education, 2015.

R2. H. Schildt, **C: The Complete Reference**, 4th *Ed.*, McGraw-Hill, 2017.

R3. A. Kelley and I. Pohl, **A Book on C**, 4th *Ed.*, Pearson Education, 2008.

R4. B. Gottfried, ***Schaum's Outline of Programming with C***, 3rd *Ed.*, McGraw-Hill, 2017.

**Online Resources**:
1. https://www.w3resource.com/c-programming-exercises/
2. https://www.includehelp.com/c-programming-examples-solved-c-programs.aspx
3. https://www.onlinegdb.com/online_c_compiler
4. https://www.tutorialspoint.com/compile_c_online.php

**Course Outcomes**: *At the end of this course, the students will be able to:*

| | |
|---|---|
| CO1 | Construct C programs for mathematical operations using control statements. |
| CO2 | Develop C programs for Array and String manipulation. |
| CO3 | Construct modular programs for better maintenance and reusability. |
| CO4 | Manipulate heterogeneous data using structure and union. |
| CO5 | Create and manipulate files using C programs. |

**Program Outcomes Relevant to the Course**:

| | |
|---|---|
| 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 (WK1 to WK4). |
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Communicative & Technical English | L-T-P | Credit | Marks |
|----------|------|-----------------------------------|-------|--------|-------|
| SEC | HS1001 | | 0-0-4 | 2 | 100 |

| Objectives | The objectives of this laboratory course are to provide practice sessions to enhance students' communication ability in the four language skills with focus on technical communication. |
|------------|---|
| Pre-Requisites | Basic knowledge of general communication skills in english is required. |
| Teaching Scheme | Regular laboratory classes with various tasks designed to facilitate technical communication through pair and/or team activities with regular assessments, presentations, discussions, role-playing, audio-visual supplements, writing activities, business writing practices and vocabulary enhancement. |

## Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test / Mini Project | Viva-voce | Total |
|------------|-------------------|------------|-------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

## Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|-----------------------|
| 1 | Introduction to the course and diagnostic test. |
| 2 | JAM: content development, structuring and delivery. |
| 3 | Group presentation. |
| 4 | Effective Verbal Communication exercises: plain English, bias-free language, formal and informal style, usage etc. |
| 5 | Activities on non-verbal communication. |
| 6 | Sounds of English: Vowels and consonants. |
| 7 | Sounds of English: Transcription. |
| 8 | Sounds of English: Syllable and stress. |
| 9 | Sounds of English: Rhythm. |
| 10 | Sounds of English: Intonation I. |
| 11 | Sounds of English: Intonation II. |
| 12 | Role play on simulated business contexts considering different channels of business communication. |
| 13 | Listening comprehension. |
| 14 | Practice on elements of business writing. |
| 15 | Composing effective paragraphs with unity, coherence, cohesion, progression. |
| 16 | Process writing. |
| 17 | Writing memos. |
| 18 | Emails and email etiquette. |
| 19 | Business letter I. |
| 20 | Business letter II. |
| 21 | Error correction: usage and grammar. |
| 22 | Reading Comprehension I: Essay – skimming, scanning, inferential comprehension, critical reading. |
| 23 | Reading Comprehension II: Short story – Analysing the tone of the author. |

| Experiment-# | Assignment/Experiment |
|---|---|
| 24 | Reading Comprehension III: News editorial – Differentiating facts from opinion. |
| 25 | Reading Comprehension IV: Texts on Science and Technology – Identifying discourse markers. |
| 26 | Reading Comprehension V: Texts on Science and Technology – Intensive reading and note-taking. |
| 27 | Note-making and summary writing. |
| 28 | Verbal Advantage: vocabulary exercises. |

**Text Books**:
T1. M. A. Rizvi, *Effective Technical Communication*, 2nd *Ed.*, Tata McGraw Hill, 2017.
T2. M. Raman and S. Sharma, *Technical Communication: Principles and Practices*, 3rd *Ed.*, Oxford University Press, 2015.
T3. B. K. Das, K. Samantray, R. Nayak, S. Pani, and S. Mohaty, *An Introduction to Professional English & Soft Skills*, Cambridge Univ. Press, 2009.

**Reference Books**:
R1. J. Seeley, *The Oxford Guide to Effective Writing and Speaking: How to Communicate Clearly*, 3rd *Ed.*, Oxford University Press, 2013.
R2. S. Kumar and P. Lata, *Communication Skils*, Oxford University Press, 2011.
R3. T. Panigrahi, *Communicative Competence*, 1st *Ed.*, Notion Press, 2024.

**Online Resources**:
1. https://nptel.ac.in/courses/109/106/109106094/: by Prof. A. Iqbal, IIT Madras
2. https://nptel.ac.in/courses/109/104/109104031/: by Dr. T. Ravichandran, IIT Kanpur
3. https://ocw.mit.edu/courses/comparative-media-studies-writing/21w-732-5-introduction-to-technical-communication-explorations-in-scientific-and-technical-writing-fall-2006/download-course-materials/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Communicate with clarity, fluency and impact. |
|---|---|
| CO2 | Develop comprehensive understanding of communication concepts, its importance, types, barriers and principles. |
| CO3 | Communicate effectively in business set-ups. |
| CO4 | Compose coherent, clear and impactful business correspondences. |
| CO5 | Practice sub-skills of reading and become adept readers. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1, WK5, and WK7). |
|---|---|
| PO7 | **Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9) |
| PO8 | **Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams. |

*Cont'd...*

| | |
|---|---|
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Workbench Practices | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| UCR | EE1003 | | 0-0-2 | 1 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this practical course is to provide hands-on exposure on tools, fasteners, computers, electrical wiring, electronic components & instruments, soldering & desoldering, making of PCB, and using other advanced tools necessary for creating working models and prototypes for engineers of circuit branches. |
| **Pre-Requisites** | Familiarity with some hand tools used in home is desired. |
| **Teaching Scheme** | Regular experiments and jobs using tools and instruments under supervision of the teacher. Demonstration will be given for each experiment. |

## Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test / Mini Project | Viva-voce | Total |
|---|---|---|---|---|---|
| 10 | 30 | 15 | 30 | 15 | 100 |

## Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|---|---|
| 1 | General introduction & familiarity with tools (measuring, marking, holding, and cutting tools), Fitting (Limit, Fit, Tolerance) and Fastening (different types of screws, rivets, nuts & bolts). |
| 2 | Disassembling and assembling a Desktop Computer System and recognize its parts. |
| 3 | Study of cables, wires, switches, fuses, MCB, fuse carriers in an electrical network. |
| 4 | Study of earthing and electrical safety, demonstration of the precautionary steps adopted in case of electrical shocks. |
| 5 | Calculation of current and power for series and parallel connected lamp load. |
| 6 | Study and design of house wiring. |
| 7 | Study of digital measuring equipment and calculation of energy consumption in an electrical system. |
| 8 | Study of basic electronics & electrical components (such as Resistor, Capacitor, Inductor, Potentiometer, Diode, Transistor, Sensors, ICs, etc.) for circuit design. |
| 9 - 10 | Design PCB for the simulated design using KiCAD. |
| 11 | Assemble PCB with components using the assembling tools (such as Soldering iron, Desoldering pump, Pliers, Cutters, Wire strippers, Crimping tool, Micro-soldering, Hot air soldering and desoldering station etc.) |
| 12 | Testing and characterization of the assembled PCB using standard testing instruments: Multimeter, Digital Storage Oscilloscope (DSO), and Function generator etc. |

**Text Books**:
T1. B. H. Deshmukh, *Electrical Materials and Wiring Practices*, Nirali Prakashan, 2018.
T2. G. Haldar, *Electronics Course Book: Basic Components, IC boards, SMD, Logic Gates, Transistors, Resistors, Capacitors, Diodes, Audio Circuit and More*, GRPV Arts and Office Supplies, 2024.
T3. R. S. Khandpur, *Printed Circuit Boards: Design, Fabrication, Assembly and Testing*, 1st *Ed.*, McGraw Hill, 2006.

**Reference Books**:
R1. H. Joshi, *Residential, Commercial and Industrial Electrical Systems: Protection, Testing and Commissioning, Vol-3*, McGraw-Hill Education, 2008.

R2.  S. Monk, *Make Your Own PCBs with EAGLE: From Schematic Designs to Finished Boards*, 1ˢᵗ *Ed.*. McGraw-Hill, 2014.

R3.  J. Varterisian, *Fabricating Printed Circuit Boards*, 1ˢᵗ *Ed.*, Newnes, 2002.

R4.  A. Kemp, *The Makerspace Workbench: Tools, Technologies and Techniques for Making*, O'Reilly Media, 2013.

**Online Resources**:

1. https://bharatskills.gov.in/pdf/E_Books/Electrcian_SEM1_TP.pdf
2. https://bharatskills.gov.in/pdf/E_Books/Electrician_SEM2_TP.pdf
3. https://bharatskills.gov.in/Home/StudyMaterial?var=WSdYV6aWadK8jUuNKxoBWg==
4. https://onlinecourses.swayam2.ac.in/nou20_cs08/preview
5. https://www.lanl.gov/safety/electrical/docs/arc_flash_safety.pdf
6. https://www.ee.iitb.ac.in/~pcpandey/courses/ee616/pcblayout_c_aug07.pdf
7. https://nptel.ac.in/courses/108108157/
8. https://nptel.ac.in/courses/122106025/
9. https://nptel.ac.in/courses/108101091/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| | |
|---|---|
| CO1 | Utilize appropriate tools for various workbench jobs within their limits, fits, and tolerance. |
| CO2 | Disassemble and reassemble a computer System and identify the components. |
| CO3 | Identify and utilize common electrical components with proper safety mechanisms. |
| CO4 | Design house wiring and measure energy consumption using digital meters. |
| CO5 | Assemble PCB with basic electronics components, and use various measuring & testing tools. |
| CO6 | Use KiCAD for creating schematic diagrams and translating it into PCB layout. |

**Program Outcomes Relevant to the Course**:

| | |
|---|---|
| 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 (WK1 to WK4). |
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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 (WK1, WK5, and WK7). |
| PO7 | **Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9) |
| PO8 | **Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams. |

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| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 1 | 1 | 1 | 1 | 1 | | 1 | | | 1 | 1 | 1 | 1 | |
| CO2 | 1 | | | | 3 | | 2 | | 2 | | 1 | | | |
| CO3 | 2 | 1 | 2 | 1 | 2 | 1 | | 1 | 1 | 1 | 1 | | | |
| CO4 | 2 | 3 | 3 | 1 | 1 | 1 | | 1 | 2 | 2 | 2 | | | |
| CO5 | 2 | 2 | 3 | 2 | 1 | | | 2 | | | 1 | 2 | 1 | |
| CO6 | 1 | 2 | 3 | 2 | 2 | | | 2 | | | 1 | 1 | 2 | 1 |

| Category | Code | Engineering Graphics | L-T-P | Credit | Marks |
|----------|------|----------------------|-------|--------|-------|
| UCR | ME1003 | | 0-0-2 | 1 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this laboratory course is to learn engineering drawing standards, conventions & practices, develop drawing skills in 2D & 3D, and use computer-aided drawing software to create meaningful engineering drawings. |
| **Pre-Requisites** | Basic understanding of 2D and 3D geometry is required. |
| **Teaching Scheme** | Regular laboratory classes using drawing tools under supervision of the teacher. Demonstration will be given for each drawing assignment using both conventional and CAD software tools as per requirement. |

## Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test / Mini Project | Viva-voce | Total |
|------------|-------------------|------------|-------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

## Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|------------------------|
| 1 | Principles of Engineering Graphics and their significance (lettering & scale) and usage of Drawing instruments. |
| 2 | Orthographic projections, Principles of orthographic projections, Projections of points and lines. |
| 3 | Projections of different planes. |
| 4 | Projection of solids, 3D to 2D views, Machine component diagrams, Sectional views of simple and compound solid models. |
| 5 | Principles of Isometric projection, Isometric Scale & Views, Isometric views of planes and solids. |
| 6 | Development of surface and intersection of surfaces. |
| 7 | Engineering curves and conics. |
| 8 | Introduction to CAD software, its GUI, toolbars and commands, shortcut keys. |
| 9 | 2D drawing using basic tools, Draw & Modify menu commands of the CAD software. |
| 10 | Orthographic projection drawings of various models using CAD software. |
| 11 | Isometric drawing & 3D modeling in CAD, different solid editing options. |
| 12 | 3D modeling of simple & compound models, and machine components using CAD. |
| 13 | Introduction to 3D printing. |

**Text Books**:
T1. N. D. Bhat, M. Panchal, ***Engineering Drawing***, Charotar Publishing House, 2008.
T2. M. B. Shah, B. C. Rana, ***Engineering Drawing and Computer Graphics***, Pearson Education, 2008.
T3. S. Tickoo, ***AutoCAD 2020 Work Book***, BPB Publications, 2020.

**Reference Books**:
R1. R. K. Dhawan, ***A Text Book of Engineering Drawing***, S. Chand Publications, 2007.
R2. K. Venugopal, ***Engineering Drawing and Graphics***, 3rd *Ed.*, New Age International, 1998.

**Online Resources**:
1. http://nptel.ac.in/courses/112103019
2. https://nptel.ac.in/courses/112/102/112102101/
3. https://freevideolectures.com/course/3420/engineering-drawing

4. https://www.autodesk.in/campaigns/autocad-tutorials
5. https://help.autodesk.com/view/ACD/2020/ENU/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Understand and apply the concepts of lettering and dimensioning for drafting of machine drawings and building drawings and different drawing concepts. |
|-----|---|
| CO2 | Recognize and interpret orthographic projections of points, lines, planes, and solids, and visualize real-world objects from isometric, solid, and sectional views. |
| CO3 | Draw 2D engineering drawings using various draw and modify tools of CAD Software. |
| CO4 | Design various 3D models by using CAD Software. |
| CO5 | Describe the modern manufacturing methods like 3D printing. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|-----|---|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Data Structures & Algorithms Lab | L-T-P | Credit | Marks |
|----------|------|----------------------------------|-------|--------|-------|
| UCR | CS1003 | | 0-0-4 | 2 | 100 |

| | |
|---|---|
| **Objectives** | Develop skills to design and analyze simple linear and non linear data structures, strengthening the ability of students to identify and apply the suitable data structure for the given real world problem. |
| **Pre-Requisites** | Knowledge of programming in C, specifically on structures, pointers, functions, recursion etc., are required. |
| **Teaching Scheme** | Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise of programming assignments. |

## Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test / Mini Project | Viva-voce | Total |
|------------|-------------------|------------|-------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

## Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|-----------------------|
| 1 | Operations on arrays – insert, delete, merge. |
| 2 | Selection Sort, Bubble sort. |
| 3 | Linear Search and Binary search. |
| 4 | Representation of sparse matrix. |
| 5, 6 | Addition and transpose of sparse matrix. |
| 7 | Implementation of stack using array. |
| 8 | Conversion of infix to postfix expression. |
| 9 | Evaluation of postfix expression. |
| 10 | Operations of queue using array. |
| 11 | Operations of circular queue. |
| 12, 13 | Single linked list operations. |
| 14, 15 | Double linked list operations. |
| 16 | Circular linked list operations. |
| 17 | Stack using linked list. |
| 18 | Queue using linked list. |
| 19 | Polynomial addition using linked-list. |
| 20, 21 | Binary Search Tree operations. |
| 22, 23 | Graph traversal (BFS, DFS). |
| 24 | Warshall's shortest path algorithm. |
| 25, 26 | Implementation Insertion Sort and Quick Sort. |
| 27, 28 | Implementation of Merge Sort and Heap Sort. |

**Text Books**:

T1. E. Horowitz, S. Sahni, S. Anderson-Freed, *Fundamentals of Data Structures in C*, 2nd *Ed.*, Universities Press, 2008.

T2. M. A. Weiss, *Data Structures and Algorithm Analysis in C*, 2nd *Ed.*, Pearson Education, 2002.

**Reference Books**:

R1. A. K. Rath and A. K. Jagadev, *Data Structures Using C*, 2nd *Ed.*, Scitech Publication, 2011.

