# NATIONAL ENGINEERING COLLEGE

*(An Autonomous Institution Affiliated to Anna University Chennai)*

## K.R.NAGAR, KOVILPATTI

www.nec.edu.in

**REGULATIONS – 2023**

**CURRICULUM & SYLLABUS**

**B. E. – ELECTRONICS AND COMMUNICATION ENGINEERING**

(Outcome Based Education & Choice Based Credit System)

## DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

### I. VISION

To produce Electronics and Communication Engineers capable of generating a knowledge economy with social responsibility.

### II. MISSION

- To impart high quality education with ethical behaviour.
- To equip the students compatible with recent trends in Electronic industries.
- To develop leadership qualities with humanity, wisdom, creativity and team spirit
- To provide a passionate environment for continual learning.

### III. PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 1: Graduates will have successful technical careers in core and related fields.

PEO 2: Graduates will pursue higher education and work in Research and Development for solving real world problems.

PEO 3: Graduates will have leadership qualities with social consciousness and ethics.

### IV. PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO 1: Analyze and design a compact and efficient system using modern tools in VLSI and Embedded systems.

PSO 2: Design and develop systems to solve contemporary problems in signal processing, communication, and networks for applications using modern tools and techniques.

### V. PROGRAM OUTCOMES (POs)

PO 1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, and engineering fundamentals, and an engineering specialization to develop solutions to complex engineering problems

PO 2: Problem Analysis: Identity, formulate, research literature, and analyze complex engineering problems, reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences with holistic considerations for sustainable development

PO 3: Design/development of solutions: Design creative solutions for complex engineering problems and design systems, components, or processes to meet identified needs with appropriate consideration for public health and safety, whole-life cost, net zero carbon, as well as resource, cultural, societal, and environmental considerations as required

PO 4: Investigation: Conduct investigations of complex engineering problems using research methods, including research-based knowledge, design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions

PO 5 : Tool Usage: Create, select and apply, and recognize limitations of appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering problems

PO 6: The Engineer and the World: When solving complex engineering problems, analyze and evaluate sustainable development impacts* to society, the economy, sustainability, health and safety, legal frameworks, and the environment

PO 7: Ethics: Apply ethical principles and commit to professional ethics and norms of engineering practice and adhere to relevant national and international laws. Demonstrate an understanding of the need for diversity and inclusion

PO 8: Individual and Collaborative Team work: Function effectively as an individual and as a member or leader in diverse and inclusive teams and in multidisciplinary, face-to-face, remote, and distributed settings

PO 9: Communication: Communicate effectively and inclusively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, taking into account cultural, language, and learning differences.

PO 10: 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.

PO 11: Lifelong 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.

# REGULATIONS 2023

## B.E. – ECE CURRICULUM AND SYLLABUS

## CHOICE BASED CREDIT SYSTEM

## SEMESTER – I

| S. No | Course Code | Course Title | Category | Periods Per Week | | | | Total Contact Periods | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | E | | |
| **Induction Programme – 2 weeks** | | | | | | | | | **0** |
| **Theory Courses** | | | | | | | | | |
| 1. | 23SH11C | தமிழர்மரபு / Heritage of Tamils | HSMC | 1 | 0 | 0 | 0 | 1 | 1 |
| 2. | 23SH12C | Mathematical Foundations for Engineers | BSC | 3 | 1 | 0 | 0 | 4 | 4 |
| 3. | 23SH13C | Introduction to Engineering | ESC | 1 | 0 | 0 | 0 | 1 | 1 |
| **Integrated Courses** | | | | | | | | | |
| 4. | 23SH14C | Technical English | HSMC | 1 | 0 | 2 | 0 | 3 | 2 |
| 5. | 23SH15C | Engineering Physics | BSC | 2 | 0 | 2 | 0 | 4 | 3 |
| 6. | 23SH16C | Engineering Chemistry | BSC | 2 | 0 | 2 | 0 | 4 | 3 |
| 7. | 23CS11C | Problem Solving Techniques | ESC | 3 | 0 | 2 | 0 | 5 | 4 |
| 8. | 23EE12C | Electrical Engineering | ESC | 3 | 0 | 2 | 0 | 5 | 4 |
| | | | **TOTAL** | **16** | **01** | **10** | **0** | **27** | **22** |

## SEMESTER – II

| S. No | Course Code | Course Title | Category | Periods Per Week | | | | Total Contact Periods | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | E | | |
| **Theory Courses** | | | | | | | | | |
| 1. | 23SH21C | தமிழரும்தொழில்நுட்பமும் / Tamils and Technology | HSMC | 1 | 0 | 0 | 0 | 1 | 1 |
| 2. | 23EC21C | Linear Algebra and Complex Analysis | BSC | 3 | 1 | 0 | 0 | 4 | 4 |
| 3. | 23EC22C /23EE22C | Material Science | ESC | 2 | 0 | 0 | 0 | 2 | 2 |
| 4. | 23GN01C | Aptitude Essentials | EEC | 1 | 0 | 0 | 0 | 1 | 1 |
| 5. | 23MC02C | Environmental Science and Engineering | MC | 2 | - | - | - | 2 | 0 |
| **Integrated Courses** | | | | | | | | | |
| 6. | 23SH22C | Professional English | HSMC | 1 | 0 | 2 | 0 | 3 | 2 |
| 7. | 23ME11C | Engineering Graphics | ESC | 2 | 0 | 4 | 0 | 6 | 4 |
| 8. | 23EC23C | Circuit Analysis | PCC | 2 | 1 | 2 | 0 | 5 | 4 |
| 9. | 23CS24C | Object Oriented Programming using C++ | ESC | 2 | 0 | 2 | 2 | 6 | 4 |
| **Practical Courses** | | | | | | | | | |
| 10. | 23GN02C | Innovation through Design Thinking | EEC | 0 | 0 | 0 | 4 | 4 | 2 |
| | | | **TOTAL** | **16** | **02** | **10** | **06** | **34** | **24** |

## SEMESTER – III

| S. No | Course Code | Course Title | Category | Periods Per Week | | | | Total Contact Periods | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | E | | |
| **Theory Courses** | | | | | | | | | |
| 1. | 23EC31C | Probability Random Process and Queuing Theory | BSC | 3 | 1 | 0 | 0 | 4 | 4 |
| 2. | 23EC32C | Signals and Systems | PCC | 3 | 1 | 0 | 0 | 4 | 4 |
| **Integrated Courses** | | | | | | | | | |
| 3. | 23EC33C | Electronic Devices | PCC | 3 | 0 | 2 | 0 | 5 | 4 |
| 4. | 23EC34C | Digital Electronics | PCC | 3 | 0 | 2 | 0 | 5 | 4 |
| 5. | 23EC35C | Computer Networks | PCC | 3 | 0 | 2 | 0 | 5 | 4 |
| **Practical Courses** | | | | | | | | | |
| 6. | 23GN03C | Intellectual Property Rights Study | EEC | 0 | 0 | 0 | 4 | 4 | 2 |
| | | | **TOTAL** | **15** | **2** | **6** | **4** | **27** | **22** |

## SEMESTER – IV

| S. No | Course Code | Course Title | Category | Periods Per Week | | | | Total Contact Periods | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | E | | |
| **Theory Courses** | | | | | | | | | |
| 1. | 23GN04C | Aptitude Excellence | EEC | 1 | 0 | 0 | 0 | 1 | 1 |
| 2. | 23EC41C | Electromagnetic Theory and Waves | ESC | 3 | 1 | 0 | 0 | 4 | 4 |
| 3. | - | Science Elective Course | BSC | 3 | 0 | 0 | 0 | 3 | 3 |
| **Integrated Courses** | | | | | | | | | |
| 4. | 23EC42C | Analog Circuits-I | PCC | 3 | 0 | 2 | 0 | 5 | 4 |
| 5. | 23EC43C | Communication Theory | PCC | 3 | 0 | 2 | 0 | 5 | 4 |
| 6. | 23EC44C | Digital Signal Processing | PCC | 3 | 0 | 2 | 0 | 5 | 4 |
| 7. | 23EC45C | Microprocessor and Microcontroller | PCC | 3 | 0 | 2 | 0 | 5 | 4 |
| **Practical Courses** | | | | | | | | | |
| 8. | 23EC46C | System Modeling Project | EEC | 0 | 0 | 2 | 2 | 4 | 2 |
| | | | **TOTAL** | **19** | **1** | **10** | **2** | **32** | **26** |

## SEMESTER – V

| S. No | Course Code | Course Title | Category | Periods Per Week | | | | Total Contact Periods | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | E | | |
| **Theory Courses** | | | | | | | | | |
| 1. | - | Program Elective Course I | PEC | 3 | 0 | 0 | 0 | 3 | 3 |
| 2. | - | Open Elective Course I | OEC | 3 | 0 | 0 | 0 | 3 | 3 |
| 3. | 23GN05C | Professional Ethics and Human Values | HSMC | 2 | 0 | 0 | 0 | 2 | 2 |
| 4. | 23EC51C | Control Systems | PCC | 3 | 1 | 0 | 0 | 4 | 4 |
| **Integrated Courses** | | | | | | | | | |
| 5. | 23EC52C | Digital Communication | PCC | 3 | 0 | 2 | 0 | 5 | 4 |
| 6. | 23EC53C | Analog Circuits II | PCC | 3 | 0 | 2 | 0 | 5 | 4 |
| 7. | 23EC54C | VLSI Design | PCC | 3 | 0 | 2 | 0 | 5 | 4 |
| **Practical Courses** | | | | | | | | | |
| 8. | 23EC55C | Simulation using Modern Tools | EEC | 0 | 0 | 2 | 2 | 4 | 2 |
| | | | **TOTAL** | **20** | **01** | **08** | **02** | **31** | **26** |

## SEMESTER – VI

| S. No | Course Code | Course Title | Category | Periods Per Week | | | | Total Contact Periods | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | E | | |
| **Theory Courses** | | | | | | | | | |
| 1. | 23MC01C | Constitution of India | MC | 2 | - | - | - | 2 | - |
| 2. | 23GN06C | Project Management and Finance | HSMC | 2 | 0 | 0 | 0 | 2 | 2 |
| 3. | - | Program Elective Course II | PEC | 3 | 0 | 0 | 0 | 3 | 3 |
| 4. | - | Program Elective Course III | PEC | 3 | 0 | 0 | 0 | 3 | 3 |
| 5. | - | Open Elective Course II | OEC | 3 | 0 | 0 | 0 | 3 | 3 |
| **Integrated Courses** | | | | | | | | | |
| 6. | 23EC61C | Wireless communication Technologies | PCC | 3 | 0 | 2 | 0 | 5 | 4 |
| 7. | 23EC62C | Antenna and Wave Propagation | PCC | 3 | 0 | 2 | 0 | 5 | 4 |
| 8. | 23EC63C | Artificial Intelligence and Machine Learning | PCC | 2 | 0 | 2 | 0 | 4 | 3 |
| **Practical Courses** | | | | | | | | | |
| 9. | 23EC64C | Product Development Practice | EEC | 0 | 0 | 2 | 2 | 4 | 2 |
| | | | **TOTAL** | **21** | **00** | **08** | **02** | **31** | **24** |

## SEMESTER – VII

| S. No | Course Code | Course Title | Category | Periods Per Week | | | | Total Contact Periods | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | E | | |
| **Theory Courses** | | | | | | | | | |
| 1. | - | Open Elective Course III | OEC | 3 | 0 | 0 | 0 | 3 | 3 |
| 2. | - | Program Elective Course IV | PEC | 3 | 0 | 0 | 0 | 3 | 3 |
| 3. | - | Program Elective Course V | PEC | 3 | 0 | 0 | 0 | 3 | 3 |
| 4. | - | Program Elective Course VI | PEC | 3 | 0 | 0 | 0 | 3 | 3 |
| **Practical Courses** | | | | | | | | | |
| 5. | 23EC71C | Mini Project | EEC | 0 | 0 | 0 | 6 | 6 | 3 |
| 6. | 23EC72C | Internship / In-Plant Training | EEC | - | - | - | - | - | 2 |
| | | | **TOTAL** | **12** | **0** | **0** | **06** | **18** | **17** |

## SEMESTER – VIII

| S. No | Course Code | Course Title | Category | Periods Per Week | | | | Total Contact Periods | Credits |
|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | E | | |
| **Practical Course** | | | | | | | | | |
| 1. | 23EC81C | Capstone Project/ Industry Practice | EEC | 0 | 0 | 0 | 12 | 12 | 6 |
| | | | | | | | **TOTAL** | **12** | **6** |

**TOTAL CREDITS: 167**

## B.E.-ECE- COURSE CATEGORY WISE CREDIT DISTRIBUTION

| Category | I SEM | II SEM | III SEM | IV SEM | V-SEM | VI-SEM | VII-SEM | VIII SEM | Credits | Percentage of Credits |
|---|---|---|---|---|---|---|---|---|---|---|
| **HSMC** | ***03*** | ***03*** | | | ***02*** | ***02*** | | | **10** | **06** |
| **BSC** | ***10*** | ***04*** | ***04*** | ***03*** | | | | | **21** | **13** |
| **ESC** | ***09*** | ***10*** | | ***04*** | | | | | **23** | **14** |
| **PCC** | | ***04*** | ***16*** | ***16*** | ***16*** | ***11*** | | | **63** | **37** |
| **PEC** | | | | | ***03*** | ***06*** | ***09*** | | **18** | **11** |
| **OEC** | | | | | ***03*** | ***03*** | ***03*** | | **09** | **05** |
| **EEC** | | ***03*** | ***02*** | ***03*** | ***02*** | ***02*** | ***05*** | ***06*** | **23** | **14** |
| | | | | | | | | | | |
| **Theory Credits** | **17** | **16** | **17** | **20** | **21** | **19** | **12** | **00** | **122** | **73** |
| **Practical Credits** | **05** | **08** | **05** | **06** | **05** | **05** | **05** | **06** | **45** | **27** |
| **TOTAL CREDITS** | **22** | **24** | **22** | **26** | **26** | **24** | **17** | **06** | **167** | **100** |

## ELECTIVE COURSES (SCIENCE STREAM)

| S.No | Course Category | Course Code | Course Name | L | T | P | E | C |
|---|---|---|---|---|---|---|---|---|
| **MATHEMATICS** | | | | | | | | |
| 1. | OEC | 23SH01E | Linear Algebra, Mathematical Logic and Set Theory | 2 | 1 | 0 | 0 | 3 |
| 2. | OEC | 23SH02E | Linear Structures and Transformations | 2 | 1 | 0 | 0 | 3 |
| 3. | OEC | 23SH03E | Number Theory | 2 | 1 | 0 | 0 | 3 |
| 4. | OEC | 23SH04E | Numerical Analysis | 2 | 1 | 0 | 0 | 3 |
| 5. | OEC | 23SH05E | Optimization Techniques | 2 | 1 | 0 | 0 | 3 |
| 6. | OEC | 23SH06E | Principles of Discrete Mathematics | 2 | 1 | 0 | 0 | 3 |
| 7. | OEC | 23SH07E | Random Processes and Queuing Theory | 2 | 1 | 0 | 0 | 3 |
| 8. | OEC | 23SH08E | Statistical Techniques and Numerical Methods | 2 | 1 | 0 | 0 | 3 |
| 9. | OEC | 23SH09E | Transforms, Mathematical Logic and Set Theory | 2 | 1 | 0 | 0 | 3 |
| **PHYSICS** | | | | | | | | |
| 10. | OEC | 23SH10E | Fundamentals of Laser Technology | 3 | 0 | 0 | 0 | 3 |
| 11. | OEC | 23SH11E | Nanomaterials for Engineers | 3 | 0 | 0 | 0 | 3 |
| 12. | OEC | 23SH12E | Photonics | 3 | 0 | 0 | 0 | 3 |
| **CHEMISTRY** | | | | | | | | |
| 13. | OEC | 23SH13E | Biology for Computing | 3 | 0 | 0 | 0 | 3 |
| 14. | OEC | 23SH14E | Biological systems for Engineers | 3 | 0 | 0 | 0 | 3 |
| 15. | OEC | 23SH15E | Polymer Science and Technology | 3 | 0 | 0 | 0 | 3 |
| 16. | OEC | 23SH16E | Sensors for Engineering Applications | 3 | 0 | 0 | 0 | 3 |

## VERTICALS AND PROGRAME ELECTIVE COURSES (PEC)

| S. No | Course Category | Course Code | Course Name | L | T | P | E | C |
|---|---|---|---|---|---|---|---|---|
| **EMBEDDED AND NETWORKING** | | | | | | | | |
| 1. | PEC | 23EC01E | Introduction to Embedded System Design | 3 | 0 | 0 | 0 | 3 |
| 2. | PEC | 23EC02E | Embedded and Realtime Systems | 3 | 0 | 0 | 0 | 3 |
| 3. | PEC | 23EC03E | Embedded Processor Architectures | 3 | 0 | 0 | 0 | 3 |
| 4. | PEC | 23EC04E | Embedded System Architecture | 3 | 0 | 0 | 0 | 3 |
| 5. | PEC | 23EC05E | Embedded System Analysis and Risk Management | 3 | 0 | 0 | 0 | 3 |
| 6. | PEC | 23EC06E | Sensors and Actuators | 3 | 0 | 0 | 0 | 3 |
| 7. | PEC | 23EC07E | Embedded System Networking | 3 | 0 | 0 | 0 | 3 |
| 8. | PEC | 23EC08E | Embedded System Software | 3 | 0 | 0 | 0 | 3 |
| 9. | PEC | 23EC09E | Linux For Embedded System* | 2 | 0 | 2 | 0 | 3 |
| 10. | PEC | 23EC39E | CryptographyandNetworkSecurity | 3 | 0 | 0 | 0 | 3 |
| 11. | PEC | 23EC40E | PrinciplesofOperatingSystem | 3 | 0 | 0 | 0 | 3 |
| 12. | PEC | 23EC54E | Adhoc and Wireless Sensor Networks | 3 | 0 | 0 | 0 | 3 |
| 13. | PEC | 23EC55E | Computer Architecture | 3 | 0 | 0 | 0 | 3 |

| S. No | Course Category | Course Code | Course Name | L | T | P | E | C |
|---|---|---|---|---|---|---|---|---|
| **VLSI** | | | | | | | | |
| 14. | PEC | 23EC10E | Advanced Semiconductor Devices | 3 | 0 | 0 | 0 | 3 |
| 15. | PEC | 23EC11E | Digital VLSI Systems Design | 3 | 0 | 0 | 0 | 3 |
| 16. | PEC | 23EC12E | Design for Testability | 3 | 0 | 0 | 0 | 3 |
| 17. | PEC | 23EC13E | Fundamentals of Semiconductor Chip Testing | 3 | 0 | 0 | 0 | 3 |
| 18. | PEC | 23EC14E | VLSI Physical Design | 3 | 0 | 0 | 0 | 3 |
| 19. | PEC | 23EC15E | Analog IC Design | 3 | 0 | 0 | 0 | 3 |
| 20. | PEC | 23EC16E | Fundamentals of Nano Electronics | 3 | 0 | 0 | 0 | 3 |
| 21. | PEC | 23EC17E | Hardware Modeling and verification using HDL* | 2 | 0 | 2 | 0 | 3 |
| 22. | PEC | 23EC19E | PCBDesign | 2 | 0 | 2 | 0 | 3 |
| 23. | PEC | 23EC51E | AdvancedCMOSFabrication | 3 | 0 | 0 | 0 | 3 |
| **SIGNAL & IMAGE PROCESSING** | | | | | | | | |
| 24. | PEC | 23EC18E | Advanced Digital Signal Processing | 3 | 0 | 0 | 0 | 3 |
| 25. | PEC | 23EC20E | Digital Image Processing | 3 | 0 | 0 | 0 | 3 |
| 26. | PEC | 23EC21E | Soft Computing and Optimization Techniques | 3 | 0 | 0 | 0 | 3 |
| 27. | PEC | 23EC22E | Foundations of Wavelets and Multirate Digital Signal Processing | 3 | 0 | 0 | 0 | 3 |
| 28. | PEC | 23EC23E | Deep Learning | 3 | 0 | 2 | 0 | 3 |
| 29. | PEC | 23EC24E | Computer Vision | 3 | 0 | 0 | 0 | 3 |
| 30. | PEC | 23EC25E | Medical Image Processing | 3 | 0 | 0 | 0 | 3 |
| **RF AND MICROWAVETECHNOLOGIES** | | | | | | | | |
| 31. | PEC | 23EC26E | RF measurements | 3 | 0 | 0 | 0 | 3 |
| 32. | PEC | 23EC27E | Smart Antennas | 3 | 0 | 0 | 0 | 3 |
| 33. | PEC | 23EC31E | Wearable Electronics | 3 | 0 | 0 | 0 | 3 |
| 34. | PEC | 23EC32E | Design and Simulation of RFCircuits and Components* | 2 | 0 | 2 | 0 | 3 |
| 35. | PEC | 23EC33E | Radar System Design | 3 | 0 | 0 | 0 | 3 |
| 36. | PEC | 23EC34E | Introduction to MEMS | 3 | 0 | 0 | 0 | 3 |
| 37. | PEC | 23EC35E | Electromagnetic Interference and Compatibility | 3 | 0 | 0 | 0 | 3 |
| 38. | PEC | 23EC36E | Microwave Theory and Techniques | 3 | 0 | 0 | 0 | 3 |
| 39. | PEC | 23EC44E | SatelliteTransmission and Reception Systems | 3 | 0 | 0 | 0 | 3 |
| **COMMUNICATIONTECHNOLOGIES** | | | | | | | | |
| 40. | PEC | 23EC28E | 5G Air Interface | 3 | 0 | 0 | 0 | 3 |
| 41. | PEC | 23EC29E | 6G Communication Concepts | 3 | 0 | 0 | 0 | 3 |
| 42. | PEC | 23EC30E | Cognitive Radio and Cooperative Communication | 3 | 0 | 0 | 0 | 3 |
| 43. | PEC | 23EC37E | Error Control Codes | 3 | 0 | 0 | 0 | 3 |
| 44. | PEC | 23EC38E | Information Theory and Coding | 3 | 0 | 0 | 0 | 3 |
| 45. | PEC | 23EC41E | Wireless System Development Using SDR* | 0 | 0 | 0 | 6 | 3 |

| S. No | Course Category | Course Code | Course Name | L | T | P | E | C |
|---|---|---|---|---|---|---|---|---|
| 46. | PEC | 23EC42E | Optical Communication and Networks | 3 | 0 | 0 | 0 | 3 |
| 47. | PEC | 23EC43E | RADAR Sensing and Processing | 3 | 0 | 0 | 0 | 3 |
| **INDUSTRIAL INTERNET OF THINGS (IIOT)** | | | | | | | | |
| 48. | PEC | 23EC45E | Microcontroller and PCB Design | 3 | 0 | 0 | 0 | 3 |
| 49. | PEC | 23EC46E | Embedded Systems for IoT | 3 | 0 | 0 | 0 | 3 |
| 50. | PEC | 23EC47E | Fundamentals of Internet of Things | 3 | 0 | 0 | 0 | 3 |
| 51. | PEC | 23EC48E | Dynamic Paradigms for IoT | 3 | 0 | 0 | 0 | 3 |
| 52. | PEC | 23EC49E | Introduction to Industry 4.0 And Industrial Internet of Things | 3 | 0 | 0 | 0 | 3 |
| 53. | PEC | 23EC50E | IoT-Driven Robotics and Automation* | 1 | 0 | 4 | 0 | 3 |
| 54. | PEC | 23EC52E | *Fundamentals of Mechatronics and Robotics* | 3 | 0 | 0 | 0 | 3 |
| 55. | PEC | 23EC53E | *Smart System Design and Prototyping** | 0 | 0 | 0 | 6 | 3 |

***compulsory**

## OPEN ELECTIVE COURSES (OEC)

| S. No | Course Category | Course Code | Course Name | L | T | P | E | C |
|---|---|---|---|---|---|---|---|---|
| 1. | OEC | 23EC01N | Sensors and its Applications in Civil Engineering | 3 | 0 | 0 | 0 | 3 |

## ONE CREDIT COURSES (OCC)

| S. No | Course Category | Course Code | Course Name | L | T | P | E | C |
|---|---|---|---|---|---|---|---|---|
| 1. | OCC | 23EC01L | Edge Computing for Wireless Communication | 1 | 0 | 0 | 0 | 1 |
| 2. | OCC | 23EC02L | VLSI System On Chip (Soc) Design | 1 | 0 | 0 | 0 | 1 |
| 3. | OCC | 23EC03L | mmwave Radar Laboratory | 1 | 0 | 0 | 0 | 1 |

| Course Code | தமிழர் மரபு (HERITAGE OF TAMILS) | L | T | P | E | C |
|---|---|---|---|---|---|---|
| **23SH11C** | (Common to all B.E. / B.Tech. Degree Programmes) | **1** | **0** | **0** | **0** | **1** |

## COURSE OUTCOMES

இப்பாடம் முடிந்ததும் மாணவர்களிடம் வளரும் திறன்

CO1:தமிழ் மொழியின் இலக்கிய வளம், ஓவிய, சிற்பக் கலையின் பரிணாம வளர்ச்சி நாட்டுப்புறக் கலை மற்றும் வீர விளையாட்டுக்கள் பற்றிய அறிவு மற்றும் விளக்கும் திறன்

CO2:தமிழர்களின் திணை சார் கோட்பாடுகள் மற்றும் இந்திய பண்பாட்டில் தமிழர்களின் பங்கு பற்றிய அறிவு மற்றும் விளக்கும் திறன்

Upon the successful completion of the course, the student will be able to

**Theory Component**

CO1:know and explain about Tamil literary resources, Dimensional growth of painting and sculpture arts, folk art and martial arts.

CO2: know andexplain about Tamils Thinai concepts, contribution of Tamils in Indian National Movements and Indian Culture

CO1:தமிழ் மொழியின் இலக்கிய வளம், ஓவிய, சிற்பக் கலையின் பரிணாம வளர்ச்சி நாட்டுப்புறக்கலை மற்றும் வீர விளையாட்டுக்கள் பற்றிய அறிவு மற்றும் விளக்கும் திறன் **L:9**

இந்திய மொழிக்குடும்பங்கள் - திராவிட மொழிகள் - தமிழ் ஒரு செம்மொழி – தமிழ் செவ்விலக்கியங்கள் - சங்க இலக்கியத்தின் சமயச் சார்பற்ற தன்மை – சங்க இலக்கியத்தில் பகிர்தல் அறம் - திருக்குறளில் மேலாண்மைக் கருத்துக்கள் - தமிழ்க் காப்பியங்கள், தமிழகத்தில் சமண பௌத்த சமயங்களின் தாக்கம் - பக்தி இலக்கியம், ஆழ்வார்கள் மற்றும் நாயன்மார்கள் - சிற்றிலக்கியங்கள் - தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி - தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு - நடுகல் முதல் நவீன சிற்பங்கள் வரை – ஐம்பொன் சிலைகள் - பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப் பொருட்கள், பொம்மைகள் - தேர் செய்யும் கலை - சுடுமண் சிற்பங்கள் - நாட்டுப்புறத் தெய்வங்கள் - குமரிமுனையில் திருவள்ளுவர் சிலை - இசைக் கருவிகள் - மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் - தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு - தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான் கூத்து, ஒயிலாட்டம், தோல்பாவைக் கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின் விளையாட்டுகள்.

CO1:know andexplain about Tamil literary resources, Dimensional growth of painting and sculpture arts, folk art and martial arts.

Language Families in India - Dravidian Languages – Tamil as a Classical Language – ClassicalLiterature in Tamil – Secular Nature of Sangam Literature – Distributive Justice in Sangam Literature- Management Principles in Thirukural - Tamil Epics and Impact of Buddhism & Jainism in Tamil Land- Bakthi Literature Azhwars and Nayanmars - Forms of minor Poetry - Development of Modernliterature in Tamil - Contribution of Bharathiyar and Bharathidhasan - Hero stone to modern sculpture - Bronze icons - Tribes and their handicrafts - Art of temple carmaking - - Massive Terracotta sculptures, Village deities, Thiruvalluvar Statue at Kanyakumari,Making of musical instruments - Mridhangam, Parai, Veenai, Yazh and Nadhaswaram - Role ofTemples in Social and Economic Life of Tamils - Therukoothu, Karagattam, Villu Pattu, Kaniyan Koothu, Oyillattam, Leather puppetry, Silambattam,Valari, Tiger dance - Sports and Games of Tamils.

CO2:தமிழர்களின் திணை சார் கோட்பாடுகள் மற்றும் இந்திய பண்பாட்டில் தமிழர்களின் பங்கு பற்றிய அறிவு மற்றும் விளக்கும் திறன் **L:6**

தமிழகத்தின் தாவரங்களும், விலங்குகளும் - தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக் கோட்பாடுகள் - தமிழர்கள் போற்றிய அறக்கோட்பாடு – சங்ககாலத்தில் தமிழகத்தில் எழுத்தறிவும், கல்வியும் - சங்ககால நகரங்களும் துறை முகங்களும் - சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி கடல்கடந்த நாடுகளில் சோழர்களின் வெற்றி - இந்திய விடுதலைப் போரில் தமிழர்களின் பங்கு - இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் - சுயமரியாதை இயக்கம் - இந்திய மருத்துவத்தில், சித்த மருத்துவத்தின் பங்கு – கல்வெட்டுகள், கையெழுத்துப் படிகள் - தமிழ்ப் புத்தகங்களின் அச்சு வரலாறு.

CO2: know andexplain about Tamils Thinai concepts, contribution of Tamils in Indian National Movements and Indian Culture

Flora and Fauna of Tamils & Aham and Puram Concept from Tholkappiyam and Sangam Literature -Aram Concept of Tamils - Education and Literacy during Sangam Age - Ancient Cities and Ports ofSangam Age - Export and Import during Sangam Age - Overseas Conquest of Cholas - Contribution of Tamils to Indian Freedom Struggle - The Cultural Influence of Tamils over the otherparts of India – Self-Respect Movement - Role of Siddha Medicine in Indigenous Systems ofMedicine – Inscriptions & Manuscripts – Print History of Tamil Books.

**REFERENCES:**

1. தமிழக வரலாறு – மக்களும் பண்பாடும் - கே.கே.பிள்ளை (வெளியீடு:தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்)
2. கணினித் தமிழ் - முனைவர். இல.சுந்தரம் (விகடன் பிரசுரம்)
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரீகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை– ஆற்றங்கரை நாகரீகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Published by: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

**L: 15; TOTAL: 15 PERIODS**

| Course Code | MATHEMATICAL FOUNDATIONS FOR ENGINEERS | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23SH12C | (Common to all B.E. / B.Tech. Degree Programmes) | 3 | 1 | 0 | 0 | 4 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Theory Component**

CO1: interpretthe nature of quadratic form by orthogonal transformation.
CO2: identify the maxima and minima of functions.
CO3: solve ordinary differential equations.
CO4: find the solution of partial differential equations.
CO5: evaluate integrals of multivariate calculus.

**Soft skill Component**

CO6 : develop communication, problem solving and interpersonal skills

**CO1: interpret the nature of quadratic form by orthogonal transformation**. **L:9, T:3**

Characteristic equation – Eigen values and Eigen vectors of a real matrix – Properties of Eigen values and Eigen vectors – Diagonalisation of a matrix by orthogonal transformation – Quadratic forms – Reduction of quadratic form to canonical form by orthogonal transformation and its nature; Cayley – Hamilton theorem (excluding proof) - Application: Stretching of a elastic membrane.

**CO2: identify the maxima and minima of functions.** **L:9, T:3**

Functions of two variables: Limit, continuity and partial derivatives; Total derivative, Jacobian, Taylor series- Application:Linearization of Non Linear systems using Taylor Series - Maxima and minima - Method of Lagrange multipliers.

**CO3: solve ordinary differential equations**. **L:9, T:3**

Solutions of first order ordinary differential equations - Equations solvable for ‘p’, equations solvable for ‘y’, equations solvable for ‘x’ - Solutions of higher order linear differential equations with constant coefficients – Cauchy’s and Legendre’s linear equations - Method of variation of parameters – Solution of simultaneous linear differential equation. Application RCL – circuit and Mass Spring System.

**CO4: find the solution of partial differential equations.** **L:9, T:3**

Formation of partial differential equations – Solutions of standard types of first order partial differential equations - Lagrange’s linear equations - Solutions of homogeneous and Non homogeneous linear partial differential equations of second and higher order with constant coefficient – Application - Shallow wave equations of first order PDE.

**CO5 : evaluate integrals of multivariate calculus** **L:9, T:3**

Double integration – Cartesian and polar coordinates - Change of order of integration - Change of variables - Cartesian to polar coordinates - Area as double integral - Triple integration - Cartesian and polar coordinates – Change of Variables- Cartesian to spherical and cylindrical coordinates. Application – Moments and centers of mass.

**TEXT BOOKS:**

1. Grewal.B.S., Higher Engineering Mathematics, Khanna Publications, 44th Edition, 2021.

2. James E. Gentle, Matrix Algebra, Springer International Publishing, 2nd Edition, 2017
3. Shanker Rao.G., Linear Albebra, WileyIndia, 1st Edition , 2017

**REFERENCES:**

1. Bali.N.P. and Manish Goyal, A Textbook of Engineering Mathematics, Laxmi Publications Private Limited, 10th Edition, 2016.
2. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley India, 10th Edition, 2017.
3. Kenneth B. Howell, Ordinary Differential Equations, CRC Press, 2020.
4. James Strewart, Daniel Clegg, Saleem Watson, Essential Calculus Early Trancendentals, Cengage Learning, 9th Edition, 2021.
5. Nanda Kumar A.K, P.S.Datti: Raju.K.George, Ordinary Differential Equations, Cambridge University press, 2017.

**L: 45; T: 15; TOTAL: 60 PERIODS**

| Course Code | INTRODUCTION TO ENGINEERING | L | T | P | E | C |
|---|---|---|---|---|---|---|
| **23SH13C** | (Common to all B.E. / B.Tech. Degree Programmes) | **1** | **0** | **0** | **0** | **1** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Theory Component**

CO1: articulate the importance of Engineering and its role in society through OBE framework
CO2: identify and describe academic pathways towards career settlement

**CO1: articulate the importance of Engineering and its role in society through OBE framework** **L:9**

Engineering – An introduction, Classification of different Engineering Disciplines, Role of Engineers in Society. Graduate Attributes (GA), Program Specific Criteria (PSC)-Program Educational Objectives (PEO), Program Outcomes (PO), Course Outcomes (CO), Choice Based Credit System (CBCS), course categories, teaching and learning process, active and passive learning, project / problem based learning, different assessments process.

**CO2: identify and describe academic pathways towards career settlement** **L:6**

Curriculum, cafeteria curriculum and self learning big picture of the Program and the significance of each course in the undergraduate Engineering Program, Discuss the different career paths for an engineering graduate. Career objective, competency requirement.

Case study: Each student has to interact with alumni mentors/seniors/faculty members/surf the internet and present a career path that inspires him/her at the end of the course

**REFERENCES:**

1. Quamrul H. MazumderIntroduction to Engineering, An Assessment and Problem Solving Approach, CRC Press, 1st Edition, 2016.
2. Saeed Moaveni, "Engineering Fundamentals an Introduction to Engineering", Cengage Learning, USA, 4th Edition, 2011.

**L: 15; TOTAL: 15 PERIODS**

| Course Code | TECHNICAL ENGLISH | L | T | P | E | C |
|---|---|---|---|---|---|---|
| **23SH14C** | (Common to all B.E. / B.Tech. Degree Programmes) | **1** | **0** | **2** | **0** | **2** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Theory Component**

CO1: apply the fundamental grammar rules in writing

CO2: utilizing phonetic transcription for pronunciation

**Practical Component**

CO3: apply the basic language skills in various aspects of communication

CO4: utilize technical terms and phrases in specific contexts

CO5: develop the pronunciation skill through various language components

CO6: distinguish different writing forms and interpret text through divergent thinking

CO7: develop effective reports with grammatical and language components

**Soft skill Component**

CO8: develop communication, team spirit, creativity and time management

**CO1: apply the fundamental grammar rules in writing** **L:13, P:26**

Parts of Speech - Word Formation using Prefix and Suffix - Sentence formation (Kinds of Sentences) - Tenses (Present, Past & Future tense) – Concord

**CO3: apply the basic language skills in various aspects of communication**

Diary Writing - Greeting and Self Introduction

**CO4: utilize technical terms and phrases in specific contexts**

Technical terms and extended definition - Essay Writing (Argumentative Essay and Analytical Essay) - Situational phrases & Conversation - Formal Letter Writing (Permission & Requisition letters)

**CO6: distinguish different writing forms and interpret text through divergent thinking**

Picture Description, Introduction to Reading Techniques (Skimming, scanning, inferring, predicting, Reading and Reviewing a book (Sci – Fi), E Mail Writing

**CO7: develop effective reports with grammatical and language components**
Listening and responding to general information (Business context) - Report Writing (Types, Structure, and Stages of report writing) - Checklist

**CO2:utilizing phonetic transcription for pronunciation** **L:2, P:4**

Phonetics (Vowels & Consonants)

**CO5: develop the pronunciation skill through various language components**

Word Transformation from one form to another - Letter Writing (Informal) - Listening and responding to general information (General context)

**TEXT BOOKS:**

1. Paul V.Anderson, Technical Communication: A Reader - Centered Approach, Cengage Learning, 9th Edition, 2017.
2. Ravindra Nath Tiwari, Technical English-II, Shashwat Publication, 1st Edition, 2020.
3. Stephen D. Krashen, Principles and Practice in Second LanguageAcquisition. Pergamon, 1987.

4. Lester Kaufman and Jane Straus, The Blue Book of Grammar and Punctuation: An Easy-to Use Guide with Clear Rules, Real-World Examples, and Reproducible Quizzes, Wiley, 2021.
5. Wells H. G., The Time Machine, Penguin Classics, 2012.

**REFERENCES:**

1. Michael McCarthy, English Grammar: The Basics, Taylor & Francis, 2021.
2. Peter Lucantoni and Lydia Kellas, Cambridge IGCSE(TM) English as a Second Language Workbook, Cambridge University Press, 6th Edition, 2022.

**L: 15; P: 30; TOTAL: 45 PERIODS**

| Course Code | ENGINEERING PHYSICS | L | T | P | E | C |
|---|---|---|---|---|---|---|
| **23SH15C** | (Common to all B.E. / B.Tech. Degree Programmes) | **2** | **0** | **2** | **0** | **3** |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to:

**Theory Components:**

CO1: identify the structural properties of crystalline materials

CO2: comprehend and apply the concepts of centre of mass and elasticity

CO3: explain thermodynamic parameters and fundamental laws and their application in various processes

CO4: illustrate the applications of different lasers and optical fibers

CO5:interpret the quantum concepts, to illustrate the quantization of energy, and computation

**Practical Components:**

CO6: compare the mechanical properties of the materials due to bending and torsion

CO7: analyze thermal conductivity of different bad conducting materials

CO8: explore the light-matter interaction by the phenomenon of interference and diffraction and photoelectric effect

**Soft skill Component:**

CO9: develop the team spirit and communication skill through group activities

**CO1: identify the structural properties of crystalline materials** **L:10**

Crystalline and amorphous materials - unit cell - primitive cell - crystal systems, Bravais lattices - Miller indices – interplanar distance – Characteristics of SC, BCC, FCC, HCP structures - Bragg's law - X-ray diffraction and its applications - Synthesis of crystalline materials

**CO2: comprehend and apply the concepts of centre of mass and elasticity** **L:6,**
**CO6: compare the mechanical properties of the materials due to bendingand torsion** **P:10**

Multi-particle dynamics - Introduction - Center of mass (CM) – CM of continuous bodies - Introduction to rigid bodies - translation - rotation – moment of inertia – theorems of moment of inertia – Torsional pendulum.

Elasticity – Stress - strain diagram and its applications - Moduli of elasticity and its relation - bending of beams - Bending moment – cantilever - theory and experiment - Uniform bending - theory and experiment – Non Uniform bending - I-shaped girders

**CO3: explain thermodynamic parameters and fundamental laws and their application in various processes** **L:6, P:8**

**CO7: analyse thermal conductivity of different bad conducting materials.**

Laws of thermodynamics –Thermo dynamical processes – Introduction to heat transfer – conduction - convection and radiation – thermal conductivity of good conductor –Radial flow of heat - Spherical shell method and cylindrical shell method – Thermal conductivity of poor conductor- Lee's disc method– Applications - heat exchangers - refrigerators and ovens

**CO4: illustrate the applications of different lasers and optical fibers** **L:6, P:6**

**CO8: explore the light-matter interaction by the phenomenon ofInterference and diffraction and photoelectric effect**

Lasers: Interaction of light with matter - Einstein coefficients and their relations – characteristics of laser - components of laser – Lasing action – Pumping methods – Types of Laser - Nd-YAG laser -semiconductor laser- Applications

Fiber optics: principle and classification of optical fibers – propagation of light in optical fiber - Numerical aperture and Acceptance angle – losses associated with optical fibers (Qualitative) – Fiber optic communication system - Applications - Displacement and pressure sensors – Endoscopy

**CO5: interpret the quantum concepts, to illustrate the quantization of energy, and computation** **L:6, P:2**

**CO8: explore the light-matter interaction by the phenomenon of interference and diffraction and photoelectric effect**

Planck's radiation law - de-Broglie hypothesis – Matter waves - Heisenberg's uncertainty principle – elementary proof – applications – Schrödinger's time-dependent and time-independent wave equation – physical significance of wave function – Introduction to quantum tunneling - applications - particle in a one-dimensional box – tunneling microscope – quantum confinement in 0D, 1D, 2D systems - quantum computation

**TEXT BOOKS:**

1. AvadhanuluM. N., KshirsagarP.G and Arun MurthyT.V.S, A Text book of Engineering Physics, S.Chand& Co, 11th Edition, 2018.
2. Kleppner D and Kolenkow R. An Introduction to Mechanics. McGraw Hill Education (Indian Edition), 2017.
3. Kenneth S Krane, Modern Physics, Wiley, 4th Edition, 2021.

**REFERENCES:**

1. WolfsonR., Essential University Physics, Volume 1 & 2, Pearson Education, 2ndIndian Edition, 2009.
2. Hitendra K. Malik, A.K.Singh, Engineering Physics, McGraw Hill Education, 2nd Edition, 2017.
3. Kyungwon An, Fundamentals of Laser Physics, World Scientific Publishing Company, 2023
4. HallidayD, Resnick RandWalker J, Principles of Physics, Wiley, 12th Edition, 2021.

**L: 30; P: 30; TOTAL: 60 PERIODS**

| Course Code | ENGINEERING CHEMISTRY | L | T | P | E | C |
|---|---|---|---|---|---|---|
| **23SH16C** | (Common to all B.E. / B.Tech. Degree Programmes) | **2** | **0** | **2** | **0** | **3** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Theory Component**

CO1: explain the suitable water treatment technologies for domestic and industrial applications
CO2: apply the knowledge of corrosion to solve the industrial problems
CO3: describe the preparation, properties and their applications of smart materials in various sectors
CO4: describe the basic components and performance analysis of batteries
CO5: predict the mechanical, electrical and electronics properties of materials using various instrumentation techniques

**Practical Component**

CO6: estimate the amount of $Ca^{2+}$/ $Mg^{2+}$, alkalinity and Chloride ion present in the water sample.
CO7: quantify the amount of acid and metal ion in the given samples by different analytical techniques

**Soft skill Component**

CO8: develop interpersonal, work ethics and communications skills for career settlement

**CO1: explain the suitable water treatment technologies for domestic andindustrial applications**

**CO6: estimate the amount of $Ca^{2+}$/ $Mg^{2+}$, alkalinity and Chloride ion present in the water sample.**

Introduction, sources and impurities in water, potable water specifications (as per WHO and BIS) - hardness-types-estimation of $Ca^{2+}$and $Mg^{2+}$ ion in water by EDTA method. Alkalinity-types-determination of alkalinity of water -chronic daily intake - incremental life time risk - hazard quotient, hazard index, contamination factor - determination of chloride ion in water using Argentometric method-municipal water treatment- physical methods and chemical methods. Disinfection-internal conditioning - calgon and carbonate conditioning. Desalination-types-Reverse Osmosis (RO) process- Forward osmosis (FO) - electro dialysis - demineralization. **L:6, P:12**

**CO2: apply the knowledge of corrosion to solve the industrial problems.**

**CO7: quantify the amount of acid and metal ion in the given samples by different analytical techniques**

Corrosion – mechanism of dry and wet corrosion-forms of corrosion– galvanic corrosion and differential aeration corrosion, crevice corrosion, pitting corrosion, microbial corrosion-stress corrosion, intergranular corrosion - determination of rate of corrosion by weight loss method. **L:6, P:6**

Protection: cathodic protection, surface coatings, corrosion inhibitors. Corrosion of industrial components: corrosion and its control in power industries, automotive industries, chemical processing industries and marine industries.

**CO3: describe the preparation,properties and their applications of smart materials in various sectors**

Polymers: introduction - classification - functional polymers: electroluminescence polymer, biodegradable polymers, fire retardant polymer, thermo responsive polymer - piezo, ferro and pyroelectric polymer - nanocomposites: introduction, synthesis, properties & applications- synthesis of nanocomposites using sol -gel process **L:6**

**CO4: describe the basic components and performance analysis of batteries**

Introduction - components - operation principle - Lead acid – Nickel metal hydride batteries- Lithium ions batteries: Lithium polymer battery, Lithium sulphur battery - fabrication and performance evaluation- safety issues - battery management system - recycling of lithium batteries. **L:6**

**CO5:predict the mechanical, electrical and electronics properties of materials using various instrumentation techniques**

**CO7: quantify the amount of acid and metal ion in the given samples by different analytical techniques.**

Spectroscopy methods: Beer-Lambert's law and its limitations– UV-visible spectroscopy and IR spectroscopy – principle - instrumentation– applications. Estimation of copper. Electro analytical methods: potentiometric titration - Estimation of $Fe^{2+}$ ion by potentiotometric method. Conductometric method-estimation of HCl by conductometric titration- pH metric method-Estimation of HCl by pH metric titration- applications. Thermal analytical methods: Thermal Gravimetric Analysis (TGA) and Differential Thermal Analysis (DTA)- Thermo Mechanical Analysis (TMA) –principle - instrumentation - Thermo gravimetric analysis of $CuSO_4.5H_2O$- applications. **L:6, P:12**

**TEXT BOOKS:**

1. Jain P.C. and Jain M, Engineering Chemistry, Dhanpat Rai Publishing Company, New Delhi, 17th Edition, 2021.
2. Dara S.S and Umare S.S, A Text Book of Engineering Chemistry, S.Chand& Company Limited, 20th Edition, 2018.
3. Agarwal S, Engineering Chemistry, Cambridge Publishing Company, 2ndEdition, 2019

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1. Benjamin M. M, Water Chemistry, Waveland Press, 2nd Edition, 2019.
2. Cicek V, Corrosion Engineering, Springer Publishing, 1st Edition, 2021.
3. Shahinpoor. M, Fundamentals of Smart Materials, Publisher: Royal Society of Chemistry, 1st Edition, 2020.
4. Berg H, Bernhardsson S, and Johansson P, Electric Vehicle Batteries: Moving from Research towards Innovation, Publisher: Springer, 1st Edition, 2019.
5. Crouch S, Skoog D, Holler F, Principles of Instrumental Analysis, 2017.

**L: 30; P: 30; TOTAL: 60 PERIODS**

| Course Code | PROBLEM SOLVING TECHNIQUES | L | T | P | E | C |
|---|---|---|---|---|---|---|
| **23CS11C** | (Common to all B.E. / B.Tech. Degree Programmes) | **3** | **0** | **2** | **0** | **4** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Theroy Component**

CO1:apply fundamentals of problem solving techniques to develop simple algorithms for arithmetic and logical problems

CO2:apply fundamental, sequential, conditional logic statements and arrays for solving basic problems

CO3: implement modular programming concept using user defined functions

CO4: inscribe programs using pointers and to allocate memory for user defined data types using dynamic memory management functions

CO5: develop file processing application programs

**Practical Component**

CO6: develop programs for simple algorithms using sequential and Control structures

CO7: inscribe programs using arrays, functions and pointers to work with multiple data items.
CO8: develop application programs using structures and files concept.

**CO1: apply fundamentals of problem solving techniques to develop simple algorithms for arithmetic and logical problems** **L:6**

Overview of programming: Problem Solving in Everyday Life, Types of Problem, Computer-based problem solving, Algorithms - Building blocks of algorithms (statements, control flow, functions) - Notation (pseudo code, flow chart) – Problem solving aspect – Top down design – Implementation of algorithms – Program Verification – Efficiency of algorithms – Analysis of algorithm.

**CO2: apply fundamental, sequential, conditional logic statements and arrays for solving basic problems** **L:12, P:10**

Data Types - Constants – Variables - Keywords – Operators– Problem Solving using fundamental algorithms. Control Statements: Branching and Looping - Algorithms Using Selection and Repetition - Summation of a set of numbers, Reversing Digits of an Integer - Implementation of fundamental algorithms and factoring methods - Array Techniques - Array order reversal, Array Counting, Finding maximum and the minimum value in a set

**CO6: develop programs for simple algorithms using sequential and Control structures**

Solve problems using control statements (Decision making and Looping)

**CO7: inscribe programs using arrays, functions and pointers to work with multiple data items.**

Problem solving based on Array Handling( 1D and 2D, Multi-dimensional arrays, traversal, rotation) - Solve problems to handle strings

**CO3: implement modular programming concept using user defined functions** **L:10, P:8**

Modular Programming approach: Modularization and recursion - Bubble Sort, Selection Sort, Linear Search, Binary Search, Implementation of sorting and searching

**CO7: inscribe programs using arrays, functions and pointers to work with multiple data items.**

Solve problems by using modular approach (Functions and Recursion)

**CO4: inscribe programs using pointers and to allocate memory for user defined data types using dynamic memory management functions** **L:12, P:10**

Pointer Concept – add numbers using call by reference – finding maximum number from list of numbers - permutations of a given string using pointers – Implementation of function returns a pointer;

Structures &Union - finding the largest element of an array using Dynamic Memory Allocation – Implementation of Student database in structure using Dynamic Memory Allocation;

**CO7: inscribe programs using arrays, functions and pointers to work with multiple data items.**

Build efficient solutions to manage memory efficiently through Pointers.

