# Department of Electronics and Communications Engineering

# B.Tech. Electronics and Communications Engineering Curriculum and Syllabus
# (Applicable to the students admitted from AY 2023-24 onwards)


## School of Engineering and Sciences
## SRM University-AP, Andhra Pradesh

**Category Wise Credit Distribution**

| Course Sub-category | Subcategory Credits | Category Credits | Learning hours |
|---|---|---|---|
| Ability Enhancement Courses (AEC) | | 8 | 240 |
| University AEC | 4 | | |
| School AEC | 4 | | |
| Value Added Courses (VAC) | | 8 | 240 |
| University VAC | 4 | | |
| School VAC | 4 | | |
| Skill Enhancement Courses (SEC) | | 17 | 510 |
| School SEC | 5 | | |
| Department SEC | 4 | | |
| SEC Elective | 8 | | |
| Foundation/ Interdisciplinary courses (FIC) | | 18 | 540 |
| School FIC | 18 | | |
| Department FIC | 0 | | |
| Core + Core Elective including Specialization (CC) | | 78 | 2340 |
| Core | 63 | | |
| Core Elective (Inc Specialization) | 15 | | |
| Minor (MC) + Open Elective (OE) | | 15 | 450 |
| Research / Design / Internship/ Project (RDIP) | | 19 | 570 |
| Internship / Design Project / Startup / NGO | 4 | | |
| UROP | 3 | | |
| Internship / Research / Thesis | 12 | | |
| Total | | 163 | 4890 |

**Semester wise Course Credit Distribution Under Various Categories**

| Category | Semester | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **I** | **II** | **III** | **IV** | **V** | **VI** | **VII** | **VIII** | **Total** | **%** |
| Ability Enhancement Courses - AEC | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 8 | **4.9** |
| Value Added Courses - VAC | 2 | 2 | 0 | 0 | 0 | 4 | 0 | 0 | 8 | **4.9** |
| Skill Enhancement Courses - SEC | 3 | 2 | 3 | 3 | 3 | 3 | 0 | 0 | 17 | **10.42** |
| Foundation / Interdisciplinary Courses - FIC | 12 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | **11.04** |
| CC / SE / CE / TE / DE / HSS | 0 | 8 | 15 | 15 | 18 | 13 | 9 | 0 | 78 | **47.8** |
| Minor / Open Elective - OE | 0 | 0 | 3 | 3 | 3 | 3 | 3 | 0 | 15 | **9.2** |
| (Research/ Design/ Industrial Practice/Project/Thesis/Internship) -RDIP | 0 | 0 | 0 | 0 | 0 | 3 | 4 | 12 | 19 | **11.65** |
| **Grand Total** | **19** | **20** | **23** | **23** | **24** | **26** | **16** | **12** | **163** | **100.0** |

| SEMESTER I | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.No** | **Category** | **Sub-Category** | **Course Code** | **Course Title** | **L** | **T/D** | **P/Pr** | **C** | **LH** |
| 1 | AEC | AEC | AEC 101 | Art of Listening, Speaking and Reading Skills | 1 | 0 | 1 | 2 | 60 |
| 2 | VAC | VAC | VAC 102 | Universal Human Values and Ethics | 2 | 0 | 0 | 2 | 60 |
| 3 | SEC | SEC | SEC 101 | Analytical Reasoning and Aptitude Skills - I | 3 | 0 | 0 | 3 | 90 |
| 4 | FIC | FIC | FIC 102 | Engineering Physics | 2 | 0 | 1 | 3 | 90 |
| 5 | FIC | FIC | FIC 103 | Calculus For Engineers | 3 | 0 | 0 | 3 | 90 |
| 6 | FIC | FIC | FIC 104 | Fundamentals of Computing and Programming in C | 3 | 0 | 1 | 4 | 120 |
| 7 | FIC | FIC | FIC 101 | Emerging Technologies | 2 | 0 | 0 | 2 | 60 |
| | | | | **Semester Total** | **16** | **0** | **3** | **19** | **570** |

| SEMESTER II | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.No** | **Category** | **Sub-Category** | **Course Code** | **Course Title** | **L** | **T/D** | **P/Pr** | **C** | **LH** |
| 1 | AEC | AEC | AEC 107 | Effective Writing and Presentation Skills | 1 | 0 | 1 | 2 | 60 |
| 2 | VAC | VAC | VAC 101 | Environmental Science | 2 | 0 | 0 | 2 | 60 |
| 3 | SEC | SEC | SEC 103 | Entrepreneurial Mindset | 2 | 0 | 0 | 2 | 60 |
| 4 | FIC | FIC | FIC 117 | Linear Algebra and Differential Equations | 3 | 0 | 0 | 3 | 90 |
| 5 | FIC | FIC | FIC 105 | Principles of Economics and Management | 3 | 0 | 0 | 3 | 90 |
| 6 | Core | CC | ECE 101 | Fundamentals of Electrical Circuits | 3 | 0 | 1 | 4 | 120 |
| 7 | Core | CC | ECE 102 | Microelectronic Devices and Circuits | 3 | 0 | 1 | 4 | 120 |
| | | | | **Semester Total** | **17** | **0** | **3** | **20** | **600** |

| SEMESTER III | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.No** | **Category** | **Sub-Category** | **Course Code** | **Course Title** | **L** | **T/D** | **P/Pr** | **C** | **LH** |
| 1 | AEC | AEC | AEC 105 | Analytical Skills for Engineers | 1 | 0 | 1 | 2 | 60 |
| 2 | VAC | VAC | VAC 103 | Co-Curricular Activities | 0 | 0 | 2 | 2* | 60 |
| 3 | VAC | VAC | VAC 104 | Community Service and Social Responsibility | 0 | 0 | 2 | 2* | 60 |
| 4 | SEC | SEC | SEC 115 | Data Structures | 2 | 0 | 1 | 3 | 90 |
| 5 | Core | CC | ECE 201 | Digital Design with HDL | 3 | 0 | 1 | 4 | 120 |
| 6 | Core | CC | ECE 202 | Signals and Systems | 3 | 0 | 1 | 4 | 120 |
| 7 | Core | CC | ECE 203 | Probability and Random Processes | 3 | 0 | 0 | 3 | 90 |
| 8 | Core | CC | ECE 204 | Design and Analysis of Analog, Mixed Signal Circuits | 3 | 0 | 1 | 4 | 120 |
| 9 | OE | OE | OE | Open Elective/Minor | 3 | 0 | 0 | 3 | 90 |
| | | | | **Semester Total** | **18** | **0** | **9** | **23** | **810** |

| SEMESTER IV | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.No** | **Category** | **Sub-Category** | **Course Code** | **Course Title** | **L** | **T/D** | **P/Pr** | **C** | **LH** |
| 1 | AEC | AEC | AEC 104 | Creativity and Critical thinking Skills | 1 | 0 | 1 | 2 | 60 |
| 2 | VAC | VAC | VAC 103 | Co-Curricular Activities | 0 | 0 | 2 | 2* | 60 |
| 3 | VAC | VAC | VAC 104 | Community Service and Social Responsibility | 0 | 0 | 2 | 2* | 60 |
| 4 | SEC | SEC | SEC 116 | Hands on with Python and Raspberry PI | 2 | 0 | 1 | 3 | 90 |
| 5 | Core | CC | ECE 205 | Principles of Modern Communication Systems | 3 | 0 | 1 | 4 | 120 |
| 6 | Core | CC | ECE 206 | Digital Signal Processing | 3 | 0 | 1 | 4 | 120 |
| 7 | Core | CC | ECE 207 | Control Systems | 2 | 1 | 0 | 3 | 90 |
| 8 | Core | CC | ECE 208 | AI/ML for Electronics Engineers | 3 | 0 | 1 | 4 | 120 |
| 9 | OE | OE | OE | Open Elective/Minor | 3 | 0 | 0 | 3 | 90 |
| | | | | **Semester Total** | **16** | **2** | **9** | **23** | **810** |

| SEMESTER V | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.No** | **Category** | **Sub-Category** | **Course Code** | **Course Title** | **L** | **T/D** | **P/Pr** | **C** | **LH** |
| 1 | VAC | VAC | VAC 103 | Co-Curricular Activities | 0 | 0 | 2 | 2* | 60 |
| 2 | VAC | VAC | VAC 104 | Community Service and Social Responsibility | 0 | 0 | 2 | 2* | 60 |
| 3 | SEC | SEC | | ARM Programming | 2 | 0 | 1 | 3 | 90 |
| 4 | Core | CC | ECE 301 | Basic CMOS VLSI Design | 3 | 0 | 1 | 4 | 120 |
| 5 | Core | CC | ECE 302 | Wireless Communication | 3 | 0 | 1 | 4 | 120 |
| 6 | Core | CC | ECE 303 | Microprocessors and Microcontrollers | 3 | 0 | 1 | 4 | 120 |
| 7 | Core | CC | ECE 304 | Electro Magnetics and Wave Propagation | 3 | 0 | 0 | 3 | 90 |
| 8 | Core | CC | ECE 305 | Internet of Things | 2 | 0 | 1 | 3 | 90 |
| 9 | OE | OE | OE | Open Elective/Minor | 3 | 0 | 0 | 3 | 90 |
| | | | | **Semester Total** | **20** | **0** | **8** | **24** | **840** |

| SEMESTER VI | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.No** | **Category** | **Sub-Category** | **Course Code** | **Course Title** | **L** | **T/D** | **P/Pr** | **C** | **LH** |
| 1 | VAC | VAC | VAC 103 | Co-Curricular Activities | 0 | 0 | 2 | 2 | 60 |
| 2 | VAC | VAC | VAC 104 | Community Service and Social Responsibility | 0 | 0 | 2 | 2 | 60 |
| 3 | SEC | SEC | | System Verilog | 2 | 0 | 1 | **3** | 90 |
| 4 | RDIP | RDIP | | UROP | 0 | 0 | 3 | 3 | 90 |
| 5 | Core | CC | ECE 307 | Antenna Design | 2 | 0 | 1 | 3 | 90 |
| 6 | Core | CC | ECE 308 | Embedded System for Design | 3 | 0 | 1 | 4 | 120 |
| 7 | Elective | CE/SE | CE/SE | Core/Specialization Elective | 3/2' | 0 | 0/1 | 3 | 90 |
| 8 | Elective | CE/SE | CE/SE | Core/Specialization Elective | 3/2' | 0 | 0/1 | 3 | 90 |
| 9 | OE | OE | OE | Open Elective/Minor | 3 | 0 | 0 | 3 | 90 |
| | | | | **Semester Total** | **16/18** | **0** | **10/12** | **26** | **690** |

| SEMESTER VII | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.No** | **Category** | **Sub-Category** | **Course Code** | **Course Title** | **L** | **T/D** | **P/Pr** | **C** | **LH** |
| 1 | Elective | CE/SE | CE/SE | Core/Specialization Elective | 3/2' | 0 | 0/1 | 3 | 90 |
| 2 | Elective | CE/SE | CE/SE | Core/Specialization Elective | 3/2' | 0 | 0/1 | 3 | 90 |
| 3 | Elective | CE/SE | CE/SE | Core/Specialization Elective | 3/2' | 0 | 0/1 | 3 | 90 |
| 4 | RDIP | RDIP | ECE 401 | Internship | 0 | 0 | 4 | 4 | 120 |
| 5 | OE | OE | OE | Open Elective/Minor | 3 | 0 | 0 | 3 | 90 |
| | | | | **Semester Total** | **9/12** | **0** | **4/7** | **16** | **480** |

| SEMESTER VIII | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.No** | **Category** | **Sub-Category** | **Course Code** | **Course Title** | **L** | **T/D** | **P/Pr** | **C** | **LH** |
| 1 | RDIP | RDIP | ECE 402 | Major Project | 0 | 0 | 12 | 12 | 360 |
| | | | | **Semester Total** | **0** | **0** | **12** | **12** | **360** |