R2. Y. Kanetkar, **Data Structures Through C**, 2<sup>nd</sup> *Ed.*, BPB Publication, 2003.

**Online Resources**:
1. https://nptel.ac.in/courses/106/106/106106127/: By Prof. H. A. Murthy, Prof. S. Balachandran, and Dr. N. S. Narayanaswamy, IIT Madras
2. https://nptel.ac.in/courses/106/102/106102064/: By Prof. N. Garg, IIT Delhi
3. https://nptel.ac.in/courses/106/106/106106130/: By Dr. N. S. Narayanaswamy, IIT Madras

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Implement various operations on array and sparse matrix. |
|-----|----------------------------------------------------------|
| CO2 | Design functions to implement basic operations on stack & queue and apply them to solve real world problems. |
| CO3 | Implement single, double & circular linked list and apply them in various real life applications. |
| CO4 | Construct binary search tree and perform traversal, insertion, deletion, and search operations on it. |
| CO5 | Perform BFS and DFS traversal operations in a graph and implement various sorting and searching algorithms. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|-----|--|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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 (WK1, WK5, and WK7). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Corporate Communication Skills | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| SEC | HS1002 | | 0-0-4 | 2 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this laboratory course is to give students adequate practice in a simulated professional environment with focus on communication skills with professionalism in a typical corporate set up. |
| **Pre-Requisites** | Knowledge of communicative and technical english is required. |
| **Teaching Scheme** | Regular laboratory classes with various tasks designed to facilitate communication and soft skills through pair and/or team activities with regular assessments, presentations, discussions, role-playing, audio-visual supplements, writing activities, business writing practices and vocabulary enhancement. |

## Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test / Mini Project | Viva-voce | Total |
|---|---|---|---|---|---|
| 10 | 30 | 15 | 30 | 15 | 100 |

## Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|---|---|
| 1 | Aspects of Inter-cultural communication and cultural conditioning. |
| 2 | Barriers to cross-cultural communication. |
| 3 | Personality test and personality development. |
| 4 | Team work and its stages. |
| 5 | Team work and leadership: Simulation. |
| 6 | Negotiation skills: Role-play. |
| 7 | Persuasive presentation I. |
| 8 | Persuasive presentation II. |
| 9 | Writing a blog. |
| 10 | Vlog making and presentation I. |
| 11 | Vlog making and presentation II. |
| 12 | Emotional Intelligence: its importance in the workplace. |
| 13 | Time management. |
| 14 | Social media etiquette. |
| 15 | Business etiquette. |
| 16 | Assertiveness at work: Role-play. |
| 17 | Power point presentation I. |
| 18 | Power point presentation II. |
| 19 | Power point presentation III. |
| 20 | Power point presentation IV. |
| 21 | Mind mapping. |
| 22 | Creative and critical thinking for problem solving. |
| 23 | Six thinking hats: Problem solving and decision making in meetings. |
| 24 | Verbal Ability I: synonyms and antonyms. |
| 25 | Verbal Ability II: One word substitution. |

*Cont'd...*

| Experiment-# | Assignment/Experiment |
|---|---|
| 26 | Verbal Ability III: Error correction. |
| 27 | Verbal Ability IV: Odd one out. |
| 28 | Verbal Ability V: Analogy. |

**Text Books**:

T1. S. B. Bachu, **Corporate Communication Skills for Professionals**, 1st *Ed.*, White Falcon Publishing, 2021.

T2. M. A. Rizvi, **Effective Technical Communication**, 2nd *Ed.*, Tata McGraw-Hill, 2017.

T3. M. Raman and S. Sharma, **Technical Communication: Principles and Practice**, 3rd *Ed.*, Oxford University Press, 2015.

**Reference Books**:

R1. P. A. Argenti and J. Forman, **The Power of Corporate Communication: Crafting the Voice and Image of Your Business**, 1st *Ed.*, Tata McGraw-Hill, 2003.

R2. J. Seely, **The Oxford Guide to Writing and Speaking**, 3rd *Ed.*, Oxford University Press, 2013.

R3. B. K. Mitra, **Effective Technical Communication - A Guide for Scientists and Engineers**, 1st *Ed.*, Oxford University Press, 2006.

**Online Resources**:

1. https://archive.nptel.ac.in/courses/109/105/109105144/: by Prof. S. Singh, IIT Kharagpur
2. https://archive.nptel.ac.in/courses/109/106/109106129/: by Dr. Ay. I. Viswamohan, IIT Madras
3. https://archive.nptel.ac.in/courses/109/104/109104030/: by Dr. T. Ravichandran, IIT Kanpur
4. https://www.ef.com/wwen/english-resources/
5. https://owl.purdue.edu/owl/purdue_owl.html
6. https://www.usingenglish.com/
7. http://www.english-test.net

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Understand aspects of communication at the workplace and check the barriers. |
|---|---|
| CO2 | Hone persuasive communication skills. |
| CO3 | Enhance interpersonal communication at the corporate workplace. |
| CO4 | Make impactful group/solo presentations and communicate with clarity. |
| CO5 | Enhance verbal ability for better communication. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1, WK5, and WK7). |
|---|---|
| PO7 | **Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9) |
| PO8 | **Individual & 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. |

*Cont'd. . .*

| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Vector Calculus & Fourier Analysis | L-T-P | Credit | Marks |
|----------|------|-----------------------------------|-------|--------|-------|
| PCR | MT2003 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to provide the knowledge of vector calculus, partial differential equations & Fourier Transforms which are essential for study of various electrical systems. |
| **Pre-Requisites** | Knowledge of calculus of single variable, coordinate geometry of two and three dimensions and ordinary differential equations is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

### Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|------------|---------------------|----------|----------|-------|
| 10 | 20 | 20 | 50 | 100 |

### Detailed Syllabus

| Module-# | Topics | Hours |
|----------|--------|-------|
| **Module-1** | Periodic function and Fourier series, Euler formula, Even and odd functions, Half range expansions. | **7 Hours** |
| **Module-2** | Fourier integrals, Fourier cosine transform, Fourier sine transform, Fourier transform. | **7 Hours** |
| **Module-3** | Vector line integrals, Line integrals independent of path, Double integrals, Green's theorem in plane surfaces, Surface integrals, Triple integrals, Gauss divergence theorem, Stoke's theorem. | **10 Hours** |
| **Module-4** | Partial Derivatives, Chain Rule, Maxima & Minima in several variables; Vector and scalar functions and fields, Derivatives, Directional derivative & gradient of a scalar field, Divergence & Curl of a vector field. | **8 Hours** |
| **Module-5** | Basic Concepts of PDEs, One Dimensional Wave Equation and its solutions, One Dimensional Heat Equation and its solutions, Two dimensional heat equation, Laplace Equation, Solution of Laplace equation in cylindrical and spherical coordinates. | **10 Hours** |
| | Total | **42 Hours** |

**Text Books**:

T1. E. Kreyszig, ***Advanced Engineering Mathematics***, 8th *Ed.*, Wiley India, 2015.

**Reference Books**:

R1. S. Pal and S. C. Bhunia, ***Engineering Mathematics***, 1st *Ed.*, Oxford University Press, 2015.
R2. B. V. Ramana, ***Higher Engineering Mathematics***, 1st *Ed.*, McGraw-Hill, 2017.

**Online Resources**:

1. https://nptel.ac.in/courses/122104017: by Prof. S. K. Ray, IIT Kanpur
2. https://nptel.ac.in/courses/111107063: by Dr. S. Gakkhar, IIT Roorkee
3. https://nptel.ac.in/courses/111105093: by Prof S. De, IIT Kharagpur
4. https://nptel.ac.in/courses/111107111: by Prof. Agrawal and Pandey, IIT Roorkee
5. https://nptel.ac.in/courses/111104519: by Prof. Prof. P. Mohanty, IIT Kanpur

P.T.O

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Determine the Fourier series of functions. |
|-----|--------------------------------------------|
| CO2 | Obtain the Fourier integral and Fourier transform of functions. |
| CO3 | Explain the concepts vector integral calculus and their applications. |
| CO4 | Describe the concepts vector differential calculus and their applications. |
| CO5 | Solve partial differential equations and interpret the solution |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|-----|--------------------------------------------|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Programming in Python | L-T-P | Credit | Marks |
|----------|------|----------------------|-------|--------|-------|
| UCR | CS2007 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to develop programming skills in Python which is rich in tools & libraries and is popularly used for solving real-life computing problems in many engineering domains. |
| **Pre-Requisites** | Basics of programming, algorithms and problem solving skills are required. Prior experience with a programming language will be beneficial. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with programming & problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|------------|---------------------|----------|----------|-------|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|----------|--------|-------|
| **Module-1** | **Introduction to Python**: Introduction, Features of Python, Data types, Variables, Literals, Input/output statements, Keywords, Identifiers, Operators, Precedence and associativity, Expressions, Control statements. | **8 Hours** |
| **Module-2** | **Data Structures**: Lists - Operations, Slicing, Built-in list functions, List comprehension, Tuples - Accessing elements, Operations using built-in tuple functions, Dictionaries - Accessing values in dictionaries, Built-in dictionary functions, Sets, Functions, Recursion, Anonymous functions; Modules: Creating modules, Import statement, Packages. | **9 Hours** |
| **Module-3** | **Object Oriented Programming**: Creating class and object, Using a class and its methods, Constructor; Inheritance: Types of inheritance, Overriding methods, Encapsulation and information hiding, Polymorphism, Operator overloading, Method overloading and overriding, Abstract method and class. | **8 Hours** |
| **Module-4** | **File Handling**: Types of files, Opening & closing, Reading & writing, Binary files; Command line arguments; Exception Handling: Errors, Types of exception, try, except, and finally, assertion; Database Connectivity: Connect with a SQL database, Executing queries, Transactions, SQLDB database connection parameters, Insert, Update, Delete operations. | **7 Hours** |
| **Module-5** | **Data Handling, Visualization, and GUI Programming**: Regular Expressions - Match & Search functions, Quantifiers, Pattern; NumPy: Introduction, Creating of arrays and matrices; Panda: Creating a DataFrame, DataFrame operations, Data manipulation and aggregation, Reshaping DataFrame objects; Matplotlib: Introduction, creating basic plots (line plot, scatter plot, bar chart, histogram), Customizing plots; Graphical User Interface: GUI toolkits, Creating GUI widgets with Tkinter, Creating layouts, Radio buttons, Checkboxes, Dialog boxes. | **10 Hours** |
| | Total | **42 Hours** |

**Text Books**:

T1. R. N. Rao, *Core Python Programming*, 3rd *Ed.*, DreamTech Press, 2021.

T2. V. Guttag, *Introduction to Computation and Programming Using Python with Application to Understanding Data*, 2nd *Ed.*, PHI Learning, 2016.

T3. W. McKinney, *Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Jupyter*, 3rd *Ed.*, O'Reilly Media, 2022.

**Reference Books**:

R1. P. Barry, *Head First Python*, 3<sup>rd</sup> *Ed.*, O'Reilly Media, 2023.
R2. A. Downey, ***Think Python: How to Think Like a Computer Scientist***, 3<sup>rd</sup> *Ed.*, O'Reilly Media, 2024.
R3. E. Matthes, ***Python Crash Course: A Hands-On, Project-Based Introduction to Programming***, 3<sup>rd</sup> *Ed.*, No Starch Press, 2023.
R4. J. Zelle, ***Python Programming: An Introduction to Computer Science***, 4<sup>th</sup> *Ed.*, Franklin, Beedle & Associates, 2024.

**Online Resources**:

1. https://nptel.ac.in/courses/106106182: By Prof. S. Iyengar, IIT Ropar
2. https://nptel.ac.in/courses/106106145: By Prof. M. Mukund, IIT Madras
3. https://nptel.ac.in/courses/106106212: By Prof. R. Rengasamy, IIT Madras
4. https://nptel.ac.in/courses/106107220: By Prof. A. Ramesh, IIT Roorkee

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Compile and debug basic python programs, and solve problems using control structures. |
|-----|------|
| CO2 | Apply the data structure for real life problems and design modular python programs. |
| CO3 | Develop applications using object oriented programming concepts using python. |
| CO4 | Apply the concept of file handling and database connectivity in real life problems. |
| CO5 | Utilize advanced tools & libraries for data analysis and develop GUI based applications. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|-----|------|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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 (WK1, WK5, and WK7). |
| 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. (WK8) |

P.T.O

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Management & Economics for Engineers | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| UCR | MG2001 | | 3-0-0 | 3 | 100 |

| Objectives | The objective of this course is to familiarize the students with elementary principles of management and economics, provide the tools needed for analyzing time value of money in engineering decision making, profit/revenue data, and make economic analysis for projects and alternatives. |
|---|---|
| **Pre-Requisites** | Basic knowledge on interest formula and derivatives is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as needed. Each session is planned to be interactive with focus on real-world problem solving. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | Introduction, Engineering Economics, It's meaning & importance, Basic problems of an economy, The concept of time value of money, Concept of Interest, Time value of equivalence, Compound interest factors, Cash flow diagrams, Calculation of time value of equivalence, Present worth comparison, Future worth comparison, Pay-back period comparison. | 9 Hours |
| **Module-2** | Equivalent annual worth comparison method, Rate of return, Internal rate of return, Incremental IRR analysis, Depreciation Analysis - Methods of depreciation, Straight line method, Declining balance method, SOYD Method & MACRS method; Analysis of public project, Cost-benefit analysis. | 9 Hours |
| **Module-3** | Theory of demand, Elasticity of demand, Price elasticity of demand, Measurement of elasticity of demand, Income elasticity & cross elasticity of demand, Law of supply, Elasticity of supply, Determination of price, Cost & Revenue concepts, Break-even analysis. | 8 Hours |
| **Module-4** | Concept of Management, Management - Art or Science, Managerial skills, Levels and types of management, Managerial environment, Functions of Management: Planning and its features & process, Types of plan, Effective planning, Organizing and its process, Formal & informal organization, Directing and its elements, Staffing and functions, Controlling & its features and process, tools of controlling. | 8 Hours |
| **Module-5** | Marketing Function: Modern concept of marketing, Marketing vs. Selling, Marketing Mix: Product and types of product, Product life cycle, Price, Factors affecting pricing, Pricing strategies, Distribution channel - Role & functions, Selection of a distribution channel, Promotion & types of promotion, Promotional strategies; HRM Function: Human resource management, Manpower planning, Recruitment, Selection, Induction, Training & development, Placement, Wage & Salary administration. | 8 Hours |
| | Total | 42 Hours |

**Text Books**:
T1. J. L. Riggs, D. D. Bedworth, and S. U. Randhawa, *Engineering Economics*, 4th *Ed.*, McGraw-Hill, 2004.
T2. H. L. Ahuja, *Principles of Micro Economics*, 16th *Ed.*, S. Chand & Co, 2008.
T3. S. A. Sherlekar, *Modern Business Organisation and Management*, Himalaya Publishing House, 2016.

**Reference Books**:

R1. C. S. Park, *Contemporary Engineering Economics*, 6th *Ed.*, Pearson Education, 2015.
R2. A. Koutsoyiannis, *Modern Micro Economics*, 2nd *Ed.*, Palgrave Macmillan UK, 2003.
R3. P. C. Tulsian and V. Pandey, *Business Organization & Management*, 1st *Ed.*, Pearson Education, 2002.
R4. K. Keller and K. Jha, *Marketing Management*, 13th *Ed.*, Pearson Education, 2018.