**CO8: develop application programs using structures and files concept.**

Develop applications using Structures

**CO5: Develop file processing application programs** **L:5, P:2**

File Handling: Files - Introduction, Types of file processing: Sequential access, Random access – Implementation of word count, copy file, Voter's age validation, Marks range validation

**CO8: Develop application programs using structures and files concept.**

Develop appliactions using Files

**TEXT BOOKS:**

1. Maureen Sprankle and Jim Hubbard, Problem Solving and Programming Concepts, Prentice Hall, 9th Edition, 2012.
2. R.G Dromey, How to solve it by Compute, Pearson education, Delhi, 2nd Edition, 2021.

**REFERENCES:**

1. Behrouz A. Forouzan, Richard F.Gilberg, P.GoldaJeyasheeli, G.Priyanka, S.T.Veena , Problem solving Using C A Structured Programming Approach, Volume I & II, 1st Edition, Cengage Publication, 2022
2. Karl Beecher, Computational Thinking: A Beginner's Guide to Problem Solving and Programming, BCS Learning & Development Limited, 1st Edition, 2017.
3. Byron S. Gottfried, Jitendar Kumar Chhabra, Programming with C, Tata McGraw Hill Publishing Company, New Delhi, 4th Edition, 2018.
4. Kernighan B.W., Ritchie D.M., C Programming Language (ANSI C), Prentice Hall of India Private Limited., New Delhi, 2nd Edition, 2010.
5. Pradip Dey and Manas Ghosh, Programming in C, Oxford University Press, New Delhi, 2018.
6. Yashavant P. Kanetkar, Let Us C, BPB Publications,16th Edition, 2020
7. H. M.Deitel, P. J. Deitel, C How to Program, Pearson Education., New Delhi, 7th Edition, 2016.

**L: 45; P: 30; TOTAL: 75 PERIODS**

| Course Code | ELECTRICAL ENGINEERING | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EE12C | | 3 | 0 | 2 | 0 | 4 |

**COURSE OUTCOMES:**

Upon the successful completion of the course, the student will be able to

**Theory Component**

CO1: Infer the significance and functionality of components in an electric circuit.
CO2: Illustrate the operation and selection of measuring instruments for circuit analysis.
CO3: Outline the electrical circuit wiring techniques for various applications.
CO4: Explain the construction, operations and speed control of various DC motors.
CO5: Describe the operation and characteristics of AC electrical machines.

**Practical Component**

CO6: Demonstrate electrical circuit wiring and the analysis of electric circuits.
CO7: Select appropriate instruments and protective devices during experiments for ensuing safety
CO8: Perform load test and infer the efficiency of various DC and AC motors

**CO1: Infer the significance and functionality of components in an electric circuit** **L:9, P:6**

Introduction to Electrical Components – RLC – Types of Sources: Fundamentals of DC and AC Sources -Voltage, current, and power– Ohm's law - Kirchhoff's Law–Electrical Appliances: Bulbs, Fans, and Heaters

**CO6: Demonstrate electrical circuit wiring and the analysis of electric circuits.**

1. Demonstration of bulbs, incandescent lamps, fans, heaters, Battery
2. Verification of Kirchoff's law and Ohm's Law

**CO2: Illustrate the operation and selection of measuring instruments for circuit analysis** **L:9, P:6**

Instruments: Functional Elements – Principles of Measurements of Electrical Quantities: Voltage, Current, Power and Energy. Electrical Installation: Components of LT Switchgear – Switch – Fuse – MCB – ELCB.

**CO7: Select appropriate instruments and protective devices during experiments for ensuing safety**

1. Measurement of Energy using Energy Meter for Single Phase System
2. Selection of protective devices.

**CO3: Outline the electrical circuit wiring techniques for various applications.** **L:9, P:6**

Introduction to Electrical Wiring: Types of Wires and Cables- Electrical Symbols - residential wiring –- Electrical Codes and Regulations - Wiring Methods -Earthing- GFCI and AFCI Protection – Uninterrupted Power supply – Types.

**CO6: Demonstrate electrical circuit wiring and the analysis of electric circuits.**

1. Residential House Wiring
2. Staircase Wiring

**CO4: Explain the construction, operations and speed control of various DC motors.** **L:9, P:6**

DC Machines: General Construction – Working Principles –Types of DC Machines – 3 point and 4 point Starters – Speed Control of DC Machines.

**CO8: Perform load test and infer the efficiency of various DC and AC motors**

1. Load test on DC shunt Motor
2. Load test on DC series Motor
3. Speed Control of DC shunt Motor

**CO5: Describe the operation and characteristics of AC electrical machines** **L:9, P:6**

Single Phase & three phase Induction Motor: Construction and operation - Starting and Speed Control of Induction Motors - Transformers: Construction and Working Principles – Auto Transformers.

**CO8: Perform load test and infer the efficiency of various DC and AC motors**

1. Load test on Single Phase Induction Motor
2. Load test on Three Phase Induction Motor
3. Load test of single Phase Transformers

**TEXT BOOKS:**

1. D.P. Kothari and I J Nagrath, "Basic Electrical and Electronics Engineering", Tata McGraw Hill, 4th Edition, 2019.
2. P.S. Bimbhra, "Electrical Machinery", Khanna Publishes, 7thEdition, 2011.

**REFERENCES:**

1. L.S. Bobrow, "Fundamentals of Electrical Engineering", Oxford University Press, 2011.
2. D.C. Kulshreshtha, "Basic Electrical Engineering", Tata McGraw Hill, Revision 1stEdition, 2011.
3. E. Hughes, "Electrical and Electronics Technology", Pearson, 2010.
4. V.D. Toro, "Electrical Engineering Fundamentals", Prentice Hall India, 1989.
5. R.K.Rajput, "Basic Electrical and Electronics Engineering", University Science Press, 2017.

**L: 45; P: 30; TOTAL: 75 PERIODS**

| Course Code | தமிழரும் தொழில்நுட்பமும்(TAMILS AND TECHNOLOGY) | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23SH21C | (Common to all B.E. / B.Tech. Degree Programmes) | 1 | 0 | 0 | 0 | 1 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**CO1:**தமிழர்களின் நெசவுமற்றும் பானைத் தொழில்நுட்பம்,வடிவமைப்புமற்றும் கட்டிடத் தொழில்நுட்பம்,உற்பத்தித் தொழில்நுட்பம் பற்றியஅறிவுமற்றும் விளக்கும் திறன்.

**CO2:**தமிழர்களின் வேளாண்மைமற்றும் நீர்ப்பாசனத் தொழில்நுட்பம்,அறிவியல் தமிழ் மற்றும் கணினித் தொழில்நுட்பம் பற்றியஅறிவுமற்றும் விளக்கும் திறன்.

Upon the successful completion of the course, the student will be able to

**CO1:**Know and explain about Tamils weaving and Pottery technology, Designand construction Technology and Manufacturing Technology.

**CO2**: Know and explain about Tamils Agriculture and irrigation technology, Scientific Tamil and Tamil computing

**CO1: தமிழர்களின் நெசவுமற்றும்பானைத்தொழில்நுட்பம், வடிவமைப்புமற்றும்கட்டிடத்தொழில்நுட்பம்மற்றும்உற்பத்தித்தொழில்நுட்பம்பற்றியஅறிவுமற்றும்விளக்கும்திறன் L :9**

சங்ககாலத்தில்நெசவுத்தொழில் - பானைத்தொழில்நுட்பம் - கருப்புசிகப்புபாண்டங்கள் - பாண்டங்களில்கீறல்குறியீடுகள்-

சங்ககாலத்தில்வடிவமைப்புமற்றும்கட்டுமானங்கள்&சங்ககாலத்தில்வீட்டுப்பொருட்களில்வடிவமைப்பு-

சங்ககாலத்தில்கட்டுமானபொருட்களும்நடுகல்லும் - சிலப்பதிகாரத்தில்மேடைஅமைப்புபற்றியவிவரங்கள் - மாமல்லபுரச்சிற்பங்களும்கோவில்களும் - மாதிரிகட்டமைப்புகள்பற்றிஅறிதல், மீனாட்சிஅம்மன்ஆலயம்மற்றும்திருமலைநாயக்கர்மஹால் - செட்டிநாடுவீடுகள் - பிரிட்டிஷ்காலத்தில்சென்னையில்இந்தோ-சாரோசெனிக்கட்டிடக்கலை- கப்பல்கட்டும்கலை - உலோகவியல் - இரும்புத்தொழிற்சாலை - இரும்பைஉருக்குதல், எஃகு - வரலாற்றுச்சான்றுகளாகசெம்புமற்றும்தங்கநாணயங்கள் - நாணயங்கள்அச்சடித்தல் - மணிஉருவாக்கும்தொழிற்சாலைகள் - கல்மணிகள், கண்ணாடிமணிகள் - சுடுமண்மணிகள் - சங்குமணிகள் - எலும்புத்துண்டுகள் - தொல்லியல்சான்றுகள் - சிலப்பதிகாரத்தில்மணிகளின்வகைகள்.

**CO1:KNOW AND EXPLAIN ABOUT WEAVING AND CERAMIC TECHNOLOGY, DESIGN AND CONSTRUCTION TECHNOLOGY, MANUFACTURING TECHNOLOGY**

Weaving Industry during Sangam Age – Ceramic technology – Black and Red Ware

Potteries (BRW)– Graffiti on Potteries - Designing and Structural construction House & Designs in household materials during Sangam Age - Building materials and Hero stones of Sangam age — Details of Stage Constructions in Silappathikaram- Sculptures and Temples of Mamallapuram- Great Temples of Cholas and other worship places - Temples of Nayaka Period - Type study (Madurai Meenakshi Temple)- Thirumalai Nayakar Mahal - Chetti Nadu Houses, Indo –Saracenic architecture at Madras during British Period- Art of Ship Building - Metallurgical studies - Iron industry - Iron smelting, steel -Copper and gold Coins as source of history - Minting of Coins — Beads making-industries Stone beads -Glass beads - Terracotta beads -Shell beads/ bone beats - Archeological evidences – Gemstone types described in Silappathikaram.

**CO2**: **தமிழர்களின்வேளாண்மை**, **நீர்ப்பாசனத்தொழில்நுட்பம்**, **அறிவியல்தமிழ்மற்றும்கணினித் தமிழ்பற்றியஅறிவுமற்றும்விளக்கும்திறன்**. **L :6**

அணை, ஏரி, குளங்கள், மதகு - சோழர்காலக்குமுழித்தூம்பின்முக்கியத்துவம் - கால்நடைபராமரிப்பு - கால்நடைகளுக்காகவடிவமைக்கப்பட்டகிணறுகள் - வேளாண்மை மற்றும்வேளாண்மைச்சார்ந்தசெயல்பாடுகள் - கடல்சார்அறிவு - மீன்வளம் - முத்து மற்றும்முத்துக்குளித்தல் - பெருங்கடல்குறித்தபண்டையஅறிவு - அறிவுசார்சமூகம்- அறிவியல்தமிழின்வளர்ச்சி - கணினித்தமிழ்வளர்ச்சி-தமிழ்நூல்களைமின்பதிப்பு செய்தல் - தமிழ்மென்பொருட்கள்உருவாக்கம் - தமிழ்இணையக்கல்விக்கழகம் - தமிழ் மின்நூலகம் - இணையத்தில்தமிழ்அகராதிகள் - சொற்குவைத்திட்டம்.

**CO2: KNOW AND EXPLAIN ABOUT AGRICULTURE TECHNOLOGY, IRRIGATION TECHNOLOGY, SCIENTIFIC TAMIL & TAMIL COMPUTING**

Dam, Tank, ponds, Sluice, Significance of KumizhiThoompu of Chola Period, Animal Husbandry - Wells designed for cattle use - Agriculture and Agro Processing – Knowledge of Sea - Fisheries — Pearl - Conche diving - Ancient Knowledge of Ocean – Knowledge Specific Society- Development of Scientific Tamil - Tamil computing – Digitalization of Tamil Books –Development of Tamil Software – Tamil Virtual Academy – Tamil Digital Library – Online Tamil Dictionaries– Sorkuvai Project.

**REFERENCE BOOKS:**

1. தமிழகவரலாறு – மக்களும் பண்பாடும் - கே.கே.பிள்ளை (வெளியீடு: தமிழ்நாடுபாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்)
2. கணினித் தமிழ் - முனைவர் இல. சுந்தரம் (விகடன் பிரசுரம்)
3. கீழடி – வைகைநதிக்கரையில் சங்ககாலநகரநாகரிகம் (தொல்லியல் துறைவெளியீடு)
4. பொருநை – ஆற்றங்கரைநாகரிகம் (தொல்லியல் துறைவெளியீடு)
5. Social Life of Tamils(Dr.K.K.Pillay)A joint publication of TNTB & ESC and RMRL
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi-Sangam City Civilization on the banks of river Vaigai (Jointly Published by:Department of Archaeology &Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to TamilNadu (Dr.K.K.Pillay)

(Published by: The Author)

**L: 15; TOTAL: 15 PERIODS**

| Course Code | LINEAR ALGEBRA AND COMPLEX ANALYSIS | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC21C | | 3 | 1 | 0 | 0 | 4 |

## COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

**Theory Component**

CO1: analyze concepts of vector spaces.
CO2: measure the similarity between different datasets using Inner product spaces.
CO3: decompose the matrix for computational convenience.
CO4: interpret analytic function in transformations.
CO5: evaluate complex integration over contour.

**CO 1: analyze concepts of vector spaces**

Vector spaces – Subspaces – Linear combinations – linear span - Linear independence and linear dependence – Bases and dimensions. **L:9,T:3**

**CO2 : measure the similarity between different datasets using Inner product spaces**

Linear transformation - Null spaces and ranges – Rank Nullity theorem - Matrix representation ofa linear transformations - Inner product space - Norms - Orthonormal Vectors - Gram Schmidt orthogonalisation process**.** **L:9,T:3**

**CO3 : decompose the matrix for computational convenience**

Generalized eigenvector - QR decomposition- generalized inverse - Singular value decomposition and applications – Pseudo Inverse - Moore – Penrose Inverse – Least square approximations. **L:9,T:3**

**CO4 : interpret analytic function in transformations**

Analytic functions–Necessary and Sufficient conditions Harmonic and orthogonal properties of analytic functions –Harmonic conjugate –Construction of analytic functions – Conformal mapping: w= z+c, cz, 1/z and bilinear transformation. **L:9,T:3**

**CO5 : evaluate complex integration over contour**

Cauchy's integral theorem and Cauchy's integral formula – Singular points – Residues – Residue theorem – Application of residue theorem to evaluate real integrals – Unit circle and semi-circular contour excluding poles on boundaries. **L:9,T:3**

## TEXT BOOKS:

1. Grewal.B.S. Higher Engineering Mathematics, 44th Edition, Khanna Publications, Delhi, 2021
2. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, Wiley India, 2017.
3. Bernard Kolman and David Hill, Elementary Linear Algebra with Application, 9th Edition Pearson Modern Classic, 2019.

## REFERENCES:

1. Bali.N.P. and Manish Goyal, A Textbook of Engineering Mathematics, 10th Edition, Laxmi Publications Private Limited, 2018.
2. Ramana B.V, Higher Engineering Mathematics, Tata Mc-Graw Hill Publishing Company,

New Delhi, 2017.
3. Jain.R.K.andIyengar.S.R.K., Advanced Engineering Mathematics,5th Edition Narosa Publishing House Private Limited, 2016.
4. Seymour Lipschutz Marc Lipson., Linear Algebra, 6th Edition, Schaum's Out lines series 2017.
5. Gilbert Strang, Linear Algebra and its Applications,4th Edition, Wellesley-Cambridge Press 2011.
6. V.Sundara Pandian, Numerical Linear Algebra, PHI Learning Limited, 2014.

**L: 45; T: 15; TOTAL: 60 PERIODS**

| | | | | | | |
|---|---|---|---|---|---|---|
| **23EC22C /** | **MATERIAL SCIENCE** | **L** | **T** | **P** | **E** | **C** |
| **23EE22C** | (Common to ECE & EEE) | **2** | **0** | **0** | **0** | **2** |

**COURSE OUTCOMES:**

**Upon successful completion of the course, the students will be able to**

**Theory Components:**

CO1: explain the conductivity in metals using free electron theory.
CO2: describe the fundamental properties ofsemiconductors.
CO3: apply the magnetic and dielectric properties for relevant electrical and electronics engineering applications.
CO4: illustrate the optical properties and their applications to optical devices.
CO5: apply the concepts of nanomaterials for nano devices.

**CO1: explain the conductivity in metals using free electron theory.**

Conduction in metals - Classical free electron theory of metals – Mobility and electricalconductivity - Thermal conductivity of metals - Wiedemann – Franz law – Quantum free electrontheory – merits and limitations of free electron theory (FET) - Fermi-Dirac Statistics - Density of States. **L:6**

**CO2: describe the fundamental properties of semiconductors.**

Energy band diagram - Direct and indirect band gap - Carrier concentration and Fermi level in anintrinsic semiconductor- Carrier concentration and Fermi level in N-type and P-type semiconductors - Carrier transport in Semiconductors: Drift, mobility, diffusion and carrierlifetime - Hall effect **L:6**

**CO3: apply the magnetic and dielectric properties for relevant electrical and electronics engineering applications.**

Magnetic materials – Classification – Hysteresis – Ferrites- $BaTiO_3$ – Application of Nd-Fe-B magnets. Electric polarization – Different types of polarization – Temperature and frequency dependence –Dielectric loss and dielectric breakdown – dielectric materials applications - capacitors and transformers. **L:6**

**CO4: illustrate the optical properties and their applications to optical devices**.

Light waves in a homogeneous medium – Refractive index – Dispersion – Classification ofOptical materials – Luminescence - Fluorescence– Phosphors – Photoconductivity – Displaydevices - Principle and working of LED, OLED, LCD - Laser diode – Photodiode (CdS and CdSe)- Optical Amplifiers. **L:6**

**CO5: apply the concepts of nanomaterials for nano devices.**

Nanomaterials - synthesis - properties - Band gap of nanomaterials – Quantum Tunneling –

Quantum cascade lasers -Nano magnets - GMR - Conductivity of metallic nanowires – Carbonnanotubes: Properties and applications - QLED – Spintronics and its device application. **L:6**

**TEXTBOOKS:**

1. Dr. M. Arumugam, Materials Science, Anuradha Publications, 2018
2. S.M.Sze and M.K.Lee, Semiconductor Physics and Devices, Wiley, 2021.
3. T.Pradeep, Nano: The Essentials: Understanding Nanoscience and Nanotechnology, McGraw-Hill Education, 2017.
4. Hilmi Unlu and Norman J.M. Horing, Progress in Nanoscale and Low-Dimensional Materials and Devices, Springer Link, 2022.

**REFERENCES:**

1. S.O Pillai, Solid State Physics, 10th edition, NEW AGE International Publishers, 2022
2. W.D.Callitser and D.G. Rethwish. Materials Science and Engineering, John Wiley & Sons, 2014.
3. Juan Martinez-Vega, Dielectric Materials for Electrical Engineering, Wiley, 2013
4. G.W. Hanson, Fundamentals of Nanoelectronics, Pearson Education, 2009.
5. J. Wilson and J.F.B. Hawkes, Optoelectronics, Pearson Education, 2018.

**L : 30; TOTAL : 30 PERIODS**

| **Course Code** | **APTITUDE ESSENTIALS** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23GN01C** | | 1 | 0 | 0 | 0 | 1 |

**COURSE OUTCOMES**

Upon the completion of the course the students will be able to

**CO1**: Recall the fundamentals in quantitative techniques and solve Number series problems quickly

**CO2**: Develop problem solving skills on Numbers and enhance arithmetic ability

**CO3**: Infer appropriate comparison and distribution methods using ratio and to form equations

**CO4**: Improve quantitative skills and solve problems on percentages and profit loss

**CO5**: Calculate data interpretation and data sufficiency in quantitative aptitude

**CO1: Recall the fundamentals in quantitative techniques and solve Number series problems quickly** **3**

Numeric series – Finding missing numbers – Odd number out series - Letter series – Symbol series - Alphanumeric series

**CO2: Develop problem solving skills on Numbers and enhance arithmetic ability** **3**

Number Types - HCF & LCM – Square root- Cubic root - divisibility criteria- Unit digit calculation- Prime factors

**CO3: Infer appropriate comparison and distribution methods using ratio and to form equations** **3**

Ratio & Proportion: Comparison of Ratios - Variations: Direct and indirect proportionAges: Present Age, Past Age & Future calculation

**CO4: Improve quantitative skills and solve problems on percentage and profit loss** **3**

Concept of Percentage – Percentage calculation - Calculation of Percentage on Population Results on Depreciation .Profit and Loss –Percentage of Profit and Loss – Discount

**CO5: Calculate data interpretation and data sufficiency in quantitative aptitude** **3**
Data Interpretation – Pie Chart – Bar Chart – Table Chart .Data Sufficiency in Logical Reasoning : Numbers, Ratio, Ages, Percentage and Profit Loss

**REFERENCE BOOKS:**

1. Dr.R.Aggarwal, " Quantitative Aptitude", S Chand Publishing, Revised Edition 2017
2. R.V.Praveen, "Quantitative Aptitude and Reasoning", 3rd Edition, Eastern Economy Edition, PHI Learning, 2016

**L:15; TOTAL : 15 PERIODS**

| **Course code** | **ENVIRONMENTAL SCIENCE AND ENGINEERING** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23MC02C** | | **2** | **0** | **0** | **0** | **0** |

**COURSE OUTCOMES:**

Upon the successful completion of the course, the student will be able to
CO1: explain the structure and functions of an ecosystem and the importance of biodiversity.
CO2: interpret the causes, effects of air and water pollution.
CO3: comprehend the causes, impacts and management of e-waste and municipal waste.
CO4: apply the knowledge of sustainability practices in the environment.

**CO1: explain the structure and functions of an ecosystem and the importance of biodiversity.** **L-6**
Introduction to Environment**,** scope and importance of environment – need for public awareness. Eco-system: structure and function. Biodiversity: Introduction - types – values of biodiversity – threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts – endangered and endemic species of India. Conservation of biodiversity: In-situ and ex-situ - Biodiversity index calculation (Simpson and Shannon diversity Index, Sorenson coefficient)

**CO2: interpret the causes, effects of air and water pollution.** **L-6**
Air pollution - Classification of air pollutants – sources – Effects - Measurements: dust monitor – gas analyzer, particle size analyzer. Water pollution – Classification – health hazards – sampling and analysis of water. Waste water treatment – different industrial effluents and their treatment – Measurement: BOD and COD – atomic absorption spectrometer. Case study (Okhla sewage water treatment plant)

**CO3: comprehend the causes, impacts and management of e-waste and municipal waste.** **L-12**
Integrated Waste Management: Introduction – Generation and types of solid waste – Swachh Bharat Mission – Solid waste management: collection, transportation, segregation and processing – Disposal: landfill – biochemical processes and energy recovery - Municipal solid waste management rules 2016.
e-Waste Management: Introduction – Composition - Types – Generation – Environmental and health hazards of e-waste – Recycling - Recovery of metals: pyrometallurgical,

hydrometallurgical, and biometallurgical process – e-waste management and handling rules 2016 – e-waste management companies in India.

**CO4: apply the knowledge of sustainability practices in the environment. L-6**

Sustainability and Management**:** Introduction - concept, needs and challenges –economic and social aspects of sustainability – unsustainability to sustainability –millennium development goals and protocols – Sustainable Development Goals-targets, indicators and intervention areas – Climate change – Global, Regional and local environmental issues and possible solutions – case studies. Concept of Carbon Credit – Carbon Footprint – Environmental management in industry – A case study – Zero waste and R concept – Circular economy – ISO 14000 Series – Material Life cycle assessment.

**TEXT BOOKS:**

1. Miller. G.T and Spoolman. S, 'Environmental Science', 16th Edition, Brooks/Cole Publishing Co., 2018.
2. Peavy. H.S, Rowe. D.R and Tchobanoglous. G, "Environmental Engineering", 2nd Edition, McGraw Hill Education, 2020.
3. Benny Joseph, 'Environmental Engineering', Tata-Mc-Graw Hill, New Delhi, 2016.
4. Gilbert M. Masters, 'Introduction to Environmental Science and Engineering', 2nd Edition, Pearson Education, 2016.

**REFERENCES:**

1. Kaushik. A and Kaushik. C.P, 'Environmental Science and Engineering', 6th Edition, New Age International Publishers, 2018.
2. Weller. K, 'Environmental Science and Biological Engineering', 1st Edition, WIT Press, 2015.

**L:30; TOTAL : 30 PERIODS**

| Course Code | PROFESSIONAL ENGLISH | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23SH22C | (Common to all B.E. / B.Tech. Degree Programmes) | 2 | 0 | 2 | 0 | 2 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Theory Component**

CO1: extend the primary language skills to develop critical thinking

CO2: build the secondary language skillsfor professional competence

**Practical Component**

CO3: apply the vital sub-functions of listening in particular context

CO4: take part in propagating ideas through effective oral communication

CO5: inferring information using various reading techniques

CO6: construct professional content via distinct methods of writing

**Soft skill Component**

CO7: develop interpersonal, communicational and behavioral attributes

**CO1:extend the primary language skills to develop critical thinking**

**CO3: apply the vital sub-functions of listening in particular context L:6,P:16**

**CO4: take part in propagating ideas through effective oral communication**

If Conditionals – Standard Abbreviations –Types of Listening (Comprehensive,

Informational, Critical Listening) –One Word Substitution, Components of Speaking
Listening for Specific Information –Listening to Speech (Oxford Union Society)
– Listening to Science Talks or Theories
Product Description – Chart Description – Process Description – Group Discussion (Uses – Structure – Strategies – Team Work – Positive & Negative Body Languages – Samples – Demo)

**CO2:build the secondary language skills for professional competence L:5,P:18**
**CO5: inferring information using various reading techniques**
**CO6: construct professional content via distinct methods of writing**
Synonyms – Intensive and Extensive Reading –Error Spotting (Based on Concord, Pronoun, Articles & Adverb Placement)– Writing Style (Persuasive, Expository & Descriptive)
Newspaper Reading – Reading Comprehension (Fiction &NonFiction)
Business Letters for Quotations and Clarification, Placing Orders and Making Complaints – Proposal Writing – Job Application Letter & Resume Preparation – Paragraph Writing – Content Writing

**TEXT BOOKS**

1. Lucantoni,Peter& Lydia Kellas, "English as a Second Language Workbook", 6th Edition, Cambridge University Press, 2022.
2. Twain, Mark "The Adventures of Tom Sawyer", 1st Edition, Pegasus, 2012.
3. Clear, James. "Atomic Habits", 1st Edition, Dreamliners, 2022.
4. Garcia, Hector & Francesc Miralles. Ikigai: The Japanese Secret to a long and Happy Life. 1st Edition, Tuttle Publishing, 2021.
5. Elbow, Peter, "Writing with Power" 2nd Edition, Oxford University Press, 1998.

**REFERENCES**

1. Butterfield, Jeff. "Soft Skills for Everyone". 2nd Edition, Cengage, 2020
2. Raman, Meenashi & Sangeetha Sharma. Professional English. 1st Edition, Oxford University Press, 2018

**L: 11; P: 34; TOTAL: 45 PERIODS**

| Course Code | ENGINEERING GRAPHICS | L | T | P | E | C |
|---|---|---|---|---|---|---|
| **23ME11C** | (Common to MECH, CIVIL, AIDS, EEE, ECE, IT) | **2** | **0** | **4** | **0** | **4** |

**COURSE OUTCOMES:**
Upon the successful completion of the course, the student will be able to
CO1: Construct the Engineering Curves and Perform Freehand Sketching.
CO2: Construct the Orthographic Projections of Points, Straight Lines and Lamina
CO3: Draw the Projections of Simple Solids in Different Positions.
CO4: Visualize the Sectional Views and Surface of Various Solids.
CO5: Draw the Isometric and Perspective Projections of Various Solids.

**CO1: Construct the Engineering Curves and Perform Freehand Sketching. L:6, P:12**
Principles of Engineering Graphics – significance. Usage of Drawing Instruments.

Lettering and dimensioning exercise Construction of ellipse, parabola and hyperbola using eccentricity method– Construction of cycloids, Epi and Hypo-cycloids. Orthographic views of simple components by Free hand drawing - Transferring measurement from the given object to the free hand sketches.

**CO2: Construct the Orthographic Projections of Points, Straight Lines and Lamina** **L:6, P:12**

Principle of orthographic projections – Conventions - First angle and third angle projections. Projections of points placed in all quadrants – projections of straight lines – inclined to both reference planes - determination of true length and inclinations. Projections of regular polygonal surfaces and circular lamina inclined to both reference planes.

**CO3: Draw the Projections of Simple Solids in Different Positions.** **L:6, P:12**

Projections of simple solids like prisms, pyramids, cylinder and cone - axis inclined to one reference plane - change of position method.

**CO4: Visualize the Sectional Views and Surface of Various Solids.** **L:6, P:12**

Sectioning of simple solids – Axis perpendicular to horizontal plane- Drawing sectional views with true shape of the section. Development of lateral surfaces of truncated solids – Prisms, pyramids, cylinder and cone.

**CO5: Draw the Isometric and Perspective Projections of Various Solids.** **L:6, P:12**

Principles of isometric projection – Isometric scale – Isometric projections of simple solids like prism, pyramid, cone and cylinder – Combination of solids. Perspective projections of simple solids by visual-ray method

**TEXT BOOKS:**

1. Bhatt N.D, "Engineering Drawing", 54th Edition, Charotar Publishing House, 2023.
2. Shah M.B and Rana B.C, "Engineering Drawing", Pearson Education, 2nd Edition, 2009.

**REFERENCES:**

1. Natrajan K.V., "A text book of Engineering Graphics", Dhanalakshmi Publishers, Chennai, 2009.
2. Agrawal B. & Agrawal C.M., "Engineering Graphics", TMH Publication,2nd Edition, 2013
3. Narayana K.L. &Kannaiah P, "Text book on Engineering Drawing", Scitech Publishers, 2011.
4. Gopalakrishna K.R, "Engineering Drawing", Subhas Publications, 32nd Edition, 2017.

**L: 30; P: 60; TOTAL: 90 PERIODS**

| Course Code | CIRCUIT ANALYSIS | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC23C | | 2 | 1 | 2 | 0 | 4 |

**COURSE OUTCOMES:**

Upon the successful completion of the course, the student will be able to

**Theory Components:**

CO1: Apply the knowledge of various network theorems to analyze the electrical circuit.

CO2: Analyze the transient response of RL,RC and RLC circuits in time domain.

CO3: Analyze the frequency domain response of resonant circuits
CO4: Apply Laplace transform for analysis of network.
CO5: Determine the parameters of two port networks.

**Practical Components:**

CO6: Demonstrate the analysis of circuits using Network theorems.
CO7: Perform simulation of transient and steady state response of first order RL and RC circuits.
CO8: Demonstrate the frequency response of series and parallel RLC circuits.
CO9: Verification of network stability using simulation
CO10: Demonstrate the determination of Two Port Network parameters.

**CO1: Apply the knowledge of various network theorems to analyze the electrical circuit** **L:6,T:3, P:6**

**CO6: Demonstrate the analysis of circuits using Network theorems**

Node voltage and Mesh current analysis, Theoretical study and experimental verification of Network Theorems: Source Transformation, Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer theorem.

**CO2:Analyze the transient response of RL, RC and RLC circuits in time domain** **L:6, T:3, CO7:** **P:6**

**PerformsimulationoftransientandsteadystateresponseoffirstorderRLandRCcircuits**

Step response and sinusoidal response of first order (series RL and series RC) and second order circuits (Series RLC), sinusoidal steady state analysis-Simulation of transient and steady state response of first order RL and RC circuits.

**CO3: Analyze the frequency response of resonant circuits** **L:6, T:3,**
**CO8: Demonstrate the frequency response of series and parallel RLC circuits** **P:6**

Series resonance, Parallel resonance, Bandwidth, Quality factor, Selectivity, Experimental verification of frequency response of series and parallel resonant circuit.

**CO4:Apply Laplace transform for analysis of network** **L:6, T:3,**
**CO9: Verification of network stability using simulation** **P:6**

Application of Laplace transforms–Circuit Element models, circuit analysis,transfer function –Network stability-Poles and Zeros - Verification of network stability using MATLAB simulation.

**CO5: Determine the parameters of two port networks** **L:6, T:3,**
**CO10: Demonstrate the determination of Two Port Network parameters** **P:6**

Theoretical study and experimental verification of Impedance parameters, Admittance parameters, Hybrid parameters, Transmission parameters, Relationships between parameters, Interconnection of two port networks

**TEXTBOOKS**

1. Robert L.Boylestad, "Introductory circuit analysis", 14th Edition, Pearson, 2023.
2. Charles K. Alexander, Mathew N.O. Sadiku, "Fundamentals of Electric Circuits", 5th Edition, Mc-Graw Hill, 2022.

**REFERENCES**

1. John Bird, "Electrical Circuit Theory and Technology", 7th Edition, Newness Publication, 2021.
2. William H.Hayt, Jack, E.Kemmerly and Steven M.Durbin, "Engineering Circuit Analysis", 9thEdition, Tata Mc-GrawHill, 2020.
3. Joseph A.Edminister, Mahmood, Nahvi, "Electric Circuits", Schaum's Series, 7th Edition, Tata Mc-GrawHill, 2017.

**L: 30;T:15;P:30;TOTAL:75PERIODS**

| Course Code | OBJECT ORIENTED PROGRAMMING USING C++ | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23CS24C | (Common to CSE, IT& ECE) | 2 | 0 | 2 | 2 | 4 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Theory Component**

CO1: apply the object oriented programming constructs to solve known applications

CO2: design effective application with inheritance, compile time and run time polymorphism

CO3: develop real-world applications by using files, streams, and exceptions

CO4: construct well-defined, efficient data handling strategies using templates and STL

**Practical Component**

CO5: demonstrate the basic OO principles such as class, objects, and constructors

CO6: implement code reusability through overloading, inheritance and polymorphism

CO7: solve problems using files and exception handling

CO8: employ problem solving skill using templates and STL

**Experiential Component**

CO9: create efficient solutions for solving real-world OOP applications

**Soft Skill Component**

CO10: demonstrate diversity and inclusive attitude while practicing project component as a team

**CO1: apply the object oriented programming constructs to solve known applications** **L:8;**
**CO5: demonstrate the basic OO principles such as class, objects, and constructors** **P:8;**
Introduction- Comparison between procedural programming paradigm and object-oriented programming paradigm. Features of object-oriented programming. Functions - Inline functions- Friend functions. Arrays -Array of objects. Pointer - Function pointer. Memory management: New and Delete. Classes and Objects - Access specifiers, Types of classes- Constructor and destructor - Types of constructor - Static members **E:8**

**CO2:design effective application with inheritance, compile time andrun time polymorphism** **L:8;**
**P:8;**
**CO6:implement code reusability through overloading, inheritance and polymorphism** **E:10**
Function Overloading, Overloading Constructors, Ambiguity in Overloading. Operator overloading - Overloading Using Friend Function- Overloading New and Delete- Overloading Special Operators. Inheritance – Types of Inheritance - Typing Conversions and Visibility – Code Reuse- Aggregation. Polymorphism- Virtual Functions – Pure Virtual Functions – Early vs. Late Binding. Run-Time Type ID and Casting Operators: RTTI – Casting Operators – Dynamic Cast.

**CO3: develop real-world applications by using files, streams, and exceptions** **L:7;**

**CO7: solve problems using files and exception handling** **P:6;**
Streams and Files: Streams classes - Sequential Input and Output operations – Random Access - File pointers - Error handling in file I/O with member function - command line arguments. Exception handling – expected and unexpected exceptions - uncaught exception - resource captures and release. Case study with real time applications. **E:4**

**CO4:construct well-defined, efficient data handling strategies using templates and STL** **L:7;**
**CO8: employ problem solving skill using templates and STL** **P:8;**
Templates- Generic programming - variadic templates – template compilation model – Generic Classes. Standard Template Library: Iterators – Auxiliary Iterator function – Algorithms – Non-modifying sequence operations – mutating sequence operations – Containers: Sequence and associative containers - Algorithms, string class – explicit, mutable and operator keywords. Namespaces: user defined namespaces, namespaces provided by library **E:8**

**TEXT BOOKS**

1. Bjarne Stroustrup, "A Tour of C++", 3rdEdition, Pearson Education, April 2023.
2. Herbert Schildt, "C++: The Complete Reference", 4thEdition, Tata McGraw–Hill Publishers, 2017.

**REFERENCE BOOKS**

1. Reema Thareja, "Object oriented programming with C++", Revised 1stEdition, Oxford University Press, 2018.
2. E.Balagurusamy, "Object oriented programming with C++", 8thEdition, McGraw Hill Education (India) Private Limited, September 2020.
3. Ivor Horton, Peter van, "Beginning C++ 20 from novice to professional", 6thEdition, APRESS media, 2020.
4. Bjorin Andrist, Viktor Sehr, "C++ High Performance: Master the art of optimizing the functioning of your C++ code", 2ndEdition, Packt Publishing Limited, December 2020.
5. Nicoloai.MJosuttis and Doug Gregor, "C++Templates: The complete guide", 1stEdition, Addison Wesley, 2020

**ONLINE COURSES**

1. https://onlinecourses.nptel.ac.in/noc23_cs78/preview
2. https://www.udemy.com/course/oops-and-c-from-basic-to-advanced
3. https://www.udemy.com/course/crash-course-on-cpp-stl/
4. https://www.coursera.org/lecture/c-plus-plus-b/1-3-standard-template-library-o3v9K
5. https://www.coursera.org/learn/object-oriented-cpp

**L:30; P:30; E:30; TOTAL: 90 PERIODS**

| **Course Code** | **INNOVATION THROUGH DESIGN THINKING** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23GN02C** | (Common to all B.E. / B.Tech. Degree Programmes) | **0** | **0** | **0** | **4** | **2** |

**COURSE OUTCOMES**

Upon completion of this course, the students will be able to

**Experiential Component**

CO1: Analyse the impact of design thinking process.

CO2: Practice design thinking process through real world problems.

**Soft skill Component**

CO3: Present survey conclusions on selected real-world problems.

**CO1: Analyse the impact of design thinking process** **30**

Design thinking process: history and phases -Ideation tools: brainstorming, mind mapping, scrambler method, six thinking hats -case studies.

**CO2: Practice design thinking process through real world problems** **30**

Real world problem selection-Practicing the preliminary stages of design thinking process - work presentation.

**TEXT BOOKS**

1. Falk Uebernickel, Li Jiang, Walter Brenner, Britta Pukall, Therese Naef, "Design Thinking: The Handbook", WS Professional, 2020
2. PavanSoni, "Design Your Thinking: The Mindsets, Toolsets and Skill Sets for Creative Problem solving", Penguin Random House, 2020

**REFERENCES**

1. Michael Lewrick, "The Design Thinking Playbook", Wiley, 2019
2. Kathryn Christopher, "Design Thinking in Engineering", Kendall Hunt Publishing Company,2019
3. Robert Curedale, "Design Thinking Process & Methods" Design Community College Inc, 5th Edition, 2019
4. David Lee, "Design Thinking in the Classroom", Ulysses Press, 2018
5. Jimmy Jain, "Design Thinking for Startups", Notion Press, 2018
6. Monika Hestad Silvia Rigoni Anders Grnli, "The Little Booklet on Design Thinking: An Introduction", Zaccheus Entertainment, 2nd Edition, 2017
7. Scott Swan, Michael G.Luchs and Abbie Griffin, "Design Thinking: New Product Development Essentials", Wiley-Blackwell, 2016
8. D.M. Arvind Mallik, "Design Thinking for Educators", Notion Press, 2019

**E:60; TOTAL:60 PERIODS**

| Course Code | PROBABILITY, RANDOM PROCESS AND | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC31C | QUEUEING THEORY | 3 | 1 | 0 | 0 | 4 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Theory Component**

CO1: grasp basic probability concepts and standard distributions

CO2: find the correlation and regression of two dimensional random variables

CO3: interpret the basic characteristic features of Random processes

CO4: evaluate spectral densities of functions.

CO5: interpret the basic characteristic features of markovian queues.

**CO 1:grasp basic probability concepts and standard distributions**

Discrete and continuous random variables - Moments - Moment generating functions and their properties. Binomial, Poisson, Geometric, Uniform, Exponential, Gamma, and Normal distributions - *Compute probabilities and moments of discrete and continuous random variables - Case Study through software* **L:9,T:3**

**CO2 : find the correlation and regression of two dimensional random variables**

Joint distributions - Marginal and conditional distributions – Covariance - Correlation and regression - Transformation of random variables. **L:9,T:3**

**CO3 : interpret the basic characteristic features of Random processes**

Classification - Stationary process - Markov process - Markov chains – Transition probabilities - Limiting distributions - Poisson process. **L:9,T:3**

**CO4 : evaluate spectral densities of functions**

Auto correlation - Cross correlation – Power spectral density–Cross spectral density-Properties–Wiener – Khintchine theorem (without proof)–Relationship between cross power spectrum and cross correlation function - *Carry out performance study on power spectrum analysis of time-domain signals using Fourier transform – Activity through programming* **L:9,T:3**

**CO5: interpret the basic characteristic features of Markovian queues**

Markovian models – Birth and Death Queuing models- Steady state results: Single and multiple server queuing models- queues with finite waiting rooms- Finite source models- Little's Formula. **L:9,T:3**

**TEXT BOOKS:**

1. Oliver C. Ibe, "Fundamentals of Applied Probability and Random processes", Academic Press, 2nd Edition, 2014.
2. Hwei Hsu, "Schaum's Outline of Theory and Problems of Probability, Random Variables and Random Processes, Tata McGraw-Hill, 3rd Edition, New Delhi, 2017
3. D. Gross and C.M. Harris, "Fundamentals of Queueing Theory", Wiley and Sons Publication Limited, 5th Edition, 2018

**REFERENCES:**

1. Miller.S.L and Childers, S.L, Probability and Random Processes with applications to Signal Processing and Communications, Elsevier Inc., 2nd Edition, 2012.
2. Yates and D.J. Goodman, Probability and Stochastic Processes, 3rd Edition, John Wiley and Sons, 2014.
3. Peyton. Z. Peebles Jr., Probability Random Variables and Random Signal Principles, 4th Edition, Tata McGraw-Hill Publishers, New Delhi, 2017.
4. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, Wiley India, 2017

**L: 45; T: 15; TOTAL: 60 PERIODS**

| **23EC32C** | **SIGNALS AND SYSTEMS** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| | | **3** | **1** | **0** | **0** | **4** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Theory Component**

CO1: Classify and analyze the types of signals and systems using properties.

CO2: Analyze any continuous time signals using Fourier Series, Fourier transform and Laplace transform and also understand their properties.

CO3: Analyze the continuous time systems using Fourier transform and Laplacetransform and to calculate the frequency response of CT- LTI systems.

CO4: Analyze the sampling concepts and aliasing effect, discrete time signals using DTFT and Z transform

CO5: Analyze the discrete time systems using DTFT and Z- transform and to calculate the frequency response of DT-LTI systems.

**CO1: Classify and Analyze the Types Of Signals And Systems Using Properties. L:9;T:3**

Standard signals-Step .Ramp, Pulse, Impulse, Real,Complex Exponential and Sinusoids.

Classification and Simulation of Continuous time signals and Discrete time signals - periodic and aperiodic signals, Deterministic and Random signals, Energy and Power Signals.

Classification of CT systems and DT systems- Linear and Non Linear, Time Variant and Time Invariant, Causal and Non Causal, Stable and Unstable.

**CO2: Analyze any continuous time signals using Fourier Series, Fourier transform and Laplace transform and also understand their properties L:9;T:3**

Fourier series analysis, Fourier Transform -signal analysis and simulation using MATLAB, Properties. Laplace Transform- signal analysis, Properties.

**CO3: Analyze the continuous time systems using Fourier transform and Laplace transform and to calculate the frequency response of CT- LTI systems. L:9;T:3**

Representation of CT-LTI system - Differential equation, Block diagram representation, Impulse response and transfer function, Convolution integral, frequency response, LTI systems analysis and MATLAB simulation using Fourier and Laplace transforms.

**CO4: Analyze the sampling concepts and aliasing effect, discrete time signals using DTFT and Z transform L:9;T:3**

Theoretical study and MATLABsimulation of Sampling and aliasing effects, DTFT(Discrete Time Fourier Transform) -signal analysis, Properties, Z Transform- signal analysis, Properties.

**CO5: Analyze the discrete time systems using DTFT and Z- transform and to calculate the frequency response of DT-LTI systems. L:9;T:3**

Representation of DT-LTI system,Difference equation, Block diagram representation, Impulse responseand transfer function, Convolution sum, Frequency Response, LTI systems analysisand MATLAB simulation using DTFT and Z-transforms.

**L: 45; T:15;TOTAL: 60 PERIODS**

**TEXT BOOKS**

1.Alan V.Oppenheim, Alan S.Willsky and S.H.Nawab, “Signals and Systems”, Pearson Education, 2nd Edition, 2015.

2.Edward W Kamen and Bonnie S. Heck, "Fundamentals of Signals and Systems usingthe Web and MATLAB", Pearson Education, 3rdEdition, 2013.

**REFERENCES**

1.Rodger E.Ziemer, William H.Tranter and D.Ronald Fannin, "Signals & Systemscontinuous and discrete", Pearson Education, 4thEdition, 2014.

2.Simon Haykin and Barry Van Veen, "Signals and Systems", 2ndEdition, WilleyPublication, 2010.

3.Hwei P. Hsu, "Signals and Systems- Schaum's Outline Series", Tata McGraw Hill, 3rdEdition, 2013.

4.M.J.Roberts, "Signals and systems Analysis using transform methods and MATLAB",Tata McGraw Hill, 2ndEdition, 2011.

| Course Code | ELECTRONIC DEVICES | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC33C | | 3 | 0 | 2 | 0 | 4 |

**COURSE OUTCOMES**

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

**Theory Component**

CO1: Analyze the diode characteristics and its applications.
CO2: Describe the operation and characteristics of Bipolar Junction Transistors.
CO3: Describe the operation and characteristics of Field Effect transistors.
CO4: Analyze various biasing circuits for a transistor
CO5: Gain knowledge and aware of the special semiconductor devices and latest technological changes.

**Practical Component**

CO6: Analyze the characteristics and the applications of PN junction diode, Zener diode
CO7: Analyze the characteristics of BJT and FETs.
CO8: Design and demonstrate various biasing circuits of a transistor

**CO1: Analyze the diode characteristics and its applications.** **L:9, P:6**
**CO6: Analyze the characteristics and the applications of PN junction diode, Zener diode**

PN junction diode, Current equations, Energy Band diagram of PN Junction, Diffusion and drift current densities, Experimental verification of forward and reverse bias characteristics, Transition and Diffusion Capacitances, Switching Characteristics, Breakdown in PN Junction Diodes, Experimental verification of applications of diode as a rectifier.

**CO2: Describe the operation and characteristics of Bipolar Junction Transistors** **L:9, P:6**
**CO7: Analyze the characteristics of BJT and FETs.**

Bipolar Junction Transistor- NPN -PNP -Operations-Early Effect-Current equations - Experimental verification of Input and Output characteristics of Common Emitter, Common Base and Common Collector.

**CO3: Describe the operation and characteristics of Field Effect transistors.** **L:9, P:6**
**CO7: Analyze the characteristics of BJT and FETs.**

JFETs - Experimental verification of Drain and Transfer characteristics -Current Equations-Pinch off voltage and its significance- MOSFET- Characteristics-

Threshold voltage -Channel length modulation, D-MOSFET, E-MOSFET-Characteristics — Comparison of MOSFET with JFET.

**CO4: Analyze various biasing circuits for a transistor.** **L:9, P:6**

**CO8: Design and demonstrate various biasing circuits of a transistor.**

BJT biasing – DC Load line and AC Load line, Quiescent point – Different Types of biasing circuits: Experimental verification of Fixed Bias Circuit, Collector to base bias, Voltage divider bias– Stability Factors – Bias compensation: Diode, Thermistor and Sensistor compensations – Biasing circuits for JFET and MOSFET.

**CO5: Gain knowledge and aware of the special semiconductor devices and latest technological changes.** **L:9, P:6**

**CO6: Analyze the characteristics and the applications of PN junction diode, Zener diode.**

Zener diode- Experimental verification of characteristics and applications, Schottky diode, Tunnel diode, SCR, DIAC, TRIAC, UJT, Advanced MOS devices- Multi gate MOSFETs.

**TEXT BOOKS**

1. G.Streetman and S.K.Banerjee, "Solid State Electronic Devices," 7th Edition, Pearson, 2015.
2. D.Neamen, D.Biswas "Semiconductor Physics and Devices", McGraw-Hill Education. 2018.
3. Millman.J and Halkias.C, "Electronic Devices and Circuits", TMH, 2015.

**REFERENCES**

1. S.M.Sze and K.N.Kwok, "Physics of Semiconductor Devices," 3rd Edition, John Wiley & Sons, 2006.
2. Y.Tsividis and M.Colin, "Operation and Modeling of the MOS Transistor", Oxford Univ. Press, 2011.
3. J.P. Colinge, FinFETs and Other Multi-Gate Transistors, Springer 2008.

**L: 45; P: 30; TOTAL: 75 PERIODS**

| Course Code | DIGITAL ELECTRONICS | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC34C | | 3 | 0 | 2 | 0 | 4 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to:

**Theory Components:**

**CO1:CDL-1:** Analyze the concept of Boolean Logic function and simplify it.

**CO2:CDL-2:** Design and implement combinational logic circuits.

**CO3:CDL-2:** Design and implement sequential logic circuits.

**CO4:CDL-2:** Design and analyze synchronous and asynchronous sequential circuits.

**CO5: CDL-1:** Illustrate the operation of Logic families, Memory architecture and Programmable Logic devices**.**

**Practical Components:**

**CO6:PDL-1:** Realize the Boolean functions using basic gates and universal gates.

**CO7:PDL-2:** Demonstrate the combinational logic circuits using digital IC's and verilog HDL.

**CO8: PDL-2:**Demonstrate the sequential logic circuits using digital IC's and verilog HDL.

**CO9:PDL-2**:Design and simulate the finite state machine for the given specification.

**CO10:PDL-1:**Simulate the logic families and memory architecture circuits.

**CO1: Analyze the concept of Boolean Logic function and simplify it.** **L:9, P:6**
**CO6: Realize the Boolean function using basic gates and universal gates.**

Boolean algebra, Number systems, De Morgan's theorem, Demonstration of the Boolean function using Logic Gates & Universal gates, Binary arithmetic, SOP, POS, Canonical forms, NAND and NOR implementation, Binary codes - Binary code, gray code, Binary coded decimal, ASCII, Code conversions, Boolean expression simplification using Karnaugh Maps.