**Note**: L-T/D-P/Pr and the class allocation is as follows.

a. Every 1 credit of Lecture/Tutorial per week is equal to one contact hour of 60 minutes
b. Every 1 credit of Discussion per week is equal to two contact hours of 60 minutes
c. Every 1 credit of Practical per week is equal to two contact hours of 60 minutes
d. Every 1 credit of Project per week is equal to two contact hours of 60 minutes (timetable not required)

| **S.No** | **Semester** | **Credits** |
|---|---|---|
| 1 | I | 19 |
| 2 | II | 20 |
| 3 | III | 23 |
| 4 | IV | 23 |
| 5 | V | 24 |
| 6 | VI | 26 |
| 7 | VII | 16 |
| 8 | VIII | 12 |
| **Total** | | **163** |

| Specialization: Embedded Systems and IoT | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.No** | **Category** | **Sub-Category** | **Course Code** | **Course Title** | **L** | **T/D** | **P/Pr** | **C** | **LH** |
| 1. | Elective | CE/SE | ECE 421 | Embedded Programming | 2 | 0 | 1 | 3 | 90 |
| 2. | Elective | CE/SE | ECE 422 | RTOS | 2 | 0 | 1 | 3 | 90 |
| 3. | Elective | CE/SE | ECE 423 | Embedded Networking | 2 | 0 | 1 | 3 | 90 |
| 4. | Elective | CE/SE | ECE 424 | IoT Architecture and Protocols | 2 | 0 | 1 | 3 | 90 |
| 5. | Elective | CE/SE | ECE 426 | SOC Design for IoT | 3 | 0 | 0 | 3 | 90 |
| 6. | Elective | CE/SE | ECE 428 | FPGA-based Embedded System Design | 2 | 0 | 1 | 3 | 90 |
| 7. | Elective | CE/SE | ECE 429 | Embedded Systems for Electric Vehicles | 3 | 0 | 0 | 3 | 90 |

| Specialization: VLSI Design | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.No** | **Category** | **Sub-Category** | **Course Code** | **Course Title** | **L** | **T/D** | **P/Pr** | **C** | **LH** |
| 1. | Elective | CE/SE | ECE 431 | VLSI Physical Design | 3 | 0 | 0 | 3 | 90 |
| 2. | Elective | CE/SE | ECE 432 | Advanced CMOS Digital IC Design | 3 | 0 | 0 | 3 | 90 |
| 3. | Elective | CE/SE | ECE 433 | CMOS RFIC Design | 3 | 0 | 0 | 3 | 90 |
| 4. | Elective | CE/SE | ECE 436 | Design Verification and Testing | 3 | 0 | 0 | 3 | 90 |
| 5. | Elective | CE/SE | ECE 437 | Nanoelectronics | 3 | 0 | 0 | 3 | 90 |
| 6. | Elective | CE/SE | ECE 438 | CAD for VLSI IC Design | 3 | 0 | 0 | 3 | 90 |
| 7. | Elective | CE/SE | ECE 440 | Semiconductor Device Modeling | 3 | 0 | 0 | 3 | 90 |

| Specialization: Advanced Communication Systems | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.No** | **Category** | **Sub-Category** | **Course Code** | **Course Title** | **L** | **T/D** | **P/Pr** | **C** | **LH** |
| 1 | Elective | CE/SE | ECE 441 | Advanced Wireless Communication Systems(5G/6G) | 2 | 0 | 1 | 3 | 90 |
| 2 | Elective | CE/SE | ECE 442 | Quantum Communications | 3 | 0 | 0 | 3 | 90 |
| 3 | Elective | CE/SE | ECE 443 | Information Theory and Coding | 3 | 0 | 0 | 3 | 90 |
| 4 | Elective | CE/SE | ECE 444 | Optical communication | 3 | 0 | 0 | 3 | 90 |
| 5 | Elective | CE/SE | ECE 472 | Computer Networks and Internet Protocols | 3 | 0 | 0 | 3 | 90 |
| 6 | Elective | CE/SE | ECE 446 | Detection and Estimation theory | 3 | 0 | 0 | 3 | 90 |
| 7 | Elective | CE/SE | ECE 447 | Satellite communication | 3 | 0 | 0 | 3 | 90 |

| Specialization: Advanced Signal Processing with AI/ML | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.No** | **Category** | **Sub-Category** | **Course Code** | **Course Title** | **L** | **T/D** | **P/Pr** | **C** | **LH** |
| 1 | Elective | CE/SE | ECE 451 | Advanced Signal Processing | 3 | 0 | 0 | 3 | 90 |
| 2 | Elective | CE/SE | ECE 452 | Deep Learning | 2 | 0 | 1 | 3 | 90 |
| 3 | Elective | CE/SE | ECE 453 | Image Processing and Computer Vision | 3 | 0 | 0 | 3 | 90 |
| 4 | Elective | CE/SE | ECE 454 | Biomedical Signal Processing | 3 | 0 | 0 | 3 | 90 |
| 5 | Elective | CE/SE | ECE 455 | Detection and Estimation Theory | 3 | 0 | 0 | 3 | 90 |
| 6 | Elective | CE/SE | ECE 456 | Digital Speech Processing | 3 | 0 | 0 | 3 | 90 |
| 7 | Elective | CE/SE | ECE 459 | Pattern recognition | 2 | 0 | 1 | 3 | 90 |

| Minor Program (Drone Technology) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **S.No** | **Category** | **Sub-Category** | **Course Code** | **Course Title** | **L** | **T/D** | **P/Pr** | **C** | **LH** |
| 1 | OE | OE | ECE 241 | Drone Fabrication and Testing | 3 | 0 | 0 | 3 | 90 |
| 2 | OE | OE | ECE 242 | Drone Security | 3 | 0 | 0 | 3 | 90 |
| 3 | OE | OE | ECE 243 | Hands on with Python and Raspberry PI for Drones | 2 | 0 | 1 | 3 | 90 |
| 4 | OE | OE | ECE 244 | Internet of Drones | 3 | 0 | 0 | 3 | 90 |
| 5 | OE | OE | ECE 245 | Embedded System Design for Drones | 2 | 0 | 1 | 3 | 90 |

SRM UNIVERSITY AP
Andhra Pradesh

**SRM University – AP, Andhra Pradesh**
Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

# B. Tech in Electronics and Communication Engineering

## Mission Statements

- Create inclusive and highly motivated individuals and leaders who promote diversity, innovation, creativity, and a high sense of responsibility towards societal progress.
- Strive for excellence by promoting interdisciplinary education and research through global collaborations.
- Deliver state-of-the-art research-based education that equips students with the skills to address contemporary challenges and contribute to the field's advancement.
- Foster a culture of innovation and entrepreneurship, by working closely with leading industry partners to translate ideas into real-life solutions.
- Aim to be a global knowledge hub by collaborating with leading institutions and industries.

## Program Educational Objectives (PEO)

**PEO 1:** Enable the undergraduate students to learn the fundamentals of Electronics and Communication Engineering deeply and lay a strong foundation for their professional careers or higher studies.

**PEO 2:** Impart the skills to design and develop solutions for complex electronics engineering problems in a multi-disciplinary environment.

**PEO 3:** Work in guided multi-disciplinary electronics and communication-related field research groups using technical know-how, common tools and environments to achieve project objectives.

**PEO 4:** Facilitate the development of effective communication skills, lifelong learning, leadership qualities and ethical professional conduct across their higher education and career paths.

## Mission of the Department to Program Educational Objectives (PEO) Mapping

| | PEO 1 | PEO 2 | PEO 3 | PEO 4 |
|---|---|---|---|---|
| **Mission Statement 1** | 3 | 3 | 2 | 3 |
| **Mission Statement 2** | 3 | 3 | 3 | 1 |
| **Mission Statement 3** | 3 | 3 | 3 | 2 |
| **Mission Statement 4** | 1 | 3 | 3 | 3 |
| **Mission Statement 5** | 3 | 3 | 3 | 3 |

## Program Specific Outcomes (PSO)

**PSO 1:** Architect modern communication systems to meet stated requirements.

**PSO 2:** Design, build and test electronic systems for given specifications.

**PSO 3:** Analyse, plan and apply the acquired knowledge in basic sciences, mathematics and Electronics and Communication Engineering to solve complex problems with technical, economic, environmental, and social contexts.

**Mapping Program Educational Objectives (PEO) to Program Learning Outcomes (PLO)**

| PEOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | POs | | | | | | | | | | | | PSOs | | |
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and | Self-Directed and Life Long | PSO 1 | PSO 2 | PSO 3 |
| **PEO 1** | 3 | 2 | 1 | 1 | 2 | - | - | 1 | 2 | 1 | - | 2 | 1 | 1 | 1 |
| **PEO 2** | 2 | 3 | 3 | 3 | 3 | - | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| **PEO 3** | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 |
| **PEO 4** | 2 | 2 | 2 | 2 | - | 2 | 2 | 3 | 3 | 3 | 1 | 3 | 1 | 1 | 3 |

# SEMESTER I

**SRM University – AP, Andhra Pradesh**
Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

# Art of Listening, Speaking and Reading Skills

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | AEC 101 | **Course Category** | Ability Enhancement Course | **L-T-P-C** | 1 | 0 | 1 | 2 |
| **Pre-Requisite Course(s)** | NA | **Co-Requisite Course(s)** | | **Progressive Course(s)** | | | | |
| **Course Offering Department** | Literature and Languages | **Professional / Licensing Standards** | | | | | | |

**Course Objectives**

To develop the students' ability to comprehend spoken language in various contexts and help them build confidence and fluency in speaking through structured activities, discussions, and presentations as well as enhance their reading skills by engaging with a variety of texts, including literary works, informational articles, and academic writings.