**Online Resources**:

1. https://nptel.ac.in/courses/112107209: by Dr. P. K. Jha, IIT Roorkee
2. https://nptel.ac.in/courses/110107150: by Prof. U. Lenka, IIT Roorkee
3. https://nptel.ac.in/courses/110104068: by Prof. J. Chatterjee and Dr. S. S. Mishra, IIT Kanpur
4. https://nptel.ac.in/courses/122105020: by Prof. K. Chakravarti, IIT Kharagpur
5. https://nptel.ac.in/courses/110105069: by Prof. A. Malik, IIT Kharagpur

**Course Outcomes**: *At the end of this course, the students will be able to:*

| | |
|---|---|
| CO1 | Understand the concepts of engineering economics and its applications. |
| CO2 | Solve problems related to engineering economics and analyze decision alternatives. |
| CO3 | Evaluate how changes in demand and supply affect market and production. |
| CO4 | Apply the concepts of management to become a good manager and a team player. |
| CO5 | Adopt appropriate marketing policies and manage human resources in an efficient manner. |

**Program Outcomes Relevant to the Course**:

| | |
|---|---|
| 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 (WK1, WK5, and WK7). |
| PO7 | **Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9) |
| PO8 | **Individual & Collaborative Team Work**: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams. |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Biology for Engineers | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| UCR | BL2001 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to integrate the knowledge of engineering and modern biology to solve problems encountered in living systems, analyze a problem from engineering and biological perspective, anticipate specific issues in working with living systems, and evaluate possible solutions. |
| **Pre-Requisites** | Basic knowledge of biology, chemistry, and physics is adequate. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on applications of biology in engineering. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | **Bioinspired Materials and Mechanisms**: Photosynthesis (photovoltaic cells, bionic leaf), Bird flying (GPS and aircrafts), Lotus leaf effect (Super hydrophobic and self-cleaning surfaces), Plant burrs (Velcro), Shark skin (Friction reducing swimsuits), Kingfisher beak (Bullet train), Human Blood substitutes - Haemoglobin-based oxygen carriers (HBOCs). | 10 Hours |
| **Module-2** | **Biomolecules-based Technology**: Carbohydrates (transformation of carbohydrates into renewable energy, biodegradable plastics and organic chemicals), Nucleic acids (biochips and biosensors), Forensics - Automated DNA sequencing, Proteins (cellular agriculture to produce tissue mimicking meat), Lipids (biodiesel), Enzymes (AI mediated enzyme engineering). | 9 Hours |
| **Module-3** | **Human Organ Systems and Bio Designs (I)**: Eye as a camera system (architecture of rod and cone cells, optical corrections, cataract, lens materials, bionic eye), Brain as a CPU system (architecture, signal transmission, brain-machine interactions), Heart as a pump system (reasons for blockages of blood vessels, Nanobots to remove artery blockage, vein detection patches). | 8 Hours |
| **Module-4** | **Human Organ Systems and Bio Designs (II)**: Lungs as purification system (architecture, gas exchange mechanisms, spirometry, abnormal lung physiology - COPD, Ventilators, Heart-lung machine); Kidney as a filtration system (architecture, mechanism of filtration, CKD, dialysis systems), Muscular and skeletal systems as scaffolds (architecture, mechanisms, bioengineering solutions for muscular dystrophy and osteoporosis). | 8 Hours |
| **Module-5** | **Genetics and Bioinformatics**: Mendelian and non-mendelian genetics, Mutation, Central dogma of molecular biology, Genetic disorders, Genetic code; Nucleotide and protein databases - EMBL, DDBJ, GenBank, UniProt, PDB, Tools used in bioinformatics - BLAST, FASTA, Machine learning applications in bioinformatics: Gene sequence analysis, Protein structure analysis, Establish phylogenetic relationship. | 7 Hours |
| | Total | 42 Hours |

**Text Books**:

T1. Y. Bar-Cohen, ***Biomimetics: Nature-Based Innovation***, 1st *Ed.*, CRC Press, 2012.
T2. S. Fox and K. Rompolski, ***Human Physiology***, 16th *Ed.*, McGraw-Hill eBook, 2022.

T3. L. Cromwell, F. J. Weibel, and E. A. Pfeiffer, *Biomedical Instrumentation & Measurements*, 2nd *Ed.*, Pearson Education, 2015.

T4. Any other book(s) and/or study material(s) as advised by the teacher.

**Reference Books**:

R1. S. Singh and T. Allen, *Biology for Engineers*, 1st *Ed.*, Vayu Education, 2020.

R2. V. Sharma, A. Munjal, and A. Shanker, *A Textbook of Bioinformatics*, 2nd *Ed.*, Rastogi Publications, 2018.

**Online Resources**:

1. https://nptel.ac.in/courses/102106065: by Prof. M. M. Gromiha, IIT Madras
2. https://nptel.ac.in/courses/121106008: Dr. M. Dixit and Prof. G. K. Suraishkumar, IIT Madras
3. https://ocw.mit.edu/courses/20-020-introduction-to-biological-engineering-design-spring-2009

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Correlate the concepts of biology in engineering for innovative materials and products. |
|-----|------------------------------------------------------------------------------------------|
| CO2 | Leverage biomolecules in food, pharma, energy, and other engineering domains. |
| CO3 | Critically analyze organ systems and improve design of bio-medical equipment. |
| CO4 | Design solutions for health challenges like prosthetics, organ regeneration, and medical devices. |
| CO5 | Determine the connection between genetic alterations, diseases, and inheritance pattern. |

**Program Outcomes Relevant to the Course**:

| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
|-----|----------------------------------------------------------------------------------------------|
| 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 (WK5). |
| 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 (WK2 and WK6). |
| 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 (WK1, WK5, and WK7). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Signals & Systems | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| PCR | EC2003 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to study the presentation of various signals in time and spectrum domains, and stability & causality of LSI systems. |
| **Pre-Requisites** | Fundamental knowledge of basic mathematics is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | Signals: Introduction, Classification: continuous/ discrete-time, commonly used continuous-time signals and discrete-time Signals, Analog/ digital signal, Periodic/ aperiodic, Even/ odd, Energy/ power, Deterministic/ random, Operation on Continuous-time and Discrete time signals: Addition, Multiplication, Differentiation/Difference, Integration/Accumulation, Shifting, Scaling, Folding and Convolution (graphical and analytical), Correlation of Discrete-Time signals & its properties. | **8 Hours** |
| **Module-2** | System and LTI/LSI System: Introduction, Classification for both continuous time and discrete time - Linear/ Non-linear, Time varying/ time invariant,Causal/ non-causal,Dynamic/ static,Stable/ unstable and Invertible/ Non-invertible, Continuous time and Discrete time LSI system, System representation through differential equations and difference equations, Response of LSI system and convolution Integral/convolution Sum, Characterization of causality and stability of linear shift invariant(LSI). | **8 Hours** |
| **Module-3** | Analysis by Fourier series and Fourier Transform: Orthogonal and Ortho-normal signal set, Fourier series, convergence of the Fourier series, Trigonometric Fourier series and exponential Fourier series, Continuous time Fourier Transform, convergence of the Fourier transform, Fourier transform of some useful signals, properties of the Fourier transform, the notion of a frequency response and its relation to the impulse response, Parseval's theorem: Energy spectral density, Power spectral density. | **9 Hours** |
| **Module-4** | Analysis by Laplace Transform: Introduction, Region of Convergence for Laplace transform, and properties of ROC, Laplace transform of some useful signals, properties of the Laplace transform, the inverse Laplace transform and Unilateral Laplace Transform and their properties, Initial value and final value theorem, solution of differential equation using Laplace transform. | **9 Hours** |
| **Module-5** | Analysis by Z-Transform: Discrete-time system analysis using the Z- transform, Mapping from S-plane to Z-plane,Z-transform, The Region of Convergence, Z-transform of some useful sequences, Properties of Z- transform,Inverse Z-transform. | **8 Hours** |
| | Total | **42 Hours** |

**Text Books**:

T1. A. V. Oppenheim, A. S. Willsky, and S. H. Nawab, *Signals and Systems*, 2<sup>nd</sup> *Ed.*, Prentice Hall India, 1992.

T2. S. Haykin and B. V. Veen, *Signals and Systems*, 2$^{nd}$ *Ed.*, John Wiley & Sons, 2002.

T3. B. P. Lathi, *Principles of Signal Processing and Linear Systems*, 2$^{nd}$ *Ed.*, Oxford University Press, 2009.

**Reference Books**:

R1. A. Ambardar, *Analog and Digital Signal Processing*, 2$^{nd}$ *Ed.*, Brooks/Cole Publishing, 1999.

R2. H. P. Hsu, *Signal and System - Schaum's Outlines*, 2$^{nd}$ *Ed.*, McGraw Hill, 2011.

R3. M. J. Roberts, *Signals and Systems - Analysis using Transform methods and MATLAB*, 2$^{nd}$ *Ed.*, McGraw Hill, 2003.

R4. A. N. Kani, *Signals and System*, 2$^{nd}$ *Ed.*, McGraw Hill Education, 2010.

**Online Resources**:

1. https://nptel.ac.in/courses/117104074/: by Prof. K.S. Venkatesh, IIT Kanpur
2. https://nptel.ac.in/courses/108105065/: by Prof. T.K. Basu, IIT Kharagpur
3. https://nptel.ac.in/courses/108104100/: by Prof. A. K. Jagannatham, IIT Kanpur
4. https://nptel.ac.in/courses/108105059/: by Prof. S. Mukhopadhyay, IIT Kharagpur
5. https://ocw.mit.edu/resources/res-6-007-signals-and-systems-spring-2011/lecture-notes/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Compare different types of signals and systems. |
|-----|--------------------------------------------------|
| CO2 | Analyze various types of LSI systems responses. |
| CO3 | Represent continuous and discrete systems in time & frequency domains using different transforms. |
| CO4 | Investigate the system stability and causality using Laplace Transform and Z-Transform. |
| CO5 | Analyze discrete time signals and systems using Z-transform. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|-----|-----|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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 (WK1, WK5, and WK7). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Circuit Theory | L-T-P | Credit | Marks |
|----------|------|----------------|-------|--------|-------|
| PCR | EE2010 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is that the student should be able to analyze any circuit configuration, synthesize circuits with any given specification of network functions, and test and improve the design as required. |
| **Pre-Requisites** | Basics of Circuit analysis, Laplace transform, Fourier transform, and Differential equations are required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|------------|---------------------|----------|----------|-------|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|----------|--------|-------|
| **Module-1** | Network Theorems: Thevenin's theorem, Norton's theorem, Superposition theorem, Reciprocity theorem, Maximum power transfer theorem, Millman's theorem (AC & DC Networks); Coupled Circuits: Introduction, Dot Convention, Coefficient of coupling, Electrical equivalent of magnetically coupled coils, Series and parallel connection of coupled coils, Transformer as a magnetically coupled circuit; Resonance: Introduction, Series Resonance, Parallel Resonance, Quality factor, Bandwidth and Selectivity for series and parallel resonant circuits, Frequency Response Curve. | 11 Hours |
| **Module-2** | Laplace Transform & its Application: Fundamentals of Laplace & Inverse Laplace Transform, initial and final value theorem; Fundamentals of Switching behavior of RL, RC & RLC circuits. Application Of Laplace Transform to Transient Analysis: Response of RL, RC & RLC network with step, sinusoidal, impulse, and ramp input. | 8 Hours |
| **Module-3** | Fourier Series and Fourier Transform: Periodic and Aperiodic functions, Fourier Series Analysis of Continuous Time Signals, Fourier Transform, Properties, Circuit analysis with Fourier Series and Fourier Transform; Filters: Introduction to Filters, Frequency Response Curve, Filter Transfer functions and cut-off frequencies. | 7 Hours |
| **Module-4** | Two-Port Networks: Introduction, z, y, ABCD and h-parameters, Reciprocity and Symmetry, Interrelation of two-port parameters, Interconnection of two-port networks; Network Functions & Response: Transfer function and driving point function for one & two-port networks, Concept of poles and zeros, Significance & Restriction on location of Poles and Zeros. | 9 Hours |
| **Module-5** | Network Synthesis: Hurwitz polynomial and its Properties, Positive real functions and their properties, Concepts of network synthesis, Realization of R-L, R-C, and L-C functions in Cauer-I, Cauer-II, Foster-I and Foster-II forms. | 7 Hours |
| | Total | 42 Hours |

**Text Books**:

T1. M. E. Van Valkenburg, **Network Analysis**, 3rd *Ed.*, Pearson Education, 2015.

T2. C. K. Alexander and M. N. O. Sadiku, **Fundamentals of Electric Circuits**, 5th *Ed.*, Tata McGraw-Hill, 2013.

T3. W. H. Hayt, J. Kemmerly, J. D. Phillips, and S. M. Durbin, *Engineering Circuit Analysis*, 9th *Ed.*, McGraw-Hill Education, 2020.

**Reference Books**:

R1. S. Ghosh, *Network Theory: Analysis And Synthesis*, 1st *Ed.*, Prentice Hall of India, 2009.

R2. P. K. Satpathy, P. Kabisatapathy, S. P. Ghosh, and A. K. Chakraborty, *Network Theory*, 1st *Ed.*, Tata McGraw-Hill, 2009.

R3. A. Chakrabarti, *Circuit Theory: Analysis and Synthesis*, 7th *Ed.*, Dhanpat Rai & Co., 2013.

R4. J. D. Irwin and R. M. Nelms, *Basic Engineering Circuit Analysis*, 11th *Ed.*, Wiley, 2015.

**Online Resources**:

1. https://nptel.ac.in/courses/108102042/: by Prof. S. C. Dutta Roy, IIT Delhi
2. https://nptel.ac.in/courses/108106075/: by Prof. V. G. K. Murti, IIT Madras
3. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/lecture-notes/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| | |
|---|---|
| CO1 | Describe network theorems, coupled circuits, and resonant circuits and apply them to solve complex network problems. |
| CO2 | Explain the switching phenomena of electrical circuits and evaluate transient and steady-state performance using Laplace Transformation. |
| CO3 | Analyze filter circuits and sinusoidal, and non-sinusoidal signals using the Fourier series and Fourier transform and its application in electrical & electronics circuit analysis. |
| CO4 | Determine two-port network parameters and their practical application to electrical and electronic circuits. |
| CO5 | Identify Network Functions and synthesize one port network using Foster and Cauer forms. |

**Program Outcomes Relevant to the Course**:

| | |
|---|---|
| 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 (WK1 to WK4). |
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| PO8 | **Individual & 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. |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Analog Circuit Design | L-T-P | Credit | Marks |
|----------|------|----------------------|-------|--------|-------|
| PCR | EC2025 | | 3-1-0 | 4 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to build a strong foundation in analog circuit design, covering lumped circuit models, operational amplifiers, and basic analysis techniques. Students learn time- and frequency-domain analysis and modeling of non-linear and active devices such as diodes, MOSFETs, and BJTs. |
| **Pre-Requisites** | Basic knowledge of differential equations and knowledge of electricity and magnetism is required for this course. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

### Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|------------|---------------------|----------|----------|-------|
| 10 | 20 | 20 | 50 | 100 |

### Detailed Syllabus

| Module-# | Topics | Hours |
|----------|--------|-------|
| **Module-1** | Derivation of resistance, capacitance and inductance; Linear circuit analysis techniques - KCL and KVL analysis, Node and Mesh analysis, Superposition principle, Thevenin and Norton equivalence; Transient response of passive circuits (RLC) - First-order and second-order; Practical RLC Circuits - Filters and matching networks. | 11 Hours |
| **Module-2** | Sinusoidal steady-state analysis - Differential equation method and impedance method, Laplace transform as a tool for frequency analysis, Frequency response of first-order and second-order circuits, Bode plot of filters, Q-factors. | 11 Hours |
| **Module-3** | Dependent sources as abstraction of active elements - Operational amplifiers, Trans-conductors and trans-impedance, Operational amplifier circuits - Filters, Gain-stage, Integrators, Differentiators, Summers, Buffer, Instrumentation amplifier and voltage regulators, Frequency response, Input/Output impedance and introduction to feedback analysis of op-Amp circuits. | 12 Hours |
| **Module-4** | I-V characteristics and small-signal modeling (low & high-frequency) of non-linear devices - Diode, MOSFET & BJT, Circuits with non-linear devices - Rectifiers, Peak detector, Oscillators, Single-stage amplifiers, Current mirrors, Differential amplifiers and Single-stage operational amplifiers, Oscillators and power amplifiers (Class-A, Class-B & Class-AB), Frequency response of non-linear circuits. | 12 Hours |
| **Module-5** | Design and analysis of switching circuits, Design of buck and boost converters, BLDC motor controllers and switch-capacitor power converters, Linearizing switching circuits and frequency response of the linearized circuit. | 10 Hours |
| | Total | 56 Hours |

**Text Books**:
- T1. R. E. Thomas, A. J. Rosa, and G. J. Toussaint, *The Analysis and Design of Linear Circuits*, 10$^{th}$ *Ed.*, John Wiley & Sons, 2023.
- T2. R. E. Erickson and D. Maksimovic, *Fundamentals of Power Electronics*, 3$^{rd}$ *Ed.*, Springer, 2020.