**CO2: Design and implement combinational logic circuits.** **L:9, P:6**
**CO7: Demonstrate the combinational logic circuits using digital IC's and verilog HDL.**

Implementation of Adder & Subtractor, Parallel adder, BCD Adder, Carry Look Ahead adder, Decoder, Implementation of Encoder & Multiplexer, Function realization using Multiplexer & Decoder, Comparator, Parity generator & checker, Driver and Multiplexed display.

**CO3: Design and implement sequential logic circuits.** **L:9, P:6**
**CO8: Demonstrate the sequential logic circuits using digital IC's and verilog HDL.**

Latches, Flipflops - SR, JK, D & T, Master-slave FFs, Implementation of Shift registers and Asynchronous Counter – Up/Down Counter & Synchronous counter- Up/Down Counter, Modulus Counters, Ring Counter, Johnson Counter. Demonstration of shift register and ripple counters.

**CO4: Design and analyze synchronous and asynchronous sequential circuits.** **L:9, P:6**
**CO9: Design and simulate the finite state machine for the given specification.**

Design of synchronous sequential circuits- Moore, Mealy, Serial Adder Design, Synchronous FSM: State machine analysis: State diagram, state assignment, state minimization, Asynchronous sequential design- Hazards, Races. Verilog HDL programming for sequence detector.

**CO5: Illustrate the operation of Logic families, Memory architecture and Programmable Logic devices.** **L:9, P:6**
**CO10: Simulate the circuits of various logic families.**

TTL specifications, TTL, ECL, CMOS Logic Family and its Interfacing, Characteristics, Memory Elements – static RAM, dynamic RAM, ROM, EPROM, FPGA, Programmable Logic devices – PLA, PAL, PLD.Verilog HDL programming for TTL and CMOS circuits.

**TEXT BOOKS:**

1. M. Morris Mano, Michael D. Ciletti, "Digital Design with an introduction to Verilog HDL", PHI, 6th Edition, 2018, Pearson Education, 2nd Edition, 2015.
2. Charles Roth, L.K.John, B.K.Lee, "Digital System Design using Verilog", Cengage, 1st Edition, 2016.

**REFERENCES:**

1. R.P. Jain, "Modern digital Electronics", Tata Mc-Graw Hill, 4th Edition, 2010.
2. Donald P.Leach, A.P.Malvino, Goutam Saha, "Digital Principles and Applications", Tata Mc-Graw Hill, 8th Edition, 2014.

3. James E. Palmer, David E. Perlman, "Schuams Outlines-Introduction to Digital Systems", Tata Mc-Graw Hill, Reprise Edition, 2020.
4. Thomas L.Floyd, "Digital Fundamentals", PHI, 11th Edition, 2017.

**L: 45; P: 30; TOTAL: 75 PERIODS**

| Course Code | COMPUTER NETWORKS | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC35C | | 3 | 0 | 2 | 0 | 4 |

**COURSE OUTCOMES**

Upon the successful completion of the course, students will be able to

**Theory Component**

CO1: Interpret the functional components of networks and its associatedmedium.

CO2:Perform flow and error control mechanisms for error free transmission and collision using various protocols.

CO3:Analyzevariousnetworkprotocolstoestablishconnectionsbetweenentities.

CO4:AnalyzetheTCP/UDPprotocolsandnetworktrafficmechanismsinthe transportlayer.

CO5:Examinetherealtimeapplicationslayerprotocolsand SDN.

**Practical Component**

CO6:Constructasimplenetworkusingnetworkingdevicesandcables.

CO7:Ensureerror-freedatatransmissionusingL2devices.

CO8: Establish a routing path between entities using various networkprotocols.

CO9:IdentifynetworktrafficusingTCP/UDPprotocols.

CO10: Implement a client-server model using various application layerprotocols.

**CO1: Interpret the functional components of networks and its associated medium.** **L:9, P:6**

**CO6: Construct a simple network using networking devices and cables.**

Data Communications – Networks - Networks models – OSI model – Layers in OSI model – Addressing – Types of Transmission Media, LineCoding,Switching:CircuitandPacketSwitch.

**CO2: Perform flow and error control mechanisms for error free transmission and collision using various protocols.** **L:9, P:6**

**CO7: Ensure error-free data transmission using L2 devices.**

Data link control: Framing – Flow and error control –Protocols for Noiseless and Noisy Channels – Error Detection: Parity, LRC, VRC, CRC – Multiple Accesses: Random access – Controlled access. Wired LANS: IEEE standards – standard Ethernet – changes in the standard. Wireless LANS: IEEE 802.11: Architecture, MAC Sub layer, Addressing Mechanism.

Experimentallearning:Bitstuffing,VLAN,ExtractingL2parametersfrommedium.

**CO3: Analyze various network protocols to establish connections between entities.** **L:9, P:6**

**CO8: Establish a routing path between entities using various network protocols.**

Logical addressing: IPv4, IPv6 addresses - Internet Protocol: Internetworking – IPv4, Ipv6 – Address mapping – ARP, RARP, BOOTP, DHCP, ICMP, IGMP, Delivery - Forwarding - Routing protocols – DSDV, OSPF – Experimentation and verification of protocols.

**CO4: Analyze the TCP/UDP protocols and network traffic mechanisms in the transport layer.** **L:9, P:6**

**CO9: Identify network traffic using TCP/UDP protocols.**

Process-to-Process delivery - User Datagram Protocol (UDP) – Transmission Control Protocol (TCP)/ Internet Protocol (IP) Suite – Experimentation and verification of UDP/TCP/IP Suite. Congestion Control – Quality of services (QoS) – Techniques to improve QoS.

**CO5: Examine the real time applications layer protocols and SDN.** **L:9, P:6**

**CO10: Implement a client-server model using various application layer protocols.**

Domain Name System (DNS) – E-mail – HTTP – FTP – WWW – Experimentation and validation of protocols. Software Defined Networking (SDN) – Modern Data Center – Traditional Switch Architecture – Evolution of SDN –SDN operations.

**TEXT BOOKS**

1. Larry Peterson Bruce Davie, "Computer Networks: A system Approach, 5th Edition, The Morgan Kaufmann Series in Networking Publisher, 2011.
2. Behrouz A. Forouzan, "Data communication and Networking", Tata McGraw-Hill, 4th Edition, 2011.

**REFERENCES**

1. Paul Goransson and Chuck Black, "Software Defined Networks: A comprehensive Approach", 1st Edition, Morgan Kaufmann, 2014.
2. Thomas D. Nadeau, Ken Gray, "SDN: Software Defined Networks", O'Reilly Media, 2013.
3. William Stallings, "Wireless Communication & Networking", Pearson Education Asia, 2009.

**L: 45; P: 30; TOTAL: 75 PERIODS**

| 23GN03C | INTELLECTUAL PROPERTY RIGHTS STUDY (Common to all B.E. / B.Tech. Degree Programmes) | L | T | P | E | C |
|---|---|---|---|---|---|---|
| | | 0 | 0 | 0 | 4 | 2 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Experiential Component**

CO1: Survey and practice the basic elements of existing patents.

CO2: Investigate and present the state of art technologies through effectual IP search.

**Soft Skill Component**

CO3: Presentpatent survey conclusions

**CO1 Survey and practice basic elements of existing patents** **30**

Basic elements of IPR – claims – infringements – Patent examination and Report - Case studies: patent survey.

**CO2 Investigate and present the state of art technologies through effectual IP search** **30**

Importance of IP search-factors to be considered for effective IP search-Hands-on Practice

**REFERENCES**

1. D.P. Mittal, "Indian Patents Law and Procedure", Taxman Publication, 2002

2. B.L. Wadera, "Patents, trademarks, copyright, Designs and Geographical Judications", 2010
3. P. Narayanan, "Intellectual Property Law", Eastern Law House, 2022
4. N.S. Gopalakrishnan &T.G.Agitha, "Principles of Intellectual Property", Eastern Book Company, Lucknow, 2009.

**E:60 TOTAL:60 PERIODS**

| Course Code | ELECTROMAGNETIC THEORY AND WAVES | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC41C | | 3 | 1 | 0 | 0 | 4 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to
CO1: Apply the theorems to determine static electric and magnetic field intensity.
CO2: Study the characteristics of time varying electric and magnetic field.
CO3: Understand the characteristics of the wave in lossless, lossy and conducting medium
CO4: Conceive the wave propagation characteristics on high frequency transmission lines.
CO5: Discuss the characteristics of TE and TM waves in waveguides.

**CO1: Apply the theorems to determine static electric and magnetic field intensity** **L:9; T:3**

Scalar and vector fields- Review of vector algebra, Rectangular, cylindrical and spherical coordinate systems. Coulomb's Law-Electric Field Intensity- Principle of Superposition. Electric field due to continuous charge distribution-infinite and finite line-circular disc.

The Biot-Savart Law in vector form, Magnetic Field intensity due to a finite and infinite wire carrying a current I, Magnetic field intensity on the axis of a circular loop carrying a current I.

**CO2: Study the characteristics of time varying electric and magnetic field.** **L:9; T:3**

Time varying field- electromotive force and magnetomotive force, Faraday's law, Displacement current, Amphere's Law – Maxwell Equations. Electromagnetic boundary conditions, Poynting Vector and Power flow in a co-axial cable.

**CO3: Understand the characteristics of the wave in lossless, lossy and conducting medium.** **L:9; T:3**

Derivation of Wave Equation, Uniform Plane Waves, Plane waves in free space and in a homogenous material. Wave equation for a conducting medium, wave propagation in good conductors, Skin effect, Wave polarization.

**CO4: Conceive the wave propagation characteristics on high frequency transmission lines.** **L:9; T:3**

Transmission Lines- Equations of Voltage and Current on TX line, Propagation constant and characteristic impedance, and reflection coefficient and VSWR, Impedance Transformation on Loss-less and Low loss Transmission line, Power transfer on TX line, Smith Chart, Admittance Chart, Applications of transmission lines: Impedance Matching, use of transmission line sections as circuit elements.

**CO5: Discuss the characteristics of TE and TM waves in waveguides.** **L:9; T:3**

Wave propagation in parallel plane waveguide, Analysis of waveguide general approach, Rectangular waveguide, Modal propagation in rectangular waveguide, Surface currents on the Waveguide walls, Field visualization, Attenuation in waveguide.

**TEXT BOOKS**

1. M.N.O.Sadiku and S.V. Kulkarni, Principles of electromagnetics, 6th Edition, Oxford (Asian Edition), 2015
2. William H. Hayt, John A. Buck, Jaleel M. Akhtar, Engineering Electromagnetics, 9th Edition, McGraw Hill India, 2020.
3. John D Ryder, "Networks lines and fields", 2nd Edition, Pearson Education India, 2015

**REFERENCES**

1. R.K. Shevgaonkar, Electromagnetic Waves, Tata McGraw Hill India, 2005
2. E.C. Jordan & K.G. Balmain, Electromagnetic waves & Radiating Systems, Pearson Education, 2nd Edition, 2015.

**L: 45; T: 15; TOTAL: 60 PERIODS**

| **Course Code** | **ANALOG CIRCUITS-I** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC42C** | | **3** | **0** | **2** | **0** | **4** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Theory Component**

CO1: Comprehend the small signal amplifiers using BJT and FET.
CO2: Compare various types of negative feedback amplifiers.
CO3: Explore the high frequency response of amplifier circuits.
CO4: Examine the performance of large signal amplifiers.
CO5: Correlate different sinusoidal oscillators for audio and radio frequencies.

**Practical Component**

CO6:Design BJT and FET amplifiers for the desired specification.
CO7:Design and demonstrate different negative feedback amplifiers.
CO8: Design and study the performance of large signal amplifiers.
CO9:Design various audio and radio frequency oscillators.

**CO1: Comprehend the small signal amplifiers using BJT and FET.**
**CO6: Design BJT and FET amplifiers for the desired specification.**

Two-Port Devices and the Hybrid Model, Small signal model of BJT and FET – Theoretical Analysis and Experimental verification of BJT and FET amplifiers using h-parameters and input impedance of BJT amplifiers. **L:9; P:6**

**CO2: Compare various types of negative feedback amplifiers.**
**CO7: Design and demonstrate different negative feedback amplifiers.**

Feedback Concepts - topologies of feedback amplifiers – Analysis of negative feedback amplifier - theoretical analysis and experimental verification of effect of feedback on gain bandwidth, input, and output impedances; **L:9; P:6**

**CO3: Explore the high frequency response of amplifier circuits.**
**CO6: Design BJT and FET amplifiers for the desired specification.**

Amplifier frequency response – Experimental verification of Frequency response of transistor amplifiers with circuit capacitors - BJT frequency response - short circuit current gain — cut off frequency - fα, fβ and unity gain bandwidth — Frequency response **L:9; P:6**

of multistage amplifiers — frequency response of FET. Tuned amplifiers – single tuned, double tuned and Stagger tuned amplifiers. (qualitative analysis only).

**CO4: Examine the performance of large signal amplifiers**
**CO8: Design and study the performance of large signal amplifiers.**

Classification of amplifiers – Conversion efficiency of class A transformer coupled class A, class B and distortion in power amplifier – Classification of tuned amplifier – Class C large signal tuned amplifier and its efficiency – Stability of tuned amplifiers and neutralization technique. **L:9; P:6**

**CO5: Correlate different sinusoidal oscillators for audio and radio frequencies**
**CO9: Design various audio and radio frequency oscillators.**

Classification - Barkhausen Criterion - General form of an Oscillator - Analysis of LC oscillators - Hartley, Colpitts, Clapp, Tuned collector oscillators. RC oscillators - phase shift, Wien bridge, Twin-T Oscillators. Quartz Crystal Construction, Electrical equivalent circuit of Crystal, Miller and Pierce Crystal oscillators, frequency stability of oscillators. **L:9; P:6**

**TEXT BOOKS**

1. Donald.A. Neamen, "Electronic Circuit Analysis and Design", 2nd Edition, Tata McGraw Hill, 2018.
2. Millman.J and Halkias.C, "Electronic Devices and Circuits", Tata McGraw-Hill, 2015.
3. David A. Bell, "Fundamentals of Electronic Devices and Circuits", Oxford University Press, 2009.
4. Robert L. Boylestad and Louis Nashelsky, "Electronic Devices and Circuit Theory", 10th Edition, Prentice Hall, 2017.

**REFERENCES**

1. Thomas L. Floyd and David M.Buchla, "Electronics Fundamentals: Circuits, Devices and Applications", 8th Edition, Pearson College Div, 2010.
2. Schilling and Belove, "Electronic Circuits", TMH, 3rd Edition, 2002.
3. Millman.J and Halkias.C., "Integrated Electronics", Tata McGraw-Hill, 2017.
4. Chenming Hu, "Modern Semiconductor Devices for Integrated Circuits", Prentice Hall, 2009

**L: 45; P: 30; TOTAL: 75 PERIODS**

| Course Code | COMMUNICATION THEORY | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC43C | | 3 | 0 | 2 | 0 | 4 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Theory Component**

CO1: Demonstrate the fundamentals of communication system and design AM system.
CO2: Demonstrate the fundamentals of communication system and design FM system.
CO3: Employ waveform coding for digitizing analog signals
CO4:Apply the concepts of information theory in identifying efficient source coding techniques
CO5: Design channel encoder and decoder for digital communication systems

**Practical Component**

CO6: Analyze time domain and spectral characteristics of AM techniques.
CO7: Analyze time domain and spectral characteristics of FM techniques.

CO8: Demonstrate the waveform coding and evaluate its BER performance
CO9: Demonstrate the lossless data compression techniques
CO10: Compare the performance of different channel encoding strategies in the presence of AWGN channel

**CO1: Demonstratethe fundamentals of communication system and design AM system.**

Electronic communication, Modes of communication, Channels, Modulation, Need for modulation, Amplitude Modulation – DSBFC, DSBSC, SSB, VSB - Modulation index, power relations, bandwidth, Envelope detector, coherent and non-coherent detector, Noise sources, Thermal noise model, AWGN, Noise figure, noise temperature and noise bandwidth, Narrowband noise, Noise performance in AM (Qualitative treatment only) **L:9; P:6**

**CO6: Analyze time domain and spectral characteristics of AM techniques.**

Generation, detection and AWGN performance measurement of Amplitude modulation system Spectral characteristics of Amplitude modulated waveform

**CO2: Demonstrate the fundamentals of communication system and design FM system.**

Angle modulation and demodulation: Narrow band, Wideband FM - Spectral analysis of modulated signal, Frequency Discriminator, Superheterodyne receiver principle, Noise performance in FM (qualitative treatment only). **L:9; P:6**

**CO7: Analyze time domain and spectral characteristics of FM techniques.**

Generation, detection and AWGN performance measurement of Frequency modulation systemSpectral characteristics of Frequency modulated waveform

**CO3: Employ waveform coding for digitizing analog signals**

Necessity for digital communication, Block diagram of digital communication system, Pulse Code Modulation, sampling theorem, aliasing, Flat top sampling, Quantization – uniform and non-uniform quantization, encoding, bitrate of PCM, SQNR of PCM with uniform quantization, companding, PCM receiver, differential PCM, Adaptive differential PCM, linear prediction coding **L:9; P:6**

**CO8: Demonstrate the waveform coding and evaluate its BER performance**

Performance analysis of PCM system with uniform quantizer and to measure bit error rate in the presence of AWGN.

**CO4: Apply the concepts of information theory in identifying efficient source coding techniques**

Introduction, theory of uncertainty, self-Information, entropy, source coding theorem, Lossless data compression algorithms: Shannon-Fano coding, Huffman coding, LZW coding, discrete memoryless channels, Mutual information, channel capacity, channel coding theorem, Information capacity theorem **L:9; P:6**

**CO9: Demonstrate the lossless data compression techniques**

Design of lossless source encoder, decoder and evaluate its vulnerability to channel error performance

**CO5: Design channel encoder and decoder for digital communication systems**

Channel encoding techniques, forward error correction, automatic repeat request, linear block code, cyclic code, convolutional code, turbo code –encoding, decoding **L:9; P:6**

**CO10: Compare the performance of different channel encoding strategies in the presence of AWGN channel**

Design of channel encoder and decoder for forward error correction

**TEXT BOOKS**

1) Simon Haykin, Communication Systems, 5th Edition, Wiley, 2021.
2) Bernard Sklar, and Fredric J.Harris "Digital Communications: Fundamentals and Applications", Pearson Education, 2020.
3) John Leis, "Communication Systems Principles Using MATLAB", John Wiley & Sons, Inc., 2018

**REFERENCES**

1) Leon W. Couch, II, "Digital & Analog Communication Systems", 8th Edition, Pearson Education, 2013.
2) Rodzer E. Ziemer and William H. Tranter, Principles of Communications Systems, Modulation and Noise, 7th Edition, Wiley, 2015.
3) J.G.Proakis, M.Salehi, Fundamentals of Communication System, 2nd Edition, Pearson Education, 2014.

**L: 45; P: 30; TOTAL: 75 PERIODS**

| **Course Code** | **DIGITAL SIGNAL PROCESSING** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC44C** | | **3** | **0** | **2** | **0** | **4** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Theory Components:**

CO1- Analyze the discrete time signals using digital transforms DFT and FFT.
CO2- Design and realize Infinite impulse response filters.
CO3- Design and realize Finite impulse response filters.
CO4-Analyze the effect of finite word length representation on digital filter's impulse response
CO5- Implement Multi rate signal processing techniques and applications.

**Practical Components:**

CO6- Perform DFT and FFT of a discrete timed sequence and validate the properties using simulation
CO7- Design IIR filters using Impulse Invariance method and Bilinear Transformation method.
CO8-Design FIR filters using Rectangular, Hamming,Hanning windows and demonstrate the filtering operation.
CO9-Analyze Finite word length effect on First order and Second order systems.
CO10- Design a Digital signal processing system to demonstrate the multi rate signalprocessing concepts.

**CO1- Analyze the discrete time signals using digital transforms DFT and FFT**
**CO6-Perform DFT and FFT of a discrete timed sequence and Validate the properties using simulation**

DFT and its properties, Relation between DTFT and DFT , DFT computations using Decimation in time and Decimation in frequency algorithms, Inverse DFT using FFT algorithms, Use of FFT in linear filtering, Sectionalized convolution-overlap add and save procedure and its implementation using MATLAB simulation and DSP processor. **L:9; P:6**

**CO2- Design and realize Infinite impulse response filters.**
**CO7- Design IIR filters using Impulse Invariance method and Bilinear Transformation method.** **L:9; P:6**

Design of analog Butterworth and Chebyshev Filters, Frequency transformation in analog domain - Design of IIR digital filters using impulse invariance technique and demonstrate the filtering operation in MATLAB and DSP processor - Design of digital filters using bilinear transform – pre warping - Realization using direct, cascade and parallel forms

**CO3- Design and realize Finite impulse response filters.**
**CO8-Design FIR filters using Rectangular Hamming,Hanningwindows and demonstrate the filtering operation.**

Symmetric and Antisymmetric FIR filters - Linear phase FIR filters – Design using Rectangular , Hamming, Hanning, and kaiser Windows and demonstrate the filtering operation in MATLAB and DSP processor –Structure for FIR system. **L:9; P:6**

**CO4- Analyze the effect of finite word length representation on digital filter's impulse response.**
**CO9- Analyze Finite word length effect on First order and Second order systems.**

Fixed point and floating point number representations - Truncation and Rounding errors - Quantization noise - derivation for quantization noise power - coefficient quantization error – Product quantization error - Overflow error, Saturation arithmetic – Round-off noise power - limit cycle oscillations due to product round off and overflow errors - signal scaling-Analysis of Finite word length representation using MATLAB simulation. **L:9; P:6**

**CO5- Implement Multi rate signal processing techniques and applications.**
**CO10- Design a Digital signal processing system to demonstrate the multi rate signal processing concepts.**

Introduction to Multi-rate signal processing-Decimation-Interpolation- Polyphase implementation of FIR filters for interpolator and decimator - Multistage implementation of sampling rate conversion using MATLAB simulation tool- Design of narrow band filters – Applications: Model of speech waveform –Vocoder. **L:9; P:6**

**TEXT BOOKS**

1.John G. Proakis, Dimitris G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, 5th Edition, Pearson, 2021.
2. Alan. V. Oppenheim, R. Schafer, "Discrete time Signal Processing", Pearson Education, 3rd Edition, 2014.

**REFERENCES**

1. E.C.Ifeachor and B.W.Jervis, "Digital signal processing - A practical approach", Pearson, 2nd Edition, 2002.
2. S.K. Mitra, "Digital Signal Processing- A Computer Based approach", Tata Mc-GrawHill, 4th Edition, 2013.
3. Johny R.Johnson, "Introduction to Digital Signal Processing", PHI, 2006.
4. Lonnie C.Ludeman, "Fundamentals of Digital Signal Processing", Wiley, 1st Edition, 2009.

**L: 45; P: 30; TOTAL: 75 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC45C | MICROPROCESSOR AND MICROCONROLLER | 3 | 0 | 2 | 0 | 4 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to:

**Theory Components:**

**CO1:**Interpret the functional blocks of 16-bit microprocessor and its instruction set.

**CO2:** Interconnecting external devices to 16-bit microprocessor for normal operation.

**CO3:** Interpret the functional blocks of 8-bit microcontroller and its instruction set

**CO4:** Interconnecting external devices to 8-bit microcontroller for normal operation.

**CO5:** Illustrate the functional block diagram of STM32 and perform interfacing operation with GPIO pins.

**Practical Components:**

**CO6:**Enabling the processor to perform basic arithmetic and logic programs using 8086.

**CO7:**Demonstrate to interconnect external devices to 16-bit microprocessor.

**CO8:**Enabling the controller to perform basic arithmetic logic programs.

**CO9:** Demonstrate to interconnect devices with 8-bit microcontroller.

**CO1: Interpret the functional blocks of 16-bit microprocessor and its instruction set** **L:9, P:6**

**CO6: Enabling the processor to perform basic arithmetic and logic programs using 8086.**

8086 Microprocessor: Evolution of Microprocessor - Hardware Architecture – Functional Building Blocks of Processor – Instruction format and addressing modes – Assembly language format – Parallel Communication Interface. Case Study: Traffic Light control

**CO2: Interconnecting external devices to 16-bit microprocessor for normal operation.**

**CO7: Demonstrate to interconnect external devices to 16-bit microprocessor.**

Memory Interfacing and I/O interfacing — Parallel communication interface — Serial communication interface — D/A and A/D Interface — Timer — Interrupt controller — DMA controller — Programming and applications Case studies: Traffic Light control, LED display, LCD display and Alarm Controller.

**CO3: Interpret the functional blocks of 8-bit microcontroller and its instruction set** **L:9, P:6**

**CO8: Enabling the controller to perform basic arithmetic logic programs**

Architecture of 8051 – Special Function Registers(SFRs) – I/O Pins Ports and Circuits – Instruction set – Addressing modes – Assembly language programming.

**CO4: Interconnecting external devices to 8-bit microcontroller for normal operation.** **L:9, P:6**

**CO9: Demonstrate to interconnect devices with 8-bit microcontroller.**

Interrupts, Timer/Counter and Serial Communication, Programming Timer Interrupts, Programming External H/W interrupts, Programming the serial communication interrupts, Interrupt Priority in the 8051, Programming 8051 Timers and Counters. Applications: Traffic light control – Washing machine - Stepper motor control – Serial Port Programming.

**CO5: Illustrate the functional block diagram of STM32 and perform interfacing operation with GPIO pins.** **L:9, P:6**

STM32: Functional Block diagram – GPIO register – $I^2C$ interface – PWM interface – RTC interface – Case Study: Timer: Watchdog.

**TEXT BOOKS:**

1. Douglas V Hall, "Microprocessors and Interfacing", 3rdEdition, McGraw Hill Education, 2017 Reprint, 2020.
2. K.UmaRao, AndhePallav, The 8051 Microcontrollers, Architecture and Programming and Applications, 3rd Edition, Pearson, 2014.
3. Aharensan, Mastering STM32 Beginner's Guide: A Practical Guide to Real-Time Embedded Programming, Clock Setup, LED Blinking and More with Registers, 2ndEdition, 2023.

**ONLINE RESOURCES:**

1. https://www.udemy.com/course/mastering-stm32f407-microcontrollers/

**REFERENCES:**

1. Krishna Kant, "Microprocessors and Microcontrollers" 2ndEdition, Prentice Hall, 2011 Reprint 2019.
2. Muhammed Ali Mazidi, Janice GillispleMaidi, Rolin.D. McKinlay, "The 8051 Microcontroller and Embedded Systems, Using Assembly and C", 2nd Edition, Pearson Prentice Hall, 2015.
3. Kenneth J Ayala, "The 8051 Microcontroller", 3rd Edition, Cengage Learning, Reprint 2014.
4. A.K.Ray and K.M. Bhurchandi, "Advanced Microprocessor and Peripherals", Tata McGraw Hill, 3rd Edition, 2013.
5. Sepehr Naimi, "The STM32F103 Arm Microcontroller and Embedded Systems: Using Assembly and C",2nd Edition, 2021

**L: 45; P: 30; TOTAL: 75 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| **23EC46C** | **SYSTEM MODELING PROJECT** | **0** | **0** | **2** | **2** | **2** |

**COURSE OUTCOMES**

Upon Successful completion of this course, the students will be able to:

**Practicalcomponent:**

CO1: Apply basic mathematics, science, and engineering concepts to develop models for systems or products across various domains.

**Experientialcomponent:**

CO2: Develop and analyze models using fundamental principles to solve real-life problems.

**Softskill component:**

CO3: Develop the ability to work collaborativelyin teamsto model and simulate systems while effectively communicating technical results using suitable tools and techniques.

**COURSE OVERVIEW**

This course is designed to equip students withtheskills to develop and analyze mathematical models for various systems across different domains. Itfocuses on applying fundamental principles of mathematics, science, and engineering to represent and predict the behaviour of these systems. Through hands-on experience, students will learn to create robust models that address real-world challenges, ranging from system optimization to problem-solving in practical applications. The

course emphasizes integrating theoretical concepts with practical solutions, preparing students to design efficient and effective models while promoting technical excellence and professional growth.

**P: 60; TOTAL: 60 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23GN04C | APTITUDE EXCELLENCE | 0 | 0 | 2 | 0 | 1 |

**COURSE OUTCOMES**

Upon the completion of the course the students will be able to

**CO1**: Infer appropriate methods to simplify computation
**CO2**: Develop problem solving skills on Time and Work and enhance arithmetic ability
**CO3**: Interpret fundamentals in quantitative techniques and solve problems quickly
**CO4**: Improve quantitative skills and solve problems on permutation and Combination
**CO5**: Acquire the knowledge of Cognitive ability and solve puzzles effectively

**CO1: Infer appropriate methods to simplify computation**

**Simplification:** Nested Series simplification(fraction) -BODMAS rule –Viraculum (or Bar) rule – Modulus of a real number –Multiplication shortcuts-Comparing Fractions-Data Sufficiency **P:6**

**CO2: Develop problem solving skills on Time and Work and enhance arithmetic ability**

**Time and Work**: Work Done - Days from Work:- Ratio – Efficiency –Work and wages - Data Sufficiency **P:6**

**CO3: Interpret fundamentals in quantitative techniques and solve problems quickly**

**Time Speed Distance:** Body moving in the same direction- Body moving in the opposite direction-Average speed- Meeting point- Data Sufficiency **P:6**

**CO4: Improve quantitative skills and solve problems on permutation and Combination**

**Probability Permutation Combination:** Fundamental Counting Principle – Computing Permutation – Circular Permutation – ComputingCombinations- Data Sufficiency **P:6**

**CO5: Acquire the knowledge of Cognitive ability and solve puzzles effectively**

**Abstract reasoning**: Mirror and water image – Figure Matrix –Pattern Completion – Logical puzzles –Dot situation - Ranking ordering.**Cognitive ability:** Blood Relation - Direction Sense Test-Data Sufficiency **P:6**

**REFERENCE BOOKS:**

1. R.V.Praveen, "Quantitative Aptitude and Reasoning" , 3rd Edition , Eastern Economy Edition, PHI Learning 2016
2. Arun Sharma," Quantitative Aptitude for CAT", McGraw Hill Edge, 10th Edition 2022
3. Dr.R.Aggarwal, " Quantitative Aptitude", S Chand Publishing, Revised Edition 2017

**P:30; TOTAL: 30 PERIODS**

| | | | | | | |
|---|---|---|---|---|---|---|
| **23GN05C** | **PROFESSIONAL ETHICS AND HUMAN VALUES** | **L** | **T** | **P** | **E** | **C** |
| | *(Common to all B.E. / B.Tech. Degree Programmes)* | **2** | **0** | **0** | **0** | **2** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

CO1: Recognize and practice the core human values and theories related to ethical behavior.

CO2: Analyze the engineering ethical breach from past study.

CO3: Distinguish and apply safety, responsibility and rights in workplaces.

**CO1: Recognize and practice the core human values and theories related to ethical behavior** **L: 10**

Moral dilemmas and moral autonomy - Kohlberg's theory - Gilligan's theory - Consensus and controversy –Case studies: Vigil mechanism, Whistle blowing - Protected disclosures - Personal ethics, work ethics and human values - Governing Regulation.

**CO2 : Analyze the engineering ethical breach from past study** **L: 10**

Engineering as experimentation - engineers as responsible experimenters - codes of ethics - a balanced outlook on law - Case study: The challenger disaster

**CO3 : Distinguish and apply safety, responsibility and rights in workplaces** **L: 10**

Safety and risk - assessment of safety and risk - risk benefit analysis and reducing risk - Collegiality and loyalty - respect for authority – confidentiality; Collective bargaining, Conflicts of interest - Case study; Occupational crime - professional rights - employee rights - Intellectual Property Rights (IPR) - discrimination. Case studies: The Three mile island and Chernobyl disaster

**TEXT BOOK**

1. Mike W Martin and Roland Schinzinger, “Ethics in Engineering”, McGraw Hill, New York,5th Edition, 2022

**REFERENCES**

1. BehnamTaebi, “Ethics and Engineering: An Introduction”, Cambridge University Press, 2021
2. AjeshFaizal, Aswathy S U, Roy V I, “Professional Ethics in Engineering: an Industry Perspective”, Noor Publishing, 2021
3. R.S.Naagarazan, “A Textbook on Professional Ethics and Human Values”, New age International Pvt. Ltd; 3rdEdition, 2022
4. Dr. P. Elamurugan, “Professional Ethics in Engineering”, Notion Press, 2021

**L:30; TOTAL:30 PERIODS**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **CONTROL SYSTEMS** | **L** | **T** | **P** | **E** | **C** |
| **23EC51C** | | **3** | **1** | **0** | **0** | **4** |

**COURSE OUTCOMES**

Upon the completion of the course the students will be able to

CO1: Explain the mathematical model of electrical systems and describe the transferfunction for a given control system using block diagram reduction techniquesand signal flow graph method.

CO2: Determine the time domain specifications for first and second order systems.

CO3: Determine the stability of a system in the frequency domain using various plots.
CO4: Determine the stability of a system in the time domain using Routh Hurwitzcriterion and Root-locus technique.
CO5: Develop a control system model in continuous and discrete time using statevariable techniques.

**CO1: Explain the mathematical model of electrical systems and describe the transfer function for a given control system using block diagram reduction techniques and signal flow graph method** **L:9 T:3**

Introduction to Control Systems: Types of Control Systems, Effect of Feedback Systems,Differential equation of Physical Systems- Electrical Systems. Block diagrams and signalflow graphs: Transfer functions, Block diagram algebra and Signal Flow graphs.

**CO2: Determine the time domain specifications for first and second order systems** **L:9 T:3**

Standard test signals, Unit step response of First and second order Systems. Timeresponse specifications of second order systems, steady state errors and error constants.Introduction to PI, PD and PID Controllers.

**CO3: Determine the stability of a system in the frequency domain using various plots.** **L:9 T:3**

Polar plots, Bode plot, stability, Nyquist plots. Performance specifications in frequencydomain. Frequency-domain methods of design, Compensation & their realization in time &frequency domain. Lead and Lag compensation.

**CO4: Determine the stability of a system in the time domain using Routh Hurwitz criterion and Root-locus technique.** **L:9 T:3**

Concept of stability-Bounded – Input Bounded – Output stability-Routh stability criterionRelative stability-Root locus concept-Guidelines for sketching root locus-Nyquist stabilitycriterion.

**CO5: Develop a control system model in continuous and discrete time using state variable techniques.** **L:9 T:3**

State variable representation-Conversion of state variable models to transfer functionsConversion of transfer functions to state variable models-Solution of state equationsConcepts of Controllability and Observability.

**TEXT BOOKS**

1. Nagarath and M.Gopal, "Control Systems Engineering", New Age International (P) Limited, Publishers, 8th Edition, 2018.
2. M.Gopal, "Control System – Principles and Design", Tata McGraw Hill, 2ndEdition,2002.

**REFERENCES**

1. Charles L. Phillips and John Parr, "Feedback Control Systems", Prentice Hall, 5thEdition, 2010.
2. Farid Golnaraghi and Benjamin C.Kuo, "Automatic Control Systems", Wiley Publications, 9th Edition, 2009.
3. Richard C. Dorf and Robert H. Bishop, "Modern Control Systems", Prentice Hall, 12th Edition, 2010.
4. K.Ogata, "Modern Control Engineering", Pearson Education Asia/PHI, 4th Edition, 2002.

**L: 45; T: 15; TOTAL: 60 PERIODS**

| **Course Code** | | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC52C** | **DIGITAL COMMUNICATION** | **3** | **0** | **2** | **0** | **4** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to:

**Theory Components:**

CO1 : Employ core concepts of various building blocks of baseband transmitter in digital communication system design.

CO2 : Employ core concepts of various building blocks of baseband receiver in digital communication system design.

CO3 : Analyse the suitability of digital modulation techniques for wireless systems.

CO4 : Apply the concepts of spread spectrum and multiple access techniques in digital communication system design.

CO5 : Comprehend the need for multi-carrier systems and fundamentals of Orthogonal Frequency Division Multiplexing (OFDM).

**Practical Components:**

CO6 : Design and analyse baseband transmitter system.

CO7 : Design and analyse baseband receiver system.

CO8 : Implement the single carrier passband communication system with various digital modulation techniques and evaluate its performance.

CO9 : Demonstrate spread spectrum communication system and multiple access communication system

CO10 : Simulate and implement OFDM transceiver system.

**CO1 : Employ core concepts of various building blocks of baseband transmitter in digital communication system design.** **L:9, P:6**

Line coding –Line coding and its types, Unipolar NRZ, Bipolar NRZ, Polar RZ, Manchester code, Differential code, Spectral analysis of unipolar NRZ and bipolar NRZ, baseband transceiver architecture Inter Symbol Interference, Nyquist Criterion, Pulse shaping filters

**CO6 : Design and analyse baseband transmitter system.**

1) Generate line codes and study ISI
2) Design of pulse shaping filter and analyze its spectrum

**CO2 : Employ core concepts of various building blocks of baseband receiver in digital communication system design.**

Receive filters – Correlation filter, Matched filter, Eye pattern, Equalization, Adaptive Equalization, Detection of known signal in the presence of Noise, Probability of Error, Maximum likelihood detection **L:9, P:6**

**CO7: Design and analyse baseband receiver system.**

1) Design of matched filter & equalizer and verification of eye pattern.
2) Probability of error of baseband system in the presence of AWGN using ML detection

**CO3 : Analyse the suitability of digital modulation techniques for wireless systems.**

**CO8 : Implement the single carrier passband communication system with various digital modulation techniques and evaluate its performance.**

Geometric Representation of signals, Passband transmission Model, Binary digital modulation techniques BASK, BPSK, QPSK, BFSK – time domain analysis, signal **L:9,**

constellation, generation & detection, bit error rate analysis. M-ary PSK, M-ary QAM – qualitative analysis. **P:6**

**CO8 : Implement the single carrier passband communication system with various digital modulation techniques and evaluate its performance.**

1) Probability of error for BPSK and performance comparison with and without error control code.
2) Probability of error for BFSK
3) Probability of error of 4-QAM, 8-QAM

**CO4 : Apply the concepts of spread spectrum and multiple access techniques in digital communication system design.**

Importance of synchronization - Pseudo noise sequences - Concept of spread spectrum- Direct sequence spread spectrum with coherent BPSK, frequency hop spread spectrum, Multiple Access Techniques - FDMA, TDMA, CDMA, SDMA **L:9, P:6**

**CO9 : Demonstrate spread spectrum communication system and multiple access communication system**

1) Design spread spectrum communication system and to compares the spectrum with traditional communication system.
2) Design CDMA transceiver

**CO5 : Comprehend the need for multi-carrier systems and fundamentals of Orthogonal Frequency Division Multiplexing (OFDM).**

Drawbacks in single carrier communication system, concept of multicarrier system - Multi carrier channel modeling - multi carrier transmission - Frequency Division Multiplexing - OFDM principle - OFDM transmitter and receiver architecture, bit error rate analysis **L:9, P:6**

**CO10 : Simulate and implement OFDM transceiver system.**

1) Design OFDM transceiver and analyze its time domain & frequency domain characteristics

**TEXT BOOKS:**

1) Bernard Sklar, and Fredric J.Harris "Digital Communications: Fundamentals and Applications", Pearson Education, 2020.
2) Simon Haykin, Digital Communication Systems, 1st Edition, Wiley, 2013.
3) Tzi-Dar Chiueh and Pei-Yun Tsai, OFDM Baseband Receiver Design for Wireless Communications, Wiley, 2007.

**REFERENCES:**

1) Mehmet Safak, Digital Communications, Wiley, 2017.
2) Krzysztof Wesołowski, “Introduction to Digital Communication Systems", Wiley, 2009
3) B.P. Lathi, "Modern digital and Analog Communication Systems", Oxford University Press, 3rd Edition, 2007.
4) Aditya K. Jagannatham, “Principles of Modern Wireless Communication - Theory and Practice”, McGraw Hill Education (India) Private Limited, 2016.
5) Richard van Nee, Ramjee Prasad, “OFDM for Wireless multimedia communications”, Artech House, 2000.

**L: 45; P: 30; TOTAL: 75 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| **23EC53C** | **ANALOG CIRCUITS – II** | **3** | **0** | **2** | **0** | **4** |

**COURSE OUTCOMES:**

Upon successfully completing the course, the students will be able to:

**Theory Components**

CO1: Describe the fabrication of IC andthe characteristics of OP-AMP.
CO2: Analyze the practicalapplications of OP-AMP.
CO3: Discuss the operation of the Phase Locked Loop and its applications.
CO4: Analyze the different types of digital-to-analogconverters and analog-to-digital converters.
CO5: Describe the various operating modes of timer IC anddifferent types of voltage regulators.

**Practical Component**

CO6: Analyze the characteristics of op-amp
CO7: Design and construct the operational amplifier-based application circuitsfor given Specifications.
CO8: Demonstrate the various applications of PLL.
CO9: Demonstrate the A/D and D/A converters.
CO10: Design of clock generation circuits and voltage regulator circuits based on specifications.

**CO1: Describe the fabrication of IC and the characteristics of OP-AMP.**

Advantages of IC over discrete components, IC manufacturing process, Fabrication of Typical circuit, General operational amplifier stages, Current mirror and current sources, Current sources as active loads, BJT Differential amplifier with active loads. **L:9 T:6**

**CO6: Analyze the characteristics of op-amp**

Examination of DC and AC performance characteristics, slew rate, and Gain bandwidth of operational amplifier in open and closed loop configurations.

**CO2: Analyze the practical applications of OP-AMP.**

V-to-I and I-to-V converters, Adder, Subtractor, Comparators, Schmitt trigger, Precision rectifier, Peak detector, Clipper and Clamper, Oscillators using op-amp, Astable and MonostableMultivibrators. **L:9 T:6**

**CO7: Design and construct the operational amplifier-based application circuits for given Specifications.**

Experimental analysis of Inverting and non-inverting op-amp, Voltage Follower, Instrumentation amplifier, Integrator, Differentiator, Filters, oscillators and multivibrators.

**CO3: Discuss the operation of the Phase Locked Loop and its applications.**

Operation of the basic PLL, Closed loop analysis, Voltage-controlled oscillator, Monolithic PLL IC 565, lock-in range, capture range of PLL, PLL phase noise, **L:9 T:6**

**CO8: Demonstrate the various applications of PLL.**

Investigationofapplying PLL for AM detection, FM detection, FSK modulation and demodulation, and Frequency synthesizing.

**CO4: Analyze the different types of digital-to-analog converters and analog-to-digital converters.L:9, P:6**

Analog and Digital Data Conversions, D/A converter, specifications, weighted resistor type, Voltage Mode and Current Mode R-2R Ladder types, Switches for D/A converters, High-speed sample and hold circuits, A/D Converters, specifications, Counter type, Servo tracking type, Successive Approximation type, Dual Slope type A/D converter, Figure of Merit, static parameters: DNL, INL. **L:9 T:6**

**CO9: Demonstrate the A/D and D/A converters.**

Experimental analysis of R-2R Ladder DAC, Inverted R-2R DAC, Flash type ADC

**CO5: Describe the various operating modes of timer IC and different types of voltage regulators.L:9, P:6**

Timer IC 555 - Description and Functional Diagram, Monostable operation, Astable operation, Linear Regulators, IC Voltage regulators, Three terminal fixed and adjustable voltage regulators,IC 723 General purpose regulator, SMPS.

**L:9**
**T:6**

**CO10: Design of clock generation circuits and voltage regulator circuits based on specifications.**

Investigation of Monostable operation, Astable operation in 555 timers, linear and switching regulators

**TEXT BOOKS**

1. Ramakant A. Gayakwad, -Operational Amplifiers and Linear IC, 4th Edition, Prentice Hall Pearson Education, 2015.
2. D.Roy Choudhry, Shail Jain, "Linear Integrated Circuits", New Age International Private Limited, 4th Edition, 2010.
3. Sergio Franco, "Design with operational amplifiers and analog integrated circuits", 3rd Edition, Tata McGraw Hill, 2007.

**REFERENCE BOOKS**

1. S.Salivahanan& V.S. Kanchana Bhaskaran, -Linear Integrated Circuits, TMH,2nd Edition, 4th Reprint, 2016
2. Paul R. Gray, Paul J. Hurst, Stephen H. Lewis and Robert G. Meyer, "Analysis and Design ofAnalog Integrated Circuits", John Wiley & Sons Inc, 5th Edition, 2009.
3. Ramakant A. Gayakwad, "Op-amps and Linear Integrated Circuits", Prentice Hall, 4th Edition,2000.

**L: 45; P: 30; TOTAL: 75 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| **23EC54C** | **VLSI DESIGN** | **3** | **0** | **2** | **0** | **4** |

**COURSE OUTCOMES:**

Upon successfully completing the course, the students will be able to:

CO1: Describe the operation of the MOS transistor and demonstrate the CMOS process technology.

CO2: Analyze various delays and power dissipation of CMOS circuits.

CO3: Design and analyze the various techniques to optimize combinational and sequential circuits for lower delay.

CO4: Illustrate the various ASIC and FPGA architectures and the principles of static timing analysis.

CO5: Demonstrate the VLSI system components using Verilog HDL.

**Practical Components:**

CO6: Analyze the characteristics of the CMOS inverter, Current source and Differential amplifier for various MOS transistors.

CO7: Estimate various delays and power dissipation of CMOS circuits.

CO8: Analyze combinational and sequential circuits using various CMOS circuit families and compare their performance metrics.

CO9: Implement the static timing analysis and different architectures of digital circuits in FPGAs.
CO10: Develop Verilog HDL code for VLSI system components, synthesize and implement the circuits in FPGAs.

**CO1: Describe the operation of the MOS transistor and demonstrate the CMOS process technology.**

MOS Transistor Theory - Ideal I-V and C-V Characteristics of MOS Transistor, Non-ideal I - V Effects, DC Transfer Characteristics of CMOS Inverter. n-well, twin tub andSOI CMOS processes, Lambda based design Rules, CMOS Process Enhancements. **L:9 T:6**

**CO6: Analyze the characteristics of the CMOS inverter, Current source and Differential amplifier for various MOS transistors.**

Experimental analysis: DC Transfer Characteristics, Schematic and Layout Generation of CMOS Inverter.

**CO2: Analyze various delays and power dissipation of CMOS circuits.**

Delay Estimation, Logical Effort and Transistor Sizing, Power Dissipation, Interconnect, Reliability, Scaling–Device models,Device characterization. **L:9 T:6**

**CO7: Estimate various delays and power dissipation of CMOS circuits.**

Examination of CMOS Circuit characterization in terms of delay and power dissipation.

**CO3: Design and analyze the various techniques to optimize combinational and sequential circuits for lower delay.**

Combinational Circuit Design: Circuit Families – Static CMOS, Ratioed Circuits, Dynamic CMOSCircuits: Pass-transistor logic Circuits, Comparison of CMOS Circuit Families, **L:9 T:6**

**CO8: Analyze combinational and sequential circuits using various CMOS circuit families and compare their performance metrics.**

Investigation of Static CMOS,Dynamic CMOS,Pass-transistor logic Circuits, andSequential CircuitDesignin CMOS circuits.

**CO4: Illustrate the static timing analysis of the arithmetic building blocks and various ASIC and FPGA architectures.**

Timing Analysis - Clock skew optimization. Clock Tree Synthesis. Full Custom ASICs, Standard-Cell Based ASICs, GateArray-Based ASICs, Channeled, Channelless, Structured Gate Array and Architecture of Generic FPGA. **L:9 T:6**

**CO9: Implement the static timing analysis of various arithmetic building blocks**

Inspection of Timing Analysis - Clock skew optimization. Clock Tree Synthesis in various arithmetic building blocks.

**CO5: Demonstrate the VLSI system components using Verilog HDL.L:9, P:6**

Design Methodologies – Modules – Instances – Test bench – Operators – Number Specification – Identifiers and Keywords – Data Types – Modules and Ports – Types of Modelling.

**CO10: Develop Verilog HDL code for VLSI system components, synthesize and implement the circuits in FPGAs.** **L:9 T:6**

Experimental analysis: Modelling: Structured Procedures, Procedural Assignments, - Design of combinational and sequential circuits using Gate-Level Modelling, Data flow Modelling, Behavioural and Structural Modelling.

**TEXT BOOKS**

1. Weste and Harris, "CMOS VLSI DESIGN: A Circuit and Systems Perspective", 5th Edition, Pearson Education, 2022.
2. Samir Palnitkar, "Verilog HDL, A Guide to Digital Design and Synthesis", 2nd Edition, Pearson Education, Reprint2021.

**REFERENCE BOOKS**

1. M.J.S.Smith, "Application Specific integrated circuits", Pearson Education, 2019.(6threprint)
2. Jan Rabaey, Anantha Chandrakasan, B.Nikolic, "Digital Integrated Circuits: A Design Perspective", PHI, 2nd Edition, 2018 (reprint).
3. UyemuraJ.P, "Introduction to VLSI circuits and systems", Wiley, 2019.
4. Wayne Wolf, "Modern VLSI design", Pearson Education, 3rd Edition, 2019.

**L: 45; P: 30; TOTAL: 75 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC55C | SIMULATION USING MODERN TOOLS | 0 | 0 | 2 | 2 | 2 |

**COURSE OUTCOMES:**

Upon successfully completing the course, the students will be able to:

**Practical Components:**

**CO1:** Ideate an electronics-based project that connects with practical application**.**

**CO2**: Design an electronic project to meet the specified performance criteria.

**Experiential Component:**

**CO3:** Simulate the electronic system using CAD tools to evaluate its performance and functionality.

**CO1: Ideate an electronics-based project that connects with practical application.**

A group of project team members has to select a project through a brainstorming session and design thinking process.

**Stage1**: Students can choose any one project topic listed below or any industry- oriented challenge.

1. Develop and simulate a high-speed comparator for Analog-to-Digital Converters (ADCs).
2. Model, simulate, and analyze mixed-signal circuits that integrate both analog and digital components.
3. Simulate QPSK modulation and demodulation processes to analyze their efficiency in digital communication systems. **P:10 E:02**
4. Design and simulate an OFDM system to evaluate its efficiency in multi-carrier communication systems.
5. Model and simulate a digital PLL for frequency synchronization in communication systems.
6. Develop and simulate a wireless sensor network node for efficient data transmission.
7. Design and simulate a smart home automation system controlled by IoT devices.
8. Design of energy-aware routing protocol for optimal data transmission in the network
9. Design of an Optimised ALU (Arithmetic and Logic Unit) for High-Speed

Arithmetic Operations

10. Design and simulate digital filters (FIR and IIR) for noise reduction and signal enhancement in communication systems.
11. Simulate noise reduction in audio signals using FFT-based filtering techniques.
12. Model a speech recognition system to identify and process spoken commands.