**Course Outcome (COs)**

| CO's | At the end of the course the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **1** | Demonstrate effective listening strategies by accurately summarizing and responding to spoken content in various contexts | **2** | **70%** | **65%** |
| **2** | Students will be able to critically analyze spoken and written texts to identify underlying themes, arguments, and perspectives. | **3, 4** | **75%** | **70%** |
| **3** | Students will construct and deliver coherent and engaging oral presentations and written responses that integrate information from multiple sources. | **5, 6** | **70%** | **60%** |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Engineering Knowledge** | **Problem** | **Design and Development** | **Analysis, Design and** | **Modern Tool and ICT** | **Society and Multicultural** | **Environment and** | **Moral, and Ethical** | **Individual and Teamwork** | **Communication Skills** | **Project Management** | **Self-Directed and Life Long** | **PSO 1** | **PSO 2** | **PSO 3** |
| Outcome 1 | | **1** | | | | **1** | | | **3** | **3** | **1** | 2 | 2 | 2 | 2 |
| Outcome 2 | | 2 | | | | **2** | | | **3** | **3** | **2** | 2 | 2 | 2 | 2 |
| Outcome 3 | | **3** | | | | **3** | | | **3** | **3** | **3** | 2 | 2 | 2 | 2 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Average** | | **2** | | | | **2** | | | **3** | **3** | **2** | **2** | 2 | 2 | 2 |

**Course Unitization Plan:**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Augmenting Listening skills** | **9** | | |
| | Course introduction and objectives: Importance of LSRW | 1 | 1 | 1 a |
| | Listening - Barriers to active listening and steps to Overcome | 2 | 1 | 1 b |
| | Listening Comprehension<br>How to take/ make notes (different ways) | 2 | 1 | 1b, 2a, 2c |
| | Listening practice: Identifying main ideas, supporting details, and inferences and summarizing<br>key points | 2 | 1 | 1b, 2a, 2c |
| | Practice sessions: memory games, Chinese whisper | 2 | 1 | NA |
| **Unit 2** | **Developing Speaking Skills** | **9** | | |
| | Strategies for good speech, Basics of grammatically correct speech | 1 | 2 | 1a, 2 a, b, c |
| | Basics of phonetics and intonation | 2 | 2 | 1a |
| | Oral presentations: do's and don'ts | 1 | 2 | 1a |
| | Speaking Practice: Just a minute/ Impromptu, Story-telling/ Story starters Group discussions, | 5 | 2 | NA |
| | | | | |
| **Unit 3** | **Communication and Persuasion** | **9** | | |
| | Verbal Communication and Nonverbal Communication | 2 | 2, 3 | 1a |
| | The art of persuasive communication (Ethos, pathos, Logos) | 2 | 2, 3 | 1a |
| | Practice sessions<br>(Convince the other Role plays, Self-introduction, Pitching, extempore, public speaking) | 5 | 2, 3 | NA |
| **Unit 4** | **Reading** | **9** | | |
| | Reading strategies (Skimming and scanning, extensive and intensive) | 2 | 2 | 1c |
| | Reading and analyzing various texts, including articles, essays, and academic papers | 3 | 2 | 1c |
| | Reading Comprehension Practice | 4 | 2 | 1c, 2a |
| **Unit 5** | **Integrated Skills and Real-World Application** | **9** | | |
| | Engaging in discussions and debates on current issues | 2 | 3 | NA |

| | | | | |
|---|---|---|---|---|
| | Real-world application of language skills (e.g., job interviews, social interactions) | 2 | 3 | NA |
| | Pitching Presentation | 5 | 3 | NA |
| | Total contact hours | 45 | | |
| | Notional hours | 15 | | |
| | **Total Leaning Hours** | **60** | | |

1. **Recommended Resources**
   a. Shoba, L. (2017). *Communicative English: A Workbook*. U.K: Cambridge University Press.
   b. Leonardo, N. (2020) *Active Listening Techniques: 30 Practical Tools to Hone Your Communication Skills*. Rockridge Press
   c. Williams, A.J. (2014) Reading Comprehension: How To Drastically Improve Your Reading Comprehension and Speed Reading Fast! (Reading Skills, Speed Reading)

2. **Recommended Online Resources**

a. https://learnenglishteens.britishcouncil.org/
b. https://www.bbc.co.uk/learningenglish/
c. https://www.ted.com/?geo=hi

**Learning Assessment:**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (60%)** | | | | **End Semester Assessments (40%)** |
|---|---|---|---|---|---|---|
| | | **CLA-1 (20%)** | **CLA-2 (20%)** | | **CLA-3 (20%)** | |
| Level 1 | Remember | 20% | | | 40% | 30% |
| | Understand | | | | | |
| Level 2 | Apply | 60% | 40% | | 40% | 30% |
| | Analyse | | | | | |
| Level 3 | Evaluate | 20% | 60% | | 20% | 40% |
| | Create | | | | | |
| **Total** | | **100%** | 100% | | **100%** | **100%** |

**SRM University – AP, Andhra Pradesh**
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**Universal Human Values and Ethics**

| Course Code | **VAC 102** | Course Category | **VAC** | L-T-P-C | **2** | **0** | **0** | **2** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **Psychology Department** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To cultivate deep understanding of human values by teaching students the core principles of universal human values and their significance.

**Objective 2:** To promote ethical decision-making skills by equipping the students with the ability to make ethical choices in life, work, and society.

**Objective 3:** To foster a diverse and inclusive ethical perspective by sensitizing the students to diversity, equity, inclusion, gender, and cultural differences.

**Objective 4:** To highlight the relevance of ethics in society and professions by showcasing the practical importance of ethics in personal, societal, and professional contexts.

**Objective 5:** To address common challenges by preparing the students to overcome obstacles to ethical behaviour, fostering a commitment to universal values.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the completion of the course learners will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Evaluate the significance of value inputs in formal education and start applying them in their life and profession | 3 | 70% | 80% |
| **Outcome 2** | Students will foster diverse and inclusive perspectives, contributing to more equitable and harmonious communities and workplaces | 2 | 70% | 70% |
| **Outcome 3** | Students will be able to apply ethical principles effectively in their personal and professional lives, leading to improved relationships and ethical practices in society | 3 | 60% | 70% |

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Life Long Learning | PSO 1 | PSO 2 | PSO 3 |
| **Outcome 1** | 2 | 2 | 3 | | | | 2 | 3 | 3 | 1 | 1 | 3 | | | |
| **Outcome 2** | | 2 | 3 | | | | 1 | 3 | 3 | 1 | | 3 | | | |
| **Outcome 3** | 2 | 3 | 3 | | | | | 3 | 3 | 1 | 1 | 3 | | | |
| **Course Average** | **2** | **2** | **3** | | | | **1** | **3** | **3** | **1** | **1** | **3** | | | |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Fundamentals of Human Values and Ethics** | **7** | 1 | 1, 2, 3, 4, 5 |
| | Introduction to human values and ethics. | 1 | | |
| | Theory of wellbeing | 2 | | |
| | Purpose and relevance of human values | 4 | | |
| **Unit 2** | **Culture and Ethical Principles** | **5** | **2** | |
| | Culture and ethics. | 2 | | |
| | Ethics in the community and society | 3 | | |
| **Unit 3** | **Ethics and Inclusivity** | **6** | **2** | |
| | Ethics and diversity & inclusion | 3 | | |
| | Equity, equality, and addressing violence | 3 | | |
| **Unit 4** | **Ethics in various life spheres** | **6** | **3** | |
| | Ethics in family, society, and workplace | 4 | | |
| | Ethics in IPR and plagiarism | 2 | | |
| **Unit 5** | **Overcoming ethical challenges** | **6** | **3** | |
| | Identifying common challenges | 3 | | |
| | Strategies to overcome challenges | 3 | | |
| **Total Contact Hours** | | **30** | | |

**Recommended Resources**


1. Landau, RS. Living Ethics. New York: Oxford University Press, 2019.
2. Nagarazan, R.S. Ethics and Human Values, New Delhi: New Age International Limited.
   Rachels, J. The Elements of Moral Philosophy. New York: McGraw Hill. 2003.
3. Singer, P. Applied Ethics. Oxford: Oxford University Press, 1986.
4. Ethics: Contemporary Readings. Edited by Harry Gensler, Earl Spurgin, James Swindle. New York, Routledge. 2004.


**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | |
|---|---|---|---|---|
| | | **CLA-1 (10%)** | **CLA 2 (20%)** | **CLA-3 (20%)** |
| | | **Theory** | **Theory** | **Theory** |
| Level 1 | Remember | 50% | 50% | 50% |
| | Understand | | | |
| Level 2 | Apply | 50% | 50% | 50% |
| | Analyse | | | |
| Level 3 | Evaluate | | | |
| | Create | | | |
| **Total** | | **100%** | **100%** | **100%** |

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**Analytical Reasoning and Aptitude Skills - I**

| Course Code | **SEC 101** | Course Category | **Humanity Sciences** | L-T-P-C | **3** | **0** | **0** | **3** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | | Progressive Course(s) | **SEC 102** | | | |
| Course Offering Department | **Mathematics** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To categorize, apply and use thought process to distinguish between concepts of quantitative methods.