**Reference Books**:
- R1. J. D. Irwin and R. M. Nelms, *Basic Engineering Circuit Analysis*, 11$^{th}$ *Ed.*, Wiley, 2015.

R2. C. K. Alexander and M. N. O. Sadiku, *Fundamentals of Electric Circuits*, 6th *Ed.*, McGraw-Hill, 2017.

R3. A. Agarwal and J. Lang, *Foundations of Analog and Digital Electronic Circuits*, 1st *Ed.*, Morgan Kaufmann, 2005.

R4. P. Horowitz and W. Hill, *The Art of Electronics*, 2nd *Ed.*, Cambridge University Press, 1989.

**Online Resources**:

1. https://nptel.ac.in/courses/117101106: by Prof A.N.Chandorkar, IIT Bombay
2. https://nptel.ac.in/courses/108102095: by Prof S. C. Dutta Roy, IIT Delhi
3. https://ocw.mit.edu/courses/6-002-circuits-and-electronics-spring-2007
4. https://ocw.mit.edu/courses/6-071j-introduction-to-electronics-signals-and-measurement-spring-2006/
5. http://www.electrical4u.com/circuit-analysis.htm
6. http://www.allaboutcircuits.com
7. https://www.electronics-tutorials.ws/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| | |
|---|---|
| CO1 | Apply linear circuit analysis techniques to find response of first-order & second-order RLC circuits. |
| CO2 | Apply differential equation and laplace transform to find steady state sinusoidal solution and frequency response of first-order & second-order circuits. |
| CO3 | Design, analyze and characterize practical Op-Amp circuits. |
| CO4 | Describe the operating characteristics of non-linear devices such as diodes, MOSFETs & BJTs and apply small-signal techniques to linearize non-linear circuits for effective linear analysis. |
| CO5 | Analyze and design switching circuits including power converters, BLDC motor controllers and switch-capacitor circuits. |

**Program Outcomes Relevant to the Course**:

| | |
|---|---|
| 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 (WK1 to WK4). |
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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. (WK8) |

P.T.O

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Programming in Python Lab | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| UCR | CS2010 | | 0-0-2 | 1 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this laboratory course is to develop problem solving skills using python programming language and prepare the students use python tools & libraries for solving advanced engineering problems. |
| **Pre-Requisites** | Knowledge of programming and basic problem solving skills are required. |
| **Teaching Scheme** | Regular laboratory classes conducted under supervision of the teacher. The experiments shall comprise programming assignments. |

## Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test / Mini Project | Viva-voce | Total |
|---|---|---|---|---|---|
| 10 | 30 | 15 | 30 | 15 | 100 |

## Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|---|---|
| 1 | Write, compile, test, and debug simple Python programs. |
| 2 | Write programs using control structures (if, if-elif-else). |
| 3 | Write programs using loop control structure (while & for loops). |
| 4 | Write programs based on the concept of lists and tuples |
| 5 | Write programs based on the concept of set and dictionaries. |
| 6 | Develop the Python programs step-wise by defining functions and calling them, function with variable number of parameters. |
| 7 | Write programs for creating class, object, methods and constructor. |
| 8 | Write programs for demonstrating inheritance, and method overriding. |
| 9 | Write programs on operator overloading, method overloading, and abstract classes. |
| 10 | Write programs on file handling, exception handling, and database connectivity. |
| 11 | Write programs using regular expressions, Numpy arrays and matrices. |
| 12 | Panda module, data frame from CSV file, reshaping & data aggregation. |
| 13 | Programs for creating different types of plots using Matplotlib libraries. |
| 14 | Creating widgets using Tkinter and designing layouts with radio buttons, checkboxes, and dialogue boxes. |

**Text Books**:
T1. R. N. Rao, **Core Python Programming**, 3rd *Ed.*, DreamTech Press, 2021.
T2. V. Guttag, **Introduction to Computation and Programming Using Python with Application to Understanding Data**, 2nd *Ed.*, PHI Learning, 2016.
T3. W. McKinney, **Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Jupyter**, 3rd *Ed.*, O'Reilly Media, 2022.

**Reference Books**:
R1. P. Barry, **Head First Python**, 3rd *Ed.*, O'Reilly Media, 2023.
R2. A. Downey, **Think Python: How to Think Like a Computer Scientist**, 3rd *Ed.*, O'Reilly Media, 2024.
R3. E. Matthes, **Python Crash Course: A Hands-On, Project-Based Introduction to Programming**, 3rd *Ed.*, No Starch Press, 2023.
R4. J. Zelle, **Python Programming: An Introduction to Computer Science**, 4th *Ed.*, Franklin, Beedle & Associates, 2024.

**Online Resources**:

1. https://nptel.ac.in/courses/106106182: By Prof. S. Iyengar, IIT Ropar
2. https://nptel.ac.in/courses/106106145: By Prof. M. Mukund, IIT Madras
3. https://nptel.ac.in/courses/106106212: By Prof. R. Rengasamy, IIT Madras
4. https://nptel.ac.in/courses/106107220: By Prof. A. Ramesh, IIT Roorkee

**Course Outcomes**: *At the end of this course, the students will be able to:*

| | |
|------|--------------------------------------------------------------------------------------------------|
| CO1 | Develop programs using various features of the Python programming language. |
| CO2 | Develop programs using built-in as well as user-defined functions in Python. |
| CO3 | Apply object-oriented concepts, perform file processing & exception handling. |
| CO4 | Explore regular expressions, NumPy and Panda modules of Python for solving real-life problems. |
| CO5 | Visualize data using matplotlib libraries and design GUI based applications. |

**Program Outcomes Relevant to the Course**:

| | |
|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 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 (WK1 to WK4). |
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK2 and WK6). |
| 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 (WK1, WK5, and WK7). |
| PO8 | **Individual & 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. |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Circuit Theory Lab | L-T-P | Credit | Marks |
|:---:|:---:|:---:|:---:|:---:|:---:|
| PCR | EE2011 | | 0-0-2 | 1 | 100 |

| | |
|:---|:---|
| **Objectives** | The objective of the course is to provide a practical working knowledge of network theory and record the experimental data effectively and correctly. |
| **Pre-Requisites** | Basic knowledge of electrical & electronics engineering, Laplace transform and differential equations is required. |
| **Teaching Scheme** | Regular laboratory experiments to be conducted using hardware and software tools under the supervision of the teacher. Demonstration along with required safety measures will be explained for each experiment. |

### Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test / Mini Project | Viva-voce | Total |
|:---:|:---:|:---:|:---:|:---:|:---:|
| 10 | 30 | 15 | 30 | 15 | 100 |

### Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|:---:|:---|
| 1 | Verification of Network Theorems (Superposition, Thevenin, Norton, Maximum Power Transfer) both in DC & AC. |
| 2 | Determination of two-port network parameters: Open Circuit(z), Short Circuit(y), Hybrid(h) and Transmission (ABCD) parameters |
| 3 | Frequency response of Low Pass and High Pass Filters. |
| 4 | Determination of self-inductance, mutual inductance, and coupling coefficient of a magnetic coupled circuit. |
| 5 | Study of resonance in R-L-C series & parallel circuit. |
| 6 | Verification of Network Theorems by modeling and simulation (Superposition, Thevenin, Norton, Maximum Power Transfer) both in DC & AC. |
| 7 | Modeling of two-port networks and determination of parameters by simulation. |
| 8 | Frequency response of Low pass, High pass, and Band pass Filters using simulation. |
| 9 | Modeling and simulation of DC and AC Transients in electrical circuits. |
| 10 | To study the characteristics of Single-tuned and double-tuned circuits. |
| 11 | Spectral analysis of a non-sinusoidal waveform. |

**Text Books**:
T1. M. E. Van Valkenburg, *Network Analysis*, 3rd *Ed.*, Pearson Education, 2015.

T2. C. K. Alexander and M. N. O. Sadiku, *Fundamentals of Electric Circuits*, 5th *Ed.*, Tata McGraw-Hill, 2013.

T3. W. H. Hayt, J. Kemmerly, J. D. Phillips, and S. M. Durbin, *Engineering Circuit Analysis*, 9th *Ed.*, McGraw-Hill Education, 2020.

**Reference Books**:
R1. S. Ghosh, *Network Theory: Analysis And Synthesis*, 1st *Ed.*, Prentice Hall of India, 2009.

R2. P. K. Satpathy, P. Kabisatapathy, S. P. Ghosh, and A. K. Chakraborty, *Network Theory*, 1st *Ed.*, Tata McGraw-Hill, 2009.

R3. A Chakrabarti, *Circuit Theory: Analysis and Synthesis*, 7th *Ed.*, Dhanpat Rai & Co., 2013.

R4. J. D. Irwin and R. M. Nelms, *Basic Engineering Circuit Analysis*, 11th *Ed.*, Wiley, 2015.

P.T.O

**Online Resources**:

1. https://nptel.ac.in/courses/108102042/: by Prof. S. C. Dutta Roy, IIT Delhi
2. https://nptel.ac.in/courses/108106075/: by Prof. V. G. K. Murti, IIT Madras
3. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/lecture-notes/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Correlate between frequency and circuit parameters at resonance condition. |
|-----|----------------------------------------------------------------------------|
| CO2 | Design and analyze different configurations in electrical networks using modern software. |
| CO3 | Employ concept of coupled circuits to electrical machines. |
| CO4 | Analyze sinusoidal & non-sinusoidal signals using Fourier series and transform. |
| CO5 | Design various filters and tuned amplifiers, and examine their frequency response. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|-----|---|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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 (WK1, WK5, and WK7). |
| PO7 | **Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9) |
| PO8 | **Individual & 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. |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Analog Circuit Design Lab | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| PCR | EC2026 | | 0-0-4 | 2 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to equip students with hands-on, end-to-end knowledge in analog circuit design from specifications and simulation to prototyping, PCB implementation and testing, bridging the theoretical knowledge with practical aspects and solving real-world problems. |
| **Pre-Requisites** | Basic knowledge of electronics and analytical skills is required. |
| **Teaching Scheme** | Regular laboratory experiments to be conducted under the supervision of teachers with the help of ICT, as and when required along with pre-lab session and demonstration for each experiment. |

## Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test / Mini Project | Viva-voce | Total |
|---|---|---|---|---|---|
| 10 | 30 | 15 | 30 | 15 | 100 |

## Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|---|---|
| 1-2 | Introduction to Linux operating system and most frequently used commands. |
| 3-4 | Introduction to ng-spice: Anatomy of a spice netlist, Simulation models for non-linear devices. |
| 4-5 | Simulation and characterization of the resistive networks. Use the "MEASURE" statements to characterize electrical parameters. |
| 5-6 | Simulation and characterization of the dynamic response of RC circuits. |
| 7-8 | AC response of RLC filter and characterization of AC parameters: 3-db frequency, DC gain, unity-gain bandwidth. |
| 9-10 | Introduction to schematic editor xschem: Hierarchical schematic and simulating with ng-spice. |
| 11-13 | Design and characterization of Op-Amp circuits: A 5V-3.3V voltage regulator. |
| 14-16 | Modeling of semiconductor devices: MOSFETS. |
| 17-19 | Simulate and characterize single-transistor MOSFET circuits, Common source amplifier. |
| 20-22 | Design and characterization of a 5V to 1.8V buck converter. |
| 23-25 | PCB design of the buck converter using KiCAD. |
| 26-28 | Building, testing and characterization of the buck converter using the analog devices multi-instrument ADALM1000. |

**Text Books**:

T1. D. A. Neamen, *Micro-electronic Circuit Analysis and Design*, 3$^{rd}$ *Ed.*, McGraw-Hill, 2006.

**Reference Books**:

R1. P. Horowitz and H. Winfield, *The Art of Electronics*, 2$^{nd}$ *Ed.*, Cambridge University Press, 1989.
R2. J.Blackburn, *Modern Instrumentation for Scientists and Engineers*, Springer, 2000.
R3. A. De Sa, *Electronics for Scientists: Physical Principles with Applications to Instrumentation*, Prentice Hall, 1997.
R4. C. Alexander and M. Sadiku, *Fundamentals of Electric Circuits*, 2$^{nd}$ *Ed.*, McGraw-Hill, 2004.
R5. J. J. Cathey, *Schaum's Outlines Electronic Devices and Circuits*, —edn2, McGraw-Hill, 2002.
R6. D. E. Johnson and V. Jayakumar, *Operational Amplifier Circuits*, Prentice Hall, 1982.

**Online Resources**:
1. https://ocw.mit.edu/courses/ec-s06-practical-electronics-fall-2004/
2. https://ocw.mit.edu/courses/6-101-introductory-analog-electronics-laboratory-spring-2007/
3. https://ocw.mit.edu/courses/6-071j-introduction-to-electronics-signals-and-measurement-spring-2006/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Operate open-source tools (ngspice, xschem and KiCAD) to design and test modern circuits. |
|---|---|
| CO2 | Characterize linear and non-linear circuits for their DC, AC and Transient performance. |
| CO3 | Design and test Op-Amp circuits for various real-world applications. |
| CO4 | Create a prototype followed by a PCB module and test and verify using test instruments. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|---|---|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

|  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 2 | 1 | 2 |  |  |  |  |  | 2 | 1 | 1 | 2 |
| CO2 | 3 | 3 | 2 | 2 | 2 |  |  |  |  |  | 2 | 2 | 2 | 2 |
| CO3 | 3 | 2 | 3 | 2 | 2 |  |  |  |  |  | 2 | 2 | 2 | 2 |
| CO4 | 2 | 2 | 3 | 3 | 3 |  |  |  |  |  | 2 | 2 | 1 | 2 |

| Category | Code | Complex Analysis & Numerical Methods | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| PCR | MT2004 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to provide the knowledge of analytic functions, poles & zeros, residue calculus, and numerical methods, along with the applications of these methods in engineering. |
| **Pre-Requisites** | Knowledge of calculus of single variables, coordinate geometry of two and three dimensions, matrix algebra and ordinary differential equations is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | Basics of Complex Numbers, Derivatives, Analytic Functions, C-R Equations, Basic elementary Complex functions. | **8 Hours** |
| **Module-2** | Complex Line Integration, Integral Theorems, Complex Power Series and Taylor Series. | **8 Hours** |
| **Module-3** | Laurent Series, Residue Integration and its application for evaluation of real integrals. | **8 Hours** |
| **Module-4** | Error Analysis, Solution of Nonlinear Equations, Bisection Method, Fixed-Point Iteration Method, Secant Method, Newton Method, Interpolation by Polynomials: Lagrange Interpolation, Newton Divided Differences, Newton's forward & backward Interpolation. | **9 Hours** |
| **Module-5** | Numerical Differentiation and Integration, Trapezoidal, Simpson's Rules, Composite Rules, Error Formulae, Gaussian Quadrature Rules, Solution of Differential Equations by Euler Method, Modified Euler Method, and Runge-Kutta Methods. | **9 Hours** |
| | Total | **42 Hours** |

**Text Books**:

T1. E. Kreyszig, *Advanced Engineering Mathematics*, 8th *Ed.*, Wiley India, 2015.

**Reference Books**:

R1. S. Pal and S. C. Bhunia, *Engineering Mathematics*, 1st *Ed.*, Oxford University Press, 2015.
R2. B. V. Ramana, *Higher Engineering Mathematics*, 1st *Ed.*, McGraw-Hill, 2017.

**Online Resources**:

1. https://nptel.ac.in/courses/111105035: by Prof. P. D. Srivastava, IIT Kharagpur.
2. https://nptel.ac.in/courses/122104017: by Prof. S. K. Ray, IIT Kanpur.
3. https://nptel.ac.in/courses/122102009: by Prof. S. R. K. Iyengar, IIT Delhi.
4. https://nptel.ac.in/courses/111107063: by Dr. S. Gakkhar, IIT Roorkee.
5. https://nptel.ac.in/courses/112102316: by Prof. A. Gupta, IIT Delhi.
6. https://nptel.ac.in/courses/111101165: by Prof. S. Baskar, IIT Bombay.
7. https://nptel.ac.in/courses/111107107: by Prof. A. K. Nayak, IIT Roorkee.