**Stage 2:** Evaluation through Review-I

The expected outcomes during the Review-I are Literature survey, Problem or gap identification, a one-page writeup including Proposed methodology, Block diagram/Flow diagram of the proposed work, real-time application and milestones of the work.

**CO2: Design an electronic project to meet the specified performance criteria.**

System design includes the conceptual design, component selection, simulation tool and requirement of any other resources, feasibility study and time requirements. **P:3**

**Stage 3:** System design should meet the specified user criteria which includes components selection and design **E:6**

**CO3: Simulate the electronic system using CAD tools to evaluate its performance and functionality.**

Create a schematic of the system using a CAD tool. Use simulation software to create a model of the system. Run the simulations to evaluate the performance and functionality of the system. Analyze the simulation results and optimize the design as needed. **P:2**

**Stage 4**: Evaluation through Review-II **E:2**

The expected outcomes during the Review-II are demonstration of the output/results, presentation of the work, documentation of the work as a research article.

**P:20; E:10; TOTAL: 30 PERIODS**

| **Course Code** | **CONSTITUTION OF INDIA** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23MC01C** | | **2** | **0** | **0** | **0** | **0** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Theory Components:**

CO1: Describe the salient features of the Indian Constitution.
CO2: Discuss the structure and functions of parliament.
CO3: Elaborate the structure and functions of state legislature.
CO4: Explain the fundamentals of organization and working of the Judiciary.
CO5: Discuss the foreign policy of India.

**CO1: Describe the salient features of the Indian Constitution.**

Salient Features – Preamble-Pillars of constitution - Fundamental Rights – Directive Principles of State Policy - Fundamental Duties. **L:6**

**CO2: Discuss the structure and functions of parliament.**

Powers and Functions of President and Prime Minister - Council of Ministers – The Legislature Structure and Functions of Lok Sabha and Rajya Sabha – Speaker. **L:6**

**CO3: Elaborate the structure and functions of state legislature**.

Features of Federal System - Administrative Relationship between Union and States - Powers and Functions of Governor and Chief Minister – Council of Ministers –State Legislature **L:6**

**CO4: Explain the fundamentals of organization and working of the Judiciary**.

Organization and Composition of Judiciary - Powers and Functions of the Supreme Court - Judicial Review – High Courts. **L:6**

**CO5: Discuss the foreign policy of India**

Foreign Policy of India – VISA Application Process- International Institutions like UNO, WTO, SAARC and Environmentalism. **L:6**

**TEXT BOOKS**

1. Basu D.D, "Introduction to Indian Constitution", Prentice Hall of India,2015.
2. Gupta D.C, "Indian Government and Politics", Vikas Publishing House, 2010.

**REFERENCES**

1. Pylee M.V, Introduction to the Constitution of India‖, Vikas Publishing House, 2011.
2. Kashyap S, Our Constitution‖, National Book Trust,2010.
3. Shukla V N, Constitution of India‖, Eastern Book Company Ltd., 2011.

**L:30; TOTAL:30 PERIODS**

| Course Code | PROJECT MANAGEMENT AND FINANCE | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23GN06C | | 2 | 0 | 0 | 0 | 2 |

**COURSE OUTCOME**

Upon the successful completion of the course, the student will be able to

**Theory Components:**

CO1: Select and formulate projects

CO2: Estimate the project cost and make an investment

CO3: Apply the scheduling and resource allocation techniques to control and monitor the project

**CO1: Select and formulate projects**

Project – Concepts –Project Life Cycle – Project constraints- Generation and Screening of Project Ideas - Project identification – Preliminary Analysis, Market, Technical, Financial, Economic and Ecological - Pre- Feasibility Report and its Clearance, Project Estimates and Techno-Economic Feasibility Report, Detailed Project Report – Different Project Clearances required. **L:10**

**CO2: Estimate the project cost and make an investment decision**.

Project Evaluation under certainty –Capital budgeting techniques; Methodology for project evaluation – Social Cost Benefit Analysis, Commercial or National Profitability, social or national profitability. **L:10**

**CO3: Apply the scheduling and resource allocation techniques to control and monitor the project**. **L:10**

Developing a Project Plan - Developing the Project Network – Constructing a Project Network (Problems) – PERT – CPM – Crashing of Project Network (Problems - Case Study) – Resource Leveling and Resource Allocation – Steps in Project Appraisal Process – Project Control Process – Control Issues – Project Audits – the Project Audit Process – project closure – team, team member and project manager evaluations.

**TEXT BOOKS**

1. Clifford Gray, Erik Larson and Gautam Desai, "Project Management: The Managerial Process", Tata McGraw Hill, 8thEdition, 2021.
2. Prasanna Chandra, "Projects, Planning, Analysis, Selection, Financing, Implementation and Review", Tata Mc-Graw Hill, 2023

**REFERENCES**

1. M Y Khan, P K Jain , "Management Accounting", McGraw Hill, 8thEdition, 2021
2. KantiSwarup, P.K.Gupta and Man Mohan, "Operations Research", S.Chand & Sons, 2019
3. Sudhakar, G P, "Project management: the managerial aspects", New Century Pub, 5thEdition, 2020.
4. Gopalakrishnan P and Ramamoorthy V.E., "Textbook of Project Management", Trinity Press, 2022
5. Dr. K.L. Gupta, "Management Accounting", SahityaBhawan Publications, 2022
6. Prem Kumar Gupta, Dr.D.S.Hira, "Problems in Operation Research (Principles & Solutions)", Kindle Edition, 2018
7. NPTEL videos:https://nptel.ac.in/courses/110107081

**L: 30; TOTAL:30PERIODS**

| Course Code | WIRELESS COMMUNICATION TECHNOLOGIES | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC61C | | 3 | 0 | 2 | 0 | 4 |

**COURSE OUTCOMES**

**Theory Components:**

Upon the successful completion of the course, the student will be able to

CO1:Employ evolution, design specification and fundamental concepts of wireless communication in wireless system design

CO2: Comprehend the impacts of multipath propagation in wireless system.

CO3: Utilize the knowledge on waveform candidates and multiple access in LTE wireless system design

CO4: Apply the concepts of multipath mitigation and capacity improvement techniques in wireless system design

CO5:Use the concepts of PHY and MAC layers of wireless networks (LAN, PAN and WAN) in designing wireless applications

**Practical Components:**

CO6: Evaluate wireless systems of different generations.

CO7: Characterize the wireless channel & evolve system design specifications through simulations.

CO8: Simulate and implement physical layer for LTE system.

CO9: Simulate the diversity technique and MIMO technique to mitigate multipath fading and to

improve capacity.
CO10: Design systems using Wi-Fi, BLE and LoRa wireless technologies.

**CO1: Employ evolution, design specification and fundamental concepts of wireless communication in wireless system design.** **L:9, P:6**

Wireless spectrum, Evolution of wireless Standards from 1G to 5G, 3GPP Process, Physical layer parameters of LTE, 5G system architecture, 6G design specification, Cellular concepts: Frequency reuse, channel assignment, Handoff strategies, interference & system capacity - Trunking theory & grade of service – Coverage and capacity improvement.

**CO6: Evaluate wireless systems of different generations**

1. Spectrum sensing using RTL-SDR
2. Simulating cell planning of 2G, 3G, 4G and 5G wireless system

**CO2: Comprehend the impacts of multipath propagation in wireless system**. **L:9, P:6**

Electromagnetic Wave Propagation Mechanisms: Reflection, Diffraction, Scattering - Large scale path loss models: Free Space, Two-Ray and Log Normal Shadowing - Link Budget design small scale fading: Doppler Shift, Delay Spread; Coherence bandwidth, Doppler spread, Coherence time - Fading due to delay spread – Fading due to Doppler spread – Level Crossing Rate – Average Fade Duration, Small Scale fading Channel Model- Rayleigh and Rician Channels

**CO7: Characterize the wireless channel & evolve system design specifications through simulations**

1. Characterization of large-scale fading channels in simulation.
2. Characterization of small-scale fading channels in simulation.

**CO3: Utilize the knowledge on waveform candidates and multiple access in LTE wireless system design.** **L:9, P:6**

Review of OFDM, Guard Interval, Guard Band, Water-Filling Algorithm, Training symbol based and DFT based channel estimation, PAPR, Adaptive modulation & coding, Filter Bank Multicarrier Modulation, Universal Filtered OFDM, Generalized Frequency Division Multiplexing, Multiple Access - OFDMA, NOMA.

**CO8: Simulate and implement physical layer for LTE system.**

1. Performance Studies of Adaptive Modulation and Coding
2. SDR Implementation of Multicarrier Modulation - OFDM

**CO4: Apply the concepts of multipath mitigation and capacity improvement techniques in wireless system design.** **L:9, P:6**

Time diversity, frequency diversity, space diversity, Combining techniques : selection combining, maximal ratio combining, equal gain combining, square law combining, MIMO System, MIMO capacity for channel known to the receiver, Singular value decomposition of the channel matrix, Space-time codes for MIMO – Alamouti code.

**CO5: Use the concepts of PHY and MAC layers of wireless networks (LAN, PAN and WAN).** **L:9, P:6**

PHY & MAC layers: 802.11a/g – OFDM based LAN, 802.11n – High Throughput LAN, 802.11ax - Wi-Fi6, Bluetooth Network Structure & Link control, Bluetooth radio, Bluetooth packet structure, Bluetooth Low Energy (BLE), Low Power Long Range

(LoRa) communication.

**CO10: Design systems using Wi-Fi, BLE and LoRa wireless technologies**

1. Wi-Fi & BLE based system design
2. LoRa based system design

**TEXT BOOKS**

1. Andreas F. Molish, "Wireless Communications from Fundamentals to Beyond 5G", Wiley, Third Edition, 2022.
2. Simon Haykin, Michael Moher and David Koilpillai, "Modern Wireless Communication", 1st Edition, Pearson Education, 2015.
3. Rappaport T. S., "Wireless communications", Pearson Education, 3rd Edition, 2010.
4. Aditya K. Jagannatham, "Principles of Modern Wireless Communication Systems", McGraw Hill Education, First Edition, 2018.

**REFERENCES**

1. Afif Osseiran, Jose F. Monserrat, Patrick Marsch, "5G Mobile and Wireless Communications Technology", Cambridge University Press, 2016.
2. Yunlong Cai, Zhijin Qin, Fangyu Cui, Geoffrey Ye Li, and Julie A. McCan, "Modulation and Multiple Access for 5G Networks", IEEE Communications Surveys & Tutorials, Vol. 20, No. 1, pp.629-646, Oct 2017.
3. Shah, A. S., Qasim, A. N., Karabulut, M. A., Ilhan, H., & Islam, M. B. (2021). Survey and performance evaluation of multiple access schemes for next-generation wireless communication systems. IEEe Access, 9, 113428-113442.
4. Banelli, Paolo, et al. "Modulation formats and waveforms for 5G networks: Who will be the heir of OFDM?: An overview of alternative modulation schemes for improved spectral efficiency." IEEE Signal Processing Magazine 31.6 (2014): 80-93.
5. https://lora-alliance.org/lorawan-for-developers/

**L:45; P: 30; TOTAL: 75 PERIODS**

| Course Code | ANTENNA AND WAVE PROPAGATION | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC62C | | 3 | 0 | 2 | 0 | 4 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Theory Component**

CO1: Analyze the different transmission line characteristics.

CO2: Explain the radiation mechanism of wire antenna and its behaviour in terms of antenna parameters.

CO3: Analyze the behaviour of antenna array using numerical technique.

CO4: Design and analyze the performance of Aperture and planar antennas.

CO5: Explain the antenna measurement and outline the factors affecting wave propagation.

**Practical Component**

CO6: Design and simulation of planar transmission lines using EM tool.

CO7: Design and simulation of wire antenna.

CO8: Design and simulate the planar microstrip antenna for the given specification.

CO9: Measure and analyze the radiation pattern of antennas using a laboratory experimental setup.

**CO1: Analyze the different transmission line characteristics.** **L:9, P:12**

Parameters at high frequency transmission lines, different types of transmission line – coaxial, waveguide, planar transmission lines-strip lines, microstrip lines and CPW lines.

**CO6: Design and simulation of planar transmission lines using EM tool.**

1. Design and simulation of strip lines
2. Design and simulation of microstrip lines
3. Design and simulation of Coplanar Waveguide lines

**CO2: Explain the radiation mechanism of wire antenna and its behavior in terms of antenna parameters.** **L:9, P:6**

**Antenna parameters** – Field regions, Radiation pattern – Radiation power density and intensity, Directivity, Gain, Antenna impedance, Polarization, Bandwidth, Beamwidth, Effective aperture, Reciprocity principle, Friss transmission formula.

**Wire Antennas** - short dipole, half wave dipole antenna, small loop antenna

**CO7: Design and simulation of wire antenna.**

1. Investigate the various characteristics of a Monopole Antenna.
2. Investigate the various characteristics of a Dipole Antenna.

**CO3: Analyze the behavior of antenna array using numerical technique.** **L:9**

Two-element isotropic array – Broadside array and end-fire array, Pattern multiplication, N-element linear array. Yagi-Uda array, log periodic array, Introduction to Smart Antennas and Beamforming techniques.

**CO4: Design and analyze the performance of Aperture and planar antennas.** **L:9, P:6**

Aperture Antennas: Babinet's Principle, Slot antenna, Horn Antenna, Reflector Antenna

Planar antenna: Microstrip Patch Antenna-rectangular and circular patch- impedance matching of microstrip antennas, planar antenna miniaturization techniques, Exploration of advanced planar antennas: metamaterial inspired antennas, Fractal, Reconfigurable and Hybrid Dielectric Resonator Antennas.

**CO8: Design and simulate the planar microstrip antenna for the given specification.**

1. Simulate and Synthesis the various characteristics of patch antenna.
2. Perform the parametric analysis of patch antenna.

**CO5: Explain the antenna measurement and outline the factors affecting wave propagation.** **L:9, P:6**

Measurements: Radiation Pattern Measurement-Gain and Directivity Measurements.

Ground Wave Propagation - Free-space Propagation - Ground Reflection, Tropospheric Propagation- Ionospheric propagation - Structure of ionosphere, skip distance, Virtual height, Critical frequency, MUF, Electrical properties of ionosphere, Faraday rotation, Whistlers.

**CO9: Measure and analyze the radiation pattern of antennas using a laboratory experimental setup.**

1. Radiation Pattern Measurement of antenna using experimental setup

**TEXT BOOKS**

1. C.A. Balanis, "*Antenna Theory: Analysis and Design,*" John Wiley & Sons, 2016.
2. R.J. Marhefka, A.S. Khan and J.D. Kraus, "*Antennas and Wave Propagation*", Tata McGraw - Hill Education 2017.

## REFERENCES

1. Frederick Emmons Terman, Electronic Radio Engineering (4/e). McGraw Hill, 2017.
2. G.S.N.Raju, "Antenna and Wave Propagation", Pearson Education, 2013.
3. W.L. Stutzman & G.A. Thiele: Antenna Theory and Design, Wiley, 3rd Edition, 2012.
4. Edward C.Jordan& Keith G.Balmain, "Electromagnetic Waves and Radiating Systems", Second Edition, Pearson Education (second edition), 2015.
5. https://onlinecourses.nptel.ac.in/noc20_ee20

**L:45; P: 30; TOTAL: 75 PERIODS**

| Course Code | ARTIFICIAL INTELLIGENCE AND MACHINE | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC63C | LEARNING | 2 | 0 | 2 | 0 | 3 |

## COURSE OUTCOMES

**Theory Components:**

Upon the successful completion of the course, the student will be able to

CO1: Apply problem solving methods and learn design of intelligent systems.
CO2: Analyze various supervised learning techniques used in both classification and prediction.
CO3: Adopt the unsupervised algorithms for clustering process.
CO4: Comprehend and apply fundamental concepts of neural networks.

**Practical Components:**

CO5: Implementation of Uninformed and informed search algorithms for problem solving.
CO6: Demonstrate the performance of different ML algorithms using supervised learning.
CO7: Demonstrate the performance of different ML algorithms using unsupervised learning.
CO8: Develop a classifier with pre-trained model.

**CO1: Apply problem solving methods and learn design of intelligent systems.** **L:7,**
**CO5: Implementation of Uninformed and informed search algorithms for problem solving** **P:6**

Introduction to AI - Agents and Environment – Typical Intelligent Agents Problem Solving Approach to typical AI problems. Problem solving by Searching: Uninformed and informed strategies, Path planning, Constraint Satisfaction Problems.

Implementation of BFS and DFS Algorithms for Path Planning for Robotic Navigation.

Implementation of a Puzzle Solver Using Backtracking for Robotic Problem Solving Tasks

**CO2: Analyze various supervised learning techniques used in both classification and prediction. (CDL1)** **L:9,**
**CO6: Demonstrate the performance of different ML algorithms using supervised learning** **P:8**

Introduction to Machine Learning- Types of Learning- Regression- Introduction - Linear Regression - Logistic Regression. Classification: Support Vector Machines - Decision Tree using ID3 – Naïve Bayes Classifier.

Implement linear regression for prediction using an appropriate datasets.
Develop Classification algorithm for an appropriate dataset and evaluate the model's accuracy and performance.

**CO3: Adopt the unsupervised algorithms for clustering process.** **L:5,**
**CO7: Demonstrate the performance of different ML algorithms using unsupervised learning.** **P:8**

Clustering - K-means-Density-based clustering algorithms, Expectation Maximization Algorithm –Dimensionality Reduction using PCA.
Apply EM and k-means algorithms to cluster data for a real time dataset and evaluate the performance using appropriate metrics.

Implement Principal Component Analysis (PCA) for reducing the dimensionality of the features.

**CO4: Comprehend and apply fundamental concepts of neural networks.** **L:9,**
**CO8: Develop a classifier with pre-trained model.** **P:8**

Artificial Neural Networks - Structure and activation functions- Perceptron- multilayer Perceptron-Back propagation- Gradient descent algorithm- CNN architecture.

Implement ANN for real time applications.
Design and implement image classification models using Convolutional Neural Network.

**TEXT BOOKS**

1. Ethem Alpaydin, Introduction to Machine Learning, MIT Press, 4th Edition, 2020.
2. Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2nd Edition 2023.
3. Stuart Russell and Peter Norvig, Artificial Intelligence – A Modern Approach, Pearson Education, 4th Edition, 2021.

**REFERENCES**

1. Pradhan, Manaranjan, and U.Dinesh Kumar, Machine Learning Using Python, Wiley, 1stEdition, 2020.
2. Josh Patterson,AdamGibson, "Deep Learning: A Practitioner's Approach", O'Reilly Media, 2017
3. Khemani D, A First Course in Artificial Intelligence, McGraw Hill Education (India) Private Limited, 1stEdition, 9thReprint, 2019.

**L:30; P: 30; TOTAL: 60 PERIODS**

| Course Code | PRODUCT DEVELOPMENT PRACTICE | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC64C | | 0 | 0 | 0 | 4 | 3 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Experiential Component**

CO1: Identify and analyze real-world problems using empathy techniques and reverse engineering approaches.
CO2: Apply forward engineering to develop innovative solutions, focusing on technical feasibility, patentability, and market potential.

**Soft skill component**

CO3: Demonstrate the functionality of the developed product through prototypes and validate its commercial and patenting potential.

**CO1: Identify and analyze real-world problems using empathy techniques and reverse engineering approaches.**

- Empathy-driven customer need identification **E: 25**
- Problem definition and market analysis
- Study of existing solutions and reverse engineering analysis
- Deriving specifications and functional gaps

- Conceptual design based on gaps and feasibility

**CO2: Apply forward engineering to develop innovative solutions, focusing on technical feasibility, patentability, and market potential.**

- Concept refinement and solution detailing
- Rough model and Working model prototype development (hardware/software)
- Technical, financial, and IP (intellectual property) feasibility study
- Cost estimation and business model canvas
- Prototype demonstration and product documentation

**E: 35**

**E: 60; TOTAL: 60 PERIODS**

| 23EC71C | MINI PROJECT | L | T | P | E | C |
|---|---|---|---|---|---|---|
| | | 0 | 0 | 0 | 6 | 3 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Experiential component:**

CO1: Identify and define an engineering problem through need analysis, systematic literature review and feasibility study.

CO2: Develop an appropriate methodology, preliminary design/model, and project plan with required resources and timelines.

**Soft skill component:**

CO3: Communicate project ideas effectively through structured documentation, teamwork, and technical presentations.

**E:90; TOTAL: 90 PERIODS**

| Course Code | INTERNSHIP / IN-PLANT TRAINING | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC72C | | 0 | 0 | 4 | 0 | 2 |

**COURSE OUTCOMES**

**Theory Components:**

Upon the successful completion of the course, the student will be able to

CO1: Apply classroom knowledge in a real-time industrial environment

CO2: Demonstrate professional skills and technical learning through documentation and presentation

1. Student shall undergo internship/in-plant training after getting prior permission from the department
2. A report should be submitted after the successful completion of internship / in-plant training.

**P: 60; TOTAL: 60 PERIODS**

**23EC81C CAPSTONE PROJECT/INDUSTRY PRACTICE**

| L | T | P | E | C |
|---|---|---|---|---|
| 0 | 0 | 0 | 12 | 6 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Experiential component:**

CO1: Identify, analyze, and define a significant engineering problem using based on need assessment, literature survey and domain knowledge.

CO2: Apply appropriate engineering methods, design principles, tools, and modern software to develop and implement asolution or prototypewith sustainability considerations.

CO3: Conduct experiments, analyze data, evaluate results, and interpret findings with integrity and ethics.

**Softskill component:**

CO4: Prepare comprehensive project documentation and effectively present technical results in reputed conferences / journals

**Course Content**

- Domain Analysis, Problem Identification, Literature Review / Market survey, Methodology, Design and Implementation, Experimental Work / Simulation / Analytical studies / Optimization / Testing, Project Management - Life cycle costing, Documentation & Presentation.

**INDUSTRY PRACTICE:**

This is applicable to the students who have got internship offer in a company for duration of 10 to 15 weeks. Learning deliverables include:

- Industry problem statement and objectives
- Weekly logbook/ progress report
- Implementation or study outcomes
- Final technical report endorsed by industry mentor and faculty guide

**E: 180; TOTAL:180 PERIODS**

| Course Code | LINEAR ALGEBRA, MATHEMATICAL LOGIC AND SET THEORY | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23SH01E | | 2 | 1 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon successfully completing the course, the students will be able to:

CO1: analyze concepts of vector spaces. (CDL 1)

CO2: measure the similarity between different datasets using Inner product spaces. (CDL 1)

CO3: decompose the matrix for computational convenience. (CDL 1)

CO4: illustrate the validity of the arguments. (CDL 1)

CO5**:** analyze the concepts of Sets, Relations and Functions. (CDL 1)

**CO1: analyze concepts of vector spaces**

Vector spaces – Subspaces – Linear combinations – linear span - Linear independence and linear dependence – Bases and dimensions. **L:6 T:3**

**CO2: measure the similarity between different datasets using Inner product spaces**

Linear transformation - Null spaces and ranges – Rank Nullity theorem - Matrix representation of a linear transformations - Inner product space - Norms - Orthonormal Vectors - Gram Schmidt orthogonalisation process**.** **L:6 T:3**

**CO3: decompose the matrix for computational convenience**

Generalized eigenvector - QR decomposition- generalized inverse - Singular value decomposition and applications – Pseudo Inverse. **L:6 T:3**

**CO4: illustrate the validity of the arguments.**

Propositional Logic – Equivalences and Implications – Normal forms – Predicate Calculus and Quantifiers - Rules of inference – Proof methods and Strategies - Forward Proof, Proof by Contradiction, Proof by Contraposition, Proof of Necessity and Sufficiency. **L:6 T:3**

**CO5: analyze the concepts of Sets, Relations and Functions**

Basic Definitions - Set operations – Laws of set theory – Relations – Properties of relations - Partial Ordering Relation - Equivalence Relation - Matrices of relations - Closure of relations – Functions – Bijective functions - Inverse and Compositions of functions. **L:6 T:3**

**TEXT BOOKS**

1. Kenneth H.Rosen, Discrete Mathematics and its Applications (with Combinatory and Graph Theory), Special Indian Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 8th Edition, 2021.
2. Bernard Kolman and David Hill, "Elementary Linear Algebra with Application" Pearson India, 9th Edition, 2019.
3. Erwin Kreyszig, "Advanced Engineering Mathematics", 10thEdition, Wiley India, 2017.

**REFERENCE BOOKS**

1. Trembly J.P and Manohar.R. Discrete Mathematical Structures with Applications to Computer Science, 1st Edition, Tata McGraw-Hill Pub. Company Limited, New Delhi,2017.
2. Friedberg, A.H., I nsel, A.J.and Spence, L., Elementary Linear Algebra, a matrix approach, 2nd Edition Pearson Publication.
3. Raju.K.George and Abhijith Ajayakumar, A course in Linear Algebra, Springer, 2024.
4. Seymour Lipschutz Marc Lipson., "Linear Algebra" Schaum's Out lines series, 6th Edition, McGraw – Hill Education, 2018.

**L : 30; T :15; TOTAL : 45 PERIODS**

| Course Code | LINEAR STRUCTURES AND | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23SH02E | TRANSFORMATIONS | 2 | 1 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon successfully completing the course, the students will be able to:

CO1: solve the linear system of equations. (CDL 1)

CO2: determine the dimension of vector spaces. (CDL 1)

CO3: find the orthonormal vectors using Inner product spaces. (CDL 1)

CO4: illustrate Jordan canonical form on a finite dimensional vector space. (CDL 1)

CO5:decompose the matrix using Generalized Eigen vectors for computation.(CDL 1)

**CO 1: solve the linear system of equations** **L:6**

General system of linear equations – Matrices– Echelon form of matrix- Solving linear systems- Consistency of a system of linear equations -LU factorization. **T:3**

**CO2: determine the dimension of vector spaces**

Vector spaces – Subspaces – Linear combinations – linear span - Linear independence and linear dependence – Bases and dimensions. **L:6 T:3**

**CO3: find the orthonormal vectors using Inner product spaces**

Linear transformation - Null spaces and ranges – Rank Nullity Theorem - Matrix representation of a lineartransformations - Inner product space - Norms - Orthonormal Vectors - Gram Schmidt orthogonalisation process. **L:6 T:3**

**CO4: illustrate Jordan canonical form on a finite dimensional vector space**

Generalized eigenvector- Chains- Canonical basis the minimum polynomial- - Algebraic and Geometric multiplicity of Eigen Values - Similar matrices-Modal matrix-Jordan canonical form. **L:6 T:3**

**CO5: decompose the matrix using Generalized Eigen vectors for computation**

Eigen-values using QR transformations – Generalized Inverse Eigen vectors – Canonical forms – Singular value decomposition and applications – Pseudo inverse **L:6 T:3**

**TEXT BOOKS**

1. Bernard Kolman and David Hill, “Elementary Linear Algebra with Application” Pearson India, 9th Edition 2019.
2. Seymour Lipschutz Marc Lipson., “Linear Algebra” Schaum’s Out lines series, Six edition, McGraw – Hill Education, 2018.

**REFERENCE BOOKS**

1. Friedberg, A.H., I nsel,A.J.and Spence, L., Elementary Linear Algebra, A Matrix Approach, 2nd Edition, Pearson 2019.
2. Jim Defranza. Daniel Gagiardi “Introduction to Linear Algebra with Applications” Waveland PrLnk, 2015.
3. Eggar.Goodaire“Linear Algebra Pure & Applied”, World Sceintific, New Delhi, first edition, 2015.
4. Raju.K.George and Abhijith Ajayakumar, A course in Linear Algebra, Springer, 2024.

**L : 30; T :15; TOTAL : 45 PERIODS**

| Course Code | NUMBER THEORY | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23SH03E | | 2 | 1 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon successfully completing the course, the students will be able to:

CO1: acquire the concepts of theory of numbers. (CDL 1)

CO2: apply the fundamental propositions to interpret solutions of congruence. (CDL 1)

CO3: find the primitive roots for the congruence. (CDL 1)

CO4: analyze the inter-relation between arithmetical functions. (CDL 1)

CO5: determine quadratic residues of congruence. (CDL 1)

**CO1 : acquire the concepts of theory of numbers**

Introduction – Divisibility- Greatest common divisor - Prime numbers - The fundamental theorem of arithmetic - The series of reciprocals of the primes - The Euclidean algorithm (without Proof) - The greatest common divisor of more than two numbers. **L:6 T:3**

**CO2 : apply the fundamental propositions to interpret solutions of congruence**

Congruence - Linear congruence - Euler-Fermat theorem - Polynomial congruence modulo p – Wilson's Theorem **L:6 T:3**

**CO3: analyze the inter-relation between arithmetical functions.**

The Mobius function $\mu$(n) – The Euler Totient function $\varphi$(n)– A relation connecting $\varphi$ and $\mu$ – A product formula for $\varphi$(n) – properties of $\varphi$(n) –Multiplicative functions– completely multiplicative function. **L:6 T:3**

**CO4: determine quadratic residues of congruence**

Quadratic Residues – Legendre's symbol and its properties – Evaluation of (-1|p) and (2|p) – Gauss lemma – The Quadratic Reciprocity law – Applications – The Jacobi symbol. **L:6 T:3**

**CO5: implement the concepts of congruence in cryptography**

Chinese remainder theorem - Applications of Chinese remainder theorem - Cryptography and its application – RSA algorithm and Rabin Cryptosystem. **L:6 T:3**

**TEXT BOOKS**

1. Tom M.Apostol, "Introduction to Analytic Number Theory", Springer International Edition, Narosa Publishing House, New Delhi, 2013.
2. G.A.Jones&J.M.Jones, "Elementary Number Theory", Springer publications, 2012.

**REFERENCE BOOKS**

1. David M.Burton, "Elementary Number Theory", McGraw Hill, 7th Edition,2023
2. Joseph H.Silverman, "A Friendly Introduction to Number Theory", Pearson Education, 4th Edition, 2019.
3. Titu Andreesu, Gabriel Dospinescu, Oleg MushKarov, Number Theory: concepts and problems, Springer Science & Business Media, 2017.
4. S B Malik , "Basic Number Theory", S Chand publications, 2nd Edition, 2018

**L : 30; T :15; TOTAL : 45 PERIODS**

| Course Code | NUMERICAL ANALYSIS | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23SH04E | | 2 | 1 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon successfully completing the course, the students will be able to:

CO1: solve algebraic and transcendental equations using numerical methods. (CDL 1)

CO2: interpolate and approximate the polynomial of data. (CDL 1)

CO3: perform numerical differentiation and integration. (CDL 1)

CO4: find numerical solution of ordinary differential equation. (CDL 1)

CO5: classify and find numerical solution of partial differential equations. (CDL 1)

**CO 1: solve algebraic and transcendental equations using numerical methods**

Solutions of Algebraic linear equations Newton - Raphson Method, Fixed Point Iteration method - Solutions of algebraic simultaneous linear equations - Gauss Elimination –Gauss Seidel Methods. **L:6 T:3**

**CO 2: interpolate and approximate the polynomial of data**

Curve Fitting – Method of Least Squares – Fitting a Straight Line – Fitting a Second Degree Parabola - Finite differences - Newton's Forward & Backward Difference Formulae - Central Differences - Stirling's Formula - Lagrange's Formula. **L:6 T:3**

**CO 3: perform numerical differentiation and integration**

Derivatives using forward and backward difference Formulae - Trapezoidal rule - Simpson's rules - Double integration using Trapezoidal and Simpson's rules. **L:6 T:3**

**CO 4: find numerical solution of ordinary differential equation**

Taylor's Series Method - Euler's Method – Runge Kutta fourth order Method – Predictor - corrector Methods - Milne's Method - Finite difference for solving ordinary differential equation. **L:6 T:3**

**CO 5: classify and find numerical solution of partial differential equations**

Classification of Partial Differential Equations of second order - Finite difference solution of one dimensional heat equation by explicit and implicit methods (Crank Nichelson and Bender Schmidth methods) - One dimensional wave equation and two dimensional Laplace and Poisson equations. **L:6 T:3**

**TEXT BOOKS**

1. Grewal, B.S., "Numerical Methods in Engineering & Science: With Programs in C, C++ & MATLAB", 11th Edition, Khanna Publishers, New Delhi, 2014.
2. M.K.Jain, S.R.K.Iyengar, R.K.Jain "Numerical Methods for scientific and Engineering Computation", 6th Edition, New age International Publishers, 2019.
3. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, J. Wiley and Sons, 2023.

**REFERENCE BOOKS**

1. Chapra, S. C and Canale, R. P. "Numerical Methods for Engineers", 8th Edition, Tata McGrawHill, New Delhi, 2021.
2. Saumyen Guha, Rajesh Srivastava "Numerical Methods: For Engineering and Science", Oxford University Press, New Delhi, 1st Edition with third impression, 2015.
3. K.Sankara Rao , "Numerical Methods For Scientists And Engineers", 5th Edition, New age International Publisher, 2018
4. Dr Chaitanya Kumar, Dr Harinderjit Kaur Chawla, Dr Indarpal Singh "A Textbook on Numerical Methods and Analysis" Sultan Chand and SonsPublisher, 2024

**L : 30; T :15; TOTAL : 45 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23SH05E | **OPTIMIZATION TECHNIQUES** | 2 | 1 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon successfully completing the course, the students will be able to:

**CO1:** find optimum solution of linear programming problem. (CDL 1)

**CO2:** determine the optimum schedule for assignment and transportation problems. (CDL 1)

**CO3:** acquire decision making in Pure and Mixed Strategies. (CDL 1)

**CO4:** analyze the network for optimal schedule. (CDL 1)

**CO5:**compute optimum solution of non-linear programming. (CDL 1)

**CO1: find optimum solution of linear programming problem**

Linear Programming Problem – Mathematical Formulation of Linear Programming Problems (LPP) – Graphical Solution Method - Canonical and Standard Forms of LPP - Simplex Method - Linear Programming using Artificial Variables - Two Phase Method. **L:6 T:3**

**CO2:acquire decision making in Pure and Mixed Strategies**

Basic Terms in Game Theory - Two-Person Zero-Sum Games - Maximin-Minimax Principal - Games without Saddle Points - Mixed Strategies-Pure and Mixed Strategies with Saddle Point- Mixed Strategy Problems by Arithmetic Method- Graphic Solution of $2 \times n$ and $m \times 2$ Games. **L:6 T:3**

**CO3: analyze the network for optimal schedule**

Development of Network Analysis - Network Analysis and Rules of Network Construction - Critical Path Method (CPM) - Programme Evaluation and Review Technique (PERT). **L:6 T:3**

**CO4: compute optimum solution of non – linear programming**

Formulating a Non-Linear Programming Problem – Constrained Optimization with equality Constraints- Graphical Solution – Kuhn- Tucker Conditions with Non negative constraints- Quadratic Programming – Wolfe's modified Simplex method. **L:6 T:3**

**CO5: solve non-linear constrained optimization**

Optimization using Gradient Descent – Constrained optimization - Lagrange Multipliers - Convex optimization - Non linear Constrained Optimization. **L:6 T:3**

**TEXT BOOKS**

1. KantiSwarup, Gupta P.K and Man Mohan, Operations Research: Introduction to management Science, Sultan Chand &Sons, 20th Revised Edition, 2022.
2. Hamdy A Taha, Operations Research - An Introduction, 10th Edition, Pearson Education, 2019.

**REFERENCE BOOKS**

1. Sharma JK., Operations Research, Trinity, New Delhi, 6th Edition, 2017.
2. Sundaresan.V, Ganapathy Subramanian. K.S. and Ganesan.K, Resource Management Techniques, A.R. Publications, 11th Edition, 2017.
3. Gupta P K, Mohan Man, Problems in Operations Research, Sultan Chand & Sons, 2014
4. V K Kapoor, Operations Research , Concept problems & solutions, Sultan Chand & Sons, 2017

**L : 30; T :15; TOTAL : 45 PERIODS**

| Course Code | PRINCIPLES OF DISCRETE MATHEMATICS | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23SH06E | | 2 | 1 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon successfully completing the course, the students will be able to:

CO1: illustrate the validity of the arguments. (CDL 1)
CO2: analyze the concepts of Sets, Relations and Functions. (CDL 1)
CO3: perform the principles of counting and solve recurrence relations. (CDL 1)
CO4: interpret the basic concepts of graphs. (CDL 1)
CO5: compute minimum Spanning Trees and shortest route for the graph. (CDL 1)

**CO1: illustrate the validity of the arguments.**

Propositional Logic – Equivalences and Implications – Normal forms – Rules of inference – Proof methods and Strategies - Forward Proof, Proof by Contradiction, Proof by Contraposition, Proof of Necessity and Sufficiency. **L:6 T:3**

**CO2: analyze the concepts of Sets, Relations and Functions**

Basic Definitions - Set operations – Laws of set theory – Relations – Properties of relations - Equivalence Relation - Matrices of relations - Closure of relations – Functions – Bijective functions - Inverse and Compositions of functions. **L:6 T:3**

**CO3: perform the principles of counting and solve recurrence relations**.

Mathematical induction - Strong induction and well ordering -The basics of counting – The pigeonhole principle - Recurrence relations – Solving linear recurrence relations – Generating functions - Inclusion and exclusion principle. **L:6 T:3**

**CO4:interpret the basic concepts of graphs**

Graphs and their properties - Special types of graphs – Matrix representation of graphs and graph isomorphism- Euler and Hamiltonian graphs. **L:6 T:3**

**CO5: compute minimum Spanning Trees and shortest route for the graph**

Trees – Some properties of Trees – Pendant vertices in a Tree – Distance and centers in a Tree – Rooted and Binary Trees - Spanning Trees- minimum spanning tree–Prim's algorithm. **L:6 T:3**

**TEXT BOOKS**

1. Kenneth H.Rosen, Discrete Mathematics and its Applications (with Combinatory and Graph Theory), Special Indian Edition, Tata McGraw-Hill Publishing CompanyLimited, New Delhi, 8th Edition, 2021.
2. Trembly J.P and Manohar.R. Discrete Mathematical Structures with Applications to Computer Science, first Edition, Tata McGraw-Hill Pub. Company Limited, New Delhi, 2020.
3. Narsingh Deo, Graph Theory with Applications to Engineering and ComputerScience, 1stEdition, Dover Publications Inc., 2016.

**REFERENCE BOOKS**

1. Ralph .P. Grimaldi, Discrete and Combinatorial Mathematics: An Applied Introduction, 5th Edition, Pearson Education Asia, Delhi, 2019.
2. Bondy, J.A., Murty.U.S.R., Graph Theory with applications, North Holland publication, 2008.
3. K.Balakrishnan, Schaum's Outline of Graph Theory, Tata Mc Graw-Hill Pub, 2020.
4. Richard J.J, Introduction to Graph Theory, 1stEdition, Parker Pub.Company, 2017.

**L : 30; T :15; TOTAL : 45 PERIODS**

| Course Code | RANDOM PROCESSES AND QUEUEING THEORY | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23SH07E | | 2 | 1 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon successfully completing the course, the students will be able to:

CO1: interpret the basic characteristic features of Random processes. (CDL 1)

CO2: encapsulate the time averages of uncertain events. (CDL 1)

CO3: evaluate spectral densities of functions. (CDL 1)

CO4: analyze the characteristics of Markovian queues. (CDL 1)

CO5**:**apply the concepts of queuing theory in networks.(CDL 1)

**CO1: interpret the basic characteristic features of Random processes** **L:6 T:3**

Classification - Stationary process - Markov process - Markov chains - Transition probabilities.

**CO2 : encapsulate the time averages of uncertain events** **L:6 T:3**

Counting Process - Ergodic process - Poisson Process - Renewal Processes - Gaussian process.

**CO3 :evaluate spectral densities of functions** **L:6 T:3**

Auto correlation - Cross correlation – Power spectral density–Cross spectral density-Properties–Wiener – Khintchine theorem (without proof).

**CO4 : analyze the characteristics of Markovian queues**

Markovian models – Birth and Death Queuing models- Steady state results: Single and multiple server queuing models- queues with finite waiting rooms- Finite source models- Little's Formula. **L:6 T:3**

**CO5: apply the concepts of queuing theory in networks** **L:6 T:3**

M/G/1 queue- Pollaczek- Khintchine formula, series queues- open and closed networks.

**TEXT BOOKS**

1. Oliver C. Ibe, "Fundamentals of Applied Probability and Random processes", Academic Press, 2nd Edition, 2014.
2. Hwei Hsu, "Schaum's Outline of Theory and Problems of Probability, Random Variables and Random Processes, Tata McGraw-Hill Education, 3rdEdition, 2017.
3. John F Shortle, James M Thompson, Donald Gross and Carl M Harris, "Fundamentals of Queueing Theory", Wiley and Sons Publication Limited, 5thEdition, 2018.

**REFERENCE BOOKS**

1. Miller.S.L and Childers, S.L, Probability and Random Processes with applications to Signal Processing and Communications, Elsevier Inc., 2nd Edition, 2012.
2. Peyton. Z. Peebles Jr., Probability Random Variables and Random Signal Principles, 4th Edition, Tata McGraw-Hill Publishers, New Delhi, 2017.
3. Erwin Kreyszig, "Advanced Engineering Mathematics", 10thEdition, Wiley India, 2017.

**L : 30; T :15; TOTAL : 45 PERIODS**

| Course Code | STATISTICAL TECHNIQUES AND NUMERICAL | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23SH08E | METHODS | 2 | 1 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon successfully completing the course, the students will be able to:

CO1: calculate the various measures of dispersion. (CDL 1)

CO2: apply the principles of hypothesis testing in small and large samples. (CDL 1)

CO3: analyze the variances in design of experiments. (CDL 1)

CO4: find solution of linear equations and to perform differentiation and integration numerically. (CDL 1)

CO5: compute numerical solution of differential equations. (CDL 1)

**CO1: calculate the various measures of dispersion**

Central tendencies - Mean, median, mode - Measures of Dispersion –Mean deviation, and Quartile deviation–Moments– Skewness –Kurtosis - Correlation and Regression. **L:6 T:3**

**CO2: apply the principles of hypothesis testing in small and large samples**

Sampling distributions - Statistical hypothesis - Large sample testsbased on Normal distribution for single mean and difference of means -Tests based on t, and F distributions - Chi-square -Contingency table for independent of attributes – Goodness of fit. **L:6 T:3**

**CO3: analyze the variances in design of experiments**

One way and two way classifications - Completely randomized design – Randomized block design – Latin square design – $2^2$ factorial design. **L:6 T:3**

**CO4: find solution of linear equations and to perform differentiation and integrationnumerically**

Solution of algebraic and transcendental linear equations - Newton - Raphson Method- Solution of simultaneous equations – Gauss Elimination method – Gauss Seidel method – Interpolation – Lagrange's Method - Numerical Differentiation – Newton's forward difference and backward difference formula – Numerical integration - Single integration using Trapezoidal and Simpson's 1/3 rd and 3/8 th rules. **L:6 T:3**

**CO5: compute numerical solution of differential equations**

Taylor's Series Method – Euler's Method – Runge Kutta fourth order Method – Predictor - corrector Methods – Milne's Method - Solution of one dimensional heat equation by explicit and implicit methods(Crank Nichelson and Bender Schmidth methods) - Two dimensional Laplace and Poisson equations. **L:6 T:3**

**TEXT BOOKS**

1. Richard A. Johnson, "Miller and Freund's Probability and Statistics for Engineers", 9th Edition, Pearson Education Private Ltd., 2018.
2. Grewal, B.S., "Numerical Methods in Engineering & Science: With Programs in C, C++ &MATLAB", 11th Edition, Khanna Publishers, New Delhi, 2014.

**REFERENCE BOOKS**

1. Dharmaraja Selvamuthu, Dipayan Das, Introduction to Statistical Methods, Design of Experiments and Statistical Quality Control, Springer Verleg Singapore Pvt. Ltd., 2018.
2. S.C. Gupta and V.K. Kapoor, "Fundamentals of Mathematical Statistics, 12th Edition, Sultan Chand & Sons, Delhi, 2014.
3. M.K.Jain.S.R.K.Iyengar,R.K.Jain "Numerical Methods for scientific and Engineering Computation", 6th Edition, New age International Publishers, 2019.
4. Chapra, S. C and Canale, R. P. "Numerical Methods for Engineers", 8th Edition, Tata McGraw - Hill, New Delhi, 2021.

**L : 30; T :15; TOTAL : 45 PERIODS**

| Course Code | TRANSFORMS, MATHEMATICAL LOGIC AND SET | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23SH09E | THEORY | 2 | 1 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon successfully completing the course, the students will be able to:

**Theory Components:**

CO1: apply Laplace transform to solve ordinary differential equations. (CDL 1)
CO2: compute the Fourier transforms of various functions. (CDL 1)
CO3: solve difference equations using Z-Transform. (CDL 1)
CO4: illustrate the validity of the arguments. (CDL 1)
CO5**:**analyze the concepts of Sets, Relations and Functions. (CDL 1)

**CO 1 : apply Laplace transform to solve ordinary differential equations**

Definition of Laplace transform and its inverse – Transforms of elementary functions – Properties – Transforms of periodic functions – Initial and final value theorems – Convolution theorem.- solutions of linear ordinary differential equations with constant coefficients. **L:6 T:3**

**CO2 : compute the Fourier transforms of various functions**

Fourier Integral theorem (without proof)–Fourier transform pair–Fourier Sine and Cosine transforms–Properties–Transforms of simple functions–Convolution theorem –Parseval's theorem. **L:6 T:3**

**CO3 : solve difference equations using Z-Transform**

Z– transform –Elementary properties – Inverse Z–transform – Convolution theorem- Initial and final value theorem – Formation of difference equations –Solutions of difference equations using Z–transform. **L:6 T:3**

**CO4: illustrate the validity of the arguments.**

Propositional Logic – Equivalences and Implications – Normal forms – Rules of inference – Proof methods and Strategies - Forward Proof, Proof by Contradiction, Proof by Contraposition, Proof of Necessity and Sufficiency. **L:6 T:3**

**CO5: analyze the concepts of Sets, Relations and Functions**

Basic Definitions - Set operations – Laws of set theory – Relations – Properties of relations - Equivalence Relation - Matrices of relations - Closure of relations – Functions – Bijective functions - Inverse and Compositions of functions **L:6 T:3**

**TEXT BOOKS**

1. Grewal.B.S. "Higher Engineering Mathematics", 44th Edition, Khanna Publications, Delhi, 2021.
2. Kenneth H.Rosen, Discrete Mathematics and its Applications, Tata McGraw-Hill Publishing Company Limited, New Delhi, 8th Edition, 2021.
3. Erwin Kreyszig, "Advanced Engineering Mathematics", 10thEdition, Wiley India, 2017.

**REFERENCE BOOKS**

1. Ramana B.V, "Higher Engineering Mathematics", Tata Mc-Graw Hill Education, New Delhi, 2017.
2. Trembly J.P and Manohar.R. Discrete Mathematical Structures with Applications to Computer Science, 1st Edition, Tata McGraw-Hill Pub. Company Limited, New Delhi, 2017.
3. J K Goyal, K.P.Gupta, Laplace and Fourier Transforms, Pragati Prakashan, 2016

**L : 30; T :15; TOTAL : 45 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23SH10E | FUNDAMENTALS OF LASER TECHNOLOGY | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon successfully completing the course , the students will be able to:

CO1: explain the fundamentals of lasers (CDL1)

CO2: demonstrate the laser surface modification process (CDL1)

CO3: describe the laser machining processes (CDL1)

CO4: identify the laser measurement and testing process (CDL1)

CO5: organizethe advanced applications and safety measures of laser (CDL1)

**CO1: explain the fundamentals of lasers**

Characteristics of laser -laser principle- population inversion-line broadening mechanisms-Q switching - threshold condition for laser-three-level and four-level systems-conditions for continuous wave (CW) and pulsed laser action- pumping schemes-classification of lasers:Er:YAG - carbon dioxide lasers - argon laser - X-Ray lasers - fiber lasers - Raman lasers. **L:9**

**CO2: demonstrate the laser surface modification process**

Laser surface heat treatment: process parameters - advantages and disadvantages of laser surface treatment; laser surface melting - laser direct metal deposition: processing parameters - methods for applying the coating material- laser alloying and cladding - advantages and disadvantages -laser physical vapor deposition - laser shock peening: analysis - advantages and disadvantages **L:9**

**CO3: describe the laser machining processes**

Laser welding parameters: beam power, spot diameter and traverse speed; welding efficiency; mechanism of laser welding: conduction mode welding, keyhole welding; laser cutting – process characteristics-fusion cutting, sublimation cutting, photochemical ablation;laser drilling –single pulse drilling-percussion drilling, trepanning applications - laser marking - dot matrix marking, engraving, image micro machining -lasers for marking - application **L:9**

**CO4: identify the laser measurement and testing process**

Laser for measurement - distance -length-velocity-acceleration-current-voltage-atmospheric effect-laser application in spatial frequency filtering. **L:9**

Holography: basic principle - methods - Holographic interferometry and applications-holography for non – destructive testing – holographic components

**CO5: organizethe advanced applications and safety measures of laser**

Laser advanced application in defence-laser weapons- industry for material handling: ASRS and AGV- medicine -laser activated therapy - photodynamic therapy, laser angioplasty, lasers in surgery - photocoagulation, photodisruption and photoablation - laser scanning confocal microscopy - Laser safety - danger - safety limits for eye and skin - class four safety arrangements - electric hazards- chemical hazards - fume hazards - explosion hazards - safety guidelines **L:9**

**TEXTBOOKS:**

1. William M. Steen, “Laser Material Processing”, Springer Verlag, 2010
2. K.Thyagarajan, AjoyK.Ghatak, “Lasers, Theory and Applications”, Springer, 2nd Edition, 2011.
3. Chunlei Guo, Subhash Chandra Singh Handbook of Laser Technology and Applications Lasers Applications: Materials Processing and Spectroscopy, 2nd Edition, (Vol.3), 2021

**REFERENCES:**

1. Uday Shanker Dixit, Shrikrishna N. Joshi, J. Paulo Davim, "Application of Lasers in Manufacturing" Springer Singapore, 1st Edition, 2019
2. Stephan Wieneke and Christoph Gerhard, "Lasers in Medical Diagnosis and Therapy Basics, applications and future prospects" IOP Publishing Ltd, 2018
3. AK Katiyar, CK Pandey and Manisha Bajpai, "Fundamentals of Laser Systems and Applications", Wiley, 2017.