**Objective 2:** To prepare and explain the fundamentals related to various possibilities.

**Objective 3:** To critically evaluate numerous possibilities related to puzzles.

**Objective 4:** Explore and apply key concepts in logical thinking to business problems.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Use logical thinking and analytical abilities to solve quantitative aptitude questions from company specific and other competitive tests. | 1 | 70% | 60% |
| **Outcome 2** | Solve questions related to Time and Distance and Time and work from company specific and other competitive tests. | 3 | 80% | 70% |
| **Outcome 3** | Understand and solve puzzle questions from specific and other competitive tests | 1 | 70% | 60% |
| **Outcome 4** | Make sound arguments based on mathematical reasoning and careful analysis of data. | 1 | 90% | 80% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Life Long Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | | | | | 1 | | | 2 | | 2 | | 1 | | | |
| Outcome 2 | | 2 | | | 3 | | | 3 | 3 | | | | | | |
| Outcome 3 | | 3 | | | | | | | 2 | | | 2 | | | |
| Outcome 4 | | | | | | | | 2 | 3 | | | 2 | | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Average** | | **3** | | | **2** | | | **4** | **4** | | | **3** | | | |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Quantitative Aptitude** | **14** | | |
| | Time, speed and distance | 5 | 1,4 | 1,4 |
| | Time and work, Pipes and cisterns | 9 | 1,4 | 1,4 |
| | | | | |
| Unit II | Numbers, LCM and HCF. | 2 | 1,4 | 1,4 |
| | P and C | 4 | 1,4 | 1,4 |
| | Probability, progressions | 4 | 1,4 | 1,4 |
| Unit III | Geometry, Mensuration | 5 | 1,2 | 2,3 |
| | Clocks and calendars | 4 | 1,3 | 1,4 |
| Unit IV | Linear equation and special equations | 5 | 1,2 | 1,2 |
| | Quadratic equations | 2 | 1,2 | 1,2 |
| | Inequalities | 2 | 2,3 | 2,3 |
| | Sets and Venn diagrams | 3 | 1,2 | 2,4 |
| **Total Contact Hours** | | 45 | | |

**Recommended Resources**

1. Arun Sharma – How to prepare for Quantitative Aptitude, Tata Mcgraw Hill.
2. R.S. Agarwal – Reasoning. Reasoning for competitive exams – Agarwal.
3. Objective Quantitative Aptitude – Oswaal books.
4. Test of reasoning and numerical ability, quantitative aptitude book – Sahitya bhavan.
5. Radian's Quantitative Aptitude.
6. Quantitative Aptitude and Reasoning – Shyam Saraf / Abhilasha Swarup.
7. Fast track objective Arithmetic – Rajesh Verma.

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (10%) | | Mid-1 (15%) | | CLA-2 (10%) | | Mid-2 (15%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 40% | | 50% | | 40% | | 50% | | 50% | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 60% | | 50% | | 60% | | 50% | | 50% | |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

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# Engineering Physics

| **Course Code** | **FIC 102** | **Course Category** | FIC | **L-T-P-C** | 2 | 0 | 1 | 3 |
|---|---|---|---|---|---|---|---|---|
| **Pre-Requisite Course(s)** | NA | **Co-Requisite Course(s)** | NA | **Progressive Course(s)** | NA | | | |
| **Course Offering Department** | Physics | **Professional / Licensing Standards** | | | | | | |

**Course Objectives**

1. Objective 1: To understand the fundamental concepts of physics and their application in engineering.
2. Objective 2: To develop problem-solving skills through physics-based problems.
3. Objective 3: To enhance practical knowledge through laboratory experiments and real-world applications.
4. Objective 4: To foster analytical and critical thinking skills.

**Course Outcome (COs)**

| CO's | At the end of the course the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **1** | Demonstrate understanding of core physics principles in mechanics, waves, modern physics, and electromagnetism | 2 | **75** | **70** |
| **2** | Apply physics principles to analyse and solve engineering physics problems | 3 | **70** | **65** |
| **3** | Demonstrate problem-solving skills using mathematical tools | 3 | **70** | **65** |
| **4** | Evaluate experimental data to interpret and explain the underlying physics concepts | 3 | **75** | **70** |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Engineering Knowledge** | **Problem** | **Design and Development** | **Analysis, Design and** | **Modern Tool and ICT** | **Society and Multicultural** | **Environment and** | **Moral, and Ethical** | **Individual and Teamwork** | **Communication Skills** | **Project Management** | **Self-Directed and Life Long** | **PSO 1** | **PSO 2** | **PSO 3** |
| Outcome 1 | 2 | 2 | 1 | 1 | 1 | | | 1 | 2 | | | 2 | 1 | 1 | 1 |
| Outcome 2 | 2 | 3 | 2 | 2 | 2 | | | 2 | 2 | | | 2 | 2 | 1 | 1 |
| Outcome 3 | 2 | 3 | 2 | 2 | 2 | | | 2 | 2 | | | 2 | 2 | 1 | 1 |
| Outcome 4 | 2 | 3 | 2 | 2 | 3 | | | 2 | 3 | | | 2 | 2 | 1 | 2 |
| **Course Average** | **2.0** | **2.8** | **1.8** | **1.8** | **2.0** | | | **1.8** | **2.3** | | | **2.0** | **1.8** | **1.0** | **1.3** |

**Course Unitization Plan: Theory**

| Unit No. | Syllabus Topics | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| Unit No. 1 | Introduction | 1 | 1 | 1, 3 |
| | Newton's laws of mechanics, Free body force diagram | 1 | 1, 2, 3 | 1, 3 |
| | Momentum and Impulse, Conservation of linear momentum | 1 | 1, 2, 3 | 1, 3 |
| | Work-Kinetic Energy Theorem and related problems | 1 | 1, 2, 3 | 1, 3 |
| | Conservation of mechanical energy: Worked outproblems | 1 | 1, 2, 3 | 1, 3 |
| | Elastic properties of solids, Stress-strain relationship, elastic constants, and their significance | 1 | 1 | 1, 2 |
| Unit No. 2 | Concept of Electromagnetic waves & EMW Spectra | 1 | 1 | 1, 2 |
| | Geometrical & Wave Optics: Laws of reflection and refraction | 1 | 1, 2, 3 | 1, 2 |
| | Concept of Interference | 1 | 1, 2, 3 | 1, 2 |
| | Phase Difference and Path Difference | 1 | 1 | 1, 2 |
| | Double-Slit Interference | 1 | 1 | 1, 2 |
| | Diffraction: types and single slit | 1 | 1, 2, 3 | 1, 2 |
| Unit No. 3 | Black Body Radiation; Wien's displacement law | 1 | 1 | 1, 2 |
| | Discussion on failure of classical laws to explain Black Body Radiation, and concept of Planck's Hypothesis | 1 | 1, 2, 3 | 1, 2 |
| | What is Light? Photon and Overview on Planck Constant | 1 | 1 | 1, 2 |
| | Photoelectric effect – Concept and Experimental Setup | 1 | 1, 2, 3 | 1, 2 |
| | Photoelectric effect – Intensity vs Current, Frequency vs Kinetic Energy, the drawback of Wave theory to explain Photoelectric effect | 1 | 1 | 1, 2 |
| | Wave properties of particle: De Broglie wave | 1 | 1 | 1, 2 |
| Unit No. 4 | **Focus on Maxwell's Equation I**: Discuss lines of force and Electrostatic flux, Introduce Gauss's law (differential and integral form) | 1 | 1 | 1, 4 |
| | Application of Gauss Law: ES field due to infinite wire and sheet. | 1 | 1 | 1, 4 |
| | Electrostatic field due to conducting and insulating sphere. | 1 | 1 | 1, 4 |
| | Concept of Electrostatic Potential and Potential Energy. Inter-relation with electrostatic field. | 1 | 1 | 1, 4 |
| | Capacitor and Capacitance: | 1 | 1, 2 | 1, 4 |
| | Capacitance of a parallel plate capacitor. | 1 | 1, 2, 3 | 1, 4 |
| Unit No. 5 | Introduce Biot-Savart Law as an alternative approach to calculate magnetic field. | 1 | 1 | 1, 4 |
| | Calculate Magnetic field due to finite current element using Biot Savart Law. | 1 | 1 | 1, 4 |
| | Focus on Maxwell's Equation IV: Discuss Ampere's circuital law. | 1 | 1 | 1, 4 |
| | Calculate Magnetic field due to Infinite wire and Solenoid using Ampere's Law. | 1 | 1, 2, 3 | 1, 4 |
| | Focus on Maxwell's Equation III: Lenz's Law and Faraday's law: Induced EMF and Current | 1 | 1, 2, 3 | 1, 4 |

| | | | | |
|---|---|---|---|---|
| | Describe Maxwell Equations as the foundation of electro-magnetism. Derive differential forms starting from Integral forms. Discuss Physical Significance. | 1 | 1 | 1, 4 |

**Course Unitization Plan: Laboratory**

| Exp No. | Syllabus Topics | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **1** | Hooke's law and determination of spring constant for a given spring | 4 | 1, 4 | 5 |
| **2** | Michelson interferometer kit with diode laser | 4 | 1, 4 | 5 |
| **3** | He-Ne laser kit: Optical Interference and Diffraction | 4 | 1, 4 | 5 |
| **4** | Diffraction by Grating and Particle size measurement | 4 | 1, 4 | 5 |
| **5** | Dielectric constant of air using dielectric constant kit. | 4 | 1, 4 | 5 |
| **6** | Verification of Stefan's Law | 4 | 1, 4 | 5 |
| **7** | Biot-savart law: To study the dependence of magnetic field on the current and magnetic field along the axis of a current carrying circular loop | 4 | 1, 4 | 5 |
| **8** | Faraday law & Induced E.M.F: Measurement of the induced voltage and calculation of the magnetic flux induced by a falling magnet | 4 | 1, 4 | 5 |
| **9** | Practice and model exam | 8 | 1, 4 | 5 |

**Recommended Resources**


1. Serway, R. A., & Jewett, J. W. (2017). Physics for Scientists and Engineers with Modern Physics (9th ed.). Cengage India Private Limited.
2. Young, H. D., Freedman, R. A., & Ford, L. C. (2018). University Physics with Modern Physics with Mastering Physics (12th ed.). Pearson.