P.T.O

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Explain the fundamental concepts of Analytic function. |
|-----|---------------------------------------------------------|
| CO2 | Evaluate complex line integral and find the Taylor's series expansion of analytic functions. |
| CO3 | Expand functions in Laurent's Series and evaluate integrations using residues. |
| CO4 | Find the root of nonlinear and transcendental equations using numerical methods and interpolate data. |
| CO5 | Perform numerical integration and solve ODE using various numerical methods. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|-----|----------|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Solid State Devices | L-T-P | Credit | Marks |
|----------|------|---------------------|-------|--------|-------|
| PEL | EC2010 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to study the underlying physics of semiconductor devices and designing different semiconductor devices for applications in industry and various other domains. |
| **Pre-Requisites** | Knowledge of solid state physics including quantum physics of electrons in isolated atom and group of atoms is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

### Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|------------|----------------------|----------|----------|-------|
| 10 | 20 | 20 | 50 | 100 |

### Detailed Syllabus

| Module-# | Topics | Hours |
|----------|--------|-------|
| **Module-1** | Introduction: Review of quantum mechanics, Electrons in periodic lattices, E-K diagrams, Energy bands in solids; Electrons and holes in semiconductors: Silicon crystal structure, Donors and acceptors in the band model, Effective mass, Density of states(D(E)), Thermal equilibrium, Fermi-Dirac distribution function(f(E)) for electrons and holes, Fermi energy, Derivation of equilibrium concentration of electrons (n) and holes (p) from D(E) and f(E), Fermi level and carrier concentrations, np product and intrinsic carrier concentration. | 10 Hours |
| **Module-2** | Electrons, holes and their transport phenomena in semiconductors: Carrier concentrations at extremely high and low temperatures - complete ionization, partial ionization and freeze-out, Energy-band diagram and Fermi-level, Variation of Ef with doping concentration and temperature; Carrier drift: Electron and hole mobilities, Drift current and conductivity and resistivity; Carrier diffusion: diffusion current, Total current density, Thermal generation, Electron-hole recombination. | 9 Hours |
| **Module-3** | PN Junction & Schottky diodes: P-N junction characteristics; Building blocks of the pn junction theory, Energy band diagram and depletion layer of a pn junction, Built-in potential, Carrier injection under forward bias-Quasi-equilibrium boundary condition; current continuity equation, I-V characteristics, Reverse biased P-N junction: Avalanche breakdown, Zener diode, Schottky diode: I-V characteristics, Comparison between Schottky barrier diode and pn-junction diode. | 8 Hours |
| **Module-4** | MOS Capacitor and MOSFET: The MOS structure, Energy band diagrams, Surface accumulation, Surface depletion, Flat-band condition and flat-band voltage, Threshold condition and threshold voltage, C-V characteristics of ideal MOS capacitor, Basic structure of MOSFET, MOSFET Vt, Qinv and I-V Characteristics. | 8 Hours |
| **Module-5** | IC Fabrication Process: Oxidation, Diffusion, Ion implantation, Photolithography, Etching, Chemical vapor deposition, Sputtering and twin tube CMOS process. | 7 Hours |
| | Total | 42 Hours |

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**Text Books**:

T1.  D. A. Neamen, *Semiconductor Physics and Devices*, 4th *Ed.*, McGraw-Hill, 2012.

T2.  G. Streetman and S. K. Banerjee, *Solid State Electronic Devices*, 7th *Ed.*, Pearson, 2014.

**Reference Books**:

R1.  S. M. Sze and K. N. Kwok, *Physics of Semiconductor Devices*, 3rd *Ed.*, John Wiley & Sons, 2006.

R2.  C. T.Sah, *Fundamentals of Solid State Electronics*, 1st *Ed.*, World Scientific Publishing Co., 1991.

R3.  D. A. Neamen and D. Biswas, *Semiconductor Physics and Devices*, 4th *Ed.*, Tata McGraw-Hill Education, 2012.

**Online Resources**:

1.  https://nptel.ac.in/courses/115102103/: by Prof. M. R. Shenoy, IIT Delhi
2.  https://nptel.ac.in/courses/113104012/: by Prof. D. Gupta, IIT Kanpur

**Course Outcomes**: *At the end of this course, the students will be able to:*

| | |
|---|---|
| CO1 | Analyze charge carrier statistics and calculate various parameters of semiconductor devices. |
| CO2 | Investigate carrier transport phenomena to calculate the conductivity of semiconductor devices. |
| CO3 | Apply the concepts to investigate the electronic properties of diodes under different conditions. |
| CO4 | Investigate the V I characteristics of MOS capacitor and MOSFET. |
| CO5 | Describe and explain the basic fabrication steps in CMOS technology. |

**Program Outcomes Relevant to the Course**:

| | |
|---|---|
| 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 (WK1 to WK4). |
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Digital Circuit Design | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| PCR | EC2031 | | 3-1-0 | 4 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to learn core digital design concepts including logic design, sequential circuits, FSMs, timing and FPGAs. These concepts will be applied through labs. A final project to design and implement a RISC-V processor using Verilog/TL-Verilog on FPGA platforms will be undertaken. |
| **Pre-Requisites** | Knowledge of basic electronics and fundamentals of number systems is required. |
| **Teaching Scheme** | Regular class room lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | **Introduction**: Review of Boolean Algebra and Logic gates, Codes, Binary codes and their application, Boolean Algebra and Identities, Algebraic reduction using Boolean algebra, Standard representation for logic functions, Sum-of-Products (SOP) and Product-of-Sums (POS) forms, Canonical SOP and POS forms, K-map representation and simplification of logic functions using K-map, Minimization of 2, 3 and 4 variable logical functions, Don't care conditions and hazards; Introduction to Verilog – Combinational Logic circuit. | 11 Hours |
| **Module-2** | **Common Logic Gates**: (N)AND/(N)OR/X(N)OR and switch representation, Noise margin and Timing parameters, Combinational Logic Components, Multiplexer, De-Multiplexer, Decoders, Encoder (Priority Encoder), BCD to 7 segment display, Design of combinational circuits using multiplexer and decoder, Arithmetic structures, Review of number systems, adder, subtracter, multiplier, Equality detector and Comparator, Verilog implementation of the logic blocks. | 11 Hours |
| **Module-3** | **Sequential Building Blocks**: Latches, Flip-flops, S-R, D, JK & T flip-flops, Master-slave JK FF, Important timing parameters (setup/hold/propagation), Finite-State Machines (FSM), Design methods for Mealy & Moore FSM with examples of counters and sequence detectors, System timing parameters and FSM synchronization. FSM design using Verilog. | 12 Hours |
| **Module-4** | **Reconfigurable Logic Architectures**: PAL, Anti-fused based, RAM-based, LUT mapping, Architectures of some commercial field-programmable gate arrays (FPGA); Verilog to FPGA design flow - RTL, synthesis, Place and Route. | 11 Hours |
| **Module-5** | **Introduction to Computer Architecture and TL-Verilog**: Basic computer architecture concepts, CPU internals, Instruction set architectures and addressing modes, Memory organization and pipelining, Implementation of a RISC-V based project in TL-Verilog using MakerChip environment in a FPGA. | 11 Hours |
| | Total | 56 Hours |

**Text Books**:

T1. M. M. Mano and M. D. Ciletti, *Digital Design: With an Introduction to Verilog HDL*, 5th *Ed.*, Pearson Education, 2013.

T2. S. Palnitkar, *Verilog HDL: A Guide to Digital Design and Synthesis*, 2$^{nd}$ *Ed.*, Prentice Hall, 2003.

T3. D. Harris and S. Harris, *Digital Design and Computer Architecture*, —edn2, Elsevier, 2012.

**Reference Books**:

R1. R. Katz and G. Borriello, *Contemporary Logic Design*, 2$^{nd}$ *Ed.*, Prentice Hall, 2004.

R2. I. Koren, *Computer Arithmetic Algorithms*, 2$^{nd}$ *Ed.*, Taylor & Francis, 2001.

R3. J. L. Hennessy and D. A. Patterson, *Computer Architecture - A Quantitative Approach*, 5$^{th}$ *Ed.*, Morgan Kaufmann, 2012.

**Online Resources**:

1. https://ocw.mit.edu/courses/6-111-introductory-digital-systems-laboratory-spring-2006/
2. https://makerchip.com: Official site for TL-Verilog and its complete ecosystem
3. https://ocw.mit.edu/courses/6-002-circuits-and-electronics-spring-2007/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| | |
|---|---|
| CO1 | Design basic and universal boolean functions using logic gates. |
| CO2 | Design and analyze combinational logic circuits. |
| CO3 | Model digital logic using Hardware Description Language (HDL). |
| CO4 | Design Finite State Machines (FSM) to solve a problem specified in terms of digital I/O. |
| CO5 | Explain computer architecture and implement RISC based processor in FPGA. |

**Program Outcomes Relevant to the Course**:

| | |
|---|---|
| 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 (WK1 to WK4). |
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Communication Systems Engineering | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| PCR | EC3045 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to learn electronic communication systems, modulation techniques, digital transmission of analog signals, random variables & sources, and filtering of noise. |
| **Pre-Requisites** | Knowledge of signals & systems and probability theory is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | **Signals & Spectra**: An Overview of Electronic Communication Systems, Types of Signal, Fourier Series, Fourier Transform, Properties of Fourier Transform, Orthogonal Signal. | **7 Hours** |
| **Module-2** | **Amplitude Modulation Systems**: Need For Frequency Translation, Double Side band with Carrier(DSB-C),Double Side band with Suppressed Carrier (DSB-SC), Modulators - Square-Law, Switching, Balanced, Detectors - Square-Law, Envelope, Synchronous, Single Side Band with Suppressed Carrier (SSB-SC), Frequency and Phase Discrimination Methods, Coherent Detection, Modulation & Demodulation Of Vestigial Side Band Modulation (VSB), Frequency Division Multiplexing, Radio Transmitter & Receiver (Super Heterodyne Receiver). | **10 Hours** |
| **Module-3** | **Angle Modulation**: Angle Modulation, Narrow band FM, Wide band FM, FM Modulators – Direct Method( Varactor Diode Method), Indirect Method (Armstrong method), Simple Slope Detector, Balanced Slope Detector, Phase Locked Loop (PLL); **Analog Pulse Modulation**: Analog to Digital - The Need, Sampling Theorem, Natural and Flat-top Sampling, Quantization of Signals, Quantization Error, Pulse Amplitude Modulation, Pulse Width Modulation and Pulse Position Modulation. | **9 Hours** |
| **Module-4** | **Digital Pulse Modulation**: The PCM System, Bandwidth of PCM System, Delta Modulation(DM) and its limitations, Adaptive Delta Modulation, Differential PCM (DPCM), Comparison Between PCM, DM, and DPCM, Digital Transmission of Analog Signal - Digital Representation of Analog Signal, Line Codes, Companding, Time Division Multiplexing, Multiplexing PCM Signals. | **8 Hours** |
| **Module-5** | **Random Variables & Processes**: Probability, Random Variables, Useful Probability Density Functions, Useful Properties and Certain Application Issues, Mathematical Representation of Noise - Sources of Noise, Frequency-Domain Representation of Noise, Superposition of Noises, Linear Filtering of Noise, Noise Bandwidth. | **8 Hours** |
| | Total | **42 Hours** |

**Text Books**:

T1. H. Taub, D. L. Schilling, and G. Saha, *Principles of Communication System*, 4th *Ed.*, Tata McGraw Hill, 2013.

T2. R. P. Singh and S. D. Sapre, **Communication Systems : Analog and Digital**, 3rd *Ed.*, McGraw Hill Education, 2012.

**Reference Books**:
R1. J. G. Proakis and M. Salehi, **Communication System Engineering**, 2nd *Ed.*, PHI, 2002.
R2. S. Haykin and M. Moher, **Communication Systems**, 5th *Ed.*, John Wiley & Sons, 2009.
R3. B. P. Lathi, Z. Ding, and H. M. Gupta, **Modern Digital and Analog Communication Systems**, 4th *Ed.*, Oxford University Press, 2017.

**Online Resources**:
1. https://nptel.ac.in/courses/117105143: by Prof. G. Das, IIT Kharagpur
2. https://nptel.ac.in/courses/108104091: by Prof. A. Jagannathan, IIT Kanpur
3. https://nptel.ac.in/courses/117102059: by Prof. S. Prasad, IIT Delhi

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Explain types of signals and apply Fourier analysis for spectral representation in communication. |
|---|---|
| CO2 | Explain and analyze AM techniques, modulators, detectors, and superheterodyne receivers. |
| CO3 | Explain performance of angle modulation and various analog pulse modulation schemes. |
| CO4 | Describe digital pulse modulation schemes and digital transmission of analog signals. |
| CO5 | Analyze random variables, noise characteristics, and their effects on communication systems. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|---|---|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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 (WK1, WK5, and WK7). |
| 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. (WK8) |

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**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | IC Fabrication Technology | L-T-P | Credit | Marks |
|----------|------|--------------------------|-------|--------|-------|
| PEL | EC3013 | | 3-0-0 | 3 | 100 |

| | |
|-----|-----|
| **Objectives** | The objective of this course is to learn the fabrication flow and IC integration process of semiconductor devices and semiconductor ICs. |
| **Pre-Requisites** | Basic knowledge of semiconductor devices such as NMOS, PMOS, CMOS, BJT and digital VLSI design is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|------------|----------------------|----------|----------|-------|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|----------|--------|-------|
| **Module-1** | **Introduction**: Moore's Law and material processing, Defects in crystals, Eutectic phase diagram, Solid solubility, Homogeneous nucleation, Heterogeneous nucleation; Growth Processes - Crystal Growth – Necking and dislocation free CZ crystal growth, Segregation of impurities along length and diameter, Defects in CZ crystals, FZ Crystal growth; Epitaxy - Vapor phase epitaxy, LPE, MBE, CVD deposition of poly-silicon, SILOX process. | **9 Hours** |
| **Module-2** | **Diffusion**: Constant and limited source diffusion, Concentration dependent diffusion, Field assisted diffusion, Junction depth, Diffusion sources; **Ion Implantation**: Basic process, Ion implantation systems, Ion penetration and profile, Ion implantation damage. | **8 Hours** |
| **Module-3** | **Annealing Oxidation**: Purpose, Dry and wet oxidation, Deal-Grove model, Oxidation system, Properties of oxides – Masking and charges in oxides; Deposition processes - Fundamentals of vacuum systems, Vacuum evaporation of thin films, DC and RF sputtering of thin films, Interconnects, Contacts and dielectrics in IC fabrication, Deposition of silicon nitride. | **9 Hours** |
| **Module-4** | **Lithography**: Pattern generation and mask making, Optical lithography – Contact, Proximity and projection printing, Photoresists – Negative, Positive, Lift-off process, Electron beam and X-ray lithographic techniques. Etching - Wet etching, Isotropic and anisotropic etching, Plasma etching, Reactive ion beam etching. | **8 Hours** |
| **Module-5** | **IC Process Integration**: Bipolar transistor fabrication, Isolation techniques, P-MOS, N-MOS and C-MOS processes. | **8 Hours** |
| | Total | 42 Hours |

**Text Books**:
T1. S. M. Sze, **VLSI Technology**, 2$^{nd}$ *Ed.*, Tata McGraw Hill, 2003.
T2. S. K. Gandhi, **VLSI Fabrication Principles: Silicon and Gallium Arsenide**, 2$^{nd}$ *Ed.*, Wiley India, 1994.

**Reference Books**:
R1. J. Plummer, M. Deal, and P. Griffin, **Silicon VLSI Technology: Fundamentals, Practice, and Modeling**, Prentice Hall, 2000.
R2. M. J. Madou, **Fundamentals of Micro Fabrication: The Science of Miniaturization**, 2$^{nd}$ *Ed.*, CRC Press, 2002.
R3. S. Mahajan, **Principles of Growth and Processing of Semiconductors**, McGraw-Hill Education, 1999.