**L : 45; TOTAL : 45 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| **23SH11E** | **NANOMATERIALS FOR ENGINEERS** | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES**:

Upon successfully completing the course , the students will be able to:

CO1: explain the fundamentals of nanomaterials (CDL1)
CO2: interpret the different properties of nanomaterials (CDL1)
CO3: demonstrate the synthesis of nanomaterials (CDL1)
CO4: illustrate the characterization of nanomaterials (CDL1)
CO5: organize the applications of nanomaterials(CDL1)

**CO1: explain the fundamentals of nanomaterials**

Introduction to nanomaterials - size effect - specific surface area - surface to volume ratio - quantum confinement effects - morphology - density - melting point - wettability - classification based on the dimension - nanoparticles - nanowires - nanoclusters - nanotubes - quantum wells - metal based nanomaterials - nanocomposites - carbon nanotubes - nanosized metals - alloys - semiconductors - ceramics **L:9**

**CO2: interpret the different properties of nanomaterials**

Mechanical behavior- comparison of bulk and nano materials - elastic and plastic deformation - tensile strength - superplasticity -hardness - nano hardness -influence of porosity - grain size – thermodynamics of nanoparticles- heat capacity – phase transformation of nanoparticles- electrical and optical properties: electrical conductivity in nano tubes, nano rods and nanocomposites - photoconductivity of nanorods - electroluminiscesnce in nanoparticles- magnetic properties: magnetic hysteresis - superparamagnetism **L:9**

**CO3: demonstrate the synthesis of nanomaterials**

Bottom-up and top-down approach - inert gas condensation - plasma arc technique - ion sputtering - ball milling - molecular beam epitaxy - chemical vapour deposition - method - electrodeposition - ultrasonication - microemulsions method - solvothermal synthesis - microwave assisted synthesis. **L:9**

**CO4: illustrate the characterization of nanomaterials**

X-ray diffraction - energy dispersive spectrum - atomic force microscopy - high resolution transmission electron microscopy - Raman spectroscopy - x-ray photoelectron spectroscopy - electrochemcial characterization measurements - cyclic voltammetry - linear sweep voltametry - Brunauer-Emmett-Teller - surface area analysis - nanoindentation - determination of nano hardness. **L:9**

**CO5: organize the applications of nanomaterials**

Functional graphene - carbon nanotube - polymer composite applications in defence and aerospace - nanomaterials for solar cells - nanoscale catalysts for energy and automobile industries - rechargeable batteries based on nanomaterials - nanomaterials for electrodes and wearable electronics - nano based coating and paints - nanosensors -gas sensors - bio sensors - nano electro mechanical systems **L:9**

**TEXTBOOKS:**

1. Charles P Poole, Frank J Ownes, Introduction to Nanoscience and Nanotechnology, An Indian Adaption, Wiley, 2020
2. Hornyak, G.Louis, Tibbals, H.F., Dutta, Joydeep, Fundamentals of Nanotechnology, CRC Press, 1st Edition, 2018
3. Dieter Vollath, Nanomaterials an introduction to synthesis, properties and applications, Wiley, 2nd Edition, 2013

**REFERENCES:**

1. Narendra Kumar, Sunita Kumbhat, Essentials in Nanoscience and Nanotechnology, Wiley, 1st Edition, 2016
2. G. Cao,Ying Wang, Nanostructures and nanomaterials: Synthesis, properties and applications, Imperial College Press, 2nd Edition, 2011
3. B.S. Murty , P. Shankar , Baldev Raj , B B Rath , James Murday, Textbook of Nanoscience and Nanotechnology, Springer, 1st Edition, 2013

**L : 45; TOTAL : 45 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| **23SH12E** | **PHOTONICS** | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES:**

Upon successfully completing the course , the students will be able to:
CO1: explain the basics of photonics (CDL1)
CO2: demonstrate the properties of photonic crystal (CDL1)
CO3: outline the basics of bio photonics (CDL1)
CO4: interpret the quantum confinement in photonic materials(CDL1)
CO5: organize the applications of photonic materials (CDL1)

**CO1:explain the basics of photonics**

Wave phenomena – interference, diffraction-photon properties - energy, flux, statistics-Interaction of photons with atoms-optical amplification-three and four level system -EDFA-semiconductor light sources-detectors-light manipulation - birefringence - Faraday's rotation - interaction of light with RF and acoustic waves - Raman-Nath diffraction experiment . **L:9**

**CO2: demonstrate the properties of photonic crystal**

Electromagnetic theory of light-electromagnetic properties of material- polarization of light; Reflection and refraction- Fresnel equations; absorption, dispersion, and scattering of electromagnetic waves -Bragg grating; 1D photonic crystals -photonic band structure-real and reciprocal lattices; 2D and 3D photonic crystals-emerging applications of photonic crystals - 1D Bragg grating - periodic dielectric wave guide - 2D photonic crystal slab and fibre. **L:9**

**CO3:outline the basics of bio photonics**

Fundamentals of light and matter-basics of light-matter interactions in molecules, cells and tissues -lasers for biophotonics -bioimaging: principles and applications-transmission microscopy, Kohler illumination-optical biosensors-light activated therapy: photo thermal and photo dynamic therapy- tissue engineering with light- optical tweezers, scissors and traps - bio nanophotonics applications - bio chip - DNA micro-arrays - gene chip - lab on chip. **L:9**

**CO4:interpret the quantum confinement in photonic materials**

Quantum confined materials: quantum wells, quantum wires, quantum dots, quantum rings, Manifestations of quantum confinement, optical properties, quantum confined stark effect, dielectric confinement effect. **L:9**

Nanoplasmonics: optical response of metals, plasmons, optical properties of metal nanoparticles, size dependent absorption and scattering, coupled nanoparticles - metal-dielectric core-shell nanoparticles - local electromagnetic fields in metal nanoparticles.

**CO5: organize the applications of photonic materials**

Excitation energy transfer – device operation: nanophotonic AND gate - nanophotonic OR gate – interconnection with photonic devices - metamaterials concept; super lens, hyperbolic metamaterials and application in high-resolution imaging: hyper lens - tunable photonic metamaterials based devices - electro-optical metamaterials - phase-change metamaterials - metamaterials in solar energy harvesting - perfect absorbers and thermal emitter **L:9**

**TEXTBOOKS:**

1. Bahaa E. A. Saleh, Malvin Carl Teich, Fundamentals of Photonics, 3rd Edition, Wiley, 2019.
2. Brian Culshaw, Introducing Photonics, Cambridge University Press, 2020.
3. Gerd Keiser, Biophotonics: Concepts to Applications, second edition, Springer Nature Singapore Pvt. Ltd 2022.

**REFERENCES:**

1. Joseph W. Haus, Fundamentals and Applications of Nanophotonics, Woodhead Publishing, 2016.
2. W.Cai and V. Shalaev, Optical Metamaterials: Fundamentals and Applications, 2nd Edition, Springer, 2024.
3. P PYupapin, K Srinuanjan, S Kamoldilok, Devices, Circuits and Systems: Nanophotonics, Pan Stanford Publishing, 2013.
4. Paulo Ribeiro, Maria Raposo, "Optics, Photonics and Laser Technology", Springer International publishing, 1stEdition, 2018

**L : 45; TOTAL : 45 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| **23SH13E** | **BIOLOGY FOR COMPUTING** | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

CO1: describe the structure, interaction and applications of biomolecules

CO2: interpret the structure and functions of the gene and protein using the bioinformatics data

CO3: simulate the behavior of simple biological models using computational softwares

CO4: identify and design molecules for new drug development by computational methods

**CO1: describe the structure, interaction and applications of biomolecules**

**Biomolecules-I :**

Introduction – monomeric units and polymeric structures of carbohydrates, proteins, nucleic acids and lipids. Enzymes: enzymatic action via Lock and key – Enzyme therapy - immune response monitoring – molecular modification – encapsulation. Agarose gel electrophoresis: SDS, PAGE and 2D – Molecular interactions: covalent and non-covalent interactions, antigen – antibody interactions. Methods to measure the interactions: UV-visible and single crystal X-ray diffraction. **L:9**

**Biomolecules -II**

Chromosome structure and function – chromosome abnormalities – chromosome dynamics – nuclear architecture. DNA transcription, replication and segregation. DNA finger printing. Pedigree analysis. Identifying human disease genes (functional cloning versus positional cloning; mutation screening). Human genome project: introduction – steps – salient features. Hap map project – salient features. **L:9**

**CO2: interpret the structure and functions of the gene and protein using the bioinformatics data** **L:9**

Bioinformatics: introduction – biological databases – types. DNA databases – EMBL, gene bank, DDBJ. Protein databases: Swiss Prot/TrEMBL, PIR. Sequence motif databases - Pfam, PROSITE, Protein structure databases, protein data Bank – SCOP, CATH, and KEGG. Sequence analysis – methods of sequencing: sangar method, maxama - gilbert method and edman degradation method, NGS methods of sequencing.Basic local alignment search tool (BLAST) – types – determining the identity of an organism from its r DNA gene nucleotide sequence. Softwares for handling the databases –ChemDiff.

**CO3: simulate the behavior of simple biological models using computational softwares** **L:9**

Quantum mechanics: influence of physics on theoretical chemistry. Semi empirical methods – slater determinants – Hartree – Fock equation. Semi empirical models - Ab-initio calculations: Thermodynamic functions – koopmans's theorem – isodesmic reactions, Density functional theory for larger molecules. Introduction to Gaussian and ADF : Geometry optimization, frequency calculation, location of transition state, intrinsic reaction co-ordinates, molecular orbitals and population analysis, natural bond orbital analysis, calculation of equilibrium constants and rate constants. Introduction to GROMACS: GROMACS input files, simulations of liquid water, water methanol mixtures, S-peptide and free energy of salvation. Introduction to SCILAB- Scilab programming: Curve fitting, integral transforms and introduction to molecular dynamics. Execution of programs for liquid argon.

**CO4: identify and design molecules for new drug development by computational methods** **L:9**

**Drug design:** General approach to discovery of new drugs – lead modification – calculation of the various drug likeness rules like Lipinski's rule, MDDR - like rule, Veber rule, Ghose filter, BBB rule, CMC-50 like rule and Quantitative estimate of drug-likeness (QED) using DruLiTo and Swiss ADME software. Pharmacokinetic properties of drug using Osiris and Molinspiration software. Structure-based drug designing approaches - target identification and validation - physiochemical principles of drug action – drug stereo chemistry – drug action - 3D database – computer aided drug design. Identification of the suitable target using Pharmmapper - Molecular docking programs using Autovinasoftwares and visualization tools - Preparation of protein and ligand using ADT and pymol-generation of paper publication-quality images and data analysis-protein-protein docking-Protein DNA docking

**TEXT BOOKS**

1. Shawn T. O'Neil, A Primer for Computational Biology, Oregon State Campus, Corvallis, USA, 2019.
2. Frank Jensen, Introduction to Computational Chemistry, 3rd Edition, Wiley publishing LLC. USA, 2016
3. Philly Charles, Genes, Genomes, Genetics and Chromosomes, Nottinghamshire, England, 2020.

**REFERENCE BOOKS**

1. Ariel Fernández Stigliano, Biomolecular Interfaces: Interactions, Functions and Drug Design, 1st Edition, Springer International Publishing AG, London, 2016.
2. S.C. Rastogi, P.Rastogi, N.Mendiratta, Bioinformatics: Methods and Applications - Genomics, Proteomics and Drug Discovery, 5th Edition, PHI Learning Pvt. Ltd., Delhi, 2022.
3. Robert A. Copeland, Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis, 3rdEdition, Wiley-Blackwell, New York, 2023.

**L: 45; TOTAL: 45 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| **23SH14E** | **BIOLOGICAL SYSTEMS FOR ENGINEERS** | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

CO1: understanding of bio design principles to create novel devices and structures and cell biology

CO2: explain the structure and stability of biomolecules

CO3: describe the principle, components and applications of various instruments for medical diagnosis

CO4: interpret the major bio-energetic pathways

CO5: explain the properties characterization and application of various biomaterials

**CO1: understand the basic principles of biology to create novel devices** **L:9**

Cell - prokaryotic and eukaryotic cells - plant cell and animal cell - structural and function of Mitochondria - Chloroplast - Lysosomes - Golgi bodies - Nucleus. Cell cycle: mitosis and meiosis. Bioinspired devices: GPS, aircrafts, swim suits, bullet train, super hydrophobic and self-cleaning surfaces.

**CO2: explain the structure and stability of biomolecules**

Introduction - monomeric units and polymeric structures of carbohydrates, proteins, nucleic acids and lipids. Molecular interactions: covalent and non-covalent interactions – methods of quantification and determination: UV – visible, CD, and SPR. **L:9**

Enzymes - classification - specific activity - enzyme activity - chemical nature of enzymes. Protein and non-protein nature of enzymes. Metalloenzymes and metal activated enzymes. Industrial applications of enzymes: biosensors and bio bleaching.

**CO3: describe the principle and applications of various instruments for medical diagnosis** **L:9**

Basic concepts of instrumentation: static and dynamic characteristics, design criteria,

instrumentation, amplifiers. Biopotential electrodes: fundamentals - body surface electrodes - microelectrodes - Principle, components and applications of microscope: light and electron microscope. Electrocardiograph, glucometer, CT, magnetic resonance imaging, ultrasonic imaging. Artificial Intelligence for disease diagnosis.

**CO4: interpret the major bio-energetic pathways**

Thermodynamics in biological systems - exothermic and endothermic versus endergonic and exergonic reactions - concept of $K_{eq}$ and its relation to standard free energy - spontaneity - ATP as an energy currency. Glucose synthesis from $CO_2$ + $H_2O$ (photosynthesis) – decomposition of glucose (Glycolysis and Krebs cycle). Energy yielding and energy consuming reactions. Concept of energy charge. Regulation of glycogenesis - measurement of blood glucose level. **L:9**

**CO5: explain the properties, characterization, and applications of various biomaterials.** **L:9**

Biomaterials: introduction - types: alloys, polymers. Composites - properties: biocompatibility, elasticity, immune compatibility, resorbability, cytotoxicity, hemocompatibility and biodegradability. Physicochemical characterization: XRD and SEM. Applications: tissue engineering, heart valves, dental and orthopaedic implants.

**TEXT BOOKS**

1. Y.Nelson, L.David, Lehninger, "Principles of Biochemistry", International Edition, New York, 7th Edition, 2017.
2. Nagata, Kazuhiro, Real-Time Analysis of Biological Interactions, Springer, Japan, 3rd Edition, 2015.
3. I. Bertini, H.B Gray, Bioinorganic Chemistry, University Science Book, California, 4thEdition, 2014.

**REFERENCE BOOKS:**

1. P.N.Bartlett, Bioelectrochemistry: Fundamentals, Experimental Techniques and Applications, 2nd Edition, John Wiley & Sons, New Delhi, 2014.
2. Ratner and Hoffmann, Biomaterial Science: An Introduction to Materials in Medicine, 2nd Edition, Elsevier Academic Press, London, 2015.
3. Lesile Cromwell, "Bio-medical instrumentation and measurement", Prentice Hall of India, New Delhi, 2nd Edition, Reprint, 2017.

**L: 45; TOTAL: 45 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| **23SH15E** | **POLYMER SCIENCE AND TECHNOLOGY** | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES:**

Upon completion of this course, the students will be able to

**CO1:** acquire knowledge on structure - property relationship of polymers

**CO2:** identify the suitable polymerization techniques for the large scale synthesis of polymers

**CO3:** explain the basic principles of various polymer processing techniques and their applications

**CO4:** interpret the chemical, thermal, electrical, and mechanical properties of the polymers

**CO5:** familiar with plastics waste disposal, value addition, associated environmental issues and legislation

**CO1: acquire knowledge on structure - property relationship of polymers** **L: 9**

Basic concepts of polymerization - polydispersity - conformation and configuration of macromolecules - stereo isomerism and tacticity in polymers - geometrical isomerism. Structure - property relationship -molecular force and chemical bonding in polymers - effect of polymerization on PDI. General rules for polymer solubility - crystallinity and orientation in polymers. Polymer chain flexibility: concept - factors deciding polymer flexibility - amorphous and crystalline polymers - crystallinity in polymers - factors affecting crystallinity - properties affected by crystallinity of polymers. Glass transition temperature and crystalline melting points. Factors affecting glass transition temperature.

**CO2: identify the suitable polymerization techniques for the large scale synthesis of polymers** **L:9**

Basic aspects of polymer synthesis - bulk, solution and suspension polymerization (styrene and MMA) - emulsion polymerization (vinyl acetate, styrene) - preparation of phenolic and epoxy resins. Modern techniques in polymerization: metathesis polymerization - controlled polymerization methods, viz., nitroxide mediated polymerization (NMD), atom transfer radical polymerization (ATRP), group transfer polymerization (GTP), and reversible addition fragmentation termination (RAFT).

**CO3: explain the basic principles of various polymer processing techniques and their applications** **L:9**

Plastics technology: raw materials - additives for compounding (fillers, plasticizers and softeners, lubricants, promoters, anti-aging additives, flame retarders, colorants, blowing agents, UV stabilizers,) - requirements and functions of additives. Pre-compounding operations: mixing, drum blenders, ribbon blenders, mixing rolls, internal mixers, mixing extruders, blenders for making organosol and plastisol, granulators, pelletizers.

Advanced fabrication techniques: RTM, RIM, filament winding, BMC/SMC. Post-forming and finishing, machining, welding and design of polymers products. Selections of polymers, additives, mold design. Analysis of defects in moulded products. Processing of reinforced thermoplastics and thermosets: manual processing methods and semi-automatic processing methods. Rubber processing: internal mixer and open mill.

**CO4: interpret the chemical, thermal, electrical, and mechanical properties of polymers** **L:9**

Physical testing: density, mechanical behaviour, MFI, and water/solvent adsorption. Chemical testing: ignition - pyrolysis - solvent extraction - elemental analysis. Thermal analysis: vicat softening point - dynamic mechanical thermal analysis. Morphological analysis: atomic force microscopy and chemical force microscopy. Spectroscopic analysis: IR peaks assigned for rubber. Study of hydrogenation, halogention, evidence for cyclization and formation of ionomers. Analysis of carbon filled rubber - Case studies.

**CO5: familiar with plastics waste disposal, value addition, associated environmental issues and legislation** **L-9**

Polymer waste: sources, collection, segregation, and identification by simple techniques. Life cycle assessment, risk factor analysis. Plastics waste management techniques: chemical recycling, thermal conversion technologies, microbial, microwave, and ultrasonic. Use of plastics waste for value addition. Plastics waste management rule - environmental issues.

**TEXT BOOKS**

1. Premamoy Ghosh, Polymer Science and Technology: Plastics, Rubber, Blends and Composites, 3rd Edition, McGraw Hill Education, 2017.
2. Richard A Petherick, Polymer Science and Technology for Engineers and Scientists, Whittles Publishing, 2010.
3. Michael L. Berins, SPI Plastics Engineering Handbook of the Society of the Plastics Industry, Inc. 1st Edition, Springer New York, 2012
4. Vishu Shah, Handbook of Plastics Testing Technology,2nd Revised Edition, Wiley–Blackwell, 1998.

**REFERENCES**

1. Gowarikar V R, Polymer science, 5th Edition, New Age International Private Limited, 2023
2. Fred W. Billmeyer, Textbook of Polymer Science, 3rd Edition, John Wiley & Sons, 2007
3. Nayak S.K, Text Book on Fundamentals of Plastics Testing, Springer (I) Private Limited, 2020
4. J S Anand, Recycling & Plastics Waste Management, Central Institute of Plastics Engineering and Technology, 1997.
5. Korschwitz J, Polymer Characterization and Analysis, John Wiley and Sons, 1990.

**L: 45; TOTAL: 45 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23SH16E | SENSORS FOR ENGINEERING APPLICATIONS | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon completion of this course, the students will be able to

CO1: Gain knowledge on basic concepts of sensors and Transducer.

CO2: know about the thermal and motion sensors for various applications.

CO3: enumerate the principles and applications of optical and magnetic sensors and transducers used in various field.

CO4: explain the construction, working principle and applications of electrochemical and electric sensors.

CO5: Design the sensors for environmental monitoring

**CO1: Gain knowledge on basic concepts of sensors and Transducer. L: 9**

Introduction – Historical development of sensors – Human body as a sensor system – sensors and transducers. Principle and classification of sensor. Sensor characteristics – sensor properties – various transducers – piezoelectric effect – pyroelectric effect – seebeckeffect and peltier effect. Advantages and limitations of Sensors.

**CO2: know about the thermal and motion sensors for various applications. L:9**

**Thermal sensors:** introduction – types - primary sensor: gas thermometer and He low temperature thermometer. Secondary sensor: Resistance thermometer and NQR thermometer. Temperature sensing technologies: IC sensor, resistive temperature detectors, thermocouples and thermistor.

**Motion sensors:** Introduction and principle. Types: Infra red and microwave. Specialized motion sensor: proximity and ranging sensor. Motion Sensors in everyday life: The role of motion sensors in home security.

**CO3: enumerate the principles and applications of optical and magnetic sensors and transducers used in various field** **L:9**

**Magnetic sensors:** Introduction – principle and applications: magnetic field sensors and magneto-resistive Sensors, hall effect sensors.

**Optical sensors:** light intensity – wavelength and color – light dependent resistors, photodiode, photo transistor, CCD, CMOS sensors. Pulse oximeter, portable pulse oximeter, wearable pulse oximeter; wearable capnometer for monitoring of expired.

**CO4: explain the construction, working principle and applications of electrochemical and electric sensors** **L-9**

**Electrochemical sensors:** Introduction - fundamental concepts – chemiresistors. Conductometric sensor: amperometric sensor - potentiometric sensors - impendence sensors.

**Electric sensors:** Introduction- conventional volt and ammeters, high current sensors, (current transformers), high voltage sensors, High power sensors. Real time applications: Glucose Monitoring

Devices, GlucoWatch G2 Biographer, GlucoTrackTM; Pulse oximeter, Portable Pulse Oximeter, wearable pulse oximeter.

**CO5: Design the sensors for environmental monitoring** **L-9**

**Environmental Sensor:** Introduction - environmental quantities**:** time, moisture acidity/alkalinity, wind-chill, radioactive count rate. Surveying and security. Sensors for environmental monitoring. Smoke and fire detector. Pressure sensor in emission testing, pollution devices, and wind management systems.

**TEXT BOOKS**

1. Jacob Fraden, Handbook of Modern Sensors: Physics, Design and Applications, 5th edition, Springer Nature, New Delhi, 2016
2. D. Patranabis, Sensors and Transducers, 2nd Edition, PHI Learning Private Limited, New Delhi, 2013.
3. John Veteline, Aravind Raghu, Introduction to sensors, CRC press, New Delhi,2011.
4. S Nihtianov, A. Luque Smart Sensors and MEMS, 2nd Edition, Woodhead Publishing Limited, New Delhi,2018.
5. Edward Sazonov and Michael R. Neuman, Wearable Sensors - Fundamentals, Implementation and Applications, Elsevier publishing company, Amsterdam, Netherland,2014.

**REFERENCE BOOKS**

1. Shantanu Bhattacharya,A K Agarwal, NripenChanda, Ashok Pandey and Ashis Kumar Sen Environmental, Chemical and Medical Sensors, Springer Verlag, Singapore,2018 .
2. Krzysztof Iniewski, Optical, Acoustic, Magnetic, and Mechanical Sensor Technologies, 1st Edition, CRC Press, New Delhi, 2017.

**L: 45; TOTAL: 45 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC01E | INTRODUCTION TO EMBEDDED SYSTEM DESIGN | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES**

Upon completion of this course, the students will be able to

CO1: Outline Embedded System design methods and power supply topologies

CO2: Describe the interfacing basics of MSP430.

CO3: Utilize Code Composer Studio for programming MSP430.

CO4: Employ the concepts of interrupts and exceptions with MSP430.

CO5: Apply the communication protocols for project design.

**CO1: Outline Embedded System design methods and power supply topologies** **L: 9**

Introduction to Embedded Systems and Computer Systems Terminology, Modular approach to Embedded System Design using Six-Box model: Input devices - output devices - embedded computer - communication block - host and storage elements - power supply. Microcontroller Based Embedded System Design - Salient Features of Modern Microcontrollers -Elements of Microcontroller Ecosystem and their significance - Design of Power Supply for Embedded Systems. Linear Regulator Topologies - Switching Power Supply Topologies. Power Supply Design Considerations for Embedded Systems.

**CO2: Describe the interfacing basics of MSP430.** **L:9**

Introduction to MSP430 Microcontroller, MSP430 CPU Architecture - Programming Methods for MSP430. Introduction to Lunchbox Platform. Fundamentals of Physical Interfacing - Connecting Input Devices: Switches, Keyboard - Output devices: LEDs, Seven Segment Displays(SSD).

**CO3: Utilize Code Composer Studio for programming MSP430** **L:9**

Advanced Physical Interfacing: Driving load - high side, low side and H-bridge. Multiplexing displays including Charlieplexing - Shaft encoder - Programming the MSP430. Basics of version control system - Git Installing and using Code Composer Studio (CCS) - Introduction to Embedded C - Interfacing LEDs and Switches with MSP430 using Digital Input and Output. Interfacing Seven Segment Displays and Liquid Crystal Displays with MSP430.

**CO4: Employ the concepts of interrupts and exceptions with MSP430** **L-9**

MSP430 Clock and Reset System. MSP430 Clock sources and distribution. Types of Reset sources - Handling Interrupts in MSP430. Writing efficient Interrupt Service Routine (ISR). Low Power Modes in MSP430. Introduction to MSP430 Timer Module and it's Modes of Operation. Generating Pulse Width Modulation (PWM) using Timer Capture Mode - ADC operation in MSP430. Interfacing Analog inputs. Generating random numbers using LFSR and other methods - Adding DAC to MSP430 - Custom Waveform generation using MSP430.

**CO5: Apply the communication protocols for project design** **L-9**

Timer Capture Modes - Measuring frequency and time period of external signals and events. Serial Communication Protocols: UART, SPI, I2C. Interfacing Universal Serial Communication Interface (USCI) Module of the MSP430 for UART Communication. Advanced Coding Exercises based on Interrupt driven Programming. Circuit Prototyping techniques. Designing Single Purpose Computers using Finite State Machine with Datapath

(FSMD) approach. MSP430 Based Project Design and Implementation. Recap of Course Coverage. Building an Electronics Project.

**REFERENCES:**

1. Designing Embedded Hardware, John Catsoulis. 2nd Edition, Shroff Publishers and Distributors. ISBN-10: 9788184042597.
2. Embedded System Design: A Unified Hardware / Software Introduction,TonyGivargis and Frank Vahid. Wiley. ISBN-10: 812650837X.
3. MSP430 Microcontroller Basics. John H. Davies. Elsevier. ISBN-10: 9789380501857. Programming Embedded Systems in C and C++. Micheal Barr. Shroff Publishers and Distributors. ISBN-10: 817366076X.

**L: 45; TOTAL: 45 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC02E | **EMBEDDED AND REALTIME SYSTEMS** | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

CO1 : Outline the components of embedded system.
CO2 : Enumerate the different Interfacing Schemes
CO3 : Outline the concepts of real time systems and its characteristics.
CO4 : Identify the features of Real – time Operating system
CO5 : Describe the features of UCOS III operating system

**CO1: Outline the components of embedded system.** **L:9**

Definition: Embedded system, Intelligent system, Expert System–Embedded system-classification –Embedded system design process – Hardware & Software: Architecture and Components of embedded system - Binary image creation from source file – Role of bootloader – Significance of Device Driver and Device Tree. Embedded System design Example.

**CO2: Enumerate the different Interfacing Schemes**

I/O devices – Component interfacing – Memory mapped I/O – I/O mapped I/O – Development and Debugging – Program design–Model of programs–Basic compilation techniques – Assembly and Linking, -simple program for I/O devices. **L:9**

**CO3: Outline the concepts of real time systems and its characteristics**

Definition: Real-time and real time systems–real time system Model-real time system characteristics–High reliability achievement ways in real time system-Hardware considerations for real time system–Examples for real time system. **L:9**

**CO4: Identify the features of Real – time Operating system**

Definition: Multi-tasking and multi-processing –Context Switching–Operating Systems Scheduling policies: Rate monotonic, EDF, Comparison example –Inter Process Communication mechanisms – Message Mailboxes – Message Queues – Evaluating operating system performance. **L:9**

**CO5: Describe the features of UCOS III operating system** **L:9**

Introduction to UCOS III Features, Services and variants. Task Management: Task creation, task stacks, stack checking, task priority, task suspending, task deletion program example for Multitasking. Memory management: Creating partition in memory, memory control block, obtaining and returning memory control block functions program example for memory management implementation-Synchronization techniques

**TEXT BOOKS**

1. Wayne Wolf, "Computers as Components Principles of Embedded Computer System Design", Morgan Kaufmann, 2nd Edition, 2008.
2. Philip A.Laplante, "Real time systems design and analysis", Wiley India Edition, 3rd Edition, 2006.

**REFERENCES:**

1. Jean J.Labrosse, "Micro C/OS-III: The Real Time Kernal", CMP Books, 2010.
2. David E-Simon, "An Embedded Software Primer", Pearson Education, 2007.
3. K.V.K.K.Prasad, "Embedded Real-Time Systems: Concepts, Design & Programming", Dream tech Press, 2005.
4. Tammy Noergaard, "Embedded Systems Architecture", Elsevier, 2006.

**L: 45; TOTAL: 45 PERIODS**

| Course Code | EMBEDDED PROCESSOR ARCHITECTURES | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC03E | | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

CO1: Outline the fundamentals of RISC architecture and its comparison with CISC.
CO2: Illustrate the CISC architecture using Renesas Microcontroller.
CO3: Analyze the SPARC architecture for embedded processor
CO4: Analyze RISC V Architecture
CO5: Explore modern development boards in RISC-V processors for embedded systems

**CO1: Outline the fundamentals of RISC architecture and its comparison with CISC** **L:9**

Basic concepts of RISC and CISC architectures-RISC design philosophy: simplicity and performance-Key differences between RISC and CISC architectures-Historical evolution of RISC processors-Applications of RISC and CISC architectures in embedded systems.Internal components of a RISC processor-Instruction set of RISC processors: types of instructions (arithmetic, logical, memory access, control)-Register file architecture-Operand addressing modes in RISC-The role of the ALU (Arithmetic Logic Unit), registers, and memory in execution. RISC vs ARM.

**CO2: Illustrate the CISC architecture using Renesas Microcontroller** **L:9**

Architecture of the Renesas RX62N -data types – Endianness- Data Arrangement – BusSpecification – Advanced Concepts: Pipelining, Operating Modes, Memory Organization, MemoryMap, I/O Registers.Basic Concepts of Serial Communications – Introduction to the RX62N Serial CommunicationInterfacing Renesas Serial Peripheral Interface, Renesas Inter Integrated Circuit Bus -Advancedconcepts Applying FIFO Data Structures for Transmission and Reception using the UART SerialCommunications

Interface.

**CO3: Analyze the SPARC architecture for embedded processor** **L:9**

History and Evolution of SPARC - Basic architecture and design of SPARC V7 & V8 – SPARC V9 Architecture – Key differences from V7 and V8. Pipeline Design in SPARC: Pipeline stages and operation – Hazard detection and resolution. Operating System Support (Linux and other OS support). SPARC in embedded application.

**CO4: Analyze RISC V Architecture** **L:9**

Design considerations for RISC-V processors in embedded systems- RISC-V instruction set -RISC-V memory model and privilege modes- open-source nature of RISC-V and its impact on embedded systems-Introduction to pipelining in RISC-V processor(Beetle ESP32 - C3) -5stage pipeline model in RISC-V (IF, ID, EX, MEM, WB)-Performance considerations in pipelined RISC-V processors (Beetle ESP32 - C3).Power efficiency and optimization techniques in RISC V- Customization of RISC-V for embedded applications-Case studies of RISC-V-based processors.

**CO5: Explore modern development boards in RISC-V processors for embedded systems** **L:9**

Overview of VEGA Processors – Core components – Instruction set Architecture – Multithreading – Parallelism. Memory Hierarchy – Virtual memory and Paging – I/O Architecture and Techniques –Synchronization and communication. Real – world applications of VEGA processors.

**TEXT BOOKS**

1. David A. Patterson and John L. Hennessy, "Computer Organization and Design: The Hardware/Software Interface" (1994).
2. "Embedded Systems Architecture - Second Edition", Daniele Lacamera (2023).
3. David A. Patterson and Andrew Waterman, "The RISC-V Reader: An Introduction to RISC-V" (2017).
4. David Money Harris and Sarah Harris, "Digital Design and Computer Architecture"(2007).
5. John Paul Shen and Mikko H. Lipasti, "Modern Processor Design: Fundamentals of Superscalar Processors" (2005).

**REFERENCES**

1. David Money Harris and Sarah Harris, "Digital Design and Computer Architecture" (2007).
2. Anthony J. Dos Reis, "RISC-V Assembly Language: A Complete Guide". (2022)
3. Shibu K. V., "Introduction to Embedded Systems: A Cyber-Physical Systems Approach" (2009).
4. Arun Sinha, Abhishek Sharma, Luiz Alberto Pasini, and Daniele Caviglia, "Smart Embedded Systems: Advances and Applications"(2023).

**L: 45 TOTAL: 45 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC04E | EMBEDDED SYSTEM ARCHITECTURE | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

CO1: Integrate the System Software in Embedded Systems.

CO2: Enumerate the Overview of CPLD and FPGA Architecture.
CO3: Outline the PCB Design Principles.
CO4: Relate the basics of PCB design.
CO5: Synthesize the component assembly.

**CO1: Integrate the System Software in Embedded Systems** **L:9**

Understanding embedded system Product specifications with Examples – Component selection - Component package types - embedded system design flow types - Preparation of Block diagram to Final Product Architecture arrival.

**CO2: Enumerate the Overview of CPLD and FPGA Architecture** **L:9**

System software – Embedded system software layered architecture - Understanding of different Operating System (Linux, Windows, VxWorks, RTOS etc) features and architectures - Basics of Boot loader functionalities – significance of Kernel and Device drivers - File system types.

**CO3: Outline the PCB Design Principles** **L:9**

Basic concepts of CPLD architecture - Difference of CPLD & FPGA - Basic interface protocol study – I2C, GPIO, SPI & UART - Packaging options – concept of on chip logic blocks design - FPGA Design flow - Preparation of Block diagram to Final FPGA Architecture arrival.

**CO4: Relate the basics of PCB design** Understanding of PCB design principles - Different PCB options - PCB component placement guidelines - PCB layout routing - Gerber generation. **L:9**

**CO5: Synthesize the component assembly** **L:9**

Understanding of basic Component assembly process - Different ways of assembly – machine assembly/manual assembly - Component storage options - Assembly flow Understanding of basic mechanical ID design - Different mechanical enclosure options - Advantages & Disadvantages of different mechanical enclosure.

**TEXT BOOKS**

1. Vilas S bagad, “Electronics product design”, Technical publications, Pune 2009
2. Rajkamal, “Embedded system- Architecture, programming and design”, Mcgraw Hill, 2017.

**REFERENCE BOOKS:**

1. Shibu K.V, “Introduction to Embedded systems”, Mcgraw Hill, 2017
2. Kiyofumi Tanaka, “Embedded systems –Theory and Methodology”, Intech publication, Croatia, 2012
3. Jack Ganssle, “The art of designing embedded system”, 2nd Edition, Newness publication, 2008.

**L: 45; TOTAL: 45 PERIODS**

| Course Code | EMBEDDED SYSTEM ANALYSIS AND RISK MANAGEMENT | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC05E | | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to
CO1: Synthesize the elements of embedded system.

CO2: Apply integration techniques for Optimal Product Performance.
CO3: Utilize the testing techniques for Robust Product Design.
CO4: Enumerate the Integrating Standards**.**
CO5: Apply Market Research Methods.

**CO1: Synthesize the elements of embedded system** **L:9**

Conceptual design arrival to Final Product Architecture - Product Use Case Analysis Product Feature Analysis - End application Analysis

**CO2: Apply integration techniques for Optimal Product Performance** **L:9**

Power Analysis - DC Analysis types - AC Analysis types - Thermal Analysis need and concepts - Signal Integrity testing methods - MTBF Analysis - Reliability Analysis - BOM Compliance Analysis - EMI/EMC Analysis need and types

**CO3: Utilize the testing techniques for Robust Product Design** **L:9**

Independent Verification and Validation concepts and methods- Endurance- Validation through Environmental -concept of design for manufacturing (DFM) and concept of design for testability

**CO4: Enumerate the Integrating Standards** **L:9**

Different Certifications need –types of Certifications for embedded system product features of FCC/CE and UL standards - DO254 standards and its components- DO178

**CO5: Apply Market Research Methods** **L:9**

Methods of Market research for products under Consumer, Industrial, Defence& Automotive domains- different schemes for existing products analysis and gap analysis Product feature enhancement analysis- Product competitor analysis for existing products arrival of Product cost vs market demand and its analysis.

**TEXT BOOKS**

1. Vilas S bagad, “Electronics product design”, Technical publications, Pune 2009.
2. John P.Uyemura, “Introduction to VLSI circuits and Systems”, Wiley student Edition,2006

**REFERENCES**

1. Gunarschirner, “Embedded system: Design, Analysis and verification”, Springer, 2013.
2. Edward Ashford Lee, “Introduction to Embedded Systems – a cyber-physical system approach”, 2nd Edition, MIT press, 2017.
3. Shibu K.V, “Introduction to Embedded systems”, Mcgraw Hill, 2017.
4. Kiyofumi Tanaka, “Embedded systems –Theory and Methodology”, Intech publication, Croatia, 2012.
5. Arnold Berger, “Embedded system Design –An Introduction to process, Tolls and Techniques”, CMP Books, 2002.
6. Jack Ganssle, “The art of designing embedded system”, 2nd Edition, Newness publication, 2008.
7. Kim H Pries, “Testing complex and embedded systems”, CRC Press, 2010.

**L: 45 TOTAL: 45 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC06E | SENSORS AND ACTUATORS | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

CO1: Outline the basics of sensors and actuator characteristics

CO2: Utilize the thin film deposition techniques for sensor fabrication

CO3: Describe Fabrication techniques to build microsensors and actuators

CO4: Discuss fabrication techniques in modern software tools

CO5: Integrate different calibration techniques and interfacing methods

**CO1: Outline the basics of sensors and actuator characteristics** **L:9**

Basics of Energy Transformation: Transducers - Sensors – Actuators. Understanding of thin film physics: Application in MOSFET and its variants. Understanding various gas sensors: Optical gas sensor, Metal oxide semiconductor gas sensor, Field effect transistor gas sensor, Piezoelectric gas sensor, Polymer gas sensor, Nano-structured based gas sensors

**CO2: Utilize the thin film deposition techniques for sensor fabrication.** **L:9**

Thin Film Deposition Techniques - Chemical Vapor Deposition – APCVD – LPCVD – UHVCVD – PECVD – ALCVD - HPCVD – MOCVD. Physical Vapor Deposition - Thermal Deposition - E-beam Evaporation – Sputtering - Pulsed Laser Deposition. Basics understanding of Photolithography for pattering layer. Overview of Etching methods.

**CO3: Describe Fabrication techniques to build microsensors and actuators** **L:9**

Design and fabrication process of Microsensors: Force Sensors, Pressure Sensors, Strain gauges and practical applications. Working principles of Actuators. Piezoelectric and Piezoresistive actuators, micropumps and micro actuators with practical applications.

**CO4: Discuss fabrication techniques in modern software tools** **L:9**

Understanding basics of microfluidics to assist Photomask design using Clewin Software, pattern transfer techniques, PDMS moulding and degassing, device bonding techniques. Simulation, Optimization and characterization of various sensors using COMSOL Multiphysics.

**CO5:Integrate different calibration techniques and interfacing method** **L:9**

Understanding of Sensor Interfacing with Microprocessor to build electronic system, Static and Dynamic Characteristic Parameters for Sensors and Actuators, Calibration of Sensor based electronics systems.

**TEXT BOOKS**

1. Sensors and Signal Conditioning Wiley-Blackwell, 2008 Jacob Fraden, Handbook of modern sensors, Springer, Stefan Johann Rupitsch.
2. Piezoelectric Sensors and Actuators: Fundamentals and Applications, Springer, 2018 Senturia S. D.
3. Microsystem Design, Kluwer Academic Publisher, 2001 J.D. Plummer, M.D. Deal, P.G. Griffin.
4. Silicon VLSI Technology, Pearson Education, 2001 S.M. Sze (Ed).

5. VLSI Technology, 2ND Edition, McGraw Hill, 1988 Madou.
6. M Fundamentals of Microfabrication, CRC Press, 1997.

**L: 45; TOTAL: 45 PERIODS**

| Course Code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| **23EC07E** | **EMBEDDED SYSTEM NETWORKING** | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to
CO1: Outline the different bus communication protocols used for embedded networking
CO2: Describe the basic concepts of embedded networking
CO3: Apply the embedded networking concepts in wireless networks
CO4: Relate different data acquisition concepts
CO5: Illustrate the system automation for different applications

**CO1: Outline the different bus communication protocols used for embedded networking** **L:9**

Embedded networking: Introduction – Cluster of instruments in System: Introduction to bus protocols – comparison of bus protocols – RS 232C, RS 422, RS 485 and USB standards – embedded ethernet – MOD bus, LIN bus and CAN bus.

**CO2: Describe the basic concepts of embedded networking** **L:9**

Elements of a network – Inside Ethernet – Building a Network : Hardware options – Cables, Connections and network speed – Ethernet controllers – Inside the internet protocol – Exchanging messages using UDP and TCP – Email for Embedded systems using FTP – Keeping devices and network secure.

**CO3: Apply the embedded networking concepts in wireless networks**

Wireless sensor networks – Introduction – Node architecture – Network topology - Localization – Time synchronization – Energy efficient MAC protocols – SMAC – Energy efficient and robust routing – Data centric routing - WSN Applications - Home Control - Building Automation - Industrial Automation. **L:9**

**CO4: Relate different data acquisition concepts**

Sensor Types & Characteristics: Sensing Voltage, Current, flux, Torque, Position, Proximity, Accelerometer - Data acquisition system- Signal conditioning circuit design- Uc Based & PC based data acquisition – UC for automation and protection of electrical appliances –processor based digital controllers for switching Actuators: Stepper motors, Relays –System automation with multi-channel Instrumentation and interface. **L:9**

**CO5: Illustrate the system automation for different applications** **L:9**

Data Acquisition, Monitoring, Communication, Event Processing, and Polling Principles, SCADA system principles –outage management– Decision support application - substation automation, extended control feeder automation, Performance measure and response time, SCADA Data Models: need – sources - interface.

**TEXT BOOKS**

1. "Embedded Systems: Architecture, Programming, and Design" Raj Kamal - McGraw-Hill Higher Education in 2008.
2. "Embedded Networking with CAN and CANopen" Olaf Pfeiffer, Andrew Ayre, and Christian Keydel - Copperhill Media in 2008.
3. "Data Acquisition Systems: From Fundamentals to Applied Design" Maurizio Di Paolo Emilio - Springer in 2013.
4. "Real-Time Systems and Programming Languages" Alan Burns and Andy Wellings - Fourth edition published by Addison-Wesley in 2009.
5. "Industrial Automation and Control System Security Principles" by Ronald L. Krutz - Published by Wiley in 2013.

**L: 45; TOTAL: 45 PERIODS**

| **Course code** | **EMBEDDED SYSTEM SOFTWARE** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC08E** | | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

CO1: Outline the fundamental components of the C programming language.

CO2:Introduction to Virtualization and Emulation with QEMU.

C03:Illustration of Advanced Virtualization and Emulation with QEMU

CO4: Describe basic programs using mPython for embedded systems.

C05: Enumerate GNU C to create embedded software applications.

**CO1: Outline the fundamental components of the C programming language. L:9**

C and Assembly - Programming Style - Declarations and Expressions - Arrays, Qualifiers and Reading Numbers - Decision and Control Statements - Programming Process - More Control Statements - Variable Scope and Functions - C Preprocessor - Advanced Types - Simple Pointers Debugging and Optimization – In-line Assembly. Embedded C Program Structure– Data types - Operators, expressions and control statements – Functions and Procedures -Structures and union.

**C02: Introduction to Virtualization and Emulation with QEMU L:9**

Introduction to Virtualization and Emulation with QEMu - Virtual Machine Creation, Configuration, and Management with QEMU- Visualization and Interaction with QEMU Virtual Machines- Performance Monitoring and Optimization in Virtualized Environments-Virtual Machine Migration and Performance Considerations.

**C03: Illustration of Advanced Virtualization and Emulation with QEMU L:9**

QEMU and KVM Integration-Advanced Networking and Storage in QEMU-Snapshotting, Cloning, and VM Migration-Security and Performance Optimization-QEMU in Cloud and Containerized Environments.

**C04: Describe basic programs using mPython for embedded systems. L:9**

Basics of mPYTHON Programming Syntax and Style – mPython Objects– Dictionaries –

comparison with C programming on Conditionals and Loops – Files – Input and Output – Errors and Exceptions – Functions – Modules – Classes and OOPS – Execution Environment.-simple programs in mPython for embedded system.

**C05: Enumerate GNU C to create embedded software applications. L:9**

Stages of Compilation - Introduction to GCC - Debugging with GDB - The Make utility - GNU Configure and Build System - GNU Binary utilities - Profiling - using gprof – Memory Leak Detection with valgrind - Introduction to GNU C Library.

**TEXT BOOKS**

1. Brian W. Kernighan and Dennis M. Ritchie, "The C Programming Language".
2. Barnett, Cox, and O'Cull,"*Embedded C Programming and the Atmel AVR* by Barnett"
3. Humble Devassy Chirammal, et al, *Mastering KVM Virtualization.*
4. Nicholas Tollervey, "Programming with MicroPython: Embedded Programming with Microcontrollers and Python.
5. Jonathan W. Valvano, "Embedded Systems: Real-Time Operating Systems for ARM Cortex-M Microcontrollers"

**REFERENCES:**

1. K. N. King, "C Programming: A Modern Approach".
2. Michael Barr and Anthony Massa "Programming Embedded Systems: With C and GNU Development Tools" O'Reilly Media (2006).
3. Francesco A. S, "QEMU: From Virtualization to Emulation" Springer (2017).
4. Jeremy L. Jones "MicroPython: A Practical Guide for Embedded Programming" Wiley.
5. Mark K. Shewmaker "The Art of Debugging with GDB" O'Reilly Media (2011

**L: 45; TOTAL: 45 PERIODS**

| **Course code** | **LINUX FOR EMBEDDED SYSTEM** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC09E** | | **2** | **0** | **2** | **0** | **3** |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

**Theory component:**

CO 1: Familiarize with the components of Embedded Linux system
CO 2: Analyse the architecture of Linux based system
CO 3: Implement the build process of embedded linux system.
CO 4: Utilize the kernel modules
CO 5: Relate between User space and Kernel space programs

**Practical Component:**

CO6: Demonstrate the UDOO NEO Board and Workspace Configuration
CO7: Construct simple Kernel modules using Yocto
CO8: Showcase GPIO handling using Kernel modules.

**CO1: Familiarize with the components of Embedded Linux system L:6;**
**CO6: Demonstrate the UDOO NEO Board and Workspace Configuration P:6**

Linux-based embedded system components-Reference hardware model - Reference hardware model implementations- CPU memory map- The role of the bootloader-

Possible scenarios. An example of bootloader operations - Linux kernel-Device tree-- Typical layout of the root filesystem.

**CO2: Analyse the architecture of Linux based system.** **L:6;**
**CO6: Demonstrate the UDOO NEO Board and Workspace Configuration** **P:6**

Linux architecture-Conceptual view of the kernel-Process scheduler- Memory manager- external interfaces, Memory manager architecture-Virtual file system, i-node, i-node interface- File interface, Virtual file system architecture- Inter-process communication architecture - Device tree example for the UDOO NEO, Device tree syntax, Device tree content, Device tree addressing-The U-Boot bootloader - UDOO NEO boot process, An example: UDOO NEO boot process.

**CO3: Implement the build process of embedded linux system** **L:6;**
**CO7: Construct simple Kernel modules using Yocto** **P:6**

Introduction: The workflow, Build systems- Build root vs Yocto – general aspects, Build root vs Yocto configuration, Build root vs Yocto – purpose-The Yocto Project: The Yocto build system, The build system workflow- configuration files– user configuration, Metadata, Machine (BSP) configuration-The build system workflow – Distribution policy- source fetching- patching, The build system workflow – configure/compile/install, The build system workflow – output analysis/packaging-image generation, SDK generation.

**CO4: Utilize the kernel modules** **L:6;**
**CO8: Showcase GPIO handling using Kernel modules** **P:6**

Introduction: CPU – I/O interface, CPU – I/O interface with polling, CPU – I/O interface with interrupt, CPU – I/O interface, CPU – I/O interface latency- Direct memory access (DMA) architecture, Direct memory access (DMA) transfer modes-The Virtual File System (VFS) abstraction, VFS – an example, VFS functions – include/linux/fs.h-The device file concept, Linux kernel modules: the initialization function, the cdev data structure, the initialization function the clean-up function, custom VFS functions.

**CO5: Relate between User space and Kernel space programs** **L:6;**
**CO8: Showcase GPIO handling using Kernel modules** **P:6**

Introduction: The reference use case, The CPU/Device interface, The module level, The module level – file operations, ioctl() implementation, open()/release() implementation, read() implementation-Passing data to/from the kernel– write() implementation- The module level –communication with the device, Memory mapped I/O- initialization, - clean-up, Memory mapped I/O – read, write- GPIO-based I/O – initialization,– clean-up,– read, write-Interrupts, Requesting the interrupt line, Freeing the interrupt line, The interrupt handler, Interrupt handling, Top-half and bottom-half, Needed support, Work queue, The user level, The user level – the application.