**Recommended Online Resources**


3. Massachusetts Institute of Technology: OpenCourseWare. (2023). Physics I: Classical Mechanics. Retrieved from Massachusetts Institute of Technology: MIT OpenCourseWare https://ocw.mit.edu/courses/physics/8-01x-classical-mechanics-fall-2023/
4. Massachusetts Institute of Technology: OpenCourseWare. (2023). Physics II: Electricity and Magnetism. Retrieved from Massachusetts Institute of Technology: MIT OpenCourseWare https://ocw.mit.edu/courses/physics/8-02x-electricity-and-magnetism-fall-2023/
5. Department of Physics, SRM University AP. Engineering Physics lab manuals. Retrieved from Engineering Physics Lab (FIC102) https://srmap.edu.in/seas/physics-teaching-lab/

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50 %) | | | | | | | | End Semester Exam (50 %) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (15 %) | | CLA-2 (15 %) | | CLA-3 (__%) | | Mid Term (20 %) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 10% | 5% | 10% | 5% | | | 20% | | 10% | 5% |
| | Understand | 10% | 5% | 10% | 5% | | | 20% | | 10% | 5% |
| Level 2 | Apply | 30% | 10% | 30% | 10% | | | 40% | | 30% | 10% |
| | Analyse | 10% | 20% | 10% | 20% | | | 20% | | 10% | 20% |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **60%** | **40%** | **60 %** | **40%** | | | **100 %** | | **60 %** | **40 %** |

**Course Designers**

a. *Dr. Jatis Kumar Dash, Associate Professor, Department of Physics, SRM University – AP, Andhra Pradesh.*
b. *Dr. Pranab Mandal, Associate Professor & Head. Dept. Of Physics. SRM University – AP, Andhra Pradesh.*
c. *Prof. M. S. Ramachandra Rao, Professor, Department of Physics, Indian Institute of Technology, Madras.*
d. *Prof. D. Narayana Rao, Raja Ramanna Fellow, University of Hyderabad, Hyderabad.*

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# Calculus For Engineers

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Code | FIC 103 | Course Category | FIC | L-T/D-P/Pr-C | 3 | 0 | 0 | 3 |
| Total Contact Hours | | 45 | Total Learning Hours | | 90 | | | |
| Pre-Requisite Course(s) | NA | Co-Requisite Course(s) | NA | Progressive Course(s) | NA | | | |
| Course Offering Department | Mathematics | Professional / Licensing Standards | | | | | | |

**Course Objectives**:

**Objective 1:** Develop a comprehensive understanding of the fundamental concepts of calculus, including limits, derivatives, and integrals. Apply calculus techniques to solve a wide range of mathematical problems.

**Objective 2:** Utilize calculus to find extreme values of functions and understand the Mean Value Theorem. Apply calculus to analyze monotonic functions, identify inflection points, and sketch curves.

**Objective 3:** Apply Lagrange multipliers to solve optimization problems with single constraints. Calculate double and iterated integrals over various regions and in polar form. Utilize triple integrals in rectangular coordinates and apply them to real-world scenarios to find volumes, masses, and more.

**Course Outcomes (COs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **CO 1** | Describe functions and their graphs to identify key characteristics such as domain, range, and behaviour. | 2 | 75% | 80% |
| **CO 2** | Compute derivatives of d-variable functions at specific points and apply various differentiation rules. | 3 | 70% | 75% |
| **CO 3** | Determine definite and indefinite integrals of functions and their applications. | 3 | 75% | 80% |
| **CO 4** | Apply calculus techniques to solve practical problems, including finding extreme values of functions. Utilize the Mean Value Theorem to understand rate of change in real-world applications. | 4 | 72% | 75% |
| **CO 5** | Analyse double and triple integrals over various regions and apply calculus to real-world problems such as finding volumes, masses, and areas. | 4 | 70% | 75% |

**Course Articulation Matrix (CLO) to (PLO)**

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Lifelong Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | **2** | **3** | | **2** | | | | | **3** | | | | | | |
| Outcome 2 | **3** | **2** | | **1** | | | | | **3** | | | | | | |
| Outcome 3 | **2** | **3** | | **1** | | | | | **3** | | | | | | |
| Outcome 4 | **3** | **3** | | **2** | | | | | **3** | | | | | | |
| Outcome 4 | **3** | **2** | | **2** | | | | | **3** | | | | | | |
| Outcome 5 | **2** | **3** | | **2** | | | | | **2** | | | | | | |
| **Course Average** | **3** | **3** | | **2** | | | | | **3** | | | | | | |

**Course Unitization Plan**

| Unit No. | Description of Topic | Contact Hours Required | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit I** | **Unit I: Limit, Continuity, Derivative, and Integrals of Single Variable** | **10 Hours** | | |
| | Functions and Their Graphs, | 1 | **CO 1** | 1 |
| | Limit of a function at a point and limit laws, | 2 | **CO 1** | 1 |
| | Continuity of a function, | 1 | **CO 1** | 1 |
| | Derivative of a function at a point, | 2 | **CO 2** | 1 |
| | Various rules of Derivative, | 1 | **CO 2** | 1 |
| | Definite and indefinite integral, | 2 | **CO 3** | 1 |
| | Fundamental Theorem of Calculus. | 1 | **CO 3** | 1 |
| **Unit II** | **Unit II: Applications of Calculus (Single Variable)** | **9 Hours** | | |
| | Extreme Values of Functions | 2 | **CO 4** | 1 |
| | The Mean Value Theorem, Monotonic Functions | 2 | **CO 4** | 1 |
| | Concavity and curve sketching | 2 | **CO 4** | 1 |
| | Newton's Method to find roots | 1 | **CO 4** | 1 |
| | Area between curves | 1 | **CO 4** | 1 |
| | Arc length. | 1 | **CO 4** | 1 |
| **Unit III** | **Unit III: Limit, Continuity, Partial Derivatives of Multi-Variables Function** | **10 Hours** | | |
| | Three-dimensional rectangular coordinate systems | 1 | **CO 1** | 1 |
| | Functions of several variables | 2 | **CO 1** | 1 |
| | Limits and continuity | 2 | **CO 2** | 1 |
| | Partial Derivatives | 1 | **CO 3** | 1 |
| | The Chain Rule, Directional Derivatives, | 2 | **CO 3** | 1 |
| | Gradient. | 2 | **CO 3** | 1 |
| **Unit IV** | **Unit IV: Extrema of Multi-Variables Function** | **6 Hours** | | |

| | | | | |
|---|---|---|---|---|
| | Extreme values | 1 | **CO 4** | 1 |
| | Saddle points | 1 | **CO 4** | 1 |
| | Absolute Maxima and Minima on Closed Bounded Regions, | 2 | **CO 4** | 1 |
| | Lagrange multipliers (Single Constraints). | 2 | **CO 4** | 1 |
| **Unit V** | **Unit V: Multiple Integrals** | **10 Hours** | | |
| | Double and Iterated Integrals over Rectangles | 2 | **CO 5** | 1 |
| | Double Integrals over General Regions. | 2 | **CO 5** | 1 |
| | Area by Double Integration, | 1 | **CO 5** | 1 |
| | Double Integrals in Polar Form | 1 | **CO 5** | 1 |
| | Triple Integrals in Rectangular Coordinates | 2 | **CO 5** | 1 |
| | Applications. | 2 | **CO 5** | 1 |
| **Total** | | 45 | | |

**Recommended Resources**

**1.** Thomas' Calculus, 14th Edition, Joel R. Hass, Christopher E. Heil, Maurice D. Weir, 2018.

**Learning Assessment (Macro)**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (60%)** | | | | **End Semester Assessments (40%)** |
|---|---|---|---|---|---|---|
| | | **CLA-1 (15%)** | **Mid-1 (25%)** | **CLA-2 (10%)** | **CLA-3 (10%)** | |
| Level 1 | Remember | 30% | 20% | 25% | 25% | 20% |
| | Understand | 20% | 30% | 30% | 25% | 30% |
| Level 2 | Apply | 25% | 30% | 25% | 25% | 25% |
| | Analyse | 25% | 20% | 20% | 25% | 25% |
| Level 3 | Evaluate | | | | | |
| | Create | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers:** Prof. V. Kannan, Dr. Fouzul Atik, Dr. Sazzad Ali Biswas, Dr. Anirban Bose

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## Fundamentals of Computing and Programming in C

| Course Code | **FIC 104** | Course Category | **Core Course (CC)** | L-T-P-C | **3** | **0** | **1** | **4** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **CSE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** Gain basic knowledge in C programming language.

**Objective 2:** Acquire knowledge on Decision making and functions in C.

**Objective 3:** Learn arrays, strings and pointers concept in C.

**Objective 4:** Understand the basics concepts of Structures, Union and File handling techniques using C Programming.

**Course Outcomes / Course Learning Outcomes (CLOs)**

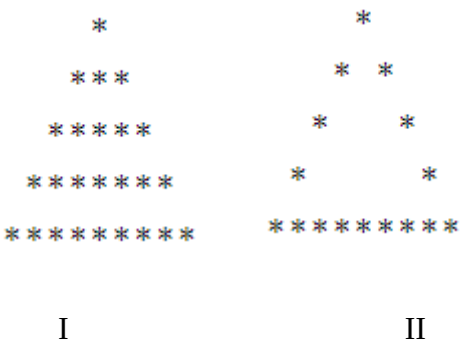
| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Describe C structures, enumerators, keywords, header files and operators | 2 | 75 % | 70% |
| **Outcome 2** | Illustrate Decision-Making statements and Functions. | 3 | 70 % | 65% |
| **Outcome 3** | Interpret arrays, strings, and pointers programming in C | 3 | 70 % | 65% |
| **Outcome 4** | Apply Structures, unions, File handling operations on different scenarios | 3 | 70 % | 65% |
| **Outcome 5** | Solve given projects based on C concepts | 4 | 70 % | 65% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Life Long Learning | PSO 1 | PSO 2 | PSO 3 |
| **Outcome 1** | 3 | 3 | 2 | 1 | | | | | | | | | 2 | 2 | 3 |
| **Outcome 2** | 3 | 3 | 2 | 1 | | | | | | | | | 3 | 2 | 3 |
| **Outcome 3** | 3 | 3 | 2 | 2 | | | | | | | | | 3 | 2 | 3 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Outcome 4** | 3 | 3 | 2 | 2 | | | | | | | | | 3 | 2 | 3 |
| **Outcome 5** | 3 | 3 | 2 | 2 | | | | | | | | 2 | 3 | 2 | 2 |
| **Course Average** | **3** | **3** | **2** | **2** | | | | | | | | **2** | **3** | **2** | **3** |