R4. S. A. Campbell, *The Science & Engineering of Microelectronics Fabrication*, 2nd *Ed.*, Oxford University Press, 2001.

**Online Resources**:
1. https://nptel.ac.in/courses/108101089: by Prof. A. N. Chandorkar, IIT Bombay
2. https://nptel.ac.in/courses/113106062: by Prof. P. Swaminathan, IIT Madras
3. https://nptel.ac.in/courses/103106075: by Dr. S. Ramanathan, IIT Madras
4. https://nptel.ac.in/courses/117106093: by Dr. N. Dasgupta, IIT Madras
5. https://ocw.mit.edu/courses/6-780-semiconductor-manufacturing-spring-2003/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| | |
|---|---|
| CO1 | Explain fundamental concepts of IC fabrication including crystal growth, epitaxy and deposition. |
| CO2 | Describe diffusion and ion implantation techniques and their role in IC fabrication processes. |
| CO3 | Explain annealing oxidation and various material deposition techniques used in IC fabrication. |
| CO4 | Analyze and explain lithography techniques and various etching processes in IC fabrication. |
| CO5 | Analyze and explain the integration of bipolar, MOS and CMOS processes in IC fabrication. |

**Program Outcomes Relevant to the Course**:

| | |
|---|---|
| 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 (WK1 to WK4). |
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK1, WK5, and WK7). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Electronic Design Automation | L-T-P | Credit | Marks |
|----------|------|------------------------------|-------|--------|-------|
| PEL | EC2027 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to equip students with skills in open-source EDA tools, scripting and GenAI techniques to automate design, simulation, verification and accelerate IC design workflows. |
| **Pre-Requisites** | Python programming, basics of TCL and familiarity with Linux is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|------------|----------------------|----------|----------|-------|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|----------|--------|-------|
| **Module-1** | Overview of the digital design flow, Design abstraction, RTL gate level, Physical design. Importance of design methodologies, Top-down vs Bottom up design methodologies, Industrial RTL to GDSII pipeline, Introduction to open-source EDA tool chain, Open source tools, Working flows, Files in each tool (RTL, Test benches, Library files, LEF, Net list and VCD files), Inter-connection of file format across tools, Introduction to Linux-based design environment, Need for automation in VLSI workflow, Introduction to scripting for tool invocation and simple automation – Batch simulation, Synthesis scripts, Automated flow execution. | **9 Hours** |
| **Module-2** | The Linux shell, Navigate the file system (pwd, cd, ls), View file contents (cat, less), create, copy, move, delete files (touch, cp, mv & rm), Use grep to search text, file permissions (chmod); Scripting fundamentals - Write a first script (#!/bin/bash), Use variables, capture command output; Decisions - Objectives, Use if, else if and else statements, Apply test conditions ([ ] or [[ ]]) for strings, numbers and files; Loops - for & while loops. | **9 Hours** |
| **Module-3** | Introduction to EDA - Motivation to automate EDA flows, Overview of a typical RTL to synthesis (via Yosys) process, Environment setup - Linux or Unix shell, Directory layout for multiple designs, Automating EDA tool invocation, Introduction to Yosys scripting, Writing batch scripts to loop over a directory of Verilog design files, Invoke Yosys or other EDA tools, Store outputs logs in structured directories, File and directory management, Log handling - File and directory operations in scripting, Redirect tool output (stdout/stderr) to log files, Capturing exit codes, Simple error handling logic, Parsing, Post-processing logs, Basics of regular expressions, Matching, Search, Groups, Extracting data from text logs, Writing a parser in Python/Perl/shell to scan log files and extract useful metrics. | **8 Hours** |
| **Module-4** | Python automation for VLSI design flow - Introduction to Python scripting, File system and process control, Variables, Conditionals, Loops, Log-file parsing, QoR computation and Adaptive re-run strategies to automate multi-step VLSI EDA flows. | **8 Hours** |

*Cont'd...*

| Module-# | Topics | Hours |
|---|---|---|
| **Module-5** | Introduction to a Gen-AI system for automated verilog generation, Use of Lang chain and Retrieval Augmented Generation (RAG) to automate the design iteration process of generation, simulation and verification. | **8 Hours** |
| | **Total** | **42 Hours** |

**Text Books**:

T1. N. H. E. Weste, D. Harris, and A. Banerjee, ***CMOS VLSI Design - A Circuits and Systems Perspective***, 4$^{th}$ *Ed.*, Pearson Education, 2010.

**Reference Books**:

R1. S. H. Gerez, ***Algorithms for VLSI Design Automation***, 1$^{st}$ *Ed.*, Willey India, 2006.
R2. J. M. Williams, ***Digital VLSI Design with Verilog***, 2$^{nd}$ *Ed.*, Springer, 2014.
R3. S. Lakshman and S. Tushar, ***Linux Shell Scripting Cookbook***, 3$^{rd}$ *Ed.*, Packt Publishing, 2017.
R4. H. P. Langtangen, ***Python Scripting for Computational Science***, —edn3, Springer, 2008.
R5. J. K. Ousterhout, ***TCL and the Tk Toolkit***, 2$^{nd}$ *Ed.*, Addison Wesley, 2006.
R6. D. Foster and K. Friston, ***Generative Deep Learning***, 2$^{nd}$ *Ed.*, Shroff/O'Reilly, 2023.
R7. Y. Kanitkar, ***Unix Shell Programming***, 1$^{st}$ *Ed.*, BRB Publications, 2003.

**Online Resources**:

1. https://nptel.ac.in/courses/106105083: by Prof. I. Sengupta, IIT Kharagpur
2. https://nptel.ac.in/courses/108106191: by Prof. S. Saurabh, IIT Delhi
3. http://iverilog.icarus.com/tutorial.html: Icarus Verilog Tutorial and Guides
4. https://yosyshq.net/yosys/: Yosys Open Synthesis Suite Documentation
5. https://python.langchain.com/en/latest/: Lang Chain Documentation
6. https://www.deeplearning.ai/courses/retrieval-augmented-generation-rag/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Explain and use open-source EDA tools to automate digital VLSI design flow in Linux. |
|---|---|
| CO2 | Develop bash scripts using variables, arguments, conditions, loops and file I/O. |
| CO3 | Automate EDA flows using scripts for file handling, tool control and log parsing. |
| CO4 | Integrate design flows using Python for file handling, tool execution and log parsing. |
| CO5 | Use GenAI, Lang Chain, and RAG to automate Verilog generation, simulation and verification. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|---|---|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |

| 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. (WK8) |
|------|---|

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Integrated Circuit Packaging | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| PEL | EC2028 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to understand integrated circuit (IC) packaging technologies, materials and design considerations to analyze and select appropriate packaging solutions for modern electronic systems. |
| **Pre-Requisites** | knowledge of semiconductor devices, electronic circuits and materials is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | **Introduction**: Fundamentals - Functions of an electronic package, Packaging hierarchy, Driving forces on packaging technology; Materials for microelectronic packaging - Packaging material properties, Ceramics, Polymers and metals in packaging; Electrical anatomy of systems packaging - Signal distribution, Power distribution, Electromagnetic interference. | 9 Hours |
| **Module-2** | **Packaging Techniques**: IC Assembly - Purpose, Requirements, Technologies, Wire bonding, Tape automated bonding, Flip chip, Wafer level packaging; Different types of IC packages - Dual-in-line package (DIP), Quad flat package (QFP), Systems packaging - MCM/SOC/SIP/SOP - Discrete, Integrated and Embedded passives. | 9 Hours |
| **Module-3** | **Reliability of Packaging**: Design for reliability - Fundamentals, Induced failures, Thermal management for IC & PWBs, Cooling requirements, Electronic cooling methods; Electrical testing - System level electrical testing, Interconnection tests, Active circuit testing, Design for testability, Trends in packaging. | 8 Hours |
| **Module-4** | **Advanced Packaging**: Chip scale packaging, Multi-chip module, Stacked package, System in package (SIP), System on chip (SOC), Specialized packages (RF, MEMS, Sensors, Harsh Environments, Wearable/Flexible). | 8 Hours |
| **Module-5** | **Mechanical & Thermal Design**: Vibration analysis, Theorem of Castigliano, Fatigue and creep analysis; Thermal Design - Basics of heat transfer, Thermal resistance, Thermal interface materials, Heat spreaders and heat sinks, System level thermal challenges. | 8 Hours |
| | Total | 42 Hours |

**Text Books**:
T1. R. R. Tummala, **Fundamentals of Micro-system Packaging**, 1st *Ed.*, McGraw-Hill, 2001.
T2. R. K. Ulrich and W. D. Brown, **Advanced Electronic Packaging**, 2nd *Ed.*, IEEE Press, 2006.

**Reference Books**:
R1. R. R. Tummala and M. Swaminathan, **Introduction to System-on-Package (SOP)**, 1st *Ed.*, McGraw-Hill, 2008.
R2. S. A. S. Moorthy, **Introduction to Electronic Packaging**, 1st *Ed.*, Notion Press, 2020.

P.T.O

**Online Resources**:
1. https://nptel.ac.in/courses/112105267: by Prof. A. Bhattacharya , IIT Kharagpur
2. https://nptel.ac.in/courses/108108031: by Prof. G. V. Mahesh, IISC Bangalore

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Describe the relevance of packaging and packaging materials for electronic systems. |
|-----|-------------------------------------------------------------------------------------|
| CO2 | Analyze various materials & techniques used in electronic packaging. |
| CO3 | Investigate electronic package for reliability, thermal management & testability. |
| CO4 | Apply various advanced packaging techniques followed in industry. |
| CO5 | Implement the mechanical and thermal aspects related to electronic packaging. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|------|---------|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Computer Organization & Architecture | L-T-P | Credit | Marks |
|----------|------|--------------------------------------|-------|--------|-------|
| MNR | CS2008 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to familiarize students about hardware design including logic design, basic structure and behaviour of the various functional modules of a modern digital computer and how they interact to provide the processing power to fulfil the needs of the user. |
| **Pre-Requisites** | Knowledge of basic digital electronics and computer fundamentals is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|------------|---------------------|----------|----------|-------|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|----------|--------|-------|
| **Module-1** | **Basic Structures of Computers**: Computer Architecture vs. Computer Organization, Functional units, Operational concepts, Registers, Bus Structure, Performance Consideration, SPEC rating. | **8 Hours** |
| **Module-2** | **Memory Location & Addresses**: Big-endian and Little-endian representation, Instruction format, Instruction set Architecture, RISC vs. CISC, Addressing modes, Instruction Sequencing, Subroutines. | **8 Hours** |
| **Module-3** | **Binary Arithmetic**: Addition and subtraction of signed numbers, Design of fast adders, Multiplication of positive numbers, Signed operand multiplication, Fast multiplication, Integer division, Representation of floating point numbers. | **8 Hours** |
| **Module-4** | **Memory System**: Basic Concepts, Speed, Size and cost, Cache memory concepts, Cache memory mapping techniques, Performance consideration; Virtual memory concepts, Translation look-aside buffer, Replacement techniques, Secondary Storage. | **10 Hours** |
| **Module-5** | **Basic Processing Units**: Fundamental concepts, Execution cycle, Single-Bus and Multi-Bus Organization, Execution of complete instruction, Hardwired control, Micro programmed control, Accessing I/O devices. | **8 Hours** |
| | Total | **42 Hours** |

**Text Books**:
T1. C. Hamacher, Z. Vranesic, and S. Zaky, *Computer Organization*, 5th *Ed.*, McGraw-Hill, 2017.
T2. W. Stallings, *Computer Organization and Architecture*, 9th *Ed.*, Prentice Hall India, 2012.

**Reference Books**:
R1. M. M. Mano, *Computer System Architecture*, 3rd *Ed.*, Pearson Education, 2007.
R2. B. Govindarajalu, *Computer Architecture and Organization*, 5th *Ed.*, Tata McGraw-Hill, 2004.
R3. N. P. Carter, *Schaum's Outline of Computer Architecture*, McGraw-Hill Education, 2002.

**Online Resources**:
1. https://nptel.ac.in/courses/106106166: by Prof. V. Kamakoti, IIT Madras
2. https://nptel.ac.in/courses/106104073: by Prof. B. Raman, IIT Kanpur
3. https://nptel.ac.in/courses/106103180: by Prof. J. K. Deka and Prof. A. Sarkar, IIT Guwahati
4. https://ocw.mit.edu/courses/6-823-computer-system-architecture-fall-2005/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Explain the architecture of a digital computer and the functions of its basic units. |
|-----|----------------|
| CO2 | Interpret instruction formats and apply addressing modes to solve basic problems. |
| CO3 | Perform binary arithmetic operations using techniques for fixed & floating-point arithmetic. |
| CO4 | Analyze memory hierarchy, explain cache & virtual memory mapping & replacement techniques. |
| CO5 | Explain control unit and compare between hardwired & microprogrammed control techniques. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|-----|----------------|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Power Electronic Devices | L-T-P | Credit | Marks |
|----------|------|--------------------------|-------|--------|-------|
| MNR | EC2024 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to study different types of power semiconductor devices and their switching characteristic, including the operation and characteristics of various power electronic converters. |
| **Pre-Requisites** | Knowledge of physics, calculus, ordinary differential equations and basic electronics is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|------------|----------------------|----------|----------|-------|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|----------|--------|-------|
| **Module-1** | Power Semiconductor Devices: Switching and V-I characteristic of devices: Transistor Family: BJT, IGBT, and MOSFET, Thyristor family: SCR, TRIAC; Series and parallel grouping of SCR, SCR triggering methods, SCR: Over voltage, Over Current, dv/dt, di/dt, Gate Protection, Snubber circuit. | 10 Hours |
| **Module-2** | AC to DC Converter: Phase Controlled Converter: Principle of phase controlled converter operation, single phase full converter with R, R-L and R-L-E load, 3 phase full converter with R, R-L and R-L-E load, single phase semi converter with R, R-L and R-L-E load. | 10 Hours |
| **Module-3** | AC to AC Converter: Single phase bi-directional controllers with R and R-L load, Single phase cycloconverters – Step up and Step down, Applications. | 6 Hours |
| **Module-4** | DC to DC Converter: First quadrant, second quadrant, first and second quadrant, third and fourth quadrant converter; Switching Mode Regulators: Buck regulators, Boost regulators, Buck-Boost regulators; Isolated Converters: Flyback & Forward Converter, Applications. | 8 Hours |
| **Module-5** | DC to AC Converter: Voltage Source Inverter (VSI) - Single phase Bridge Inverters, 3-Phase Inverters - 180° mode conduction, 120° mode conduction, Voltage control of 3-Phase Inverters by Sinusoidal PWM (PWM VSI), Current Source Inverter (CSI); Power Electronics Applications: UPS, SMPS, Induction Heating, AC/DC drives speed control. | 8 Hours |
| | Total | 42 Hours |

**Text Books**:

T1. M. H. Rashid, *Power Electronics: Devices, Circuits, and Applications*, 4th *Ed.*, Pearson Education, 2017.

T2. P. S. Bhimbra, *Power Electronics*, 6th *Ed.*, Khanna Publishers, 2014.

**Reference Books**:

R1. M. D. Singh and K. B. Khanchandani, *Power Electronics*, 2nd *Ed.*, McGraw-Hill, 2017.

R2. P. C. Sen, *Power Electronics*, 1st *Ed.*, McGraw Hill India, 2001.