**REFERENCES**

1. Christoper Collinan, „Embedded Linux primer ‟, Prentice Hall, 2006.
2. Richard Jones, “Beginning Linux Programming”, Wiley Publishing Inc, 2008.
3. Craig Hollabaugh, “*Embedded Linux: Hardware, Software and Interfacing*”, Pearson Education, 2002.
4. http://www.armcommunity.com

5. http://www.arm.com/resources/education/education- kits
6. Doug Abbott, "*Linux for embedded and real time applications*", Elsevier Science, 2003.

**L: 30; P: 30; TOTAL: 60 PERIODS**

| Course code | ADVANCED SEMICONDUCTOR DEVICES | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC10E | | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

CO1: Describe the fundamental principles of semiconductor physics

CO2: Summarize the characteristics of MOSFET and Multi-gate Devices.

CO3: Explore the unique properties of III-V compound semiconductors and their advantages over silicon for high-speed applications.

CO4: Explore emerging semiconductor concepts and TFETs

CO5: Illustrate the synthesis and construction of Nanoscale FETs & SET.

**CO1: Describe the fundamental principles of semiconductor physics** **L:9**

Introduction, Concept of Energy Band, E-k diagram, Fermi level - Fermi-Dirac distribution. Equilibrium electron-hole concentration, temperature-dependence. Carrier scattering and mobility, velocity saturation, Drift-diffusion transport.

**CO2: Summarize the characteristics of MOSFET and Multi-gate Devices** **L:9**

MOSFET scaling & Moore's law, short channel effects-channel engineering-source/drain engineering-high k dielectric –SOI MOSFET: single gate double gate–triple gate–surround gate, Quantum Effects: volume inversion–mobility– threshold voltage– inter sub-band scattering.

**CO3: Explore the unique properties of III-V compound semiconductors and their advantages over silicon for high-speed applications.** **L:9**

Overview of compound semiconductors: III-V materials (GaAs, GaN, InP) & alloys, heterostructure band diagrams, MODFET & High Electron Mobility Transistors (HEMTs): structure, characteristics, and high-frequency applications, introduction to quantum well, applications of heterostructure device technologies.

**CO4: Explore emerging semiconductor concepts and TFETs** **L:9**

Basics of Tunneling-WKB approximation, Landauer's tunneling formula, advanced tunneling models, Tunnel FET – Device structure, Qualitative behaviour, drain current model and surface potential model. types of TFET.

**CO5: Illustrate the synthesis and construction of Nanoscale FETs & SET** **L:9**

Carbon nanotube - Band structure of carbon nanotube - Band structure of graphene - Physical structure of nanotube - Band structure of nanotube - Carbon nanotube FETs - Carbon nanotube MOSFETs - Schottky barrier carbon nanotube FETs, Molecular electronics – Single-Electron Transistors (SET).

**TEXT BOOKS**

1. Sze, Simon M., Yiming Li, and Kwok K. Ng. Physics of semiconductor devices. John wiley& sons, 2021.
2. Colinge JP, FINFETs and other multi-gate transistors, Springer–Series on integrated circuits

and systems, 2008
3. Mark Lundstrom, Jing Guo, Nanoscale Transistors: Device Physics, Modeling and Simulation, Springer, 2006

**REFERENCES**

1. Sneh Saurabh, Mamidala Jagadesh Kumar, Fundamentals of Tunnel Field-Effect Transistors, CRC Press Taylor & Francis Group, 2016.
2. Fluker M.H., Nanotechnology: Importance and Applications, IK International Publishing, 2010

**L: 45; TOTAL: 45 PERIODS**

| Course code | DIGITAL VLSI SYSTEMS DESIGN | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC11E | | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

**CO1:** Explain the **architectural design concepts** of digital circuits.
**CO2:** Design the digital **data path circuits**.
**CO3:** Design and implement **high speed CMOS** circuits
**CO4:** Explain the **sources of power dissipation** in Digital ICs.
**CO5:** Explain the concept **of Low power Digital VLSI** design techniques

**CO1: Explain the architectural design concepts of digital circuits.** **L:9**

Efficient Techniques for Algorithm to Architecture Mapping- Fundamentals of Efficient Design and Implementation strategies of Digital VLSI Design (Clock Tree synthesis, Timing Closure, Synthesis)-Static Timing Analysis-Clock Skew

**CO2: Design the digital data path circuits.** **L:9**

Recent Trends on Adder/Subtractor Design-Recent Trends on Multiplier/Divider Design-Efficient VLSI Architecture for FIR filter-Arithmetic and logic circuit-Processor Control Logic: Hardwired control unit-Micro programmed control unit.

**CO3: Design and implement high-speed CMOS circuits** **L:9**

Historical Perspective and Future Trends in Digital Circuit and System Design-Logical Effort - A Way of Designing Fast CMOS Circuits- Arithmetic Implementation Strategies for Digital design-Interconnect aware design: Impact of scaling-Buffer insertion

**CO4: Explain the sources of power dissipation in Digital ICs.** **L:9**

Static Power Dissipation: Transistor leakage mechanisms-Channel engineering for leakage reduction-Active Power Dissipation: Short circuit dissipation-Switching dissipation.

**CO5: Explain the concept of Low power Digital VLSI design techniques** **L:9**

Designing for Low Power-Multiple $V_{th}$ techniques-Dynamic $V_{th}$ technique-Supply voltage scaling technique-Low voltage low power logic styles.

**REFERENCES:**

1. Seetharaman Ramachandran, "Digital VLSI Systems Design- A Design Manual for Implementation of Projects on FPGAs and ASICs Using Verilog", Springer International

Edition, 2011
2. Andrew B Kahng, Jens Lienig, Igor L. Markov, Jin Hu, "VLSI physical design: From graph partitioning to timing closure" Springer, II Edition, 2022
3. Jan M. Rabaey, Anantha Chandrakasan, and Borivoje Nikolić, "Digital Integrated Circuits: A Design Perspective" Pearson, 2016
4. Kaushik Roy, "Low Power CMOS VLSI Circuit Design", Wiley- Inter science, 2009.
5. Kiat-Seng Yeo and Kaushik Roy, "Low-Voltage, Low-Power VLSI Subsystems", TATA Mc Graw Hill Edition, 2005.
6. Sanjay Churiwala, "Designing with Xilinx FPGAs using Vivado", Springer, 2017
7. Ivan Suderland,Bob Sproull and D. Harris, "Logical Efforts: Designing Fast CMOS Circuits", Morgan Kaufmann, 1999.
8. Giovanni. De Michel, " Synthesis and optimization of digital circuits", Tata McGraw Hill Edition, 2017

**L: 45; TOTAL: 45 PERIODS**

| Course code | DESIGN FOR TESTABILITY | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC12E | | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to
CO1: Describe the Testability using various fault models
CO2: Explain the Testability of ATPG
CO3: Demonstrate the design for the Testability of Memory Circuits
CO4: Illustrate the concepts of Built-In Self-Test
CO5: Illustrate boundary scan using various scanning techniques

**CO1: Describe the Testability using various fault models**

Introduction to Testing: Testing Philosophy, Role of Testing, Digital and Analog VLSI Testing, VLSI Technology Trends affecting Testing, Types of Testing, Fault Modelling: Defects, Errors and Faults, Functional Versus Structural Testing, Levels of Fault Models, Single Stuck-at Fault. **L:9**

**CO2: Explain the Testability of ATPG** **L:9**

Logic and Fault Simulation: Simulation for Design Verification and Test Evaluation, Modelling Circuits for Simulation, Algorithms for True-value Simulation, Algorithms for Fault Simulation, ATPG.

**CO3: Demonstrate the design for the Testability of Memory Circuits** **L:9**

Testability Measures: SCOAP Controllability and Observability, High-Level Testability Measures, Digital DFT and Scan Design: Ad-Hoc DFT Methods, Scan Design, Partial-Scan Design, Variations of Scan.

**CO4: Illustrate the concepts of Built-In Self-Test** **L:9**

Built-In Self-Test: The Economic Case for BIST, Random Logic BIST: Definitions, BIST Process, Pattern Generation, Response Compaction, Built-In Logic Block Observers, Test-Per-Clock, Test-PerScan BIST Systems, Circular Self-Test-Path System, Memory BIST,

Delay Fault BIST.

**CO5: Illustrate boundary scan using various scanning techniques** **L:9**

Boundary Scan Standard: Motivation, System Configuration with Boundary Scan: TAP Controller and Port, Boundary Scan Test Instructions, Pin Constraints of the Standard, Boundary Scan Description Language: BDSL Description Components, Pin Descriptions.

**TEXT BOOK:**

1. M.L. Bushnell, V. D. Agrawal, "Essential of Electronic Testing for Digital, Memory and Mixed Signal VLSI Circuits", Kluwer Academic Publishers.

**REFERENCES:**

1. M. Abramovici, M. A. Breuer and A.D Friedman, Digital Systems and Testable Design", Jaico Publishing House.
2. P. K. Lala, "Digital Circuits Testing and Testability", Academic Press.

**L: 45; TOTAL: 45 PERIODS**

| Course code | FUNDAMENTALS OF SEMICONDUCTOR CHIP TESTING | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC13E | | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to
CO1: Explain the need for IC testing.
CO2: Describe the architecture of ATE.
CO3: Analyze the performance of IC based on the IC testing principles.
CO4: Explain the various features of CAD tools used for IC testing.
CO5: Explain the concept of DFT.

**CO 1: INTRODUCTION TO SEMICONDUCTOR IC TESTING** **L:9**

Design and manufacturing cycle of an IC –Logic Verification – Manufacturing defects in an IC – Manufacturing test – Need for CHIP testing – Types of CHIP testing – Engineering testing, production testing, QA testing, Customer inspection testing. Automated Test Equipment (ATE)– Types of ATE-ATE subsystems – Test head, Main frame, Test computer, Manipulator. Common accessories of an ATE – Load boards, Probe cards.

**CO:2 AUTOMATIC TEST EQUIPMENT ARCHITECTURE** **L:9**

Architecture of a mixed signal ATE – Digital subsystem, Pogo blocks, digitizers– Drivers, Comparators, PMU, Timing and formatting units,Sequence controller, Digital source memory, digital capture memory, ATE Pin Electronics. Analog source and Capture memory. Types of ATE- Digital ATE and Mixed Signal ATE.

**CO 3: TESTING – CONCEPTS AND METHODS** **L:9**

Introduction to testing in digital domains – Data sheet of typical IC – DC Parametric test, continuity test, leakage test, IDD static test – VIL/VIH, VOL/VOH, IIL, IIH, IOL, IOH IDD dynamic test – AC Parameters Test – AC Timing Tests – Setup Time, Hold Time, Propagation Delay, ATE Time Measurement subsystem. Digital Functional Test – Pattern, Timing, Levels.Test plan and Test Programs.

**CO 4: TEST DATA ANALYSIS USING CAD TOOLS AND ESD PROTECTION** **L:9**

Introduction to data analysis– Data visualization tools – Data logs – Lot summaries – Wafer map – shmoo plots – Histograms – Statistical process control – Standard deviation – Mean – Process capability Index – Six sigma quality – Reproducibility – Introduction to ESD – Sources of ESD – ESD models – ESD protection circuits – Latch up test.

**CO 5: FAULT MODELS AND PRINCIPLES OF DESIGN FOR TESTABILITY** **L:9**

Fault models – Simple examples with stuck at and bridging faults – Controllability and observability – Principles of DFT – Scan based Techniques – Boundary scan test – JTAG-Built in self test.

**TEXT BOOKS**

1. Mark burns & Gordon W Roberts, "An Introduction to mixed signal IC testing and measurement", Oxford University Press, 1st Edition, 2000.
2. Michael L. Bushnell &Vishwani D. Agrawal, "Essentials of electronic testing" Kluwer academic publishers, 2000.

**REFERENCES**

1. William J. Greig, "Integrated Circuit Packaging, Assembly and Interconnections", Springer, 2007.
2. Artur Balasinki, "Semiconductors: Integrated Circuit Design for Manufacturability", CRC Press, 1st Edition, 2011.

**L:45; TOTAL: 45 PERIODS**

| **Course code** | **VLSI PHYSICAL DESIGN** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC14E** | | **3** | **0** | **0** | **0** | **3** |

**PREREQUISITES:** Basic concepts in digital circuit design.

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

CO1: Explain the importance of physical design automation in the VLSI Design cycle.

CO2: Describe the different types of routing algorithms and routing problems in the design cycle.

CO3: Analyze the various timing issues and the different ways to enhance the performance of the circuit.

CO4: Analyze the various clocking issues and provide the appropriate solutions

CO5: Analyze the noise performance, layout compaction and physical verification.

**CO1: Explain the importance of physical design automation in the VLSI Design cycle.** **L:9**

Introduction - Design Representation - VLSI Design Styles - VLSI Physical Design Automation.

**CO2: Describe the different types of routing algorithms and routing problems in the design cycle.** **L:9**

Partitioning-Floor planning-Floor planning Algorithms-Pin Assignment-Placement- Grid Routing- Global Routing- Detailed Routing- Power and ground routing- Some Case studies.

**CO3: Analyze the various timing issues and the different ways to enhance the performance of the circuit.** **L:9**

Time Closure- Timing Driven Placement- Timing Driven Routing- Miscellaneous Approaches to Timing Optimization.

**CO4: Analyze the various clocking issues and provide the appropriate solutions.** **L:9**

Clock Design- Clock network synthesis- Clock network synthesis- Some Case studies

**CO5: Analyze the noise performance, layout compaction and physical verification.**

Physical Synthesis- Performance-Driven Design Flow- Interconnect Modeling- Design Rule Check- Layout Compaction- Testing of VLSI Circuits-Fault Modeling- Fault Simulation- Test Pattern Generation-Design for Testability- Boundary Scan Standard- Built-in Self-Test- Low Power VLSI Design-Techniques to Reduce Power-Gate Level Design for Low Power- Other Low Power Design Techniques-Algorithmic Level Techniques for Low Power Design. **L:9**

**REFERENCES**

1. A.B. Kahing, J.Lienig, I.L.Markov, and J.Hu, "VLSI Physical Design: From graph partitioning to timing closure", Springer 2011.
2. M.L.Bushnell and V.D.Agarwal, "Essentials of Electronic Testing", Kluwer Academic Publishers, 2000.
3. S.M.Sait and H.Youssef, "VLSI Physical Design Automation: Thoery and Practice", World Scientific Publishers, 1999.
4. N.A.Sharwani, "Algorithms for VLSI Design Automation", Kluwer Academic Publishers, 1999.

**L: 45; TOTAL: 45 PERIODS**

| **Course code** | **ANALOG IC DESIGN** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC15E** | | **3** | **0** | **0** | **0** | **3** |

**PRE-REQUISITES: Circuit Theory, Signals and Systems, Analog Circuits**

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

CO1: Explain the advanced concepts in analog circuit design specifically relevant to CMOS IC design.

CO2: Explain the circuit noise and mismatch, their analysis, and their impact on CMOS OpAmp design.

CO3: Design and analyze the cascode amplifier using opamp at the transistor level

CO4: Design and analyze the negative feedback amplifier using opamp at the transistor level.

CO5: Design and analyze the differential amplifier using opamp at the transistor level

**CO1: Explain the advanced concepts in analog circuit design specifically relevant to CMOS IC design.** **L:9**

Simple MOSFET Circuits-MOSFET Current Mirrors-Cascode Amplifiers-MOSFET in Integrated Circuits-MOSFET Capacitances.

**CO2: Explain the circuit noise and mismatch, their analysis, and their impact on CMOS OpAmp design.** **L:9**

Noise-Noise of Simple Circuits-Systematic Mismatch-Random Mismatch- Differential Amplifiers

**CO3: Design and analyze the cascode amplifier using opamp at the transistor level.** **L:9**

Folded-CascodeOpAmp- Single stage opamp realization-Two stage miller compensated opamp-Two stage miller compensated opamp-Two and three stage miller compensated opamps; Feedforward compensated opamp- Two Stage Opamp-Two Stage Opamp; Three Stage and Triple Cascade Opamps- Common Mode Rejection Ratio ; Example.

**CO4: Design and analyze the negative feedback amplifier using opamp at the transistor level.** **L:9**

Negative Feedback-Stability of Negative Feedback Systems-Dominant Pole-Compensation - Active Load-One Stage OpAmps- Negative feedback amplifier-Step response, sinusoidal steady state response- Loop gain and unity loop gain frequency; Opamp- Opamp realization using controlled sources; Delay in the loop-Negative feedback amplifier with ideal delay-small delays-Negative feedback amplifier with ideal delay-large delays- Negative feedback amplifier with parasitic poles and zeros-Negative feedback amplifier with parasitic poles and zeros; Nyquist criterion-Phase margin.

**CO5: Design and analyze the differential amplifier using opamp at the transistor level.** **L:9**

Differential Amplifiers Offset-One Stage OpAmps - Noise & Offset-One Stage OpAmps -Slew Rate-One Stage OpAmps – Datasheet- Fully differential single stage opamp-Common mode feedback-Fully differential single stage opamp – 2-Fully differential two stage opamp; Fully differential versus pseudo-differential.

**REFERENCES**

1. Behzad Razavi, “Design of Analog CMOS Integrated Circuits”, Second Edition, McGraw Hill Education, 2017.
2. Kenneth Martin, Chan Carusone and David Johns, “Analog Integrated Circuit Design”, Second Edition, Wiley Publication, 2013.
3. Philip E.Allen and Douglas R.Holberg, “CMOS Analog Circuit Design”, Third Edition, Oxford University Press, 2013.
4. Meyer Gray and Hurst Lewis, “Analysis and Design of Analog Integrated Circuits”, Fifth Edition, Wiley Publication, 2009.

**L: 45; TOTAL: 45 PERIODS**

| Course code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| **23EC16E** | **FUNDAMENTALS OF NANO ELECTRONICS** | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

CO1 : Explain the fundamental concepts of nanoelectronics

CO2: Describe the structure and properties of crystal lattices and heterostructures

CO3: Apply the knowledge and analyze the fundamental mechanisms of electron transport in

nanostructures

CO4: Explore the principles and challenges of MOSFET scaling

CO5: Comprehend the principles of quantum tunneling and its applications in advanced transistor technologies

**CO1 : Explain the fundamental concepts of nanoelectronics** **L:9**

Introduction to nanoelectronics, Limitations of conventional microelectronics, Classical particles, Classical waves, Wave–particle duality, Wave Mechanics- The Schrodinger wave equation, Wave mechanics of particles.

**CO2 Describe the structure and properties of crystal lattices and heterostructures** **L:9**

Introduction- Semiconductors, Crystal lattices: Bonding in crystals- Electron energy bands- Semiconductor heterostructures - Lattice-matched and pseudomorphic heterostructures, Carbon nanomaterials: nanotubes and fullerenes.

**CO3 Apply the knowledge and analyze the fundamental mechanisms of electron transport in nanostructures** **L:9**

Introduction, Time and length scales of the electrons in solids, Statistics of the electrons in solids and nanostructures, The density of states of electrons in nanostructures, Electron transport in nanostructures

**CO4 Explore the principles and challenges of MOSFET scaling** **L:9**

Moore's Law- Technology Scaling and Reliability Challenges. Basic MOS Transistor Types, Modes of operation, n-MOS operation, Drain Current, Threshold Voltage, Energy band diagram of MOSFET, nanoscale MOSFET, SCEs- scaling limits, system integration limits.

**CO5 Comprehend the principles of quantum tunneling and its applications in advanced transistor technologies** **L:9**

Tunnel effect -Tunneling element -Tunnel Junctions – Applications of Tunneling – Gate Oxide Tunneling - Tunneling diode - Resonant tunneling diode

**TEXT BOOKS:**

1. Vladimir V. Mitin, Viatcheslav A. Kochelap, Michael A. Stroscio, "Introduction to Nanoelectronics Science, Nanotechnology, Engineering, and Applications" Cambridge University Press, 2011.
2. G.W. Hanson, Fundamentals of Nanoelectronics, Pearson Education, 2009.

**REFERENCES:**

1. Mircea Dragoman and Daniela Dragoman, Nanoelectronics: Principles and Devices, Artech House, 2009.
2. Robert Puers, Livio Baldi, Marcel Van de Voorde and Sebastiaan E. Van Nooten, Nanoelectronics: Materials, Devices, Applications, Wiley, 2017.
3. Brajesh Kumar Kaushik, Nanoelectronics: Devices, Circuits and Systems, Elsevier science, 2018

**L: 45; TOTAL: 45 PERIODS**

| Course code | HARDWARE MODELLING AND | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC17E | VERIFICATION USING HDL | 2 | 0 | 2 | 0 | 3 |

**PRE-REQUISITES:** Basic concepts in digital circuit design. Familiarity with a programming language like C and C++.

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

CO1: Explore the hierarchical modelling concepts for Digital System Design.

CO2: Write a verilog code for digital circuits and perform simulation using CAD tool.

CO3: Apply the System Verilog language rules for new hierarchy and connectivity features, and interfaces.

CO4: Apply the System Verilog verification features, including classes, strings, queues and dynamic arrays.

CO5: Develop system verilog code for digital systems using CAD tool.

**CO1: Explore the hierarchical modelling concepts for Digital System Design.**

Evolution of CAD-Emergence of HDLs-Typical HDL-based Design flow-Trends in HDLs -Top down and bottom up design methodology-Differences between Modules and Module Instances-Parts of a Simulation-Module definition-Port declaration-Connecting ports- Design block. **L:6 P:4**

**CO2: Write a verilog code for digital circuits and perform simulation using CAD tool.** **L:6 P:6**

Gate level Modelling: Basic verilog gate primitives-Rise, Fall and Turn off delays-Min, Max and Typical delays-Data flow modelling: Continuous Assignments – DelaySpecification – Expressions – Operators – Operands-Behavioural Modelling: initial and always statements-Blocking and Non-blocking statements-Delay control-Event control-Sequential and Parallel blocks.

**CO 3: Apply the System Verilog language rules for new hierarchy and connectivity features, and interfaces** **L:6 P:4**

Data types: Logic -Bit – Signed integers – Strings – Enumeration – Arrays – Queues – Structures – User defined data types – Control flow – Events – Functions and Tasks – System Verilog Threads – Inter process communication - Semaphores – Mailboxes – Interfaces – Modports – Clocking blocks.

**CO 4: Apply the System Verilog verification features, including classes, strings, queues and dynamic arrays.** **L:6 P:6**

Class handles – Objects - Constructors - Random Stimulus - constrained random stimulus - Randomization – Constraints – Methods - Polymorphism and Virtuality-Interfaces in Verification - Assertion-Based Verification (ABV) – System Verilog Assertions (SVA) - Direct Programming Interface (DPI) - Interprocess Synchronization

**CO 5: Develop system verilog code for digital systems using CAD tool.** **L:6 P:10**

HDL coding and Verification for combinational logic circuits – HDL coding and Verification for sequential Logic Circuits – HDL coding and Verification for simple IP cores.

## REFERENCES

1. S.Palnitkar, Verilog HDL:A Guide to Digital Design and Synthesis, Prentice Hall, 2nd Edition, 2003.
2. VaibbhavTaraate, "Digital Logic Design Using Verilog: Coding and RTL Synthesis", Springer, 2016.
3. S.Ramachandran, "Digital VLSI Systems Design", Springer International Edition, 2011.
4. Basavaraj Hakari, "System Verilog for Verification", Notion Press, 2021.
5. Chris Spear, Greg Tumbash, "SystemVerilog for Verification: A Guide to Learning the Testbench Language Features", Third Edition, Springer, 2012.
6. Mike Mintz, Robert Ekendahl, "Hardware Verification with System Verilog", Springer, 2010.
7.Weblink: www.chipverify.com

**L: 30; P:30; TOTAL: 60 PERIODS**

| Course Code | ADVANCED DIGITAL SIGNAL PROCESSING | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC18E | | 3 | 0 | 0 | 0 | 3 |

## COURSE OUTCOMES:

Upon successful completion of the course the students will be able to

CO1: Discuss the essentials for the postgraduate level research in the area of statistical signal processing.

CO2: Model random signals and determine its solution.

CO3: Estimate the coefficient for perfect reproduction filter for both the stationary and non-stationary signals.

CO4: Design FIR and IIR adaptive filters using adaptive algorithms.

CO5: Estimate the power spectrum for discrete random signals using classical and non-classical methods.

**CO1: Discuss the essentials for the postgraduate level research in the area of statistical signal processing.** **L:9**

Random Processes - Ensemble Averages, Gaussian processes, Stationary processes, Auto covariance and Autocorrelation matrices, Bias and Estimation, Parseval's theorem, Wiener-Khintchine relation, White noise, Power Spectral Density, Spectral factorization, Filtering Random Processes, Special types of Random Processes - ARMA, AR, MA.

**CO 2: Model random signals and determine its solution.**

Least Squares method, Pade approximations, Prony's method – Pole zero modeling, All pole modeling, Linear prediction, Forward and Backward prediction, Finite data records, stochastic models, Solution of Prony's normal equations – Levinson Durbin recursion. **L:9**

**CO 3: Estimate the coefficient for perfect reproduction filter for both the stationary and non-stationary signals.** **L:9**

FIR Wiener filter – Filtering, Linear prediction, Noise cancellation, Lattice representation,Causal and Non-causal IIR Wiener filters, Weiner Deconvolution, Discrete Kalman filter.

**CO 4: Design FIR and IIR adaptive filters using adaptive algorithms.** **L:9**

FIR adaptive filters, Steepest Descent Adaptive Filter, LMS algorithm, Normalized LMS algorithm, Noise cancellation, Channel equalization, Adaptive Recursive filters, Recursive Least squares algorithm.

**CO 5: Estimate the power spectrum for discrete random signals using classical and non-classical methods** **L:9**

Nonparametric methods - Periodogram, Modified periodogram, Bartlett, Welch and Blackman-Tukey methods, Parametric methods - ARMA, AR and MA model based spectral estimation

**REFERENCES**

1. Monson H. Hayes, "Statistical Digital Signal Processing and Modeling", John Wiley and Sons, Inc, Singapore, 1st Edition, 2008.
2. John G. Proakis and Dimitris K Manolakis, "Digital Signal Processing", Pearson Education, 4th Edition, 2009.
3. Alan V. Oppenheim and Ronald W. Schafer, "Discrete-Time Signal Processing", 3rd Edition, Prentice Hall, 2009.
4. Emmanuel C. Ifeachor and Barrie W. Jervis, "Digital signal processing: A practical approach", 2nd Edition, Prentice Hall, 2002.

**L: 45; TOTAL: 45 PERIODS**

| **Course Code** | **DIGITAL IMAGE PROCESSING** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC20E** | | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

CO 1: Comprehend the components of a digital image processing system.

CO 2: Discuss the concepts of image enhancement in spatial and frequency domain.

CO 3: Discuss the concepts of various image restoration and degradation technique and methods used in digital image processing.

CO 4: Analyze the concepts of image segmentation and representation techniques.

CO 5: Analyze the fundamental principle of color image processing and image compression techniques.

**CO 1 Comprehend the components of a digital image processing system**

Digital Image Processing: The Origins of Digital Image Processing - Fundamental Steps in Digital Image Processing - Components of an Image Processing System, Digital Image Fundamentals: Elements of Visual Perception - Image Sensing and Acquisition - Image Sampling and Quantization - Some Basic Relationships between Pixels - Linear and Nonlinear Operations **L:9**

**CO 2 Discuss the concepts of image enhancement in spatial and frequency domain.**

Image Enhancement in the Spatial Domain: Background - Some Basic Intensity Transformation Functions - Histogram Processing - Basics of Spatial Filtering - Smoothing Spatial Filters - Sharpening Spatial Filters - Combining Spatial Enhancement Methods, Image Enhancement in the Frequency Domain: Background - Sampling and the Fourier Transform of Sampled Functions - Smoothing Frequency Domain Filters - Sharpening Frequency Domain Filters: Homomorphic Filtering. **L:9**

**CO3 Discuss the concepts of various image restoration and degradation technique and methods used in digital image processing** **L:9**

A Model of the Image Degradation or Restoration Process - Noise Models - Restoration in the Presence of Noise Only - Spatial Filtering - Linear, Position - Invariant Degradations - Estimating the Degradation Function - Inverse Filtering - Minimum Mean Square Error (Wiener) Filtering - Constrained Least Squares Filtering - Geometric Mean Filter

**CO4 Analyze the concepts of image segmentation and representation techniques**.

Edge detection, Edge linking via Hough transform – Thresholding - Region based segmentation – Region growing – Region splitting and merging – Morphological processing- erosion and dilation, Segmentation by morphological watersheds – basic concepts – Dam construction – Watershed segmentation algorithm. **L:9**

**CO5 Analyze the fundamental principle of color image processing and image compression techniques**. **L:9**

Color Fundamentals - Color Models - Pseudo color Image Processing - Basics of Full - Color Image Processing - Color Transformations - Smoothing and Sharpening - Color Segmentation - Noise in Color Images, Image Compression: Fundamentals - Image Compression Models - Error-Free Compression - Lossy Compression - Image Compression Standards

**TEXT BOOKS:**

1. Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", Fourth Edition, Prentice Hall, 2022
2. Anil K. Jain, Fundamentals of Digital Image Processing, Pearson, 2002.

**REFERENCES:**

1. Rafael C. Gonzalez, Richard E. Woods, and Steven L. Eddins, "Digital Image Processing Using MATLAB", Third Edition, Tata McGraw-Hill, 2020.
2. Kenneth R. Castleman, Digital Image Processing', Pearson, 2006
3. William K. Pratt, Digital Image Processing', John Wiley, New York, 2002.

**L: 45; TOTAL: 45 PERIODS**



| Course Code | SOFT COMPUTING AND OPTIMIZATION | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC21E | TECHNIQUES | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

CO 1: Acquire knowledge in various neural network architectures.

CO 2: Analyze the principles of fuzzy logic.

CO 3: Develop Neuro-Fuzzy model.

CO 4: Explore and implement conventional optimization techniques.

CO 5: Comprehend and apply the core principles and techniques of Genetic Algorithms

**CO 1: Acquire knowledge in various neural network architectures**

Machine Learning using Neural Network, Learning algorithms, Supervised Learning Neural Networks – Feed Forward Networks, Radial Basis Function, Unsupervised Learning Neural Networks – Self Organizing map , Adaptive Resonance Architectures, Hopfield network. **L:9**

**CO 2: Analyze the principles of fuzzy logic**

Fuzzy Sets – Operations on Fuzzy Sets – Fuzzy Relations – Membership Functions-Fuzzy Rules and Fuzzy Reasoning – Fuzzy Inference Systems – Fuzzy Expert Systems – Fuzzy Decision Making **L:9**

**CO3: Develop Neuro-Fuzzy model.**

Adaptive Neuro-Fuzzy Inference Systems – Coactive Neuro-Fuzzy Modelling – Classification and Regression Trees – Data Clustering Algorithms – Rule base Structure Identification – Neuro-Fuzzy Control – Case Studies. **L:9**

**CO 4: Explore and implement conventional optimization techniques.**

Introduction to optimization techniques, Statement of an optimization problem, classification, Unconstrained optimization-gradient search method-Gradient of a function, steepest gradient conjugate gradient, Newton's Method, Marquardt Method, Constrained optimization –sequential linear programming, Interior penalty function method, external penalty function method. **L:9**

**CO 5: Comprehend and apply the core principles and techniques of Genetic Algorithms** **L:9**

Genetic algorithm - working principle, Basic operators and Terminologies, Building block hypothesis, Travelling Salesman Problem, Particle swam optimization, Ant colony optimization.

**TEXT BOOKS:**

1. Fakhreddine O. Karray, Clarence W. De Silva, Soft Computing and Intelligent Systems Design Theory, Tools and Applications, Pearson Edn., 2004.
2. David E. Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning, Addison Wesley, 2009.

**REFERENCES:**

1. Singiresu S. Rao, Engineering optimization Theory and practice, John Wiley & sons, inc,Fourth Edition, 2009.
2. James A. Freeman and David M. Skapura, Neural Networks Algorithms, Applications, and Programming Techniques, Pearson Edn., 2003.
3. Jyh-Shing Roger Jang, Chuen-Tsai Sun, EijiMizutani, Neuro-Fuzzy and Soft Computing, Prentice-Hall of India, 2003.

**L: 45; TOTAL: 45 PERIODS**

| **Course Code** | **FOUNDATIONS OF WAVELETS AND MULTIRATE DIGITAL SIGNAL PROCESSING** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC22E** | | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

CO 1: Acquire the basic knowledge of wavelets concept.

CO 2: Apply the concept of piecewise constant representation of functions using the Haar wavelet.

CO 3: Analyze filter banks in the Z-domain, and their role in wavelet analysis and synthesis.

CO 4: Evaluate filter bank performance in the frequency domain.

CO 5: Relate Fourier transform to wavelet construction using filter bank.

**CO 1: Acquire the basic knowledge of wavelets concept** **L:9**
Origin of Wavelets, Haar Wavelet, Dyadic Wavelet, Dilates and Translates of Haar Wavelets, L2 norm of a function.

**CO 2: Apply the concept of piecewise constant representation of functions.** **L:9**
Ladder of Subspaces, Scaling Function of Haar Wavelet, Demonstration: Piecewise constant approximation of functions, Vector Representation of Sequences, Properties of Norm, Parseval's Theorem

**CO 3: Analyze filter banks in the Z-domain, and their role in wavelet analysis and synthesis.** **L:9**
Angle between Functions & their Decomposition, Additional Information on Direct-SumIntroduction to Filter Bank, Haar Analysis Filter Bank in Z-domain, Haar Synthesis Filter Bank in Z-domain

**CO 4: Evaluate filter bank performance in the frequency domain.**
Frequency Response of Haar Analysis Low pass Filter bank, Frequency Response of Haar Analysis High pass Filter bank, Ideal Two-band Filter bank, Disqualification of Ideal Filter bank, Realizable Two-band Filter bank, Demonstration: DWT of images **L:9**

**CO 5: Relate Fourier transform to wavelet construction using filter bank.** Fourier transform of scaling function, Construction of scaling and wavelet functions from filter bank, Demonstration: Constructing scaling and wavelet functions, Conclusive Remarks and Future Prospects **L:9**

**TEXT BOOKS**

1. Michael W. Frazier, "An Introduction to Wavelets Through Linear Algebra", Springer, 1999.
2. Stephane Mallat, "A Wavelet Tour Of Signal Processing", Academic Press, Elsevier, 1998, 1999, Second Edition.

**REFERENCE BOOKS**

1. http://nptel.ac.in/courses/117101001/: The lecture series on Wavelets and Multirate Digital Signal Processing created by Prof. Vikram M. Gadre in NPTEL.
2. Barbara Burke Hubbard, "The World according to Wavelets - A Story of a Mathematical Technique in the making", Second edition, Universities Press (Private) India Limited 2003.
3. P.P.Vaidyanathan, "Multirate Systems and Filter Banks", Pearson Education, Low Price Edition.

**L: 45; TOTAL: 45 PERIODS**

| **Course Code** | **DEEP LEARNING** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC23E** | | **3** | **0** | **2** | **0** | **3** |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

**Theoretical Component:**

CO1: Explore the concepts of Artificial Neural Networks to solve real-world classification and

recognition problems.

CO2: Explain the importance of regularization in preventing overfitting and improving the model performance.

CO3: Explain the principles of Convolutional Neural network and Applications.

CO4: Analyze the concepts of Recurrent Neural networks for various applications.

CO5: Explore the principles of generative modelling and understand their applications in generative tasks.

**Practical Component:**

**CO6**: Develop a neural network for a basic pattern recognition problem.

**CO7**: Demonstrate various optimization techniques to improve the performance of deep learning models.

**CO8**: Demonstrate the convolution operation and its role in feature extraction for image and data processing.

**CO9**: Implement RNN and CNN for solving real world problems

**CO10**: Implement Autoencoders and GAN

**CO 1 Explore the concepts of Artificial Neural Networks to solve real-world classification and recognition problems** **L:9; P:6**

**CO6- Develop a neural network for a basic pattern recognition problem.**

Basics of artificial neural networks (ANN): Artificial neurons, Computational models of neurons, Structure of neural networks, Functional units of ANN for pattern recognition .The Perceptron Convergence Theorem, Relation between the Perceptron and Bayes Classifier for a Gaussian Environment.Implement a basic artificial neuron and simulate its functionality using a simple dataset.

**CO 2 Explain the importance of regularization in preventing overfitting and improving the model performance.** **L:9; P:6**

**CO7- Demonstrate various optimization techniques to improve the performance of deep learning models.**

Feed forward neural networks-Multilayer feedforward neural networks (MLFFNNs), Backpropagation learning, Empirical risk minimization-Regularization: Parameter Norm Penalties - L2 Parameter Regularization, Dataset Augmentation. Optimization for Training Deep Models. Evaluate the model performance with different optimizers: SGD with Momentum- RMSProp- Adam-Adagrad.

**CO3 Explain the principles of Convolutional Neural network and Applications.**

**CO8 Demonstrate the convolution operation and its role in feature extraction for image and data processing** **L:9; P:6**

Convolutional Neural Networks: The Convolution Operation– Pooling – Variants of the basic Convolution Function – Training CNNs: weights initialization, batch normalization, implementation of CNNsapplications: Computer Vision, Image Generation, Image Compression.

**CO4 Analyze the concepts of Recurrent Neural networks for various application**

**CO9 Implement RNN and CNN for solving real world problems** **L:9; P:6**

Recurrent Neural Networks: Introduction – Bidirectional RNNs – Deep Recurrent Networks – Long Short Term Memory (LSTM), Bidirectional LSTMs.Implementation of RNN/CNN for solving real world problems

**CO5 Explore the principles of generative modeling and understand their applications in generative tasks** **L:9; P:6**

**CO10 Implement Autoencoders and GAN**

Generative models: Restrictive Boltzmann Machines (RBMs), Stacking RBMs, Belief nets, Learning sigmoid belief nets, Deep belief nets and its implementation.

**TEXT BOOKS:**

1. Bengio, Yoshua, Ian J. Goodfellow, and Aaron Courville, "Deep learning" An MIT Press book in preparation, 2nd Edition, 2016.
2. Dr.AdrianRosebrock, "Deep Learning for Computer Vision with Python: Starter Bundle", PyImage Search, 1st Edition, 2017.

**REFERENCE BOOKS:**

1. Deng & Yu, Deep Learning: Methods and Applications, Now Publishers, 1st Edition, 2013.
2. Michael Nielsen, Neural Networks and Deep Learning, Determination Press, 1st Edition, 2015.

**L: 45; P:30 TOTAL: 75 PERIODS**

| **Course Code** | **COMPUTER VISION** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC24E** | | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

CO1: Explore the goals of computer vision and methods of image formation.

CO2: Realize the fundamental image processing techniques of computer vision.

CO3: Explore the computational methods on digital images.

CO4: Extract features form Images and do analysis of Images.

CO5: Elaborate understanding on object detection techniques.

**CO1: Explore the goals of computer vision and methods of image formation.** **L:9**

Introduction to Computer Vision - Goals of Computer Vision - Image Formation and Radiometry -Image formation- Radiometric quantities - Shape from shading - Photometric stereo-2D transformations- 3D transformations- Single camera setup of image formation - Image formation in a stereo vision setup - Basics of stereo correspondence-Inverse Radon transform- back-projection method - Inverse Radon transform - Fourier transform method.

**CO2: Realize the fundamental image processing techniques of computer vision.**

Fundamentals-Point operations-Geometric operations-Spatial operations-Operations between images-Discrete Fourier transform - Discrete cosine transform - K-L transform-Wavelet transform-Curvelet transform - Ridgelet transform- Shearlet transform-Contourlet transform- Spatial domain filtering-Frequency domain filteringHomomorphicfiltering-Wiener filter for image restoration-Colour models-Colour constancy-Colour image **L:9**

enhancement and filtering

**CO3: Explore the computational methods on digital images**. **L:9**

Mathematical Morphology - Binary morphological operations- Applications of binary morphological operations - Grayscale morphological operations - Distance transformation - Image Segmentation – Threshold - Region-based segmentation methods-Edge detection-based segmentation - Deformable models for image segmentation – Image Segmentation Applications

**CO4: Extract features form Images and do analysis of Images.** **L:9**

Image Descriptors and Features - Texture Descriptors - Texture representation methods - Gabor filter - MPEG-7 homogeneous texture descriptor- Local binary patterns - Colour Features - Edge Detection- Gradient-based methods-Laplacian of Gaussian operator-Difference of Gaussian operator- Canny edge detector- Hough transform for detection of a line and other shapes- Chain code and shape number - Fourier descriptors - Boundary representation by B-spline curves- SUSAN edge and corner point detector - Moravec corner detector- Feature extraction applications

**CO5: Elaborate understanding on object detection techniques.** **L:9**

Introduction - Linear Regression - Linear discriminant functions for pattern classification - Minimum distance classifier - Elementary Statistical Decision Theory - Gaussian Classifier - Parametric approaches - Non-parametric approaches - Clustering for Knowledge Representation-Dimension Reduction – Unsupervised,Supervised - Semi-supervised linear dimension reduction - Finding patterns in an image - Shape similarity measurement by Hausdorff distance-Object recognition applications.

**TEXT BOOKS**

1. M.K.Bhuyan, “Computer Vision and Image Processing: Fundamentals an Applications”, CRC Press, 2nd Edition, 2020.
2. R. C. Gonzalez, R. E. Woods. Digital Image Processing. Addison Wesley Longman, Pearson Education, 4th Edition, 2018.
3. Richard Szeliski, Computer Vision: Algorithms and Applications (CVAA). Springer, 2016.

**REFERENCES**

1. Sonka, Hlavac, and Boyle. Thomson, “Image Processing, Analysis, and Machine Vision”, Cengage Learning, 4th Edition, 2017.
2. D. Forsyth and J. Ponce, “Computer Vision - A modern approach”, Pearson Education, Inc., 2nd Edition, 2015.
3. B. K.P. Horn, “Prentice Hall Robot Vision”, McGraw-Hill, 1st Edition, 2015.

**L: 45; TOTAL: 45 PERIODS**

| **Course Code** | **MEDICAL IMAGE PROCESSING** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC25E** | | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

CO 1: Describe the Medical image fundamentals and its reconstruction

CO 2: Describe medical image formats and its processing

CO 3: Discuss the image registration and visualization

CO 4: Classify the medical image segmentation procedures

CO 5: Explain ultrasound, PET and SPECT imaging methods

**CO 1: Describe the Medical image fundamentals and its reconstruction** **L:9**

Introduction to medical imaging technology, systems, and modalities. Brief history; importance; applications; trends; challenges. Medical Image Formation Principles: X-Ray physics; X-Ray generation, attenuation, scattering; dose Basic principles of CT; reconstruction methods; artifacts; CT hardware. Magnetic Resonance Imaging (MRI), Mathematics of MR; spin physics; NMR spectroscopy; imaging principles and hardware.

**CO 2: Describe medical image formats and its processing** **L:9**

Medical Image Storage, Archiving and Communication Systems and Formats Picture archiving and communication system (PACS); Formats: DICOM Radiology Information Systems (RIS) and Hospital Information Systems (HIS). Medical Image Processing, Enhancement, Filtering Basic image processing algorithms Thresholding; contrast enhancement; SNR characteristics; filtering; histogram modelling.

**CO 3: Discuss the image registration and visualization**

Rigid body visualization, Principal axis registration, Interactive principal axis registration, Feature based registration, Elastic deformation based registration, Medical image fusion, Image visualization –2D display methods, 3D display methods, virtual reality based interactive visualization. Image artifacts. **L:9**

**CO 4: Classify the medical image segmentation procedures**

Medical Image Segmentation - Histogram-based methods; Region growing and watersheds; Markov Random Field models; active contours; model-based segmentation. Multi-scale segmentation; semi-automated methods; clustering-based methods; classification-based methods; atlas-guided approaches; multi-model segmentation. Medical Image Registration,Intensity-based methods; cost functions; optimization techniques. **L:9**

**CO 5: Explain ultrasound, PET and SPECT imaging methods** **L:9**

PET and SPECT Ultrasound Imaging methods; mathematical principles; resolution; noise effect; 3D imaging; positron emission tomography; single photon emission tomography; ultrasound imaging; applications. Medical Image Search and Retrieval Current technology in medical image search, content-based image retrieval, new trends: ontologies. Applications. Other Applications of Medical Imaging Validation, Image Guided Surgery, Image Guided Therapy, Computer Aided Diagnosis/Diagnostic Support Systems.

**TEXT BOOKS**

1. Atam P.Dhawan, “Medical Image Analysis”, Wiley Interscience Publication, NJ, USA 2003.
2. Paul Suetens, "Fundamentals of Medical Imaging", 2nd Edition, Cambridge University

Press, 2009.

**REFERENCE BOOKS**

1. J.Michael Fitzpatrick and Milan Sonka, "Handbook of Medical Imaging, Medical Image Processing and Analysis", SPIE Publications, Volume 2, 2009.
2. Kayvan Najarian and Robert Splinter, "Biomedical Signal and Image Processing", 2nd Edition, CRC Press, 2005.
3. Geoff Dougherty, "Digital Image Processing for Medical Applications", 1st Edition, Cambridge University Press, 2009.
4. Jerry L. Prince and Jonathan Links, "Medical Imaging Signals and Systems", 1st Edition, prentice Hall, 2005.
5. John L. Semmlow, "Biosignal and Medical Image Processing", 2nd Edition, CRC Press, 2008.

**L: 45; TOTAL: 45 PERIODS**

| **Course Code** | **RF MEASUREMENTS** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC26E** | | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

CO1: Interpret core RF parameters and assess mismatch effects in transmission lines.

CO2: **Apply** RF network and power measurement techniques with attention to error sources and detector characteristics.

CO3: Identify and utilize RF passive and active components in practical measurement setups.

CO4: Outline the process of using network analyzers for S-parameter measurement and calibration.

CO5: **Describe** RF spectra and noise characteristics to evaluate overall RF system performance using modern instrumentation.

**CO1: Interpret the core RF parameters and assess mismatch effects in transmission lines.** **L:9**

Basic RF system parameters- Characteristic impedance of transmission lines- Reflection coefficient and its physical interpretation-Voltage Standing Wave Ratio (VSWR) and measurement techniques-Return loss and mismatch loss- Wavelength and frequency relationships in RF domain-Decibel notation: gain, loss, and power level representation-Transmission line behavior at high frequencies – practical considerations.

**CO2: Apply RF network and power measurement techniques with attention to error sources and detector characteristics.** **L:9**

Basics of network analysis: linear vs. non-linear systems-Network principles and practical applications-Measurement errors: sources, modeling, and mitigation- Fundamentals of power measurements: average power, peak power-Units of power measurement (dBm, dBW, mW)-Detectors: thermal detectors, diode detectors and bolometers – characteristics and operating ranges, Measurement accuracy and uncertainty-Demonstration and operation of RF power meters and detectors.

**CO3: Identify and utilize RF passive and active components in practical measurement setups.** **L:9**

Overview of RF measurement test setups- Passive components: RF cables, Attenuators, Power splitters, Directional Couplers-Active components: RF amplifiers, Mixers, Local oscillators (LO)-Impedance matching techniques- Signal routing principles- Calibration basics for RF measurement chains-Influence of component characteristics on measurement precision.

**CO4: Outline the process of using network analyzers for S-parameter measurement and calibration.** **L:9**

Vector Network Analyzer (VNA)-principle-architecture-Calibration techniques: SOLT, TRL, - limitations- Interpretation of S-parameters- Frequency sweep - power sweep measurements-Smith chart: impedance transformation- matching analysis, and measurement interpretation-Measurement uncertainty -Error correction models and calibration verification.

**CO5: Describe RF spectra and noise characteristics to evaluate overall RF system performance using modern instruments.** **L:9**

Noise sources- Noise power- SNR, SINAD, Noise Figure (NF)- Noise Temperature- Spectrum analyzer: fundamentals- Superheterodyne architecture- Functional block diagram- Input attenuation and reference level-Resolution bandwidth (RBW)- video bandwidth (VBW), sweep time, and span relationships-Detector modes and selectivity-Zero-span operation - time-domain measurements-Performance evaluation of RF systems through spectrum analysis.

**TEXT BOOKS:**

1. Hemant Kumar, E. S. Gopi, "RF, Microwave and Millimeter Wave Technologies", Springer Cham, 2024.
2. Michael Steer, "Fundamentals of Microwave and RF Design", The University of North Carolina Press, 2019.

**REFERENCES:**

1. David M.Pozar, "Microwave Engineering", fifth edition, Wiley, 2024.
2. Valeria Teppati, Andrea Ferrero, Mohamed Sayed "Modern RF and Microwave Measurement Techniques" Cambridge University Press, 2013.

**L:45; TOTAL: 45 PERIODS**

| Course Code | SMART ANTENNAS | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC27E | | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

CO1: Describe the fundamental antenna parameters and the basic concepts of cellular communication.

CO2: Summarize the smart antenna concepts used across broad frequency ranges.

CO3: Outline the principles and basic algorithms involved in direction-of-arrival estimation in antenna arrays.

CO4: Discuss the fundamental ideas and practical challenges related to beamforming techniques.

CO5: Interpret how multi-antenna techniques improve signal quality in modern wireless communication systems.

**CO1: Describe the fundamental antenna parameters and the basic concepts of cellular communication** **L:9**

Introduction and basics of mobile radio propagation, free-space propagation model, link budget design, propagation models, types of small-scale fading, statistical models for multipath propagation. Antennas for Mobile Communication: Mean effective gain, Human body interactions and specific absorption rate, mobile satellite antennas, Macrocell antennas, microcell antennas, Picocell antennas, femtocell antennas, space diversity antennas.

**CO 2 Summarize the smart antenna concepts used across broad frequency ranges** **L:9**

Need for smart antennas, standards for smart antennas, types of smart antennas, features and benefits, architecture, advantages and disadvantages of smart antennas, introduction to orthogonal signals, signal propagation: multipath and co-channel Interference.

**CO3: Outline the principles and basic algorithms involved in direction-of-arrival estimation in antenna arrays** **L:9**

DOA Estimation Fundamentals: Introduction, Array Response Vector, Received Signal Model, Subspace-Based Data Model, Signal Auto-covariance, Conventional DOA Estimation Methods, Conventional Beam forming Method, Capon's Minimum Variance Method, Subspace Approach to DOA Estimation, MUSIC Algorithm, ESPRIT Algorithm, Uniqueness of DOA Estimates.

**CO4 Discuss the fundamental ideas and practical challenges related to beamforming techniques** **L:9**

Fundamentals of beamforming, Types of beamforming, Beamforming techniques, DOA-assisted beamforming, Beamforming in MIMO and Massive MIMO, Performance measures, Practical considerations: RF chain limitations, calibration, phase errors.