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **UNIT I** | **INTRODUCTION TO COMPUTER SCIENCE** | **12** | 1 | 1 |
| | Fundamentals of Computing, Historical perspective, Early computers | 2 | 1 | 1,2 |
| | Computing machine. Basic organization of a computer: ALU, input-output units, memory, program counter - variables and addresses - instructions: store, arithmetic, input and output | 2 | 1 | 1,2 |
| | Problem solving: Algorithm / Pseudo code, flowchart, program development steps | 1 | 1 | 1,2 |
| | Computer languages: Machine, symbolic and high-level langua Level languages | 1 | 1 | 1,2 |
| | Creating and Running Programs: Writing, editing (any editor), compiling (gcc) | 1 | 1 | 1,2 |
| | linking, and executing in Linux environment | 1 | 1 | 1,2 |
| | **Lab Experiment 1:** GCC Compiler using Linux, various Linux commands used to edit, compile and executing | 2 | 1 | 1,2 |
| | **Lab Experiment 2:** a) Calculation of the area of the triangle.<br>b) Swap two numbers without using a temporary variable.<br>c) Find the roots of a quadratic equation | 2 | 1 | 1,2 |
| **UNIT II** | **C PROGRAMMING BASICS** | **12** | | |
| | Structure of a C program, identifiers Basic data types and sizes. Constants, Variables | 1 | 1 | 1,2 |
| | Arithmetic, relational and logical operators, increment and decrement operator's | 1 | 1 | 1,2 |
| | Conditional operator, assignment operator, expressions Type pe Conversions, | 1 | 1 | 1,2 |
| | Conditional Expressions Precedence and order of evaluation, Sample Programs. | 1 | 1 | 1,2 |
| | **SELECTION & DECISION MAKING**: if-else, null else, nested if, examples, multi-way selection: switch, else-if, examples. | 1 | 1 | 1,2 |
| | **ITERATION**: Loops - while, do-while and for, break, continue, | 1 | 1 | 1,2 |
| | initialization and updating, event and counter controlled loops and examples. | 1 | 1,2 | 1,2 |
| | **Lab Experiment 3:** a) Find the sum of individual digits of a positive integer and find the reverse of the given number.<br>b) Generate the first n terms of Fibonacci sequence.<br>c) Generate all the prime numbers between 1 and n, where n is a value supplied by the user. | 1 | 1, 2 | 1,2 |

| | | | | |
|---|---|---|---|---|
| | **Lab Experiment 4:** a) Print the multiplication table of a given number n up to a given value, where n is entered by the user.<br>b) Decimal number to binary conversion.<br>c) Check whether a given number is the Armstrong number or n | 2 | 1, 2 | 1,2 |
| | **Lab Experiment 5:** Triangle star patterns<br>  <br>I II | 2 | 1, 2 | 1,2 |
| **UNIT III** | **FUNCTIONS AND ARRAYS** | **12** | | |
| | User defined functions, standard library functions | 1 | 2,3 | 1,2 |
| | Passing 1-D arrays, 2-D arrays to functions. | 1 | 2,3 | 1,2 |
| | Recursive functions - Recursive solutions for Fibonacci series, towers of Hanoi. | 1 | 2,3 | 1,2 |
| | C Pre-processor and header files | 1 | 2,3 | 1,2 |
| | Concepts, declaration, definition, storing and accessing elements | 1 | 2,3 | 1,2 |
| | one dimensional, two dimensional and multidimensional arrays | 1 | 2,3 | 1,2 |
| | array operations and examples, Character arrays and string manipulations | 1 | 2,3 | 1,2 |
| | **Lab Experiment 6:**<br>**a)** (nCr) and (nPr) of the given numbers<br>b. $1+x+x^2\2+x^3\3!+x^4\4!+\ldots\ldots\ldots X^n\n!$ | 1 | 2,3 | 1,2 |
| | **Lab Experiment 7: a)** Interchange the largest and smallest numbers in the array.<br>b. Searching an element in an array<br>b. Sorting array elements. | 1 | 2,3 | 1,2 |
| | **Lab Experiment 8:**<br>a. Transpose of a matrix.<br>b. Addition and multiplication of 2 matrices. | 1 | 2,3 | 1,2 |
| | **Lab Experiment 9:**<br>a. Function to find both the largest and smallest number of an array of integers.<br>b. Liner search.<br>**c.** Replace a character of string either from beginning or ending or at a specified location. | 1 | 2,3 | 1,2 |
| | **Lab Experiment 10:**<br>Pre-processor directives<br>a. If Def<br>b. Undef | 1 | 2,3 | 1,2 |

| | | | | |
|---|---|---|---|---|
| | c. Pragma | | | |
| **UNIT IV** | **POINTERS** | **12** | | |
| | Concepts, initialization of pointer variables | 1 | 3,4 | 1,2 |
| | pointers as function arguments, passing by address, dangling memory, address arithmetic | 2 | 3,4 | 1,2 |
| | character pointers and functions, pointers to pointers | 1 | 3,4 | 1,2 |
| | pointers and multi-dimensional arrays, dynamic memory management functions | 1 | 3,4 | 1,2 |
| | command line arguments | 1 | 3,4 | 1,2 |
| | **Lab Experiment 10:**<br>a. Illustrate call by value and call by reference.<br>b. Reverse a string using pointers<br>c. Compare two arrays using pointers | 2 | 3, 4 | 1,2,3 |
| | **Lab Experiment 11:**<br>a. Array of Int and Char Pointers.<br>b. Array with Malloc(), calloc() and realloc(). | 2 | 3, 4 | 1,2,3 |
| | **Lab Experiment 12:**<br>a. To find the factorial of a given integer.<br>b. To find the GCD (greatest common divisor) of two given integers.<br>**c.** Towers of Hanoi | 2 | 3, 4 | 1,2,3 |
| **UNIT V** | **ENUMERATED, STRUCTURE AND UNION TYPES** | **12** | | |
| | Structures - Declaration, definition, and initialization of structures, accessing structures | 1 | 5 | 2, 3, 4 |
| | nested structures, arrays of structures, structures and functions, pointers to structures, | 2 | 5 | 2, 3, 4 |
| | self-referential structures. Unions, typedef, bit-fields, program applications | 2 | 5 | 2, 3, 4 |
| | Bit-wise operators: logical, shift, rotation, masks. | 1 | 5 | 2, 3, 4 |
| | **FILE HANDLING**: Concept of a file, text files and binary files, formatted I/O, file I/O operations and example programs. | 2 | 5 | 2, 3, 4 |
| | **Lab Experiment 13:**<br>a. Reading a complex number<br>b. Writing a complex number.<br>c. Addition of two complex numbers<br>**d.** Multiplication of two complex numbers | 2 | 5 | 2, 3, 4 |
| | **Lab Experiment 14:**<br>a. File copy<br>b. Word, line and character count in a file. | 2 | 5 | 2, 3, 4 |
| **Total Hours** | | **60** | | |

**Recommended Resources:**

1.The C programming Language by Brian Kernighan and Dennis Richie.
2.Programming in C, Pradip Dey and Manas Ghosh, Second Edition, OXFORD Higher Education, 2011.
3.Problem Solving and Program Design in C, Hanly, Koffman, 7th edition, PEARSON 2013.
4.Programming with C by R S Bichkar, Universities Press, 2012.

**Other Resources**

1. **"Programming with C"**, Byron Gottfried, Mcgraw hill Education, Fourteenth reprint,2016

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|
| | | Theory (40%) | | | | Practical (10%) | | |
| | | CLA-1 (10%) | Mid-1 (10%) | CLA-2 (10%) | CLA-3 (10%) | | Th | Prac |
| Level 1 | Remember | 70% | 60% | 30% | 30% | 50% | 50% | 50% |
| | Understand | | | | | | | |
| Level 2 | Apply | 30% | 40% | 70% | 70% | 50% | 50% | 50% |
| | Analyse | | | | | | | |
| Level 3 | Evaluate | | | | | | | |
| | Create | | | | | | | |
| **Total** | | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

**Course Designers**

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# Emerging Technologies

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | FIC 101 | **Course Category** | Foundation/ Interdisciplinary course | **L-T-P-C** | 2 | 0 | 0 | 2 |
| **Pre-Requisite Course(s)** | | **Co-Requisite Course(s)** | | **Progressive Course(s)** | | | | |
| **Course Offering Department** | ECE | **Professional / Licensing Standards** | | | | | | |

**Course Objectives**

1. Foster a comprehensive grasp of diverse emerging technologies and their transformative impacts on society and industries.
2. Cultivate critical thinking skills to analyze challenges, opportunities, and applications within each technological domain.
3. Develop practical skills through hands-on experiences and assignments, translating theoretical concepts into real-world applications.
4. Raise awareness of ethical considerations, particularly in the context of Artificial Intelligence, encouraging responsible and informed decision-making.

**Course Outcome (COs)**

| CO's | At the end of the course the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **1** | Exhibit a thorough understanding of quantum computing principles, including superposition, entanglement, and interference. | **1** | **80** | **90** |
| **2** | Illustrate understanding by explaining the history, synthesis, and applications of nanomaterial and green hydrogen. | **1** | **80** | **90** |
| **3** | Understand and classify 3D printing technologies. | **2** | **75** | **85** |
| **4** | Demonstrate understanding of the evolution, classification, and applications of UAVs. | **2** | **75** | **85** |
| **5** | Apply knowledge of Artificial Intelligence and Machine Learning to address classification, regression, clustering, and decision-making problems. | **2** | **75** | **85** |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** |
|---|---|

| | Engineering Knowledge | Problem | Design and Development | Analysis, Design and | Modern Tool and ICT | Society and Multicultural | Environment and | Moral, and Ethical | Individual and Teamwork | Communication Skills | Project Management | Self-Directed and Life Long | PSO 1 | PSO 2 | PSO 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outcome 1 | 1 | 2 | 1 | 1 | 3 | 1 | 1 | 2 | 1 | 3 | 1 | 2 | 1 | 1 | 1 |
| Outcome 2 | 1 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 1 |
| Outcome 3 | 2 | 1 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 2 |
| Outcome 4 | 3 | 3 | 3 | 2 | 1 | 3 | 2 | 3 | 2 | 1 | 3 | 3 | 2 | 2 | 1 |
| Outcome 5 | 2 | 3 | 2 | 1 | 1 | 2 | 1 | 3 | 1 | 1 | 2 | 3 | 2 | 2 | 1 |
| **Course Average** | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 1 |