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**Online Resources**:
1. https://nptel.ac.in/courses/108101038/: by Prof. Fernandes and Chatterjee, IIT Bombay.
2. https://nptel.ac.in/courses/108/102/108102145/: by Prof. G. Bhuvaneshwari, IIT Delhi.
3. https://ocw.mit.edu/courses/6-334-power-electronics-spring-2007/pages/lecture-notes/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| | |
|---|---|
| CO1 | Articulate the characteristics of power semiconductor devices and fundamentals of thyristors. |
| CO2 | Analyze the operation of AC-DC converters and its application in the practical field. |
| CO3 | Interpret the operation of AC-AC converters and analyze their performance. |
| CO4 | Design and analyze the operation of DC-DC converters and their use in DC drives. |
| CO5 | Investigate the operation of DC–AC converters, SPWM modulation technique and applications. |

**Program Outcomes Relevant to the Course**:

| | |
|---|---|
| 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 (WK1 to WK4). |
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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 (WK1, WK5, and WK7). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Operating Systems | L-T-P | Credit | Marks |
|----------|------|-------------------|-------|--------|-------|
| MNR | CS2003 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to understand the fundamental concepts, techniques & algorithms, and internal working principles of a computer operating system to become a system designer or an efficient application developer. |
| **Pre-Requisites** | Knowledge of computer programming and data structures is required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required, sessions are planned to be interactive with focus on problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|------------|---------------------|----------|----------|-------|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|----------|--------|-------|
| **Module-1** | **Introduction**: Overview, Evolution of operating system, Types of systems - Batch Processing, Multiprogramming, Time Sharing systems; Personal Computers, Parallel, Distributed, and Real-time Systems; Operating System Services, System components, System calls. | 7 Hours |
| **Module-2** | **Process Management**: Process concepts, states, PCB, Process scheduling queues, queuing diagram, Types of schedulers, Operations on process; Interprocess communication - shared memory, message passing, Concept of buffering, Thread overview, Benefits of multi-threaded program, User and kernel threads, Multi-threading models, Issues with multi-threading - thread cancellation, thread pools, thread specific data; CPU Scheduling: Dispatcher, Scheduling - Criteria, Algorithms - FCFS, SJF, SRTF, RR, Priority, Multi-level Queue (MLQ), MLQ with Feedback. | 9 Hours |
| **Module-3** | **Process Synchronization**: Background, Bounded-buffer – Shared-memory solution to Producer-consumer problem, Race condition, Critical section problem - Peterson's solution, Synchronization hardware: TestAndSet(), swap() instructions, Semaphores - Counting and binary semaphore, spinlocks, Classical problems of synchronization - Bounded-buffer problem, Readers-writers problem, Dining-philosophers problem, Monitors; Deadlock: System model, characterization, Resource-allocation graph, Methods for handling deadlocks, Deadlock prevention & avoidance, Banker's algorithm, Deadlock detection & recovery. | 9 Hours |
| **Module-4** | **Memory Management**: Background, Logical & physical address space, Dynamic loading & dynamic linking, Swapping, Contiguous memory allocation, Dynamic storage allocation problem, Overlays, Paging, Segmentation; Virtual Memory: Background, Demand paging, Page fault, Basic page replacement policy, Page replacement algorithms - FIFO, OPT, LRU, LRU Approximation, LFU, MFU, Thrashing, Working-set model. | 9 Hours |

| Module-# | Topics | Hours |
|---|---|---|
| Module-5 | **Secondary Storage Structure**: Overview of mass storage structure, Disk structure, Disk scheduling - FCFS, SSTF, SCAN, C-SCAN, LOOK, CLOOK, Swap-space management, RAID structure; File System: Concept, Access methods, Directory structure, Directory implementation, Allocation methods, Free space management, Case Studies: The LINUX System visual representations of your data, Avoiding common pitfalls. | 8 Hours |
| | **Total** | **42 Hours** |

**Text Books**:

T1. A. Silberschatz, P. B. Galvin, and G. Gagne, ***Operating System Concepts***, 10<sup>th</sup> *Ed.*, Wiley, 2018.

T2. M. Milenković, ***Operating Systems: Concepts and Design***, 2<sup>nd</sup> *Ed.*, Tata McGraw-Hill, 2010.

**Reference Books**:

R1. A. S. Tanenbaum, ***Modern Operating Systems***, 5<sup>th</sup> *Ed.*, PHI, 2022.

R2. P. B. Prasad, ***Operating Systems and System Programming***, 3<sup>rd</sup> *Ed.*, Scitech Publications, 2018.

**Online Resources**:

1. https://nptel.ac.in/courses/106102132/: by Prof. S. Bansal, IIT Delhi
2. https://nptel.ac.in/courses/106108101/: by Prof. P. C. P. Bhatt, IISc Bangalore
3. https://nptel.ac.in/courses/106106144/: by Prof. C. Rebeiro, IIT Madras
4. https://nptel.ac.in/courses/106105214/: by Prof. S. Chattopadhyay, IIT Kharagpur
5. https://www.cse.iitb.ac.in/~mythili/os/: Notes & slides by Prof. M. Vutukuru, IIT Bombay
6. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-828-operating-system-engineering-fall-2012/lecture-notes-and-readings/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Explore principles behind various types of operating systems, system components, system calls, protection mechanisms and services. |
|---|---|
| CO2 | Explain different schedulers, scheduling policies, and design new scheduling algorithms for real life problems. |
| CO3 | Describe the significance of process synchronization through classical synchronization problems and deadlock handling mechanisms. |
| CO4 | Describe the working principle of main memory, cache memory and virtual memory organization and solve memory related problems. |
| CO5 | Articulate secondary storage management, and analyze the performance of various disk scheduling algorithms. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|---|---|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |

*Cont'd...*

| 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 (WK8). |
|---|---|
| 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 (WK2 and WK6). |
| 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 (WK1, WK5, and WK7). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Data Mining & Data Warehousing | L-T-P | Credit | Marks |
|----------|------|-------------------------------|-------|--------|-------|
| MNR | CS3013 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to analyze large, complex, information-rich data in various domains, study the concepts and applications of data warehouses and discover useful patterns by applying data mining techniques. |
| **Pre-Requisites** | Knowledge of database management systems, probability, statistics and programming language are required. |
| **Teaching Scheme** | Regular classroom lectures with use of ICT as and when required; sessions are planned to be interactive with focus on problem solving activities. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|------------|---------------------|----------|----------|-------|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|----------|--------|-------|
| **Module-1** | **Data Warehousing**: Concepts and applications, Difference between operational database and data warehouses, OLTP and OLAP systems, 3-tier architecture, ETL Process, Data Marts, Data staging area, Metadata. | **8 Hours** |
| **Module-2** | **Data Mining**: Concepts and applications, KDD process, Data Objects and attributes types, Basic Statistical Descriptions of Data – Central tendency - variation, spread, standard deviation and Boxplot, Data similarity; Data Pre-processing – Data cleaning, binning, integration, reduction and transformation; Correlation Analysis – Pearson's coefficient, Chi-Square and Covariance. | **10 Hours** |
| **Module-3** | **Mining Frequent Patterns**: Introduction, Market Basket Analysis, Association rule mining, Support, Confidence, Lift, Frequent Item-sets, Closed Item-sets, Maximal Item-set and generation, Apriori and FP-Growth algorithms, Evaluation of association patterns, Association and Correlation analysis. | **8 Hours** |
| **Module-4** | **Classification**: Concepts and applications, Decision Tree Induction, Information Gain, Bayes Theorem, Naïve Bayesian Classifier, K Nearest Neighbor; Classification evaluation techniques (Confusion matrix – Precision, Recall & F-Measure), Handling the class imbalance problem (Oversampling, Undersampling, Threshold moving and Ensemble techniques). | **8 Hours** |
| **Module-5** | **Clustering**: Concepts and applications, Partition-based Clustering – K-Means and K-Medoid algorithms, Hierarchical clustering – Agglomerative and Divisive methods, Density-based Clustering – DBSCAN, Graph-based clustering, Clustering evaluation techniques (Silhouette Coefficient and Dunn's Index). | **8 Hours** |
| | Total | **42 Hours** |

**Text Books**:

T1. J. Han, M. Kamber, and J. Pei, **Data Mining: Concepts and Techniques**, 3rd *Ed.*, Morgan Kaufmann, 2011.

T2. R. Thareja, **Data Warehousing**, 1st *Ed.*, Oxford University Press, 2009.

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**Reference Books**:

R1. A. Berson and S. J. Smith, ***Data Warehousing, Data Mining & OLAP***, 1st *Ed.*, McGraw Hill Education, 2017.

R2. P. N. Tan, M. Steinbach, A. Karpatne, and V. Kumar, ***Introduction to Data Mining***, 2nd *Ed.*, Pearson Education, 2019.

**Online Resources**:

1. https://nptel.ac.in/courses/106105174/: by Prof. P. Mitra, IIT Kharagpur
2. https://nptel.ac.in/courses/110107092: by Prof. G. Dixit, IIT Roorkee
3. http://infolab.stanford.edu/~ullman/mining/2003.html: notes by Stanford University
4. https://www.cse.iitb.ac.in/~krithi/courses/631/anand.ppt: by Prof. A. Deshpande, IIT Bombay

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Describe the concepts and applications of Data Warehouse and its components. |
|-----|------------------------------------------------------------------------------|
| CO2 | Explain the concepts of Data Mining and its applications. |
| CO3 | Construct frequent patterns and association rules by discovering correlations among data. |
| CO4 | Compare key classification algorithms and apply them to real life problems in multiple domains. |
| CO5 | Apply different clustering algorithms for solving real life problems in various domains. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|-----|------------------------------------------------------------------------------|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Digital Marketing & SMO | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| MNR | MG2002 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to provide students with foundational knowledge and practical skills in digital marketing tools, platforms and analytics, enabling them to design, execute and evaluate effective data-driven marketing campaigns across digital channels. |
| **Pre-Requisites** | Basic understanding of marketing, computer fundamentals and familiarity with the internet, websites and social media platforms is required. |
| **Teaching Scheme** | Regular classroom lectures with the use of ICT tools as and when required; sessions are planned to be interactive with emphasis on real-world case studies, demonstrations and exposure to digital marketing tools. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | **Digital Marketing**: Fundamentals of Marketing Concepts and Principles, Key Marketing Terminology, Role of Marketing in the Digital Age, Digital Marketing Channels and Platforms, Role of Data in Digital Marketing; Introduction to Google Ads, Setting Up Google Ads Campaigns, Keyword Research and Selection, Ad Copywriting Best Practices, Ad Formats and Extensions, Bid Management and Budgeting, Quality Score Optimization, Performance Measurement and Reporting. | **8 Hours** |
| **Module-2** | **Content Creation & Email Marketing**: Content Creation Tools and Platforms, Visual Content Creation (Graphics, Images, Videos), Content Marketing Strategy Development, Content Distribution and Promotion, Content Calendar Planning, Measuring Content Marketing Effectiveness; Email Marketing - Introduction, Email Marketing Platforms, Designing Effective Email Campaigns, Automation Workflows and Drip Campaigns, Email Marketing Analytics and Tracking. | **7 Hours** |
| **Module-3** | **Marketing on Social Media**: Advertising on Facebook and Instagram, Ad Campaign Objectives, Ad Creatives and Visuals, Ad Placements and Audience Targeting, Facebook Pixel and Conversion Tracking; Video Advertising on YouTube, Video Ad Creation and Optimization, Targeting Options and Metrics; Advertising Formats on Twitter, Campaign Measurement and Reporting. | **8 Hours** |
| **Module-4** | **SEO & SMO Management**: SEO Fundamentals and Principles, Keyword Research and Analysis, On-Page SEO Optimization, Off-Page SEO Including Link Building and Backlinks, Technical SEO and Site Audit, SEO Tools and Platforms such as SEMrush and Ahrefs; Setting Up Organizational Pages on Social Platforms, Content Calendar Creation, Use of Social Media Management Tools such as Buffer and Hootsuite, Social Media Analysis and Management. | **8 Hours** |

| Module-# | Topics | Hours |
|---|---|---|
| Module-5 | **B2B & Marketing Analytics**: B2B Digital Marketing on LinkedIn, LinkedIn Advertising Formats, Targeting Options, Sponsored Content and InMail, Lead Generation Campaigns, Campaign Optimization; Influencer Marketing Strategy, Influencer Identification and Collaboration, Measuring Influencer Marketing ROI, Influencer Marketing Platforms and Tools; Web Analytics Fundamentals, Analytics Setup and Usage, Conversion Rate Optimization Principles, Website Traffic and User Behavior Analysis. | 11 Hours |
| | **Total** | 42 Hours |

**Text Books**:
  T1. S. Gupta, *Digital Marketing*, 3rd *Ed.*, McGraw-Hill, 2022.
  T2. D. Chaffey and F. Ellis-Chadwick, *Digital Marketing: Strategies, Implementation and Practice*, 6th *Ed.*, Pearson Education, 2015.
  T3. T. L. Tuten and M. R. Solomon, *Social Media Marketing*, 3rd *Ed.*, Sage Publications, 2017.

**Reference Books**:
  R1. D. Chaffey and P. R. Smith, *Digital Marketing Excellence: Planning, Optimizing and Integrating Online Marketing*, 5th *Ed.*, Routledge Publication, 2017.
  R2. E. Enge, S. Spencer, J. C. Stricchiola, and R. Fishkin, *The Art of SEO: Mastering Search Engine Optimization*, 3rd *Ed.*, O'Reilly Media, 2015.
  R3. S. S. Chauhan, P. Bhatia, and V. Prakash, *Digital and Social Media Marketing*, 1st *Ed.*, Mahe Publications, 2023.
  R4. M. O. Opresnik, S. Hollensen, and P. Kotler, *Social Media Marketing: A Practitioner Approach*, Indian Edition, Vikas Publishing, 2022.

**Online Resources**:
  1. https://nptel.ac.in/courses/110105091: by S. Das, IIT Kharagpur
  2. https://nptel.ac.in/courses/110107081: by IIT Roorkee
  3. https://nptel.ac.in/courses/110105085: by IIT Kharagpur
  4. https://nptel.ac.in/courses/110106120: by IIT Madras
  5. https://nptel.ac.in/courses/110106144: by IIT Bombay
  6. https://academy.hubspot.com/courses
  7. https://skillshop.withgoogle.com/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Explain digital marketing fundamentals and design basic Google Ads with performance analysis. |
|---|---|
| CO2 | Create content and email marketing campaigns using tools, automation and analytics. |
| CO3 | Design and analyze social and video advertising campaigns across major digital platforms. |
| CO4 | Apply SEO techniques and manage social media using industry tools and performance metrics. |
| CO5 | Implement B2B, influencer and analytics strategies to optimize digital marketing outcomes. |

**Program Outcomes Relevant to the Course**:

| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
|---|---|

*Cont'd...*

| | |
|---|---|
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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 (WK1, WK5, and WK7). |
| PO7 | **Ethics**: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9) |
| PO8 | **Individual & 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Fundamentals of Business Analytics | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| MNR | MG2005 | | 3-0-0 | 3 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to introduce the fundamental concepts of business analytics with preliminary tools & techniques used for discovering important knowledge and use them for achieving business goals. |
| **Pre-Requisites** | Basic knowledge of mathematics, probability & statistics, and intermediate level of competence in spreadsheet applications is required. |
| **Teaching Scheme** | Regular classroom lectures, power point presentations with use of ICT as required, with examples, real-life case studies, assignments and projects. |

## Evaluation Scheme

| Attendance | Teacher's Assessment | Mid-Term | End-Term | Total |
|---|---|---|---|---|
| 10 | 20 | 20 | 50 | 100 |

## Detailed Syllabus

| Module-# | Topics | Hours |
|---|---|---|
| **Module-1** | **Introduction**: Business Intelligence and Business Analytics, Its importance & need for businesses, Business process flow, Business challenges, Decision making under uncertainty, Data driven decision making; Types of analytics: Descriptive, Diagnostic, Predictive, Prescriptive. | 6 Hours |
| **Module-2** | **Business Statistics**: Data types, Descriptive and Inferential statistics, Sampling techniques, Measure of central tendencies, Measure of dispersion, Hypothesis Testing, Chi Square test, Regression and Correlation. | 8 Hours |
| **Module-3** | **Basic Analysis**: Tools and functionalities of spread- sheets, Data recording rules, Formatting, Conditional formatting, Data protection, Working with multiple sheets & files, Hyperlinking, Cell reference, Sort, Filter, Find and replace, Data cleaning, Applying spreadsheet functions. | 8 Hours |
| **Module-4** | **Advanced Analysis**: Data calculation and manipulation functions (Text, Unique, Sort, Transpose, Filter etc.), Data extraction Functions (Nested Ifs, If And, If Or, Xlookup, Vlookup, Index etc.), Pivot table and charts; Automation using Macros, Basics of power query, Business reporting and visual analytics, Slicers, Advanced functions on cloud-based spreadsheets (Importhtml, Importdata, Importrange, Query, Finance). | 8 Hours |
| **Module-5** | **Business Analytics using AI**: AI tools for data insight, Business verticals, Sales and Marketing analytics, Finance analytics, Human resources analytics, Supply chain analytics. | 7 Hours |
| | Total | 42 Hours |

**Text Books**:
  T1. V. Chavda, *Fundamentals of Business Analytics*, 1st *Ed.*, Himalaya Publishing House, 2024.
  T2. U. D. Kumar, *Business Analytics: The Science of Data-Driven Decision Making*, 2nd *Ed.*, Wiley Publication, 2017.