**CO5: Interpret how multi-antenna techniques improve signal quality in modern wireless communication systems** **L:9**

MIMO Antennas Introduction, Multiple-Antenna MS Design, RAKE Receiver Size, Mutual Coupling Effects, Dual-Antenna Performance Improvements, Downlink Capacity Gains, Principles of MIMO systems: SISO, SIMO, MISO,MIMO, Hybrid antenna array for mmWave massive MIMO: Massive Hybrid Array Architectures, Hardware Design for Analog Subarray.

**TEXT BOOKS:**

1. Constantine A. Balanis & Panayiotis I. Ioannides, "Introduction to Smart Antennas", Morgan & Claypool Publishers' series-2007
2. Ahmed El Zooghby, 'Smart Antenna Engineering', ARTECH HOUSE, INC, 2005
3. J.D. Krauss, "Antennas for all applications", 3rd edition, by, TMH, 2002.
4. Praveen Kumar Malik, Pradeep Kumar, Sachin Kumar, Dushyant Kumar Singh, "Smart Antennas: Recent Trends in Design and Applications", Bentham Books, 2021.

**REFERENCE BOOKS:**

1. Lal Chand Godara, "Smart Antennas", CRC Press, LLC-2004
2. F.B.Gross - Smart Antennas for Wireless Communications, McGraw-Hill., 2005.

3. J.D.Kraus and Ronald J Marhefka - Antennas For all Applications, TMH, 2003

**L:45; TOTAL: 45 PERIODS**

| Course Code | 5G AIR INTERFACE | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC28E | | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

CO1: Utilize the design requirement and fundamental concept of 5G NR in air interface design.

CO2: Employ propagation behaviours, stochastic and geometry-based channel models in 5G PHY layer design.

CO3:Evaluate NR waveform design requirements and implement OFDM with appropriate numerologies to mitigate impairment.

CO4: Use multi-antenna techniques, beamforming and MIMO, to improve NR link performance and beam management.

CO5: Apply 5G FEC techniques using LDPC and Polar codes to enhance reliability in SISO and MIMO communication systems.

**CO1: Utilize the design requirement and fundamental concept of 5G NR in air interface design.** **L:9**

5G NR Access Technology, Standardization, Spectrum, use cases, NR PHY key technology components, physical time-frequency resources, physical channels, physical signals, Duplexing scheme, frame structure

**CO2: Employ propagation behaviours, stochastic and geometry-based channel models in 5G PHY layer design.** **L:9**

Propagation fundamentals – Scattering & absorption, Propagation channel characterization – Frequency delay domain, doppler time domain, directional domain, Measurements – transmission loss, delay domain & directional domain measurements, 5G stochastic channel models, Geometry based modeling

**CO3: Evaluate NR waveform design requirements and implement OFDM with appropriate numerologies to mitigate impairment.** **L:9**

Waveform design requirement for 5G NR, KPI for NR waveform design, frequency localization, baseband complexity, power efficiency, suitability of OFDM for NR, 15kHz baseline numerology & scaling, OFDM numerology implementation, Improving power efficiency of NR waveform, effects of synchronization errors, impairment mitigation

**CO4: Use multi-antenna techniques, beamforming and MIMO, to improve NR link performance and beam management.** **L:9**

Role of multiantenna techniques in NR, beamforming, precoding, diversity, spatial multiplexing, antenna array architectures, UE antennas, massive MIMO, CSI Acquisition, Downlink & Uplink MIMO transmission, beam management, beam forming gain, beam tracking

**CO5: Apply 5G FEC techniques using LDPC and Polar codes to enhance reliability in SISO and MIMO communication systems.** **L:9**

Fundamental Limits of FEC, FEC schemes for Bi-AWGN Channel, LDPC codes, Polar codes, Coding schemes for the short block length regime, coding schemes for SISO & MIMO case

**TEXT BOOKS:**

1. Ali Zaidi, Fredrik Athley, Jonas Medbo, Ulf Gustavsson, Giuseppe Durisi and Xiaoming Chen, "5G Physical Layer Principles, Models and Technology Components", Academic Press, Elsevier. 2018.

**REFERENCE BOOKS**

1. Tzi-Dar Chiueh and Pei-Yun Tsai, "OFDM Baseband Receiver Design for Wireless Communications", John Wiley & Sons (Asia), 2007.
2. Aditya K. Jagannatham, Principles of Modern Wireless Communication Systems, McGraw Hill Education, First Edition, 2018.
3. Afif Osseiran, Jose F. Monserrat, Patrick Marsch, ―5G Mobile and Wireless Communications Technology‖, Cambridge University Press, 2016.
4. Yunlong Cai, Zhijin Qin, Fangyu Cui, Geoffrey Ye Li, and Julie A. McCan, ―Modulation and Multiple Access for 5G Networks‖, IEEE Communications Surveys & Tutorials, Vol. 20, No. 1, pp.629-646, Oct 2017.
5. Shah, A. S., Qasim, A. N., Karabulut, M. A., Ilhan, H., & Islam, M. B. (2021). Survey and performance evaluation of multiple access schemes for next-generation wireless communication systems. IEEE Access, 9, 113428-113442.
6. Banelli, Paolo, et al. "Modulation formats and waveforms for 5G networks: Who will be the heir of OFDM?:An overview of alternative modulation schemes for improved spectral efficiency" IEEE Signal Processing Magazine 31.6 (2014): 80-93.

**L:45; TOTAL: 45 PERIODS**

| **Course Code** | **6G COMMUNICATION CONCEPTS** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC29E** | | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

CO1: Analyze 6G evolution, KPIs, architecture, spectrum, and challenges to apply system-level design considerations.

CO2: Apply time-frequency analysis to analyze OTFS waveform behavior in static and time-varying channels.

CO3:Employ OTFS receiver architectures to analyze equalization, MAP decoding, and delay-Doppler channel estimation.

CO4: Utilize power-domain NOMA concepts to analyze its performance in the presence of MIMO, Cooperative and OTFS links.

CO5: Apply AI-driven PHY techniques to analyze integrated communication, sensing, and ML-based joint coding.

**CO1 : Analyze 6G evolution, KPIs, architecture, spectrum, and challenges to apply system-level design considerations.** **L:9**

Evolution of mobile communication, 6G KPIs and Use Cases, 6G Network considerations & requirements, 6G system architecture, 6G standardization,

Challenges in 6G, Design Issues in 6G, RF & Optical Spectrum.

**CO2 : Apply time-frequency analysis to analyze OTFS waveform behavior in static and time-varying channels.** **L:9**

Mathematical foundations to time-frequency analysis, time-frequency foundations, linear-time varying channel, waveform design in Gabor setting, revisit of OFDM & its variants, OTFS signal generation, OTFS as OFDM with time interleaving, Performance in AWGN channel, Performance in time varying wireless channel.

**CO3: Employ OTFS receiver architectures to analyze equalization, MAP decoding, and delay-Doppler channel estimation.** **L:9**

Receiver Structure for OTFS, MAP decoding, Factor Graph Description, Equalization Algorithm, LMMSE receiver design for OTFS, Delay doppler channel estimation, time domain channel and equalization

**CO4 : Utilize power-domain NOMA concepts to analyze its performance in the presence of MIMO, Cooperative and OTFS links.** **L:9**

Power domain NOMA, Power allocation, successive interference cancellation, achievable rate, NOMA in MIMO, cooperative NOMA, Delay Doppler Power Domain NOMA OTFS – Power allocation schemes, link level performance

**CO5: Apply AI-driven PHY techniques to analyze integrated communication, sensing, and ML-based joint coding.**

Fundamental & Distributed AI, Dynamic Bayesian Network Theory, Intelligent Air Interface Framework, Joint Source and Channel Coding based on ML, 6G PHY network coding Integrated Terrestrial and Non-Terrestrial Communication, Integrated Sensing and Communication, Introduction to semantic communication. **L:9**

**TEXT BOOKS:**

1. Suvra Sekhar Das and Ramjee Prasad, "OTFS: Orthogonal Time Frequency Space Modulation A Waveform for 6G", River Publishers, 2021.
2. Wen Tong and Peiying Zhu, "6G: The Next Horizon from Connected People and Things to Connected Intelligence", Cambridge University Press, 2021.

**REFERENCE BOOKS:**

1. Ramjee Prasad, Anand Raghawa Prasad, Albena Mihovska, and Nidhi, "6G Enabling Technologies New Dimensions to Wireless Communication", River Publishers, 2022.
2. Jonathan Rodriguez, Christos Verikoukis, John S. Vardakas and Nikos Passas, "Enabling 6G Mobile Networks", Springer, 2022.
3. Xianzhong Xie, Bo Rong and Michel Kadoch, "6G Wireless Communications and Mobile Networking", Bentham Books imprint, 2021.

**L:45; TOTAL: 45 PERIODS**

| Course Code | COGNITIVE RADIO AND COOPERATIVE | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC30E | COMMUNICATION | 3 | 0 | 0 | 0 | 3 |

## COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

CO1: Explain the basic concepts of cognitive radio and software defined radio systems.

CO2: Analyze spectrum sensing, sharing and management techniques for cognitive radio applications.

CO3: Describe cooperative communication concepts and relay protocols

CO4: Apply cooperation techniques for spectrum sharing and resource allocation in cognitive radio networks.

CO5: Assess advanced cooperative strategies and secure communication.

**CO 1: Explain the basic concepts of cognitive radio and software defined radio systems.** **L:9**

Introduction to spectrum scarcity and dynamic spectrum access needs-Software Defined Radio (SDR) concepts and reconfigurable radio architecture-Cognitive Radio system model, cognitive cycle- Primary users and Secondary users concept, Simple interference models-Dynamic spectrum access models, interweave, underlay, overlay- Basic regulatory concepts for spectrum sharing. **L:9**

**CO2 :Analyze spectrum sensing, sharing and management techniques for cognitive radio applications**

Spectrum sensing fundamentals: hypothesis testing, detection and false alarm probabilities. Energy detection method, Matched filter detection basics, cyclostationary feature detection, Cooperative sensing: centralized vs distributed, hard and soft combining rules. Spectrum sharing models, power control, and interference temperature concept. Dynamic spectrum allocation and spectrum handoff mechanisms.

**CO3:Describe cooperative communication concepts and relay protocols**Introduction to cooperative communication and relay channel models, Relaying strategies: Amplify-and-Forward (AF), Decode-and-Forward (DF), SDR based relay implementation and reconfigurable relay architecture, Cooperative diversity, outage probability, and error performance analysis, Relay selection criteria and distributed cooperation. **L:9**

**CO4 :Apply cooperation techniques for spectrum sharing and resource allocation in cognitive radio networks.** **L:9**

Integration of cooperative communication into cognitive radio networks, Cooperative spectrum sensing and data fusion among cognitive users, Primary–secondary cooperation and spectrum leasing models, Cooperative MAC and routing protocols for CRNs, Joint power and bandwidth allocation strategies for cooperative users.

**CO5: Assess advanced cooperative strategies and secure communication.** **L:9**

Multi-relay network optimization and distributed cooperation, Game-theoretic and auction-based cooperative spectrum sharing, SDR security threats: spectrum sensing attacks, primary user emulation, Security mechanisms for SDR platforms and cognitive radio networks, Energy-efficient cooperative network designs, Security and trust management in cooperative networks. Machine learning for cooperative decision making. Case Study- Future research directions in cooperative wireless and 6G networks.

**TEXT BOOKS:**

1. Linda Doyle, Software Defined Radio: Architectures, Systems and Functions, Wiley, 2024.
2. Ying-Chang Liang et al, Cognitive Radio Networks: From Theory to Practice, Springer, 2020.

**REFERENCES:**

1. Bin Cao, Xiang Cheng, and Lu Wang, 'Cooperative Cognitive Radio Networking', Springer Briefs, 2016.
2. Hüseyin Arslan, "Cognitive Radio Communications and Networks", Academic Press, 2019.
3. 'Handbook of Cognitive Radio', Springer, 2019.

**L:45; TOTAL: 45 PERIODS**

| Course Code | WEARABLE ELECTRONICS | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC31E | | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

CO1: Describe the key components, materials, and design principles of wearable electronic devices.

CO2: Identify the materials, fabrication methods, and mechanical properties of flexible and stretchable electronics for wearable applications.

CO3: Analyze and apply energy-harvesting techniques to develop self-powered wearable systems with efficient power management.

CO4: Assess the physiological and ergonomic impacts of wearable devices on human users.

CO5: Integrate wearable robotics, networking protocols, and sustainability concepts to design innovative and eco-friendly wearable systems.

**CO1: Describe the key components, materials, and design principles of wearable electronic devices.** **L:9**

Introduction - significance of wearable electronics- Miniaturization trends and comparison with traditional electronics- Key hardware components: sensors, microcontrollers, wireless modules, and power units- Flexible, stretchable, and conductive materials for wearables- System integration challenges: durability, washability, and user comfort-Power management and energy harvesting basics- Signal acquisition, processing, and wireless communication protocols-Regulatory and safety standards.

**CO2: Identify the materials, fabrication methods, and mechanical properties of flexible and stretchable electronics for wearable applications.** **L:9**

Introduction to flexible, stretchable, and printable electronics- Materials including organic semiconductors, conductive polymers, and nanomaterials- Fabrication techniques and mechanical characterization- Biocompatibility and ergonomic considerations for long-term wear- Challenges and opportunities in flexible wearable device design.

**CO3: Analyze and apply energy-harvesting techniques to develop self-powered wearable systems with efficient power management.** **L:9**

Battery limitations - need for self-powered devices- Energy harvesting materials and mechanisms: photovoltaic, piezoelectric, thermoelectric- Design and integration of energy harvesters into wearable systems-Case studies: smart rings and contactless RF-powered devices.

**CO4: Assess the physiological and ergonomic impacts of wearable devices on human users.** **L:9**

Introduction to Intelligent Wearables -Risks of Intelligent Wearables: health effects, data privacy issues, safety hazards, device performance reliability, environmental concerns, social and psychological implications-EMF Exposure from Wearables-Safety Guidelines for Wearables: international standards and regulations, Specific Absorption Rate (SAR) compliance, best practices for safe usage-Case Studies.

**CO5: Integrate wearable robotics, networking protocols, and sustainability concepts to design innovative and eco-friendly wearable systems.** **L:9**

Wearable robotics and implantable therapeutic systems. MINDS framework: Miniaturization, Intelligence, Networking, Digitization, Standardization. Wireless networking protocols (BLE, NFC, IoT). Environmental sustainability.

**TEXT BOOKS:**

1. Xiaoming Tao, "Wearable Electronics and Photonics", 3rd Edition, Woodhead Publishing Series in textiles, 2023.
2. Yong Zhu, Nanshu Lu, Mechanics of Flexible and Stretchable Electronics", Wiley, September 2024.

**REFERENCE BOOKS:**

1. Yukang Xue, "A review on Intelligent Wearables: Uses and Risks", Wiley 2019.
2. Gabriel Glynn, Mark Frederick, Tom West, "Safety and Wearable Technology Impact, Applications, and Implementation in Industry", 1stEdition, CRC Press, 2025.

**L:45; TOTAL: 45 PERIODS**

| Course Code | DESIGN AND SIMULATION OF RF CIRCUITS | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC32E | AND COMPONENTS | 2 | 0 | 2 | 0 | 3 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

CO1: Explain the behavior of passive components at RF frequencies.

CO2: Design impedance matching network using lumped and distributed components.

CO3: Analyze the performance of high-frequency components.

CO4:Design and analyze RF oscillators and VCOs.

CO5: Identify system-level requirements of RF transceivers and describe the role of sub-blocks.

**Practical Component:**

CO6: Measure and interpret S-parameters to assess the performance of RF matching networks.

CO7: Design and model power dividers and couplers using EM simulation software.

CO8: Design and simulate RF oscillators and VCOs to analyze their performance.

**CO1: Explain the behavior of passive components at RF frequencies.** **L:9**

Introduction to RF systems and applications – RF spectrum – Microwave bands – RF behavior of passive components – Tuned resonant circuits – Vector representation – Inductors and capacitors at RF – Voltage and current behavior in capacitor circuits – Tuned RF/IF transformers.

**CO2: Design impedance matching network using lumped and distributed components.** **L:9**

Design of matching networks using lumped elements – Design rules for matching networks – Impedance transformation using lumped components – L, T, and Pi matching networks – Microstrip matching networks – Quarter-wave impedance transformer.

**CO6: Measure and interpret S-parameters to assess the performance of RF matching networks.** **P:3**

1. Design and Simulation of L-Network Matching Using EM Tools
2. Design and Simulation of T- and Pi-Network Matching Using EM Tools
3. Design and Simulation of Microstrip and Quarter-Wave Transformer Matching Networks

**CO3: Analyze the performance of high-frequency components.** **L:9**

Power dividers and couplers – Basic properties – Design aspects of power dividers – Wilkinson power divider – Even–odd mode analysis of Wilkinson divider – Quadrature (90°) hybrid coupler – High-frequency filters – Filter phase function – Linear-phase filters – Insertion-loss method – Filter transformations – Stepped-impedance filter design.

**CO7: Design and model power dividers and couplers using EM simulation software.** **P:3**

1. Design and Simulation of Wilkinson Power Divider Using EM Tools
2. Design and Simulation of Quadrature (90°) Hybrid Coupler Using EM Tools

**CO4: Design and analyze RF oscillators and VCOs.**

Basic principles of RF oscillators – Cross-coupled oscillator architecture – Three-point oscillators – Voltage-controlled oscillators (VCOs) – LC VCOs with wide tuning range – Phase noise fundamentals – VCO design procedures – LO interfacing techniques – Mathematical modeling of VCOs – Quadrature oscillator design. **L:9**

**CO8: Design and simulate RF oscillators and VCOs to analyze their performance.**

1. Design and Simulation of LC and Cross-Coupled Oscillators **P:3**
2. Design and Simulation of Voltage-Controlled Oscillators (VCOs)

**CO5: Identify system-level requirements of RF transceivers and describe the role of sub-blocks.**

System-Level Considerations – Receiver, Transmitter, Frequency Synthesizer, Frequency Planning. Receiver Design - LNA Design, Mixer Design, AGC. TX Design- PA Design, Upconverter. Synthesizer Design- VCO Design, Divider Design, Loop Design. **L:9**

**TEXT BOOKS:**

1. Behzad Razavi, RF Microelectronics, 3rd Edition, Pearson Education, 2022.
2. George D. Vendelin, “Microwave Circuit Design using Linear and Nonlinear Techniques”, 3rd Ed., Wiley, 2021.
3. Thomas H. Lee, The Design of CMOS RF Integrated Circuits, 3rd Edition, Cambridge University Press, 2010.

4. Reinhold Ludwig and Pavel Bretchko, RF Circuit Design: Theory and Applications, 2nd Edition, Pearson Education, 2000.

**REFERENCE BOOKS:**

1. David M. Pozar, Microwave Engineering, 4th Edition, John Wiley & Sons, 2012.
2. Robert H. Caverly, CMOS RFIC Design Principles, 1st Edition, Artech House, 2016.

**L:30; P:30;TOTAL: 60 PERIODS**

| **Course Code** | **RADAR SYSTEM DESIGN** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC33E** | | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

CO1: Classify radar system components and understand their principles, applications, and architecture

CO2: Identify the technologies used to extend the range of radar systems

CO3 Analyze various radar signal processing techniques.

CO4 Describe the principles of radar detection theory for minimizing false alarm probability.

CO5 Analyze advanced radar system configurations and assess their effectiveness.

**CO1 Classify radar system components and understand their principles, applications, and architecture** **L:9**

Fundamentals of Radar Systems-Introduction to radar systems, Importance and applications of radar, Basic principles of radar operation. Radar transmitters and receivers, Antenna systems, Signal processing, Display and control systems, Radar System Architecture- ADC, DAC and OCXO.

**CO2: Identify the technologies used to extend the range of radar systems** **L:9**

CW Radar Mathematical model and applications, Pulsed radar, Pulsed Doppler, Tacking radar, Search radar and search radar, MTI filter

**CO3 Analyze various radar signal processing techniques.**

Pulse compression, Doppler processing, Clutter rejection, Target tracking algorithms. **L:9**

**CO4 Describe the principles of radar detection theory for minimizing false alarm probability.**

Detection in radar receiver –Matched Filler Receiver, Correlation Detection, Detection Criteria, Detector Characteristics, Performance of the Radar Operator, Automatic Detection, Constant-False-Alarm-Rate (CFAR) Receiver **L:9**

**CO5 Analyze advanced radar system configurations and assess their effectiveness.** **L:9**

Range and Doppler resolution, Signal-to-noise ratio, Monostatic and bistatic radar configurations, phased array systems, and Design and implementation ECCM features in Radar

**TEXTBOOKS**

1. Merrill Ivan Skolnik"Introduction to Radar Systems", Tata McGraw Hill Edition, 2nd Edition, 2007.
2. B.R.Mahafza "Radar Systems Analysis and Design using MATLAB", CRC Press, 3rd Edition, 2013.
3. S.M.Sherman and D.K.Barton"Monopulse Principles and Techniques", Artech house, 2011.

**REFERENCE BOOKS**

1. M.A.Richards"Fundamentals of Radar Signal Processing", Tata McGraw Hill edition, 2nd Edition 2013.
2. H.M. Jolt"Ground Penetrating Radar: Theory and Applications", Elsevier, 2020.

**L:45; TOTAL: 45 PERIODS**

| Course Code | INTRODUCTION TO MEMS | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC34E | | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES**

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

CO1: Develop electrical and mechanical model of MEMS and understand materials and fabrication aspects of MEMS and Microsystems

CO2: Analyze the mechanics of MEMS design

CO3: Analyze electrostatic model and circuit issues in MEMS

CO4: Explain the general concept and applications of MEMS

CO5: Illustrate the concepts of Optical and RF MEMS

**CO1: Develop electrical and mechanical model of MEMS and understand materials and fabrication aspects of MEMS and Microsystems.** **L:9**

MEMS and Microsystems, Miniaturization, Typical products, Micro sensors, Micro actuation, MEMS with micro actuators, Microaccelorometers and Micro fluidics, MEMS Materials: Substrates and Wafers, Active substrate materials, Silicon, Silicon compounds, Silicon Piezoresistors, Gallium Arsenide, Quartz, Polymers, Packaging materials, Micro fabrication-Substrate, wafer cleaning, Pattern transfer.

**CO2: Analyze the mechanics of MEMS design.** **L:9**

Elasticity, Stress, strain and material properties, Bending of thin plates, Spring configurations, torsional deflection, Mechanical vibration, Resonance, Thermo mechanics – actuators, force and response time, Fracture and thin film mechanics.

**CO3: Analyze electrostatic model and circuit issues in MEMS.** **L:9**

Electrostatic Actuators: charge control, voltage control, spring suspended C, pull-in voltage, linearization methods, comb drive actuators, levitation, equivalent circuits, Piezoelectric, Thermal, Magnetic actuators, gap closers, rotary finger pull up, inch worms, Electronics Interface, Feedback systems, Noise, circuit and system issues.

**CO4: Explain the general concept and applications of MEMS** **L:9**

Scaling issues for MEMS- Scaling issues of Physical systems, Computational issues, Fabrication issue, and Material issue. Design rules: Manufacturing issues and design rule checking. MEMS systems in industrial and automotive applications- Sensors and

analysis systems, Case studies – Capacitive accelerometer, Peizo electric pressure sensor, Microfluidics for Biological application, Microelectrode arrays, CAD for MEMS.

**CO5: Illustrate the concepts of Optical and RF MEMS** **L:9**

Optical MEMS, - System design basics – Gaussian optics, matrix operations, resolution. Case studies- MEMS scanners and retinal scanning display, Digital Micro mirror devices. RF Mems – design basics, case study – Capacitive RF MEMS switch, performance issues, Case Study: Micro machined Antennas, Micro strip antenna, Micromachining for antennas fabrication, Reconfigurable antennas

**TEXT BOOKS**

1. Stephen D Senturia, "Microsystems Design", Kluwer Academic Publishers Springer, 2016.
2. Nadim Maluf, "An Introduction to Micro Electro Mechanical System Engineering", Artech House, 2nd Edition, 2004.

**REFERENCES**

1. MEMS Devices", CRC press, Taylor & Francis group, Boca Raton, 2009.
2. Chang Liu, "Foundations of MEMS", Pearson Education, 2012.
3. Ai QunLiu,"Photonic -Based Sensors and Devices for Communications, Medical and Aerospace Applications", CRC press, Taylor & Francis, (2008).

**L: 45; TOTAL: 45 PERIODS**

| Course Code | ELECTRO MAGNETIC INTERFERENCE AND | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC35E | COMPATIBILITY | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES**

On the successful completion of the course, students will be able to
CO1: Describe EMI/EMC concepts to practical electronic design.
CO2: Discuss various EMI coupling principles.
CO3: Illustrate the fundamental concepts of EMI control with examples.
CO4: Describe the various standards and regulations.
CO5: Analyze EMI test methods and instrumentation.

**CO1: Describe EMI/EMC concepts to practical electronic design.** **L:9**

Introduction to EMI and EMC, Intra and inter system EMI, Elements of Interference, Sources and Victims of EMI, Conducted and Radiated EMI emission and susceptibility, Case Histories, Radiation hazards to humans, Various issues of EMC, EMC Testing categories, EMC Engineering Application.

**CO2: Discuss various EMI coupling principles.** **L:9**

Electromagnetic field sources and Coupling paths, Coupling via the supply network, Common mode coupling, Differential mode coupling, Impedance coupling, Inductive and Capacitive coupling, Radiative coupling, Ground loop coupling, Cable related emissions and coupling, Transient sources, Automotive transients.

**CO3: Illustrate the fundamental concepts of EMI control with examples.** **L:9**

Working principle of Shielding and Murphy's Law, LF Magnetic shielding, Apertures and shielding effectiveness, Choice of Materials for H, E, and free space fields, Gasketing and sealing, PCB Level shielding, Principle of Grounding, Isolated grounds, Grounding strategies for Large systems, Grounding for mixed signal systems, Filter types and operation, Surge protection devices, Transient protection.

**CO4: Describe the various standards and regulations.** **L:9**

Need for Standards, Generic/General Standards for Residential and Industrial environment, Basic Standards, Product Standards, National and International EMI Standardizing Organizations; IEC, ANSI, FCC, AS/NZS, CISPR, BSI, CENELEC, ACEC. Electro Magnetic Emission and susceptibility standards and specifications, MIL461E Standards.

**CO5: Analyze EMI test methods and instrumentation.** **L:9**

Fundamental considerations, EMI Shielding effectiveness tests, Open field test, TEM cell for immunity test, Shielded chamber , Shielded anechoic chamber, EMI test receivers, Spectrum analyzer, EMI test wave simulators, EMI coupling networks, Line impedance stabilization networks, Feed through capacitors, Antennas, Current probes, MIL -STD test methods, Civilian STD test methods.

**TEXT BOOKS**

1. Clayton Paul, "Introduction to Electromagnetic Compatibility", Wiley Interscience, 2006
2. V. Prasad Kodali, "Engineering Electromagnetic Compatibility", IEEE Press, Newyork, 2001.

**REFERENCES**

1. C.R.Paul, "Introduction to Electromagnetic Compatibility", John Wiley and Sons, Inc, Second Edition, 2006.
2. Bemhard Keiser, "Principles of Electromagnetic Compatibility", Artechhourse, Norwood, Third Edition, 1989.
3. Henry W.Ott. "Noise Reduction Techniques in Electronic Systems", A Wiley Inter Science Publications, John Wiley and Sons, New York, Second Edition, 1988.
4. Donald R. J. White, William G. Duff, "A Handbook Series on Electromagnetic Interference and Compatibility: Electrical noise and EMI specifications, Standards and Regulations", Don White Consultants, 1981.

**L: 45; TOTAL: 45 PERIODS**

| Course Code | MICROWAVE THEORY AND TECHNIQUES | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC36E | | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES**

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

CO1: Identify the essential characteristics of RF and Microwave transmission lines.

CO2: Explain various microwave network parameters and devices.

CO3: Describe the design of microwave circuit.

CO4: Describe the application based antenna system and measurement of network antenna parameter.

CO5: Explain different applications of microwave systems.

**CO1: Identify the essential characteristics of RF and Microwave transmission lines.** **L:9**

Introduction to Microwaves – History and Applications, Mathematical model of Microwave Transmission – Concept of mode, Characteristics of TEM, TE and TM modes, Losses associated with microwave transmission, Concept of impedance in microwave transmission, Analysis of RF and Microwave Transmission lines – Coaxial line, Rectangular waveguide, Circular waveguide, Microstrip line.

**CO2: Explain various microwave network parameters and devices.** **L:9**

Equivalent voltages and currents for non-TEM lines, Network parameters for microwave circuits, Scattering Parameters, Microwave Passive Components – Power divider, Resonator, Microwave Active Components – Oscillators, Mixers.

**CO3: Describe the design of microwave circuit.** **L:9**

Impedance transformation, Impedance matching, Microwave Filter design, RF and Microwave amplifier design, Microwave power amplifier design, Low noise amplifier design, Microwave Mixer and Oscillator design.

**CO4: Describe the application-based antenna system and measurement of network antenna parameter.** **L:9**

Microwave antenna parameters, Microwave antenna – Ground based systems, Airborne based systems, Satellite borne systems, Microwave planar antenna. Measurements – Network Analyzer and Measurement of scattering parameters, Spectrum Analyzer and Measurement of spectrum of a microwave spectrum of a microwave signal.

**CO5: Explain different applications of microwave systems.** **L:9**

Radar systems, Cellular phone, Satellite communication, RFID, GPS, Effect of Microwaves on human body, Medical and Civil applications of microwaves, EMI/EMC, MMIC, RF MEMS, Microwave Imaging.

**TEXT BOOKS**

1. David M. Pozar, "Microwave Engineering", Third Edition, Wiley India.
2. S.Ramo, J.R.Whinnery and T.V.Duzer, "Fields and Waves in Communication Electronics", Third Edition, Wiley India

**REFERENCES**

1. R.E.Collin, "Foundations for Microwave Engineering", 2nd Edition, IEEE Press.
2. Samuel Y Liao, “Microwave Devices and Circuits”, Pearson Education, 3rd Edition, 2003.
3. M. M. Radmanesh, “RF and Microwave Electronics illustrated”, Pearson Education, 2007.

**L: 45; TOTAL: 45 PERIODS**

| Course Code | ERROR CONTROL CODES | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC37E | | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES**

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

CO1: Understand linear algebra essential for channel coding.

CO2: Design a convolutional encoder and decoder for error control.

CO3: Comprehend error correction methods implemented in a digital communication system which involves convolution codes.

CO4: Design a Low Density Parity Check encoder and decoder for error control in 5G systems.

CO5: Design a Polar encoder and decoder for error control in 5G and beyond systems.

**CO1: Understand linear algebra essential for channel coding.** **L:9**

Types of codes, Modulation and coding, Maximum likelihood decoding, Types of error, error control strategy, Performance measures, Coded modulation, Groups, Fields, Binary field arithmetic, construction of Galois Field (GF), properties of GF, Computations using GF arithmetic, vector spaces, matrices, Case study: CRC Encoding and Decoding.

**CO2: Design a convolutional encoder and decoder for error control.** **L:9**

Encoding methods, Structural and distance properties, Catastrophic encoders, polynomial and rational encoders, constraint length and minimal encoders, systematic encoders, Optimum decoding, Implementation issues, add-compare-select method, decoding streams of data, output decisions, Hard and soft decoding, quantization, synchronization issues, asymptotic coding gain, puncturing.

**CO3: Comprehend error correction methods implemented in a digital communication system which involves convolution codes.** **L:9**

Burst-error-correcting codes, Single and Phased Burst-error-correcting codes, Bunds on Burst-error-correcting capability, Burst-error-correcting convolutional codes, Interleaved convolutional codes, Burst-and-Random-error-correcting convolutional codes, Basic Automatic-Repeat-Request (ARQ) schemes, Selective-Repeat ARQ, Hybrid ARQ, Hybrid ARQ systems using Convolutional codes.

**CO4: Design a Low Density Parity Check encoder and decoder for error control in 5G data channel.** **L:9**

LDPC codes, Tanner Graph, Geometric Construction, EG-LDPC and PG LDPC codes, decoding of LDPC codes, Code construction by column and row splitting, Breaking cycles in Tanner graph, Shortened finite geometry LDPC codes, Construction of Gallager LDPC codes, random LDPC codes, Irregular LDPC codes.

**CO5: Design a Polar encoder and decoder for error control in 5G control channel.** **L:9**

Introduction to Polar codes, Polar transform, Channel Polarlization, (n,k) Polar codes – Encoder, successive cancellation decoder, successive cancellation list decoding, fixed point quantization for successive cancellation decoder

**TEXT BOOKS**

1. Martin Tomlinson, Cen Jung Tjhai, Marcel A. Ambroze and Mohammed Ahmed Mubarak Jibril, "Error-Correction Coding and Decoding - Bounds, Codes, Decoders, Analysis and Applications", springer Open, 2017.
2. Shu Lin, Daniel J. Costello, "Error Control Coding: Fundamentals and Applications", 2nd Edition, Pearson, 2011.
3. W.Cary Huffman, "Fundamentals of Error-Correcting Codes", Cambridge University Press, June 2012.

**REFERENCES**

1. Juane Li, Shu Lin, Khaled Abdel-Ghaffar, William E. Ryan, and Daniel J. Costello, "LDPC CodeDesigns, Constructions, and Unification", Cambridge University Press, December 2016
2. R. M. Roth, Introduction to Coding Theory, Cambridge University Press, 2006.
3. Tood.K. Moon, "Error Correction Coding: Mathematical Methods and Algorithms", John Wiley 2005.
4. S.B. Wicker, "Error Control Systems for Digital Communication and Storage", Prentice-Hall 1995.

**L: 45; TOTAL: 45 PERIODS**

| Course Code | INFORMATION THEORY AND CODING | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC38E | | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES**

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

CO1: Comprehend fundamentals required for subsequent development of information theory.

CO2: Understand the compression of data without any loss in information using source coding techniques.

CO3: Describe various binary channels and analyze the channel capacity.

CO4: Understand the essentials of information theory for Gaussian channels.

CO5: Explain the basic concepts of rate distortion theory.

**CO1: Comprehend fundamentals required for subsequent development of information theory.** **L:9**

Entropy, Joint Entropy and Conditional Entropy, Relative Entropy and Mutual Information, Chain Rules for Entropy, Jensen‟s Inequality and its consequences, Log Sum Inequality and its applications, Data-Processing Inequality, Fano‟s Inequality, Markov Chains, Entropy Rate.

**CO2: Understand the compression of data without any loss in information using source coding techniques.** **L:9**

Kraft Inequality, Variable Length Codes, Prefix Codes, Optimal Codes, Bounds on the Optimal Code Length, Kraft Inequality for Uniquely Decodable Codes, Source Coding Theorem, Huffman Codes and its optimality, Shannon–Fano–Elias Coding, Arithmetic codes, Lempel Ziv codes, Run Length codes.

**CO3: Describe various binary channels and analyze the channel capacity.** **L:9**

Noiseless Binary Channel, Noisy Channel with Non overlapping Outputs, Binary Symmetric Channel, Binary Erasure Channel, Symmetric Channels, Properties of Channel Capacity, Channel Coding Theorem, Zero-Error Codes, Hamming Codes, Feedback Capacity, Source–Channel Separation Theorem.

**CO4: Understand the essentials of information theory for Gaussian channels.** **L:9**

Differential Entropy, AEP for Continuous Random Variables, Joint and Conditional Differential Entropy, Properties of Differential Entropy, Gaussian Channel, Converse to the Coding Theorem for Gaussian Channels, Band limited Channels, Parallel Gaussian Channels, Gaussian Channels with Feedback.

**CO5: Explain the basic concepts of rate distortion theory.** **L:9**

Quantization, Definitions, Calculation of the Rate Distortion Function – Binary function, Gaussian function, Simultaneous Description of Independent Gaussian Random Variables, Converse to the Rate Distortion Theorem, Strongly Typical Sequences and Rate Distortion, Characterization of the Rate Distortion Function, Computation of Channel Capacity and the Rate Distortion Function.

**TEXT BOOKS**

1. Thomas M. Cover, Joy A. Thomas, “Elements of Information Theory”, John Wiley & Sons, 2012.
2. Monica E. Borda, "Fundamentals in Information Theory and Coding", Springer, 2011.

**REFERENCES**

1. PredragIvanis, Dusan Drajic, "Information Theory and Coding - Solved Problems", Springer International Publishing, 2017.
2. A. B. Robert, Information Theory, Dover Special Priced Titles, 2007.
3. R. M. Roth, Introduction to Coding Theory, Cambridge University Press, 2006.
4. R. E. Blahut, Algebraic Codes for Data Transmission, Cambridge University Press, 2002.

**L: 45; TOTAL: 45 PERIODS**

| Course Code | CRYPTOGRAPHY AND NETWORK SECURITY | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC39E | | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES**

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

CO1: Describe the need for security and the various security techniques.
CO2: Explain the various symmetric and asymmetric key algorithms.
CO3: Apply suitable authentication functions to ensure authentication.
CO4: Analyze the different types of security services used in various applications.
CO5: Explain the solutions for security at the system level.

**CO1: Describe the need for security and the various security techniques.**

OSI Security Architecture - Security Goals - Types of Attacks - Passive attack, active attack - Security services – Overview of Cryptography - Classical Encryption techniques – Substitutional Ciphers, Transposition Ciphers – Steganography.

**CO2: Explain the various symmetric and asymmetric key algorithms.** **L**

Block Ciphers - Data Encryption Standard - Block Cipher Design Principles and Modes of Operation – Advanced Encryption Standard – Triple DES, Stream Cipher-RC4. Public Key Cryptography and RSA – Diffie-Hellman key Exchange.

**CO3: Apply suitable authentication functions to ensure authentication.** **L**

Authentication requirements – Authentication functions – Message Authentication Codes - Hash functions- SHA-1-Digital signatures: Digital signature standards - Entity Authentication: Biometrics, Key management Techniques.

**CO4:Analyze the different types of security services used in various applications** **L**

Authentication Applications: Kerberos – X.509 Authentication Service – Electronic Mail Security – PGP – S/MIME - IP Security – Web Security

**CO5:Explain the solutions for security at the system level.** **L**

Intrusion detection – password management – Viruses and related Threats – Virus Counter measures – Firewall Design Principles – Trusted System.

**TEXT BOOKS**

1. William Stallings, "Cryptography and Network Security – Principles and Practices", Pearson Education, 7thEdition, 2017.
2. Behrouz A. Foruzan, "Cryptography and Network Security", Tata McGrawHill, 2007.

**REFERENCES**

1. Bruce Schneier, "Applied Cryptography", John Wiley & Sons Inc, 2nd Edition, 2001.
2. Charles B. PFleeger, Shari Lawrence P Fleeger, "Security in Computing", Pearson Education, 3rd Edition, 2003.

**L: 45; TOTAL: 45 PERIODS**

| Course Code | PRINCIPLES OF OPERATING SYSTEM | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC40E | | 3 | 0 | 0 | 0 | 3 |

**Pre-Requisites: Fundamentals of Computers**

**COURSE OUTCOMES**

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

CO1: Conceptualize the components involved in designing a contemporary OS and determine the various ways of structuring an operating system.

CO2: Discuss Handle processes, threads, and their communication and solve some of the common operating systems problems such as deadlock and synchronization.

CO3: Explore various techniques of allocating memory to processes and realize the role of virtual memory.

CO4: Evaluate disk scheduling algorithms and interpret the mechanisms adopted for file accessing in distributed applications.

CO5: Express the methods used to implement virtualization and general structure of distributed operating systems.

**CO1: Conceptualize the components involved in designing a contemporary OS and determine the various ways of structuring an operating system.** **L:9**

Introduction - Computer-System Organization, Computer-System Architecture, Operating System Structure, Operating-System Operations, Operating system, Protection and Security - Kernel Data Structures - Computing Environments - Open-Source Operating Systems, Operating-System Structures–Operating-System Services, System Calls, System Programs, Operating-System Design and Implementation.

**CO2:Discuss Handle processes, threads, and their communication and solve someof the common operating systems problems such as deadlock and synchronization.** **L:9**

Processes– Process Scheduling, Operations on Processes, Inter-process Communication, Communication in Client– Server Systems, Threads - Multithreading Models, Process Synchronization - The Critical-Section Problem, Petersons Solution, Semaphores, and Classic Problems of Synchronization, CPU Scheduling - Scheduling Algorithms, Thread Scheduling, Deadlocks - Methods for Handling Deadlocks, Deadlock Prevention, Avoidance and Detection, Recovery from Deadlock.

**CO3: Explore various techniques of allocating memory to processes and realize the role of virtual memory.** **L:9**

Main Memory– Swapping, Contiguous Memory Allocation, Segmentation, Paging, Segmentation with paging, Structure of the Page Table, Virtual Memory - Demand Paging, Page Replacement, Allocation of Frames, Thrashing.

**CO4:Evaluate disk scheduling algorithms and interpret the mechanisms adopted for file accessing in distributed applications.** **L:9**

Mass-Storage Structure - Disk Structure, Disk Attachment, Disk Scheduling, Disk Management, File-System Interface - Access Methods, Directory and Disk Structure, File System Implementation - File-System Structure and Implementation, Directory Implementation, Allocation Methods.

**CO5: Express the methods used to implement virtualization and general structure of distributed operating systems.** **L:9**

Virtual Machines – Building Blocks, Types of Virtual Machines and Their Implementations, Virtualization and Operating-System Components, Distributed Systems - Types of Network-based Operating Systems, Network Structure, Communication Structure and Protocols.

**TEXT BOOKS**

1. G. Abraham Silberschatz, Peter Baer Galvin, Greg Gagne Operating System Concepts, 9th Edition, John Wiley & Sons Private Limited, 2013.
2. Operating Systems: Internals and Design Principles, 8th Edition, William Stallings, Pearson Education Limited, 2015.

**REFERENCES**

1. Andrew S. Tanenbaum, Modern Operating System, 4thEdition, Pearson Education Limited, 2014.

2. Operating System: A Design-oriented Approach, 2nd Edition, Charles Crowley, Irwin Publishing, 2011.

**L: 45; TOTAL: 45 PERIODS**

| Course Code | WIRELESS SYSTEM DEVELOPMENT USING | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC41E | SDR | 0 | 0 | 0 | 6 | 3 |

## OBJECTIVES

- To equip students with the theoretical and practical skills required to design, implement, and evaluate wireless communication systems using Software Defined Radio (SDR) platforms.
- To provide hands-on experience with industry-grade tools such as USRP, Radar Development Boards, SoC FPGA platforms, and GNU Radio Communications for real-time wireless experimentation.
- To develop student capability to create, test, and optimize wireless links, radar sensing modules, and modern digital communication prototypes aligned with 4G/5G/B5G concepts.
- To prepare students for careers in wireless communication, embedded systems, and next-generation radio technologies through prototype development and experiential learning.

## COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

CO1: Design, implement, and validate wireless communication and radar sensing systems using SDR platforms such as USRP, Radar Development Boards, and SoC FPGA boards. CO2: Analyze, test, and optimize real-time wireless signals and communication protocols using SDR tools, digital modulation techniques, and spectrum analysis methods.

CO3: Demonstrate effective teamwork and communication skills in the collaborative design and development of wireless systems.

## GUIDELINES

- Each team must develop ONE real-time wireless communication or radar application using SDR platforms.
- All projects must be approved by the course coordinator and must align with CO1 and CO2.
- Themes must be unique, with no duplication from current or previous semesters.
- Teams must maintain complete documentation including system block diagrams, SDR flowgraphs, FPGA configuration files, MATLAB/Python scripts, test results, and iterative refinements.
- Collaborative work is essential; each member must have clearly defined responsibilities.
- The final output must include:
  - Working prototype (SDR/USRP/Radar/SoC based)
  - Complete design documentation
  - End-to-end demonstration using real-time wireless transmission/reception
- Projects must be completed and presented within the scheduled time frame.

## POTENTIAL AREAS FOR PROJECT SELECTION

Students may choose projects from (but not limited to) the following real-time domains:

**Wireless Communication Systems**
- Real-time QPSK/QAM transmitter–receiver with USRP
- OFDM-based wireless link design
- Cognitive radio spectrum sensing
- Frequency hopping spread spectrum communication
- Channel estimation and equalization systems

**Radar & Sensing**
- Continuous-wave radar for motion detection
- FMCW radar for distance/velocity estimation
- Fall detection using radar sensing
- Gesture recognition using mm Wave radar

**Advanced Wireless Systems**
- MIMO beamforming implementation
- RTL-SDR based signal interception and decoding
- 5G NR physical layer prototype
- LoRa/LPWAN PHY layer prototyping using SDR

**FPGA & Embedded SDR Applications**
- DE0-SoC based digital down conversion
- FPGA-accelerated modulation/demodulation
- Baseband processing pipeline on ARM + FPGA hybrid SoC

**Security & Defense Wireless Applications**
- RF fingerprinting for device authentication
- Jammer detection using SDR
- Secure short-range communication system

**Smart City & IoT with Wireless Link**
- IoT gateway using SDR
- RF localization & asset tracking
- Wireless sensor network PHY layer

**L:45; TOTAL: 45 PERIODS**

| Course Code | OPTICAL COMMUNICATION AND NETWORKS | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC42E | | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Theory Components:**

CO 1: Explain the concept of light propagation through optical fiber.

CO 2: Explain the various losses and dispersion in optical fiber.

CO 3: Describe the principles, operation, and characteristics of optical sources and detectors.

CO 4: Measure various fiber optic parameters and describe the role of connecting devices.

CO 5: Explain different types of optical networks.

**CO1: Explain the concept of light propagation through optical fiber.**

Introduction, Ray theory transmission- Total internal reflection-Acceptance angle – Numerical aperture – Skew rays – Electromagnetic mode theory of optical propagation – EM waves – modes in Planar guide – phase and group velocity – cylindrical fibers – SM fibers. **L:9**

**CO2: Explain the various losses and dispersion in optical fiber.**

Attenuation - Material absorption losses in silica glass fibers: Intrinsic absorption, Extrinsic absorption - Linear scattering losses: Rayleigh Scattering, Mie Scattering -Nonlinear scattering losses: Stimulated Brillouin Scattering, Stimulated Raman Scattering – Fiber Bend Loss – Dispersion- Chromatic dispersion: Material dispersion, Waveguide dispersion- Intermodal dispersion: Multimode step index fiber, Multimode graded index fiber. **L:9**

**CO3: Describe the principles, operation, and characteristics of optical sources and detectors.**

Optical sources: The laser: Introduction - Absorption and emission of radiation, Population inversion, Optical feedback and laser oscillation, Threshold condition for laser oscillation- Stimulated emission and lasing- Hetero junctions. LED: Introduction- Power and Efficiency - LED structures: Planar LED, Surface emitter LED, Edge emitter LED- LED Characteristics. Optical Detectors:Introduction ,Optical Detection Principles, Quantum Efficiency, Responsivity, P-N Photodiode ,P-I-N Photo Diode and Avalanche Photodiode. **L:9**

**CO4: Measure various fiber optic parameters and describe the role of connecting devices.**

Introduction-Theoretical study and experimental verification of Fiber Attenuation Measurement, Fiber Dispersion Measurements, Fiber Cut off Wavelength Measurements, Numerical Aperture Measurements- Fiber Diameter Measurements. Fiber Refractive index profile– Fiber alignment and Joint Losses – Fiber Splices – Fiber connectors – Expanded Beam Connectors – Fiber Couplers. **L:9**

**CO5: Explain different types of optical networks.**

Introduction- Optical Network Concepts: Optical Networking Terminology, Optical Network Node And Switching Elements, Wavelength Division Multiplexed Networks, Wavelength Routing Networks: Routing And Wavelength Assignment, Optical CDMA – Ultra High Capacity Networks. **L:9**

**TEXT BOOKS**

1. John M. Senior, “Optical Fiber Communication”, Pearson Education, 2nd Edition, 2014.
2. Gerd Keiser, “Optical Fiber Communication”, Mc Graw Hill, 4th Edition, 2013.

**REFERENCES**

1. J.Gower, “Optical Communication System”, Prentice Hall of India, 2nd Edition, 2003.
2. Rajiv Ramaswami, “Optical Networks”, 3rd Edition, Elsevier, 2012.
3. Govind P. Agarwal, “Fiber-optic communication systems”, 3rd Edition, John Wiley & sons, 2004.
4. R.P. Khare, “Fiber Optics and Optoelectronics”, Oxford University Press, 1st Edition, 2013.

**L: 45; TOTAL: 45 PERIODS**

| Course Code | RADAR SENSING AND PROCESSING | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC43E | | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

CO1: Analyse radar fundamentals to apply frequency bands, propagation, resolution, and cross-section concepts across applications.

CO2: Apply CW, FMCW, and OFDM radar principles to analyse range, velocity, and CFAR-based target detection.

CO3: Employ antenna array processing to analyse beamforming, angle estimation, and MIMO radar performance.

CO4: Utilize radar sensing methods to analyse grid mapping, localization, and mm-Wave SAR applications.

CO5: Apply TI IWR1843 architecture to analyse subsystem functions, RF specifications, and signal processing flow.

**CO1: Analyse radar fundamentals to apply frequency bands, propagation, resolution, and cross-section concepts across applications.** **L:9**

Frequency bands, radar equation, radar cross section, measurands, wave propagation, resolution, separability, accuracy, unambiguity, automotive radars, radars for rail, air & water vehicles, medical applications, Monostatic and bistatic radars

**CO2: Apply CW, FMCW, and OFDM radar principles to analyse range, velocity, and CFAR-based target detection.** **L:9**

Types of radar: Pulsed Radar, CW radars, SFCW Radar, Pulsed Doppler Radar, Tracking Radar, Ground Penetrating Radar, FMCW radars, OFDM radar, signal processing - key quantities and terms, windowing, range & velocity estimation of CW, FMCW and OFDM radars, target detection using CFAR algorithms.