**Course Unitization Plan**

| Unit No. | Syllabus Topics | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit No. 1** | Quantum Computer and early ideas, classical and quantum computing approaches, superposition, entanglement, and interference in quantum computing. | 1 | 1 | 1 |
| | QUBITS and their types; representation of data in quantum mechanics. | 1 | 1 | 1 |
| | Shor's Algorithm, Grover's search algorithm. | 1 | 1 | 1 |
| | Quantum programming languages; Obstacles in building quantum computers. | 1 | 1 | 1 |
| | Applications of quantum computers; Opportunities in the field of quantum computing. | 1 | 1 | 1 |
| | Introduction of quantum communication pillers, quantum network, Heisenberg's uncertainty principle and QKD. | 1 | 1 | 1 |
| | Challenges in QKD, National Quantum Mission, Future perspectives. | 1 | 1 | 1 |
| **Unit No. 2** | Introduction to the nanometer scale. history of nanomaterials | 1 | 2 | 2 |
| | Synthesis of nanomaterials: Bottom-up and Top-down approach | 1 | 2 | 2 |
| | Tools & techniques to characterize nanomaterials. Applications of nanomaterials. | 1 | 2 | 2 |
| | Green Technology: Definition, types of Green Technologies, Green Hydrogen production. | 1 | 2 | 2 |
| | Challenges involved in the storage of Green Hydrogen produced from PEM based electrolysis. | 1 | 2 | 2 |

| | | | | |
|---|---|---|---|---|
| | Applications of Green Hydrogen. | 1 | 2 | 2 |
| **Unit No. 3** | Introduction to 3D printing and additive manufacturing | 1 | 3 | 3 |
| | Capabilities of 3D printing | 1 | 3 | 3 |
| | Applications of 3D printing | 1 | 3 | 3 |
| | Classification based on ASTM | 1 | 3 | 3 |
| | Working principles of 3D printing technologies | 1 | 3 | 3 |
| **Unit No. 4** | Introduction to the evolution of drones | 1 | 4 | 4 |
| | Classification of drones | 1 | 4 | 4 |
| | Basic components of drones | 1 | 4 | 4 |
| | Principles of flight | 1 | 4 | 4 |
| | Applications of drones | 1 | 4 | 4 |
| | Drones rules in India, Challenges and future scope. | 1 | 4 | 4 |
| **Unit No. 5** | Introduction to Artificial Intelligence, Machine Learning and Deep learning | 1 | 5 | 5 |
| | Supervised (Classification and regression) learning | 1 | 5 | 5 |
| | Unsupervised (Clustering) learning | 1 | 5 | 5 |
| | Reinforcement learning (Decision making) | 1 | 5 | 5 |
| | Features and Applications of AI and ML | 1 | 5 | 5 |
| | Threats of AI: Lack of Regulation | 1 | 5 | 5 |

**Recommended Resources**

1. Quantum Computation and Quantum Information by Michael A. Nielsen, Isaac L. Chuang, Massachusetts Institute of Technology.
2. Nanotechnologies: Principles, Applications, Implications and Hands-on Activities – A compendium for educators by Luisa Filipponi and Duncan Sutherland, European Commission Research and Innovation.
3. Additive manufacturing: Principles, Technologies and applications by C.P. Paul and A.N. Jinoop, Publisher: McGraw Hill
4. Make: Getting Started with Drones: Build And Customize Your Own Quadcopter by Terry Kilby and Belinda Kilby.
5. Artificial Intelligence: A Modern Approach by Stuart Russell and Peter Norvig

**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **CLA-1 (20%)** | **CLA-2 (20%)** | **CLA-3 (20%)** | **CLA-4 (20%)** | **CLA-5 (20%)** |
|---|---|---|---|---|---|---|
| Level 1 | Remember | 90 % | 90 % | 80 % | 75 % | 85 % |
| | Understand | | | | | |
| Level 2 | Apply | 10 % | 10 % | 20 % | 25 % | 15 % |
| | Analyse | | | | | |
| Level 3 | Evaluate | 0 % | 0 % | 0 % | 0 % | 0 % |
| | Create | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers**

*Dr. Sunil Chinnadurai, Associate Professor, ECE Department.*
*Dr. Pardha Saradhi Maram, Associate Professor, Chemistry Department.*
*Dr. Sangjukta Devi, Assistant Professor, Mechanical Engineering Department.*
*Dr. Harish Puppala Assistant Professor, Civil Engineering Department.*
*Dr. Ravi Kumar, Assistant Professor, Physics Department.*
*Dr. Sujith Kalluri, Associate Professor, ECE Department.*

# SEMESTER II

**SRM University – AP, Andhra Pradesh**
Neerukonda, Mangalagiri Mandal
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# Effective Writing and Presentation Skills

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | AEC 107 | **Course Category** | Ability Enhancement Course | **L-T-P-C** | 1 | 0 | 1 | 2 |
| **Pre-Requisite Course(s)** | AEC 101 | **Co-Requisite Course(s)** | | **Progressive Course(s)** | | | | |
| **Course Offering Department** | Literature and Languages | **Professional / Licensing Standards** | | | | | | |

**Course Objectives**

Demonstrate proficiency in written communication, including the ability to compose clear, grammatically structured writing and critically analyse information from various sources, conduct research effectively, and use evidence to support their arguments in both written assignments and oral presentations.

**Course Outcomes (COs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **CO 1** | Develop coherent and well-structured written communication by generating clear and concise written content with logical organization, appropriate grammar, vocabulary, and sentence structure. | 1, 2 | 70% | 60% |
| **CO 2** | Recognize and analyze the expectations of specific target audiences by adjusting tone, language and style to suit the intended purpose of the message and tailoring written content to various formats such as reports, essays, emails, and professional correspondence. | 3, 4 | 70% | 60% |
| **CO 3** | Increased Confidence in Public Speaking with the ability to deliver structured, well-organized, and persuasive presentations by employing visual and interactive aids, storytelling techniques. | 5, 6 | 70% | 70% |
| **CO 4** | Develop strong critical thinking and research skills, enabling students to evaluate information critically, synthesize sources effectively, and provide well-reasoned arguments in their written work and presentations. | 3, 4, 5, 6, | 60% | 60% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem | Design and Development | Analysis, Design and | Modern Tool and ICT | Society and Multicultural | Environment | Moral, and Ethical | Individual and Teamwork | Communicatio n Skills | Project Management | Self-Directed and Life Long | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | | | | | | | | | **3** | **3** | **1** | 2 | 2 | 2 | 2 |
| Outcome 2 | | 2 | | | | **1** | | | **3** | **3** | **2** | 2 | 2 | 2 | 2 |
| Outcome 3 | | **2** | | | | **2** | | | **3** | **3** | **3** | 2 | 2 | 2 | 2 |
| Outcome 4 | | **2** | | | | **3** | | | | | | | | | |
| **Course Average** | | **2** | | | | **2** | | | **3** | **3** | **2** | **2** | 2 | 2 | 2 |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Basics of Grammatically correct writing** | **9** | | |
| | SVO | 1 | 1 | 1a, 2a,b |
| | Punctuation | 3 | 1 | 1a, 2a,b |
| | Articles and Preposition | 2 | 1 | 1a, 2a, b |
| | Tense and Apostrophe | 1 | 1 | 1a, 2a, b |
| | Subject-Verb-Agreement | 2 | 1 | 1a, 2a, b |
| | | | 1 | |
| **Unit 2** | **Categories of Writing** | **9** | | |
| | Emails – different types (Official mails : Requesting Leave/ Enquiring vacancy/ Resigning from job/ requesting internship etc.) | 3 | 1, 2 | 1b, c |
| | Notice and Agenda, | 2 | 1, 2 | 1b, c |
| | Minutes of Meeting | 2 | 1, 2 | 1b, c |
| | Paragraph writing | 2 | 1, 2 | 1b, c |
| | | | | |
| **Unit 3** | **Advanced Writing** | **9** | | |
| | Writing Cover Letters | 3 | 1, 2 | 1e |
| | Resume writing | 2 | 1, 2 | 1d |
| | SOP, Abstract | 2 | 1, 2 | 1g |
| | Project Report Writing | 2 | 1, 2 | 2, d |
| | | | | |
| **Unit 4** | **Effective Presentation Techniques** | **9** | | |
| | Understanding the elements of successful presentations – Non-verbal communication in presentaions | 3 | 2,3, 4 | 1f, 2c |

| | | | | |
|---|---|---|---|---|
| | Creating engaging PPTs | 2 | 2,3, 4 | 1f, 2c |
| | Structuring presentations for clarity and impact - Logical flow of topics and connected writing in line with storyboard | 2 | 2, 3, 4 | 1f, 2c |
| | Handling Questions and Answers | 2 | 2, 3, 4 | 1f, 2c |
| **Unit 5** | **Project Based Learning** | **15** | | |
| | Community Based Project | 15 | 1, 2, 3, 4 | NA |
| | | | | |
| | Total Contact Hours | 45 | | |
| | Notional Hours | 15 | | |
| | **Total Learning Hours** | **60** | | |

**1. Recommended Resources**


a. Swan, M. (2005). *Practical English usage* (Vol. 688). Oxford: Oxford university press.
b. Fenning, C. (2023). *Effective Emails: The secret to straightforward communication at work: 1 (Business Communication Skills)*: Sanage Publishing
University Press.
c. Talbot, F. (2009). *How to Write Effective Business English: The Essential Toolkit for Composing Powerful Letters, Emails and More, for Today's Business Needs.* Kogan Page Publishers
d. Yate, M. (2016). *Knock'em Dead Resumes: A Killer Resume Gets More Job Interviews!* Simon and Schuster.
e. Yate, M. J. (2018). *Ultimate Cover Letters: Master the Art of Writing the Perfect Cover Letter to Boost Your Employability* (Vol. 5). Kogan Page Publishers.
f. Carnegie, D. (2013). *The Art of Public Speaking*. Wyatt North Publishing, LLC.
g. Yakhontova, T. V. (2003). *English academic writing for students and researchers. Lviv: PAIS.*


**2. Recommended Online Resources**

d. https://learnenglishteens.britishcouncil.org/
e. https://www.bbc.co.uk/learningenglish/
f. https://www.ted.com/?geo=hi
g. https://www.tifr.res.in/~cccf/data/InternDocs/How_to_write_a_structured_Project_Report.pdf

**Learning Assessment (Macro)**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (60%)** | | | | **End Semester Assessments (40%)** |
|---|---|---|---|---|---|---|
| | | **CLA-1 (20%)** | **CLA-2 (20%)** | **CLA-3 (20%)** | | |
| Level 1 | Remember | 20% | 20% | | | 50% |
| | Understand | | | | | |
| Level 2 | Apply | 40% | 40% | | 50% | 50% |
| | Analyse | | | | | |
| Level 3 | Evaluate | 40% | 40% | | 50% | |
| | Create | | | | | |
| **Total** | | **100%** | **100%** | | **100%** | **100%** |

**SRM University – AP, Andhra Pradesh**
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**Environmental Science**

| Course Code | **VAC 101** | Course Category | **AECC / FC** | L-T-P-C | **2** | **0** | **0** | **2** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | - | Co-Requisite Course(s) | - | Progressive Course(s) | - | | | |
| Course Offering Department | **Environmental Science** | Professional / Licensing Standards | - | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To study the scope of Environmental Science and the idea of sustainability.