**Reference Books**:
  R1. J. R. Evans, *Business Analytics*, 3rd *Ed.*, Pearson Education, 2011.
  R2. S. Gupta and A. Jathar, *Marketing Analytics*, 1st *Ed.*, Wiley Publication, 2021.
  R3. R. Bhattacharya and A. M. Bhattacharyya, *Supply Chain Analytics*, 1st *Ed.*, Sage Publications, 2022.

**Online Resources**:
1. https://nptel.ac.in/courses/110105089: by Prof. R. P. Pradhan, IIT Kharagpur
2. https://nptel.ac.in/courses/110106050: by Dr. S. Vaidhyasubramaniam, IIT Madras

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Appreciate business processes, concepts of business intelligence and analytics. |
|-----|--------------------------------------------------------------------------------|
| CO2 | Apply statistical methods for descriptive, inferential, predictive and diagnostic analytics. |
| CO3 | Leverage spreadsheet tools for data entry, cleaning, analysis & visualization through dashboards. |
| CO4 | Apply advanced tools for data extraction, pivoting, automation and visual analytics. |
| CO5 | Employ AI-driven analytics across commercial functions to guide key managerial decisions. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|-----|---|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

| Category | Code | Linux & TCL for SSD Lab | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| PCR | EC2029 | | 0-0-2 | 1 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to solve selected problems from solid state devices using the programming language TCL. The labs will be done on Linux OS. It will give the students introductory exposure and head start to Linux and TCL, two essential environments in VLSI ecosystem. |
| **Pre-Requisites** | This lab will run in parallel with the Solid State Devices theory course. |
| **Teaching Scheme** | Regular laboratory experiments to be conducted under the supervision of teachers with the help of ICT as and when required along with pre-lab session and demonstration for each experiment. |

## Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test / Mini Project | Viva-voce | Total |
|---|---|---|---|---|---|
| 10 | 30 | 15 | 30 | 15 | 100 |

## Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|---|---|
| 1 | Introduction to TCL Scripting and Linux Environment: Learning objectives - Setup of the environment, Write & execute basic TCL scripts, Print statements, Variables, Expressions, Simple I/O; Sample Task - Write a TCL script to print "Welcome to VLSI Lab" and display system path/variables. |
| 2 | Band Diagram Calculation and Visualization: Write a TCL program to input doping concentrations and calculate built-in voltage for a pn junction; Print values for energy band alignment. |
| 3 | Carrier Concentration and Fermi Level Calculation Inputs: Doping type and level, Temperature. TCL script to compute electron and hole concentrations and fermi level position in intrinsic and extrinsic semiconductors. |
| 4 | Drift and Diffusion Current Simulation: Script asks for Electric field, Doping and Mobility, Computes drift and diffusion currents for electrons and holes. |
| 5 | TCL Array Operations with Semiconductor Parameters: Store material constants (such as Si, Ge, GaAs) in arrays and Write scripts to retrieve and display parameters like bandgap, mobility, dielectric constant. |
| 6 | Material Parameter Retrieval with GUI: Introduce Tk and basic GUI construction; Task - Design a simple Tk GUI; The user selects a material (Si, Ge, GaAs) from a dropdown menu and the script displays bandgap, mobility and dielectric constant in GUI labels/fields. |
| 7 | Capacitance-Voltage (C-V) Analysis of a PN Junction: Script to compute and plot values for Space charge width and Junction capacitance versus bias voltage. |
| 8 | TCL Loops and Conditional Statements for Piecewise Device Modeling: Implement a Piecewise I-V model of a Practical diode, Separating forward, Reverse and Breakdown regions using TCL loops and conditionals. |
| 9 | Basic MOS Capacitor Simulation: TCL program to take parameters (oxide thickness, doping, voltage) and Compute flat-band voltage, Threshold voltage and Inversion charge for MOS structure. |

*Cont'd...*

| Experiment-# | Assignment/Experiment |
|---|---|
| 10 | Temperature Dependence in Semiconductor Parameters: Script inputs temperature, calculates and Prints variations in Intrinsic carrier concentration, Conductivity and Mobility for silicon. |
| 11 | MOSFET Switch Simulator with GUI: Use Tk to create an interactive interface, TCL/Tk GUI where students adjust Gate voltage and Threshold voltage using sliders or entry boxes; The interface visually indicates if the MOSFET is ON or OFF (Ex: A color indicator or message); This reinforces both Device theory and Event-driven GUI programming. |
| 12 | Mini Project: Band Structure Exploration and Parameter Report: Group activity - Students write and debug a TCL script that takes inputs for various materials and outputs their basic device parameters and graphical summaries (using ASCII plots or CSV export for graphing). |

**Text Books**:
T1. B. Welch, K. Jones, and J. Hobbs, ***Practical Programming in Tcl and Tk***, Prentice Hall, 2003.
T2. D. A. Neamen, ***Semiconductor Physics and Devices***, 4$^{th}$ *Ed.*, McGraw-Hill, 2012.
T3. G. Streetman and S. K. Banerjee, ***Solid State Electronic Devices***, 7$^{th}$ *Ed.*, Pearson, 2014.

**Reference Books**:
R1. P. Raines, ***Tcl/Tk Pocket reference***, 1$^{st}$ *Ed.*, O'Reilly Media, 1998.
R2. S. M. Sze, ***VLSI Design***, 2$^{nd}$ *Ed.*, McGraw-Hill Education, 1998.

**Online Resources**:
1. https://nptel.ac.in/courses/117106113: By Prof. A. Iyer, IIT Madras
2. https://www.tcl-lang.org/man/tcl8.5/tutorial/tcltutorial.html: TCL Basics
3. https://wiki.tcl-lang.org/page/Online+Tcl+and+Tk+Tutorials: Curated collection of tutorials
4. https://www.youtube.com/playlist?list=PL1h5a0eaDD3rsGDFnVki_fFEtDWQfXjca: TCL Tutorials by VLSI Academy
5. https://linuxjourney.com/: Interactive Linux tutorials

**Course Outcomes**: *At the end of this course, the students will be able to:*

| CO1 | Execute TCL scripts on Linux to model and analyze basic solid-state devices. |
|---|---|
| CO2 | Solve standard semiconductor device problems computationally, including calculations of carrier concentrations, current-voltage characteristics and temperature effects. |
| CO3 | Design simple graphical user interface (GUI) applications using TCL /Tk to interactively simulate or visualize solid-state device behaviors and parameters. |
| CO4 | Use a Linux-based environment for scientific programming and scripting, developing skills in OS navigation, script debugging and tool integration. |

**Program Outcomes Relevant to the Course**:

| 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 (WK1 to WK4). |
|---|---|
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |

*Cont'd...*

| 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 (WK5). |
|---|---|
| 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 (WK8). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

|  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 2 | 2 | 1 | 1 |  |  |  |  |  |  | 1 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 2 | 1 |  |  |  |  |  |  | 2 | 2 | 2 | 2 |
| CO3 | 2 | 2 | 2 | 1 |  |  |  |  |  |  | 2 | 2 | 2 | 2 |
| CO4 | 2 | 2 | 3 | 2 |  |  |  |  |  |  | 1 | 2 | 2 | 1 |

| Category | Code | Digital Circuit Design Lab | L-T-P | Credit | Marks |
|----------|------|----------------------------|-------|--------|-------|
| PCR | EC2032 | | 0-0-4 | 2 | 100 |

| | |
|---|---|
| **Objectives** | The objective of the course is to provide hands-on experience on design and implementation of digital systems using modern digital design flow from Verilog to FPGA implementation. The course will also provide extensive experience of using digital lab equipment digital scope and logic analyzer. |
| **Pre-Requisites** | Knowledge of basic electronics is required. |
| **Teaching Scheme** | Regular laboratory experiments to be conducted under the supervision of teachers and demonstrators with the help of ICT as and when required along with pre-lab session and demonstration for each experiment. |

## Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test / Mini Project | Viva-voce | Total |
|------------|-------------------|------------|-------------------------|-----------|-------|
| 10 | 30 | 15 | 30 | 15 | 100 |

## Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|--------------|------------------------|
| 1-3 | Introduction to open-source Verilog simulator: iverilog and viewer gtk wave. Simulation of basic combinational gates and verification of it. Design a combinational circuit using tools from the lecture (K-Map, Don't care and Hazards). |
| 4-6 | Verilog implementation and verification of Combinational logic components - Multiplexer, De-Multiplexer, Decoders, Encoder (Priority Encoder) and BCD to 7 Segment display, |
| 7-9 | Verilog implementation and verification of arithmetic structures - Adder, Subtractor, Multiplier, Equality detector and comparator. Verilog implementation of the logic blocks. (Introduction to Gate level modeling and Data flow modeling). |
| 10 | Introduction to Behavioral modeling in Verilog. |
| 11-13 | Behavioral modeling of Finite-State Machine - Implementation of traffic light controller. |
| 14-16 | Introduction to Verilog synthesis and place-and-route using open-source EDA tools (yosys & pnr). |
| 17-19 | FPGA implementation of a traffic light controller. Test & debug of a digital system using digital scope and logic analyzer. |
| 20-25 | Project Work: A single-cycle RISC-V processor from TL-Verilog to FPGA. |

**Text Books**:
T1. M. M. Mano and M. D. Ciletti, ***Digital Design: With an Introduction to Verilog HDL, VHDL and System Verilog***, 6$^{th}$ *Ed.*, Pearson Education, 2018.

T2. S. Palnitkar, ***Verilog HDL: A Guide to Digital Design and Synthesis***, 2$^{nd}$ *Ed.*, Pretince Hall, 2003.

T3. D. Harris and S. Harris, ***Digital Design and Computer Architecture***, 2$^{nd}$ *Ed.*, Elsevier, 2012.

**Reference Books**:
R1. A. M. Michelén, ***Digital Electronics Laboratory Manual***, Pearson Education, 2000.

R2. J. W. Stewart and C. -Y. Wang, ***Digital Electronics Laboratory Experiments: Using the Xilinx XC95108 CPLD with Xilinx Foundation : Design and Simulation Software***, 2$^{nd}$ *Ed.*, Pearson, 2004.

P.T.O

**Online Resources**:
1. https://makerchip.com: TL-Verilog and its ecosystem.
2. https://www2.mvcc.edu/users/faculty/jfiore/Resources/DigitalElectronics1LaboratoryManual.pdf
3. https://www.elprocus.com/top-digital-electronic-projects-for-electronics-engineering-students/
4. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-111-introductorydigital-systems-laboratory-spring-2006/

**Course Outcomes**: *At the end of this course, the students will be able to:*

| | |
|------|------------------------------------------------------------------------------------------|
| CO1 | Solve real-word problems using digital circuits. |
| CO2 | Model digital circuits using a hardware description language (HDL). |
| CO3 | Synthesize the model digital circuit into FPGA hardware, test and characterize it using digital test instrument. |
| CO4 | Understand the basics of the RISC-V processor by modeling it in a transaction level description language. |

**Program Outcomes Relevant to the Course**:

| | |
|------|------------------------------------------------------------------------------------------|
| 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 (WK1 to WK4). |
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 | PSO3 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|
| CO1 | 3 | 3 | 2 | 1 | 1 | | | | | | 1 | 3 | 2 | 1 |
| CO2 | 3 | 2 | 3 | 1 | 2 | | | | | | 1 | 2 | 3 | 2 |
| CO3 | 2 | 2 | 3 | 2 | 3 | | | | | | 2 | 2 | 3 | 2 |
| CO4 | 3 | 2 | 2 | 2 | 2 | | | | | | 2 | 2 | 2 | 2 |

| Category | Code | Communication Systems Engineering Lab | L-T-P | Credit | Marks |
|---|---|---|---|---|---|
| PCR | EC2030 | | 0-0-2 | 1 | 100 |

| | |
|---|---|
| **Objectives** | The objective of this course is to get practical exposure to communication engineering by conducting experiments on spectrum analysis, FDM, TDM, PAM, PCM, FM & AM techniques using hardware & software. |
| **Pre-Requisites** | Basic knowledge of signals and systems, AM & FM modulation is required. Acquaintance with MATLAB and LabVIEW would be beneficial. |
| **Teaching Scheme** | Regular laboratory experiments are to be conducted under supervision of the teacher; Demonstration will be given for each experiment in the pre-lab session. |

## Evaluation Scheme

| Attendance | Daily Performance | Lab Record | Lab Test / Mini Project | Viva-voce | Total |
|---|---|---|---|---|---|
| 10 | 30 | 15 | 30 | 15 | 100 |

## Detailed Syllabus

| Experiment-# | Assignment/Experiment |
|---|---|
| 1 | To plot and analyze the spectrum of following signals with aid of spectrum analyzer: Sine wave, Square wave, Triangle wave and Saw tooth wave of frequencies 1 KHz, 10 KHz, 50 KHz, 100 KHz and 1 MHz. |
| 2 | Study and analyze various AM modulation & demodulation techniques. |
| 3 | Study of FM modulation & demodulation technique. |
| 4 | Study and analyze the process of frequency division multiplexing & de-multiplexing. |
| 5 | Study and analyze the pulse amplitude modulation and demodulation system. |
| 6 | Study and analyze the pulse code modulation and de-modulation system. |
| 7 | Study and analysis of different AM techniques using MATLAB. |
| 8 | Study and analysis of FM technique using MATLAB. |
| 9 | Simulate AM modulation & demodulation system using Lab View software. |
| 10 | Simulate FM modulation & demodulation system using Lab View software. |
| 11 | Study and analyze time division multiplexing. |
| 12 | Study the functioning of delta and adaptive delta modulator. |

**Text Books**:
T1. H. Taub, D. L. Schilling, and G. Saha, *Principles of Communication Systems*, 4th *Ed.*, McGraw-Hill Education, 2013.
T2. R. P. Singh and S. D. Sapre, *Communication Systems: Analog and Digital*, 3rd *Ed.*, McGraw-Hill Education, 2014.

**Reference Books**:
R1. J. G. Proakis and M. Salehi, *Communication System Engineering*, 2nd *Ed.*, PHI, 2002.
R2. S. Haykin and M. Moher, *Communication Systems*, 5th *Ed.*, John Wiley & Sons, 2009.
R3. B. P. Lathi, Z. Ding, and H. M. Gupta, *Modern Digital and Analog Communication Systems*, 4th *Ed.*, Oxford University Press, 2017.

P.T.O

**Online Resources**:
1. https://nptel.ac.in/courses/117105143: by Prof. G. Das, IIT Kharagpur
2. https://nptel.ac.in/courses/108104091: by Prof A. K. Jagannatham, IIT Kanpur
3. https://nptel.ac.in/courses/117102059: by Prof. S. Prasad, IIT Delhi

**Course Outcomes**: *At the end of this course, the students will be able to:*

| | |
|-----|-------------------------------------------------------------------------------|
| CO1 | Analyze frequency spectrum of different type of waveforms. |
| CO2 | Implement and analyze analog modulation schemes using spectrum analyzer for communication. |
| CO3 | Understand multiple signal transmission using FDM and TDM schemes. |
| CO4 | Realize the PAM and PCM systems. |
| CO5 | Explain the functioning of Delta modulator and adaptive delta modulator. |

**Program Outcomes Relevant to the Course**:

| | |
|------|-------------------------------------------------------------------------------|
| 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 (WK1 to WK4). |
| PO2 | **Problem Analysis**: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development (WK1 to WK4). |
| 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 (WK5). |
| 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 (WK8). |
| 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 (WK2 and WK6). |
| 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. (WK8) |

**Mapping of COs to POs and PSOs** (1: Low, 2: Medium, 3: High)

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

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