**CO3: Employ antenna array processing to analyse beamforming, angle estimation, and MIMO radar performance.** **L:9**

Antenna arrays - fundamental consideration, signal model, calibration, beam former & power evaluation, angular resolution, angle estimation - correlation, Fourier Transform, Bartlett Beamformer, MUSIC algorithm, Phased arrays & performance of MIMO radars

**CO4: Utilize radar sensing methods to analyse grid mapping, localization, and mm-Wave SAR applications.** **L:9**

Radar based grid maps - Amplitude Grid Map, probabilistic occupancy grid map, simultaneous localization and mapping, synthetic aperture radar for mm-Wave applications

**CO5: Apply TI IWR1843 architecture to analyse subsystem functions, RF specifications, and signal processing flow.** **L:9**

IWR1843 TI FMCW mm-Wave single chip radar sensor - features, functional block diagram, sub systems, pin diagram, signal distribution, power supply specification, RF specification, CPU specification, timing & switching characteristics

**TEXT BOOKS:**

1. Christian Waldschmidt, Christina Bonfert and Timo Grebner, "Millimeter Wave Radar

Hardware and Signal Processing", Springer imprint, 2025.
2. IWR1843 Single-Chip 76 to 81GHz FMCW mmWave Sensor Datasheet, Texas instruments, Sep 2024

**REFERENCE BOOKS:**

1. Simon Haykin, "Adaptive Radar Signal Processing", John Wiley & Sons, 2007.
2. Mark A.Richards, “Fundamentals of Radar Signal Processing”, Tata McGraw Hill, 2nd Edition, 2014
3. Lee Andrew Harrison, “Introduction to Radar with Python and Matlab”, Artech House, Illustrated Edition, 2019
4. Merrill I. Skolnik, "RADAR HANDBOOK", McGraw Hill, Third Edition, 2008

**L:45; TOTAL: 45 PERIODS**

| Course Code | SATELLITE TRANSMISSION AND | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC44E | RECEPTION SYSTEMS | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

CO1: Comprehend satellite orbits, trajectories and their associated parameters.
CO2: Evaluate the electronic subsystems of satellites and Earth stations.
CO3:Apply link-budget techniques to analyse satellite communication link parameters.
CO4: Explain multiple access technique and standards used in satellite communication systems.
CO5: Explain the functional applications and operational significance of various satellite systems.

**CO1: Comprehend satellite orbits, trajectories and their associated parameters** **L:9**

Orbital Mechanics- Orbit equations, Kepler's Laws, Newton's laws, orbital parameters, orbital perturbations, Station keeping, Geostationary and non-Geo-stationary orbits - Look angle calculation- Limits of visibility –Satellite launching procedures.

**CO2: Evaluate the electronic subsystems of satellites and Earth stations**

Satellite Subsystems— Attitude and orbit control system, tracking, command and monitoring ,Power system , Transponders, Antennas, earth control considerations, effects of earth-Perturbation, sun transit, moon transit, satellite power design. **L:9**

**CO3 : Apply link-budget techniques to analyse satellite communication link parameters** **L:9**

Satellite uplink and downlink analysis and design, link budget, C/N calculation, performance impairments-system noise, inter modulation distortion, interference, propagation Characteristics and frequency considerations- System reliability and design life time.

**CO4 : Explain multiple access technique and standards used in satellite communication systems.** **L:9**

Frequency division multiple access – Time division multiple access-structure, standards and system design; Onboard Processing systems; Demand assigned multiple access, Code division multiple access , Spread spectrum transmission and reception.

**CO5 : Explain the functional applications and operational significance of various satellite systems** **L:9**

Communication Satellite - Frequency bands, Orbits, Payload, Satellite Telephony, Satellite Radio, Satellite television, regional and national satellite systems. Remote sensing satellites - Orbits, payload, Types of image: image classification, Interpretation. Weather forecasting satellites – Orbits, payloads, applications.

**TEXT BOOKS**

1. Dennis Roddy, "Satellite Communication", McGraw Hill International, 4th Edition, 2017.
2. Anil K. Maini, VarshaAgrawal, "Satellite Communication", Wiley India, 3rd Edition, 2014.
3. Timothy Pratt, Charles, W.Bostain, Jeremy E.Allnutt, "Satellite Communication", 3rd Edition, Wiley Publications, 2021.

**REFERENCES**

1. Bruce R. Elbert, "Introduction to Satellite Communication", Artech House Bostan London, 3rd Edition, 2008.
2. M.Richharia, "Satellite Communication Systems-Design Principles", Macmillan, 2nd Edition, 2010.
3. Tri T. Ha, "Digital Satellite Communication", McGraw Hill, 2nd Edition, 2009.

**L:45; TOTAL: 45 PERIODS**

| **Course Code** | **MICROCONTROLLER AND PCB DESIGN** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC45E** | | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

CO1: Illustrate the architecture and programming in 8085 Microprocessors.

CO2: Demonstrate the architecture and interfacing of 8051 Microcontroller.

CO3: Develop programs with pic16/18 microcontroller.

CO4: Write programming to interface sensors and actuators using Arduino.

CO5: Illustrate PCB layout development and fabrication process

**CO1: Illustrate the architecture and programming in 8085 microprocessors.**

Introduction – 8085 Microprocessor: Architecture, pinouts and signals, Instruction set and addressing modes - Memory interfacing, I/O ports and data transfer concepts - arithmetic programming using 8085 with counting & Indexing - delay calculations. **L:9**

**CO2: Demonstrate the architecture and interfacing of 8051 microcontroller.**

Overview of the 8051 family – Architecture: CPU, ALU, address, data and control bus, - Timer – Interrupt structure - 8051 Instruction set - arithmetic programming using 8051- Interfacing: LED, LCD, keypad, Analog to Digital Converter and Stepper motor. **L:9**

**CO3: Develop programs with pic16/18 microcontroller.**

PIC16 /18 architecture, Memory organization – Addressing modes – Instruction set - Programming techniques – Timers – I/O ports – Interrupt programming. **L:9**

**CO4: Write programming to interface sensors and actuators using arduino.**

Introduction to Arduino – variables - data types – setup – loop – functions – Conditional statements - Looping statements – Pulse Width Modulation – Analog to Digital Converter – Serial Communication – I2C communication – SPI communication – Interrupts – **L:9**

Interfacing: LED, Switch, LCD, Motor Drivers, Analog Sensors – I2C based sensors – SD card – Bluetooth devices.

**CO5: Illustrate pcb layout development and fabrication process.**

Overview of PCB concepts and applications - Types of PCBs: Single-sided, double-sided, multi-layer - Understanding PCB materials and components - Introduction to popular PCB design software - Drawing schematics: Components, connections, and annotations - Designing the PCB layout: Placing components and routing traces - Design rules and considerations (clearance, trace width) - Preparing files for manufacturing (Gerber files) - Introduction to assembly and soldering techniques. **L:9**

**TEXT BOOKS**

1. Senthilkumar N., Saravanan M. and Jeevananthan.S, "Microprocessor and Microcontrollers", Oxford University Press, Aug 2016.
2. Krishna Kant "Microprocessor and Microcontrollers", Eastern Company Edition, Prentice HallPrivate Limited, New Delhi, Jan 2013.
3. Monk, S., "Programming Arduino: Getting Started with Sketches", McGraw-Hill Education, Oct 2016.

**REFERENCES**

1. M. A.Mazidi, J. G. Mazidi and R. D. McKinlay, "The 8051Microcontroller and Embedded Systems: Using Assembly and C", Pearson Education, 2007.
2. K. J. Ayala, "8051 Microcontroller", Delmar Cengage Learning,2004.
3. R. S. Gaonkar, ", Microprocessor Architecture: Programming and Applications with the 8085", Penram International Publishing, 1996.
4. Blum, J., "Exploring Arduino: Tools and Techniques for Engineering Wizardry", Wiley, Jul 2013.
5. Kuo, S. and Lee, M., "Practical Guide to PCB Design", CRC Press, Jan 2018.

**L: 45; TOTAL: 45 PERIODS**

| **Course Code** | **EMBEDDED SYSTEMS FOR IoT** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC46E** | | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

CO1: Comprehend the fundamental concepts and basic building blocks of embedded system.

CO2: Employ the concepts of embedded networking and interrupt mechanism in IoT system design.

CO3: Apply the knowledge of hardware and software architecture of embedded system in IoT product development.

CO4: Design and develop firmware using embedded C language for IoT applications.

CO5: Design and develop firmware using python language for IoT applications.

**CO1: Comprehend the fundamental concepts and basic building blocks of embedded system.**

Introduction to Embedded Systems –Classifications- selection of embedded processor- on chip processor memory types- external EEPROM interfacing for data storage–data representation and its orientation in memory concept- data manipulation in registers using logical operations- real world analog and digital sensor data conversion -Timer **L:9**

concept and Real Time Clock.

**CO2: Employ the concepts of embedded networking and interrupt mechanism in IoT system design.**

Embedded Networking: Introduction, I/O Device Ports & Buses– Serial Bus communication protocols - RS232 standard – CAN – Inter Integrated Circuits (I2C) – Difference between interrupt and exception-Programmed-I/O busy-wait approach without interrupt service mechanism- interrupt sources in Cortex M3 processor- simple programs using external and internal interrupt. **L:9**

**CO3: Apply the knowledge of hardware and software architecture of embedded system in IoT product development.**

Component selection - Component package types-embedded system design flow types-Preparation of Block diagram to Final Product Architecture arrival - Embedded system software layered architecture-Understanding of different Operating System (Linux, VxWorks, RTOS) features and architectures - Basics of Boot loader functionalities–significance of Kernel and Device drivers - File system types. **L:9**

**CO4: Design and develop firmware using embedded C language for IoT applications.**

Introduction to C and Assembly - Declarations and Expressions - Arrays, Qualifiers and Reading Numbers - Decision and Control Statements - Programming Process - Functions - C Preprocessor - Advanced Types - Simple Pointers Debugging and Optimization – In-line Assembly - Object oriented programming with C, Header files for Project and Port, Cr eating hardware delays - Need for timeout mechanism - Creating loop timeouts - Creating hardware timeouts. IoT use cases: Smart home automation. **L:9**

**CO5: Design and develop firmware using python language for IoT applications.**

Basics of PYTHON Programming Syntax and Style – Python Objects– Dictionaries – comparison with C programming on Conditionals and Loops – Files – Input and Output – Errors and Exceptions – Functions – Modules – Classes and OOP – Execution Environment.-simple programs in mPython for embedded system. IoT Use Case: IoT Edge Computing. **L:9**

**TEXT BOOKS**

1. Rajkamal, “Embedded system- Architecture, programming and design”, McGraw Hill, 2017.
2. Christian Hill, “Learning Scientific Programming with Python”, Cambridge University Press, 2016.
3. Michael J Pont, “Embedded C”, Pearson Education, 2007.

**REFERENCES**

1. David Griffiths, Dawn Griffiths, “Head First C”, O‟reilly, 2015.
2. Vilas S bagad, “Electronics product design”, Technical publications, Pune 2009.
3. Shibu K.V, “Introduction to Embedded systems”, McGraw Hill, 2017.
4. Kiyofumi Tanaka, “Embedded systems–Theory and Methodology”, Intech Publication, Croatia, 2012.

**L: 45; TOTAL: 45 PERIODS**

| **Course Code** | **FUNDAMENTALS OF INTERNET OF THINGS** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC47E** | | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

CO1: Conceive the basic components and working principles of IoT.

CO2: Analyze IoT communication and networking protocols.

CO3: Design IoT models leveraging Arduino platforms.

CO4: Configure IoT models utilizing Raspberry Pi frameworks.

CO5: Integrate of cloud services for IoT applications.

**CO1: Conceive the basic components and working principles of IoT.**

Definitions and functional requirements –IoT conceptual framework – IoT architectural view- Components: Control units–Sensors-Actuators- Communication modules – Power sources. Communication technologies: RFID –Bluetooth–ZigBee–WiFi–MobileInternet–M2Mcommunication. **L:9**

**CO2: Analyse IoT communication and networking protocols.**

Data acquisition, storage, organization, and analytics- Networking Protocols: CoAP, MQTT, SMQTT, AMQP, CoAP vs HTTP- Communication Protocols: OAuth2, XMPP IEEE 802.15.4 Standards: Zigbee, 6LoWPAN, Wireless HART, Z-Wave-Simulators. **L:9**

**CO3: Design IoT models leveraging arduino platforms.**

Interoperability in IoT-Arduino Programming Basics-Integrating Sensors and Actuators with Arduino-Programming Arduino for IoT Applications-Sensor data reading-Mobile Device Connectivity with Arduino-Communication via Bluetooth and USB-Internet Connection using Wi-Fi/Ethernet. **L:9**

**CO4: Configure IoT models utilizing raspberry pi frameworks.**

Introduction to Python Programming- Overview of Raspberry Pi hardware- GPIO Pins-Reading sensor data -controlling actuators - Configuring network and remote access: SSH, VNC -Communication protocols :I2C, SPI, UART–programming Raspberry Pi with Python. **L:9**

**CO5: Integrate of cloud services for IoT applications.**

Cloud Storage Models & Communication APIs-WAMP (Web Application Messaging Protocol)- AutoBahn for IoT- Xively Cloud for IoT- Cloud Integration with IoT Devices- Data Visualization and Remote Monitoring via Cloud- case studies - IoT in Cities- Home-Healthcare-Agriculture-autonomous vehicles. **L:9**

**TEXT BOOKS**

1. Sudip Misra, Mukherjee, A., & Roy, A., "Introduction to IoT", Cambridge University Press, ISBN: 9781108842952, 2021.
2. Arsh deep Bahga, Vijay Madisetti, "Internet of Things, A Hands-on Approach", University Press, 1st Edition, 2015.
3. Raj Kamal, "Internet of Things: Architecture and Design Principles", McGraw-Hill Education Pvt. Ltd., 1st Edition, 2018.
4. Marco Schwatrz, "Internet of Things with Arduino Cookbook", Packt Publications, 1st Edition, 2016.

**REFERENCES**

1. Oliver Hersent, David Boswarthick, Omar Elloumy, "The Internet of Things", published by Wiey, 1st Edition, 2015.
2. Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-on-Approach)", VPT, 1st Edition, 2014.
3. Marco Schwatrz, "Internet of Things with Arduino Cookbook", Packt Publications, 1st Edition, 2016.

**L: 45; TOTAL: 45 PERIODS**

| **Course Code** | **DYNAMIC PARADIGMS FOR IoT** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC48E** | | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

CO1: Explore advanced concepts for IoT applications, including dynamic frameworks, architectures and real-world use cases.

CO2: Integrate protocol-based modular programming techniques to design secure and scalable IoT solutions.

CO3: Employ data structures and algorithms for enabling real-time IoT communication and decision-making.

CO4: Analyze secure, scalable cloud solutions for IoT data management and visualization.

CO5: Build comprehensive IoT applications integrating libraries, frameworks, andmodern paradigms.

**CO1: Explore advanced concepts for IoT applications, including dynamic frameworks, architectures and real-world use cases.**

Introduction to IoT Development: Setting up virtual environments tailored for IoT development- IoT Hardware Overview: Raspberry Pi, ESP32, Arduino, and Edge Devices - Advanced Constructs: Iterators, Generators, Decorators, and their applications in IoT scenarios. Case Study: Initializing IoT devices with scripts. **L:9**

**CO2: Integrate protocol-based modular programming techniques to design secure and scalable IoT solutions.**

Communication Protocols for IoT: MQTT, HTTP, CoAP, and Web Socket. Libraries: Paho-MQTT, Requests - Secure Communication: Encryption, Authentication, Public/Private Key Infrastructure (PKI), TLS, OAuth2- Real-Time Data Acquisition: APIs and IoT over 5G. **L:9**

**CO3: Employ data structures and algorithms for enabling real-time IoT communication and decision-making.**

Libraries: NumPy - Pandas - Visualization Libraries: Matplotlib- Seaborn – Data Filtering and Analysis - Stream Processing: Kafka, Spark, and Flink -Predictive Analytics: Scikit-learn, TensorFlow, Keras - Time-Series Forecasting and Anomaly Detection. **L:9**

**CO4: Analyze secure, scalable cloud solutions for IoT data management and visualization.** **L:9**

Cloud Platforms for IoT: AWS IoT, Google Cloud IoT, and Azure IoT-RESTful APIs - Introduction to Serverless Architectures: AWS Lambda, Google Functions- Building Micro services with Fast API, Flask - Visualization Dashboards using Python: Plotly, Dash.

**CO5: Build comprehensive IoT applications integrating libraries, frameworks, andmodern paradigms.**

IoT Automation: Scheduling Tasks - Event Handling - Designing IoT Dashboards - Integration of Node-RED and MQTT- Case Study: Smart Home Automation- Voice Assistants. **L:9**

**TEXT BOOKS**

1. Simon Monk, "Programming the Raspberry Pi: Getting Started with Python", 2nd Edition, McGraw Hill Professional, 2016.
2. Michael Hausenblas,"IoT Cloud Platforms and Python Frameworks", 1st Edition, Packt Publishing, 2019.
3. Agus Kurniawan, "IoT Projects with ESP32 and Raspberry Pi", 1st Edition, Packt Publishing, 2019.

**REFERENCES**

1. Eben Upton and Gareth Halfacree, "Raspberry Pi User Guide", 4th Edition, Wiley & Sons, 2016.
2. Alex Bradbury and Ben Everard, "Learning Python with Raspberry Pi", 1st Edition, Wiley & Sons, 2014.
3. Cyrille Rossant, "IPython Interactive Computing and Visualization Cookbook", 2nd Edition, Packt Publishing, 2018.
4. William Beekman, "Raspberry Pi IoT Projects", 1st Edition, Apress, 2020.
5. Enrique Ramos, "Python for Data Science: A Hands-on Approach", Packt Publishing, 2020.

**L:45; TOTAL:45PERIODS**

| **Course Code** | **INTRODUCTION TO INDUSTRY 4.0 AND** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC49E** | **INDUSTRIAL INTERNET OF THINGS** | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOME**

Upon the successful completion of the course, the student will be able to

CO1: Comprehends the evolution of Industrial Internet of Things (IIoT).

CO2: Describe key components, architectures and communication technologies of IIoT.

CO3: Summarize the computing strategies in IIoT environments.

CO4: Identify the security challenges and requirements of IIoT environments.

CO5: Explore industrial IoT Applications in various domains.

**CO1: Comprehends the evolution of Industrial Internet of Things (IIoT).**

Introduction: Sensing & actuation, Communication- Networking- Industry 4.0: Globalization and Emerging Issues, The Fourth Revolution, LEAN Production Systems, Smart and Connected Business Perspective, Smart Factories- Cyber Physical Systems: Attack Detection and Mitigation -Role of CPS in industry - Next Generation Sensors, Collaborative Platform- Product Lifecycle Management, Augmented Reality and Virtual Reality, Artificial Intelligence, Big Data and Advanced Analysis. **L:9**

**CO2: Describe key components, architectures and communication technologies of IIoT.**

Cybersecurity in Industry 4.0, Basics of Industrial IoT: Industrial Processes-Industrial Sensing & Actuation, Industrial Internet Systems, IIoT-Introduction, Business Model - Reference Architecture- Industrial IoT- Layers: IIoT Sensing-IIoT Processing- IIoT Communication-IIoT Networking. **L:9**

**CO3: Summarize the computing strategies in IIoT environments.**

Industrial IoT: Big Data Analytics and Software Defined Networks: IIoT Analytics - Introduction, Machine Learning and Data Science - R and Julia Programming, Data Management with Hadoop-SDN in IIoT- Data Center Networks. **L:9**

**CO4:Identify the security challenges and requirements of IIoT environments.**

Security in IIoT: Need for IIoTsecuirty- security goals-trustworthy IIoT - IT and OT security requirement – IIoT security risk management- Classes of Attackers -STRIDE thread model – IIoT attack vectors – Trust permeation-trust flow- Trust functionalities – security framework for IIoT - IIoT security building blocks- end devices protection - challenges, requirements, and solutions. Fog devices protection- cloud security-data protection-communication protection-security monitoring. **L:9**

**CO5: Explore industrial IoT Applications in various domains.**

Industrial IoT- Application Domains: Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management, Industrial IoT- Application Domains: Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries. Real case studies: Milk Processing and Packaging Industries, Manufacturing Industries - Student Projects - Virtual Reality Lab- Steel Technology Lab. **L:9**

**TEXT BOOKS**

1. Sudip Misra, C. Roy, and A. Mukherjee, “Introduction to Industrial Internet of Things and Industry 4.0”, CRC Press, 2020.S
2. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, Alasdair Gilchrist Publications: Apress”, Apress Berkeley, CA, ISBN - 978-1-4842-2046-7, https://doi.org/10.1007/978-1-4842-2047-4.
3. Bartodziej, Christoph Jan, “The Concept Industry 4.0 An Empirical Analysis of Technologies and Applications in Production Logistics”, Springer: Publication in the field of economic science, ISBN: 978-3-658-16501-7, 2016.

**REFERENCES**

1. Dr. Ovidiu Vermesan& Dr. Peter Friess, “Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems”, River Publishers, ISBN-8792982964, 2013.
2. Daniel Minoli, “Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications”, ISBN: 978-1-118-47347-4, Willy Publications, 2013.

**L: 45; TOTAL: 45 PERIODS**

| **Course Code** | **IoT-DRIVEN ROBOTICS AND AUTOMATION** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC50E** | | **1** | **0** | **4** | **0** | **3** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Theory Components:**

CO1:Select the controllers, actuator and communication protocols for the robotic system.
CO2: Explore IoT components and communication devices with cloud infrastructure.
CO3:Comprehend industrial automation fundamentals, components, and applications.

**Practical Components:**

CO4: Conduct Experimental Verification and Validation of Robotic Systems.
CO5:Implement an IoT system to collect and store data in the cloud.
CO6: Configure and Develop Mechatronics Systems for Simple Automation.

**Soft skill component:**

CO7: Lead effectively as an individual and in multidisciplinary teams.

**CO1: Select the controllers, actuator and communication protocols for the robotic systems.** **L:5 P:20**

**CO4: Conduct Experimental Verification and Validation of Robotic Systems.**

Analog and digital signal – Introduction to microprocessor and microcontroller – Atmega328p – pin out and specification – programming concepts – data types – conditions – looping statement – ADC, DAC – Types of motors and actuators – motor driver – analog and digital sensor – LCD interface with Experimental verification – IR sensor – Ultrasonic sensor.

Experimental verification of line following robot and Obstacle avoiding robot - Servo and stepper motor, driver – gyroscope – Experimental verification of Self-balancing robot.

**CO2: Explore IoT components and communication devices with cloud infrastructure.** **L:5 P:20**

**CO5: Implement an IoT system to collect and store data in the cloud.**

IoT Architecture and Components - Data Collection and Communication Protocols - Cloud Storage and Analytics: Storing IoT data in cloud platforms - Backend Integration for Web and Mobile Applications: Installing and configuration

Experimental verification of Environment Monitoring systems, Energy Consumption Monitoring - Smart Agriculture Monitoring - Smart Home Security System

**CO3:Comprehend industrial automation fundamentals, components, and applications.** **L:5 P:20**

**CO6:Configure and Develop Mechatronics Systems for Simple Automation.**

Concept of automation- Industrial automation 4.0 – components–Importance of PLC and SCADA – Various automation systems. 3D printing – CAD modelling overview- Robot body arm and end effector design – design considerations. Prototyping.

Experimental verification of automation projects such as automatic punching machine, automatic material sorting system, automatic loading clamping and de-clamping using pneumatic actuators, and various robotic end effector designs for pick and place.

**TEXT BOOKS**

1. John J. Craig,"Introduction to Robotics: Mechanics and Control",4th Edition,Pearson, 2017, ISBN: 978-0133489798
2. Arshdeep Bahga and Vijay Madisetti,"Internet of Things: A Hands-On Approach", 1st Edition, VPT, 2014, ISBN: 978-0996025515.
3. Peter Waher,"Mastering IoT: An IoT Developer's Guide", Packt Publishing, 2021, ISBN: 978-1801077540.
4. Godfrey C. Onwubolu,"Mechatronics: Principles and Applications", Butterworth-Heinemann, 2005, ISBN: 978-0750663793.
5. Jonathan W. Valvano, "Embedded Systems: Introduction to ARM Cortex-M Microcontrollers", 5th Edition, Create Space Independent 2014, ISBN: 978-1477508992.

**REFERENCES**

1. Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, and Giuseppe Oriolo, "Robotics: Modelling, Planning and Control", Springer, 2010, ISBN: 978-1846286414.
2. Rajkumar Buyya and Amir Vahid Dastjerdi "Internet of Things: Principles and Paradigms", Morgan Kaufmann, 2016, ISBN: 978-0128053959.
3. John W. Webb and Ronald A. Reis,"Programmable Logic Controllers: Principles and Applications" 5th Edition, Prentice Hall, 2002, ISBN: 978-0130607188.
4. Katsuhiko Ogata, "Modern Control Engineering", 5thEdition, Prentice Hall, 2009, ISBN: 978-0136156734.
5. Francis X. Govers,"Artificial Intelligence for Robotics" Packt Publishing, 2018, ISBN: 978-1788835442.

**L: 45; TOTAL: 45 PERIODS**

| Course code | | L | T | P | E | C |
|---|---|---|---|---|---|---|
| **23EC51E** | **ADVANCED CMOS MICROFABRICATION** | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES:**

Upon successful completion of the course the students will be able to

CO1: Explain the fundamentals of microfabrication and apply SEMulator 3D to visualize basic virtual fabrication steps.

CO2: Describe semiconductor manufacturing steps with application of process concepts to interpret CMOS layouts in SEMulator 3D.

CO3: Explain the modules in advanced CMOS/FinFET processing and analyze changes in device architecture from planar MOSFET to FinFET.

CO5: Explain ILD and low-k materials, apply 3D IC/TSV integration concepts, and analyze the performance differences between Planar FET and FinFET inverters.

**CO1: Explain the fundamentals of microfabrication and apply SEMulator 3D to visualize basic virtual fabrication steps.** **L:9**

Overview of the semiconductor industry and VLSI fabrication processes - Microfabrication and Moore's law, Semiconductor value chain: design, fabrication, packaging, system, product, Design Rules - Wafer Preparation - Circuit abstraction to layout and cross-section, Introduction to SEMulator 3D- Exploration of SEMulator 3D for virtual fabrication.

**CO2: Describe semiconductor manufacturing steps with application of process concepts to interpret CMOS layouts in SEMulator 3D.** **L:9**

Manufacturing process from SiO2 to the wafer, Wafer Modification, Deposition: Physical Vapor Deposition, Chemical Vapor Deposition, Electroplating, Lithography - Process Exploration of Spacer formation and Multiple Patterning Techniques in Advanced Lithography Photoresist-types. Etching: Wafer RCA cleaning, Wet etch, Dry etch, Isotropic versus anisotropic etch. Chemical-mechanical processing. Layout Design and Virtual Fabrication of NMOS, PMOS and CMOS inverter using SEMulator 3D.

**CO3: Explain the modules in advanced CMOS/FinFET processing and analyze changes in device architecture from planar MOSFET to FinFET.** **L:9**

Isolation module: Advantages and challenges of STI versus LOCOS. Device architecture: Planar to FinFET, use of SiGe and strain. Gate module: $SiO_2$ versus High-k dielectrics, polysilicon versus metal gate, gate-first versus gate-last, integration challenges of replacement metal gate. Well & junction module: Basics of implantation, source-drain and well implants, other implants.

**CO4: Describe contact formation along with interconnect technologies with analysis of RC delay and electromigration challenges.** **L:9**

Contact module: contact resistance issues of simple metal- silicon contact, metal silicide's, salicidation, evolution from Ti to Co to Ni silicide.

Interconnect module: Need for multiple metal layers, RC delay, challenge of electromigration, evolution from Al vs Cu, Damascene and dual-Damascene process, W plugs and via.

**CO5: Explain ILD and low-k materials, apply 3D IC/TSV integration concepts, and analyze the performance differences between Planar FET and FinFET inverters.** **L:9**

Intermediate dielectric: Need for ILD, low-k due to RC delay, $SiO_2$ to SiOF to SiOC to porous SiOC, material and integration challenges

Emerging Trends - 3D ICs and Through-Silicon Vias (TSVs) Process integration-challenges in integration, yield and reliability considerations- Process study of Dual – Damascene technique for advanced interconnect fabrication- Comparative analysis of Planar FET and FINFET Inverter design and performance.

**TEXT BOOKS:**

1. Plummer, James D., and Peter B. Griffin. "Integrated Circuit Fabrication: Science and Technology", Cambridge University Press, 2023.

2. Stephen A. Campbell,"The Science and Engineering of Microelectronic Fabrication", Oxford Press: New York, NY, USA, 2001.

3. Hilleringmann, Ulrich. "Silicon Semiconductor Technology: Processing and Integration of Microelectronic Devices"Springer Vieweg, 2023.

**REFERENCE BOOKS:**

1. By Sorab K Ghandhi, "VLSI Fabrication Principles: Silicon and Gallium Arsenide", 2nd Ed, John Wiley, 2008.

2. Richard C. Jaeger, "Introduction To Microelectronic Fabrication" Prentice hall, 2nd edition, 2002.

3. Swaminathan, Parasuraman, "Semiconductor materials, devices, and fabrication", Wiley, 2017.

**WEB SOURCES:**

1.nptel.ac.in/courses/102108078

2. https://www.lamresearch.com/product/semulator3d/

**L: 45; TOTAL: 45 PERIODS**

| 23EC52E | FUNDAMENTALS OF MECHATRONICS AND ROBOTICS | L | T | P | E | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES**

Upon completion of this course, the students will be able to

**Theory Component**

CO1: Discuss the mechatronics design and its applications.

CO2: Explain the industrial robot's anatomy and specifications.

CO3: Discuss the classification and working principles of various sensors.

CO4: Elaborate on various categories of drives and control systems.

CO5: Elaborate on mechatronics system blocks employed in real-time automation and robotics engineering.

**CO1 Discuss the mechatronics design and its applications. 9**

Mechanical System-Definition-Philosophy and approach; Systems and Design: Mechatronic approach, Integrated Product Design, Modelling, Analysis and Simulation, Man-Machine Interface. Case study on the application of Mechatronics system in Automation and Robotics, Process Automation, Manufacturing, Product design and testing.

**CO2 Explain the industrial robot's anatomy and specifications. 9**

An overview of Robotics – classification by coordinate and control systems. Components of Industrial Robotics- Basic terminology- End effectors-types, Mechanical grippers, and other grippers- Specifications - Robot selection- Present and future applications.

**CO3 Discuss the classification and working principles of various sensors. 9**

Sensor and transducer- classification - characteristics and calibration of different sensors. Measurement of displacement, position, motion, force, torque, strain gauge, pressure flow, and temperature sensor sensors. Optical encoder, tactile and proximity, ultrasonic transducers, Optoelectronics sensor, gyroscope sensors. Micro-sensors and MEMS. Selection of sensors.

**CO4 Elaborate on various categories of drives and control systems. 9**

Hydraulic and Pneumatic drives, Electrical Actuators such as servo and Stepper motors, Drive circuits, and open and closed loop controls. Proportional (P), Proportional and integral (PI) and Proportional, integral and Derivative (PID) control systems.

**CO5 Elaborate on mechatronics system blocks employed in real-time automation and robotics engineering. 9**

Smart automation systems (e.g., driverless cars, domestic/warehouse mobile robots, intelligent transportation systems, robotic construction machines, Car parking barriers, Motion and temperature control of washing machine, Autofocus camera, 3D printer, etc.). Smart irrigation systems, Pick and place robots, Arc welding robots and Drone systems.

**L: 45; TOTAL:45 PERIODS**

**TEXT BOOKS**

1. Bolton, W., Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, 7thEdition, Pearson Education, 2019.
2. NitaigourPremchand Mahalik, ―Mechatronics - Principles, Concepts and Applications, Tata McGraw-Hill Pub. Co. Ltd., New Delhi, 2006.
3. Rafael C. Gonzales, Richard. E. Woods, "Digital Image Processing, 4th Edition, Pearson Education", 2018.
4. Kevin M. Lynch and Frank C. Park, "Modern Robotics: Mechanics, Planning and Control", 1st edition, Cambridge University Press, 2017.
5. Bruno Siciliano and Oussama Khatib, "Handbook of Robotics", Springer Verlag, 2016.

**REFERENCES**

1. Harry H. Poole, "Fundamentals of Robotics Engineering", Springer, 2012.
2. Saeed B. Niku, "Introduction to Robotics: Analysis, Control, Applications", 2nd Edition, Wiley Publishers, 2010.
3. Siegwart, Nourbakhsh, "Introduction to Autonomous Mobile Robots", 2nd Edition, MIT Press, 2011

**NPTEL Online resources**

1. Robotics by Prof. Dilip Kumar Pratihar - IIT Kharagpur, https://onlinecourses.nptel.ac.in/noc21_me76/preview.
2. Robotics by Prof. D.K. Pratihar - IIT Kharagpur, https://onlinecourses.nptel.ac.in/noc24_ge31/preview

| **Course Code** | **SMART SYSTEM DESIGN AND PROTOTYPING** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC53E** | | **0** | **0** | **0** | **6** | **3** |

**OBJECTIVE**

Equip students to apply the knowledge and practical skills for the design, develop, and implementation of innovative smart products / systems.

To provide a comprehensive understanding of the principles and applications of robotics and IoT, fostering the ability to create connected intelligent systems that address real-world challenges.

To gain experience in prototype development, system integration, and deploying IoT-enabled robotic solutions, preparing them for advanced roles in the rapidly evolving fields of automation that integrate electronics, Computer programming, mechatronics, machine learning, AI, robotics and Internet of Things (IoT) technologies.

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Practical Component**

CO1: Design and develop robotic systems integrated with IoT sensors and actuators for real-world applications. (CDL3).

CO2: Create functional systems using sensors, actuators, and microcontrollers.

**Soft skill Component**

CO3: Demonstrate effective teamwork and communication skills in the collaborative design and

development of IoT-integrated robotic systems.

| | |
|---|---|
| **CO1: Design and develop robotic systems integrated with IoT sensors and actuators for real-world applications. (CDL3).** | **L:9** |
| **CO2: Create functional systems using sensors, actuators, and microcontrollers.** | **L:9** |
| **CO3: Demonstrate effective teamwork and communication skills in the collaborative design and development of IoT-integrated robotic systems.** | **L:9** |

**Guidelines:**

The course requires each team to develop **ONE REAL-TIME APPLICATION PROJECT**. All projects must be approved by the course coordinator before commencement, ensuring they align with the course outcomes. Each project's theme or real-time application must be unique and should not repeat projects from the current or previous semesters. Throughout the project development phase, teams must maintain detailed documentation, including design schematics, source code with comments, test results, and any modifications made during the process. This documentation is critical for ensuring transparency and tracking the project's progress. Collaboration is essential, and each team should respect individual contributions, with clearly defined roles and responsibilities, to ensure efficient execution. Projects must be completed within the given timeframe and presented as a team, supported by comprehensive design documentation and a fully developed prototype. Examples of Potential areas for project selection are provided below, though these are not exhaustive. Each of these fields offers opportunities to develop real-time applications that can address contemporary challenges with innovative solutions:

- Agriculture Automation
- Home Automation
- Medical Robotics and Engineering
- Environmental Engineering
- Automobile Engineering
- Industrial Process and Automation
- Smart Cities with IoT interface
- Transportation
- Safety Engineering
- Defense and Security
- Autonomous Vehicles and Drone Technology
- Packing and Labeling Technology
- Automated Sorting Systems
- Smart Navigation
- Forest Control and Security

Waste Management

**E: 90; TOTAL:90 PERIODS**

| **Course Code** | **ADHOC AND WIRELESS SENSOR NETWORKS** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC54E** | | **3** | **0** | **0** | **0** | **3** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Theory Components:**

CO1: Identify and Distinguish between the Ad hoc and Wireless Sensor Networks.

CO2: Describe the MAC protocol issues of ad hoc networks.

CO3: Analyze the concepts for designing a routing Protocol for MANETs.

CO4: Explain the concepts of network architecture and MAC layer protocol for WSN.
CO5: Discuss the WSN routing issues by considering QoS measurements.

**CO1: Identify and Distinguish between the Ad hoc and Wireless Sensor Networks**
Fundamentals of Wireless Communication Technology -The Electromagnetic Spectrum - Radio propagation Mechanisms - Characteristics of the Wireless channel mobile ad hoc networks (MANETs) - Wireless Sensor Networks (WSNs): concepts and architectures - Applications of Ad Hoc and Sensor Networks - Design Challenges in Ad hoc and Sensor Networks**.**

**CO2: Describe the MAC protocol issues of ad hoc networks.**
Issues in designing a MAC Protocol - Issues in Designing a MAC Protocol for Ad Hoc Wireless Networks - Design Goals of a MAC Protocol for Ad Hoc Wireless Networks - Classification of MAC Protocols -Contention based protocols - Contention based protocols with Reservation Mechanisms - Contention based protocols with Scheduling Mechanisms - Multi channel MAC - IEEE 802.11.

**CO3: Analyze the concepts for designing a routing Protocol for MANETs**.
Routing Protocol: Issues in designing a routing protocol for Ad hoc networks - Classification-proactive routing - reactive routing (on-demand) - hybrid routing - Transport Layer protocol for Ad hoc networks - Design Goal of a Transport Layer Protocol for Ad Hoc Wireless Networks - Classification of Transport Layer solutions-TCP over Ad hoc wireless - Network Security - Security in Ad Hoc Wireless Networks - Network Security Requirements.

**CO4: Explain the concepts of network architecture and MAC layer protocol for WSN.**
Single node architecture: hardware and software components of a sensor node -WSN Network architecture: typical network architectures -data relaying and aggregation strategies -MAC layer protocols: self-organizing - Hybrid TDMA/FDMA and CSMA based MAC -IEEE 802.15.4.

**CO5: Discuss the WSN routing issues by considering QoS measurements.**
Issues in WSN routing -OLSR - Localization -Indoor and Sensor Network Localization - absolute and relative localization - triangulation - QOS in WSN - Energy Efficient Design - Synchronization.

**TEXT BOOKS**

1. C. Siva Ram Murthy and B. S. Manoj, Ad Hoc Wireless Networks-Architectures and Protocols, New Delhi: Pearson Education, 2013.
2. Holger Karl & Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley, 2005.

**REFERENCES**

1. Rangisetti, A. K. (2023). Advanced Network Simulations Simplified: Practical guide for wired, Wi-Fi (802.11 n/ac/ax), and LTE networks using ns-3. Packt Publishing Ltd.
2. Luo, J., Chen, Y., Wu, M., & Yang, Y. (2021). A survey of routing protocols for underwater wireless sensor networks. IEEE Communications Surveys & Tutorials, 23(1), 137-160.
3. Akbar, M. S., Hussain, Z., Sheng, M., & Shankaran, R. (2022). Wireless body area sensor networks: Survey of mac and routing protocols for patient monitoring under IEEE 802.15. 4 and IEEE 802.15. 6. Sensors, 22(21), 8279.

**L: 45; TOTAL:45 PERIODS**

| Course Code | COMPUTER ARCHITECTURE | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC55E | | 3 | 0 | 0 | 0 | 3 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

**Theory Components:**

CO1: Describe the basic organization and fundamental components of general-purpose computer system.

CO2: Describe the representation and manipulation of data on the computer.

CO3: Discuss about implementation schemes of control unit and pipeline performance.

CO4: Discuss the various types of parallelism architectures and GPU architectures.

CO5: Explain the memory hierarchy and I/O systems interfacing.

**CO1: Describe the basic organization and fundamental components of general-purpose computer system.**

Architecture and function of general computer system - Basic Operational Concepts, Bus Structures, Software Performance – Memory locations & addresses – Memory operations – Instruction and instruction sequencing – addressing modes – assembly language - System buses, Multi-bus organization.

**CO2: Describe the representation and manipulation of data on the computer**.

Signed number representation, fixed and floating point representations, character representation. Computer arithmetic - integer addition and subtraction, ripple carry adder, carry look-ahead adder - multiplication - shift-and-add, Booth multiplier, carry save multiplier - Division - non-restoring and restoring techniques, floating point arithmetic.

**CO3: Discuss about implementation schemes of control unit and pipeline performance.**

A Basic MIPS implementation – Building a Datapath – Control Implementation Scheme – Hardwired control – micro programmed control - Pipelining – Pipelined Datapath and control – Handling Data Hazards & Control Hazards – Exceptions. Case study: RISC vs CISC Architecture.

**CO4: Discuss the various types of parallelism architectures and GPU architectures.**

Parallel processing challenges – Flynn's classification – Single Instruction Single Data (SISD), Multiple Instruction Multiple Data (MIMD), Single Instruction Multiple Data (SIMD), Single Program Multiple Data (SPMD), and Vector **Architectures -** Introduction to Graphics Processing Units, GPU vs CPU, GPU Architecture Overview – Intel's Gen8 GPU

**CO5: Explain the memory hierarchy and I/O systems interfacing**.

Memory Hierarchy – memory technologies – cache memory – measuring and improving cache performance – virtual memory, Translation Lookaside Buffer's – Accessing I/O Devices – Interrupts – Direct Memory Access – Bus structure – Bus operation – Arbitration – Interface circuits – Universal Serial Bus**.**

**TEXT BOOKS**

1. David A. Patterson and John L. Hennessy, "Computer Organization and Design: The Hardware/Software Interface", Morgan Kaufmann / Elsevier, 5th Edition, 2014.
2. Carl Hamacher, Zvonko Vranesic, Safwat Zaky and Naraig Manjikian, "Computer Organization and Embedded Systems", Tata McGraw Hill, 6th Edition, 2012.

## REFERENCES

1. William Stallings, "Computer Organization and Architecture – Designing for Performance", Pearson Education, 8th Edition, 2010.
2. John P. Hayes, "Computer Architecture and Organization", Tata McGraw Hill, 3rd Edition, 2012.
3. John L. Hennessey and David A. Patterson, "Computer Architecture – A Quantitative Approach", Morgan Kaufmann / Elsevier Publishers, 5th Edition, 2012.

**L: 45; TOTAL: 45 PERIODS**

| Course Code | SENSORS AND ITS APPLICATIONS IN CIVIL ENGINEERING | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC01N | | 3 | 0 | 0 | 0 | 3 |

## COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

CO1: Explain the principles of sensors and transducers.

CO2: Describe the classification of sensors related to civil engineering. CO3: Interface various types of sensors in embedded processor.

CO4: Explore the physical basics of thermography.

CO5: Apply the concept of thermography in civil engineering.

**CO1: Explain the principles of sensors and transducers.** **L:9**

Overview of Sensors and Transducers - Role of Sensors in Modern Technology - Input/output signals (analog vs. digital) - Measurement principles: physical, chemical, biological, and environmental parameters - Sensitivity, range, accuracy, precision, resolution - Response time - Types of errors: systematic and random - Calibration methods and importance.`

**CO2: Describe the classification of sensors related to civil engineering.** **L:9**

Physical sensors: temperature, pressure, displacement, force - Chemical sensors: gas, pH, humidity sensors - Biological sensors: biosensors, glucose sensors - Analog sensors vs. digital sensors.

**CO3: Interface various types of sensors in embedded processor.** **L:9**

Force sensors - pressure sensors - displacement sensors - Strain gauges - piezoelectric sensors - capacitive sensors – Thermocouples – Thermistors – Accelerometers - gyroscopes and vibration sensors - Air quality and water quality sensors – Ultrasonic sensors – Infrared Sensors – Signal Conditioning - Sensors interfacing with Microcontroller – Embedded processing.

**CO4: Explore the physical basics of thermography.** **L:9**

Basic principle – Emissivity - Law for Black-Body Radiation - Law for Real Bodies Radiation -Effects of the Environment on Measuring - Effects of the Atmosphere - Effects of Ambient Radiation and Background Radiation - Evaluation Equation of Thermography - Effects of Misjudgment Concerning Emissivity and Ambient Radiation Temperature - Passive Thermography – Active Thermography

**CO5: Apply the concept of thermography in civil engineering.** **L:9**

Identifying Building Defects - Water leaks, moisture intrusion - Insulation defects and thermal bridging - Electrical system faults - Thermal performance audits - Detecting air leakage and inefficiencies in HVAC systems - Detection of delamination, cracks, and voids - Heat retention in cracks - Early detection of structural failures - Fatigue cracks, corrosion, and welding defects - Bridge Inspection with Thermography - Road Pavement Analysis - Identifying roof leaks, basement leaks, and moisture problems - Assessing energy losses in buildings.

**TEXT BOOKS**

1. Rithter, Torsten, Fouad, Nabil, Guidelines for Thermography in Architecture and Civil Engineering: Theory, Application Areas, Practical Implementation, Birkhauser, ISBN: 9783035622676, 2021.
2. Ian R. Sinclair, Sensors and Transducers, 3rd Edition, ISBN 0 7506 4932 1, Oxford Press, 2017.
3. De Silva, C.W.(2018). *Sensors and actuators: Engineering system instrumentation*. CRC Press.
4. Vetelino, J., &Reghu, A. (2011). *Introduction to sensors: Sensors technology*. Artech House.
5. J.G.Webster, *Measurement, Instrumentation, and Sensors Handbook*, 2nd Ed. Boca Raton, FL: CRC Press, 2015.

**L: 45; TOTAL: 45 PERIODS**

| Course Code | EDGE COMPUTING FOR WIRELESS | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC01L | COMMUNICATION | 1 | 0 | 0 | 0 | 1 |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to
CO1: Understand fundamentals of edge computing and edge intelligence.
CO2: Understand the architecture and components of edge computing.
CO3: Utilize the edge computing technologies for shaping futuristic technologies.

**CO1: Understand fundamentals of edge computing and edge intelligence.**

Fundamentals of Edge computing - Distributed Computing, The Basic Concept and Key Characteristics of Edge Computing, 5G and 6G Communication Technologies. **L:5**

**CO2: Understand the architecture and components of edge computing.**

Architecture and components of Edge computing, Introduction to Edge Computing Architecture, Different Grades/Layers of Edge, Capabilities of Edge Infrastructure. **L:5**

**CO3: Utilize the edge computing technologies for shaping futuristic technologies.** **L:5**

Edge Intelligence with 5G/6G Networks, Technology Drivers; IoT–Edge–Cloud Continuum - Concepts and Approach.

**TEXT BOOKS**

1. Lanyu Xu and Weisong Shi, "Edge Computing, Systems and Applications", IEEE Press, Wiley, 2025.

2. Rute C. Sofia and John Soldatos, "Shaping the Future of IoT with Edge Intelligence, How Edge Computing Enables the Next Generation of IoT Applications", River Publishers, 2023.

**REFERENCE**

1. Robert Oshana, "Essentials of Edge Computing", NXP, 2022.

**L: 15; TOTAL: 15 PERIODS**

| **Course Code** | **VLSI SYSTEM ON CHIP (SOC) DESIGN** | **L** | **T** | **P** | **E** | **C** |
|---|---|---|---|---|---|---|
| **23EC02L** | | **1** | **0** | **0** | **0** | **1** |

**COURSE OUTCOMES**

Upon the successful completion of the course, the student will be able to

CO1: Understand the basic concepts of System on Chip and its design life cycle and applications.

CO2: Utilize VLSI design to understand the SOC synthesis and Static Timing Analysis (STA).

CO3: Understand SOC design for testability and SOC design verification.

**CO1: Understand the basic concepts of System on Chip and its design life cycle and applications.** **L:5**

System on Chip (SOC), Constituents of SOC, SOC Development Life Cycle, Design Center Infrastructure, SOC Design Flow, Applications, RTL fundamentals.

**CO2: Utilize VLSI design concepts to understand the SOC synthesis and Static Timing Analysis (STA).**

SOC Synthesis, Design Rule Constraints (DRC), SOC Design synthesis, Low-Power Synthesis, Reports; SOC Timing analysis, Timing definition, Timing delay calculation concepts, Timing analysis, Modelling process, Voltage and Temperature variations, Timing and Design constraints, Organizing Paths to Groups, Design Corners, Challenges of STA during SOC design. **L:5**

**CO3: Understand SOC design for testability and SOC design verification.**

SOC Design for Testability Guidelines, DFT Logic Insertion Techniques, Boundary Scan, Memory Built- In Self-Test (MBIST), Challenges in SOC DFT, DFT Simulations and Tools; Importance of Verification, Verification plan and strategies, Verification methods and Tools, Formal verification, FPGA validation, Validation on Development Boards. **L:5**

**TEXT BOOK**

1. Veena S. Chakravarthi, "A Practical Approach to VLSI System on Chip (SoC) Design", 2nd Edition, Springer Cham, 2022.

**REFERENCES**

1. Ross K. Snider, "Advanced Digital System Design using SoC FPGAs", Springer Cham, 2024.
2. Charles Chien, "Digital Radio Systems on a Chip, A Systems Approach", Springer New York, NY, 2013.
3. Cem Ünsalan and Bora Tar, "Digital System Design with FPGA: Implementation Using Verilog and VHDL", 1st edition, McGraw Hill, 2017.
4. René Beuchat, Florian Depraz, Andrea Guerrieri, and Sahand Kashani, "Fundamentals of System-on-Chip Design on Arm Cortex-M Microcontrollers", arm Education Media, 2021.

**L: 15; TOTAL: 15 PERIODS**

| Course Code | mmWAVE RADAR LABORATORY | L | T | P | E | C |
|---|---|---|---|---|---|---|
| 23EC03L | | 0 | 0 | 2 | 0 | 1 |

## COURSE OUTCOMES

Upon the successful completion of the course, the student will be able to

CO1: Implement mmWave RADAR signal processing techniques using hardware and software tools.

CO2: Demonstrate hands-on proficiency in configuring mmWave RADAR systems, visualizing point-cloud data, and validating advanced algorithms.

## LIST OF EXPERIMENTS

1. mmWave RADAR kit setup and point-cloud visualization
2. Implementation of FMCW radar and its performance evaluation
3. Generation of range profile using 1D FFT
4. Range–Doppler processing and moving target detection
5. Implementation of MUSIC algorithm for high-resolution angle estimation

## REFERENCES

1. Christian Waldschmidt, Christina Bonfert, Timo Grebner**,** ***Millimeter Wave Radar Hardware and Signal Processing*****, Springer, 2025.**
2. Texas Instruments, IWR1843 Single-Chip 76–81 GHz FMCW mmWave Sensor Datasheet, TI, September 2024.
3. Mark A. Richards, Fundamentals of Radar Signal Processing, 2nd Edition, Tata McGraw-Hill, 2014.
4. Lee Andrew Harrison, Introduction to Radar with Python and MATLAB, Artech House, 2019.
5. Merrill I. Skolnik, Radar Handbook, 3rd Edition, McGraw-Hill, 2008.

## WEB LINK

**https://dev.ti.com/tirex/explore/node?node=A__AEIJm0rwIeU.2P1OBWwlaA__radar_toolbox__1AslXXD__LATEST**

**P: 15; TOTAL: 15 PERIODS**