**Objective 2:** To acquire basic knowledge of environmental ethics, critical environmental laws, and policies.

**Objective 3:** To explore various sources and challenges in the renewable energy sector in replacing conventional energy.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Recognise the scope and purview of Environmental Science, the Idea of sustainability, environmental ethics, and global efforts to overcome the hindrance for sustainability. | 2 | 80% | 70% |
| **Outcome 2** | Interpret the environmental laws and policies. | 3 | 80% | 70% |
| **Outcome 3** | Investigate climate change, the way it affects life at different scales (global, regional, and local scales), and various mitigation strategies. | 2 | 70% | 60% |
| **Outcome 4** | Analyse the extent of environmental pollution and pollution reduction strategies through and resource optimization, renewable energy, and waste management. | 3 | 70% | 60% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Lifelong Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 1 | - | - | - | 1 | - | 3 | 1 | 1 | - | 1 | 1 | | | |
| Outcome 2 | 1 | - | 1 | - | 1 | - | 3 | - | 1 | - | 1 | 1 | | | |
| Outcome 3 | 1 | - | - | - | 1 | - | 3 | - | 1 | - | 1 | 1 | | | |
| Outcome 4 | 1 | - | - | - | 1 | - | 3 | - | 1 | - | 1 | 1 | | | |
| **Course Average** | **1** | **-** | **1** | **-** | **1** | **-** | **3** | **1** | **1** | **-** | **1** | **1** | | | |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Fundamental Concepts in Environmental Science** | **10** | 1 | 1, 2, 3, 4, 5, 6, 7, 8, 10 |
| | Human population and environment | 2 | | |
| | Environmental education and awareness<br>Environmental ethics<br>Evolution of Environmental ethics – Leopold's land ethics, Silent Spring | 2 | | |
| | Population growth, Ecological overshoot, and Ecological Footprint | 2 | | |
| | Defining global sustainability, Garret Hardin's "Tragedy of the Commons', Brundtland commission report,<br>Principles of sustainable development, Sustainable Development Goals (SDGs), Triple bottom line of sustainable development | 1 | | |
| | Technology and Society: Information Technology - Human health & Environmental health, Environmental misconception | 1 | | |
| | Sustainable ethics: Overcoming the obstacles of sustainability<br>Individualizing Responsibility for a sustainable future - Consumption and its impact on sustainable development | 2 | | |
| **Unit 2** | **Social issues and Environment** | **5** | 2 | 1, 3, 9 |
| | Fronterism, Biological Imperialism, and Natural rights, Significance of Human rights; Human rights and environment | 2 | | |
| | Wastewater reclamation, Water conservation, Rainwater harvesting, Watershed management, Urban problems related to energy, Nuclear accidents | 2 | | |
| | Global Environmental Policy, Environmental acts and laws, Water Act 1974, Environmental Protection Act 1986 | 1 | | |
| **Unit 3** | **Global Climate Change** | **5** | 3 | 10, 3 |
| | Differentiating Climate and Weather, Interconnection of Earth systems (Hydrosphere, Geosphere, Cryosphere, Atmosphere, and Biosphere) | 1 | | |
| | Climate change through data (global temperature, and $CO_2$ – Mauna Lao Earth observatory) | 1 | | |
| | Climate change: Impacts - Extreme weather events, Sea-level rise, Food and water security, and Human health & well-being, Biodiversity loss | 1 | | |
| | Climate change: Adaptation – local to global scales, Synthesis | 1 | | |
| | Disaster management – landslides, Tsunamis floods, earthquakes, anthropogenic disasters, Bhopal tragedy | 1 | | |
| | Communicating climate change | | | |
| **Unit 4** | **Energy and Environment** | 5 | 4 | 3, 4 |
| | Renewable Energy: Global Status and trends | 1 | | |

| | | | | |
|---|---|---|---|---|
| | Global Renewable Energy Applications | 1 | | |
| | Technical Issues, Challenges & Opportunities Solar, tidal, hydropower, Bioenergy, nuclear | 2 | | |
| | Renewable Energy Markets | 1 | | |
| **Unit 5** | **Environmental Pollution and Management** | **5** | 2, 4 | 3, 11 |
| | Pollution: Air pollution, Noise pollution, Water pollution, Soil pollution | 1 | | |
| | Solid waste management: Collection, Handling, and solid waste management rules | 1 | | |
| | E-waste and hazardous waste management, biomedical waste management | 1 | | |
| | Wastewater treatment systems: Industrial and sewage treatment | 2 | | |
| **Total Contact Hours** | | **30** | | |

**Recommended Resources**


1. Daniel D. Chiras (2012), Environmental Science 9th Edition. Jones & Barlet Publishers
2. Carson, R. (2002). Silent spring. Houghton Mifflin Harcourt.
3. Rajagopalan, R (2015). Environmental Science – from crisis to cure, 3rd Edition. Oxford Higher Education.
4. Walter K Dodds (2018). Humanity's Footprint: Momentum, Impact, and Our Global Environment. Columbia University Press
5. Hayley Stevenson (2018). Global Environmental Politics Problems, Policy and Practice. Cambridge University Press
6. Garette Hardin (1968). The Tragedy of the Commons. Science 162 (3859), 1243-1248. DOI: 10.1126/science.162.3859.1243
7. Brutland Commission Report, 1987. Oxford University Press
8. TRANSFORMING OUR WORLD: The 2030 Agenda for Sustainable Development
9. Shastri, S.C. (2015) Environmental Law by 5th edition, EBC Publications.
10. Intergovernmental Panel on Climate Change (IPCC) Synthesis Report, 2014.
11. C.S. Rao (2018) Environmental Pollution Control Engineering, New Age International Publishers.


**Other Resources**


1. W. Cunningham, M. Cunningham (2016). Principles of Environmental Science (8th Edition), McGraw-Hill
2. Divan Shyam (2002). Environmental Law and Policy in India, OUP India
3. Jonathan Cowie, (2002). Climate change: Biological and Human Aspects, 2nd Edition. Cambridge University Press
4. Hanjalic, Kemo, Roel Van de Krol, and Alija Lekic, eds. (2017). Sustainable energy technologies: options and prospects. Springer Science & Business Media


**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (50%)** | | | | | | | | **End Semester Exam (50%)** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **CLA-1 (10%)** | | **Mid-1 (15%)** | | **CLA-2 (10%)** | | **Mid-2 (15%)** | | | |
| | | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** |
| Level 1 | Remember | 70% | | 70% | | 30% | | 30% | | 70% | |
| | Understand | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Level 2 | Apply<br>Analyse | 30% | | 30% | | 70% | | 70% | | 30% | |
| Level 3 | Evaluate<br>Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designers**

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**Entrepreneurial Mindset**

| Course Code | **SEC 103** | Course Category | **Foundation Course** | L-T-P-C | **2** | **0** | **0** | **2** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **Management** | Professional / Licensing Standards | - | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To develop a foundation in innovation and entrepreneurship among the students.

**Objective 2:** To enhance analytical skills of students for practical application of their ideas.

**Objective 3:** To make students proficient in designing solutions.

**Objective 4:** To introduce students to different phases of entrepreneurship.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Describe and classify the basic concepts of Innovation and Entrepreneurship | 2 | 90% | 80% |
| **Outcome 2** | Discuss the concept of Design Thinking and prototyping | 2 | 80% | 70% |
| **Outcome 3** | Apply design thinking to generate innovative ideas and strategize implementation plan | 3 | 65% | 60% |
| **Outcome 4** | Prepare a business plan by assessing customer segment, market validation and product development | 4 | 60% | 60% |

**Course Articulation Matrix (CLO) to (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Management Knowledge | Analytical Reasoning and | Critical and Reflective | Strategic Thinking and | Modern Tools and ICT Usage | Environment and | Moral, Multicultural | Individual and Teamwork | Communication Skills | Leadership Readiness | Self-Directed and Lifelong | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 3 | 1 | 1 | | | | | | | | | 2 | 3 | 2 |
| Outcome 2 | 2 | 2 | 2 | | 2 | | 2 | | | | | 3 | 2 | 2 |
| Outcome 3 | 1 | 3 | 3 | 2 | | | | 3 | | 3 | 3 | | 3 | 2 |
| Outcome 4 | 2 | 3 | 3 | 2 | | | | 3 | 2 | 3 | 3 | 3 | | 3 |
| **Course Average** | **2** | **2** | **3** | **2** | **1** | **0** | **1** | **2** | **1** | **2** | **2** | **3** | **3** | **3** |

**Course Unitization Plan - Theory**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Entrepreneurship & Inventions** | **5** | | |
| | Entrepreneurship and Types of Entrepreneurship | 2 | 1 | 3,4 |
| | Entrepreneurs and their Characteristics | 1 | 1 | 3,4 |
| | Innovation & its Types | 2 | 1 | 1 |
| **Unit 2** | **Exploration & Summarizing Facts** | **3** | | |
| | Structured exploration and quantifying the data | 2 | 3,4 | 3,4 |
| | Analysing the data | 1 | 3,4 | 3,4 |
| **Unit 3** | **Reflection, Synthesizing and ideating** | **3** | | |
| | Summarizing facts and designing a workable model | 3 | 3,4 | 3,4 |
| **Unit 4** | **Prototyping** | **8** | | |
| | Definition and Basics of Prototyping | 2 | 2,3,4 | 2 |
| | Types and methods of Prototyping | 4 | 2,3,4 | 2 |
| | Innovations in prototyping | 2 | 2,3,4 | 2 |
| **Unit 5** | **Concept Ideation & Design Thinking** | **8** | | |
| | Importance of Idea | 1 | 3,4 | 1,2 |
| | Idea Generation Techniques | 1 | 3,4 | 1,2 |
| | Validating the idea | 1 | 3,4 | 1,2 |
| | Definition and Basics of Design Thinking | 2 | 2 | 5 |
| | Stages of Design Thinking | 3 | 2 | 5 |
| **Unit 6** | **Market Validation** | **5** | | |
| | Concept of Market Validation and its importance | 2 | 3,4 | 3,4 |
| | Customer survey | 1 | 3,4 | 3,4,5 |
| | Feedback and modifying the idea | 2 | 3,4 | 3,4,5 |
| **Unit 7** | **Segmentation of the potential users/ customers** | **3** | | |
| | Customer segment and its types | 2 | 4 | 3,4 |
| | Understanding niche customer segment | 1 | 4 | 3,4 |
| | Reaching the real customers | 1 | 4 | 3,4 |
| **Unit 8** | **Industry Validation** | **2** | | |
| | Industry validation and mentoring | 2 | 3,4 | 3,4,5 |
| **Unit 9** | **Solution Design** | **8** | | |
| | Generate an Innovative Idea | 3 | 3,4 | 1,2,5 |
| | Develop a Business Plan | 5 | 4 | 3,4 |
| **Total Contact Hours** | | **45** | | |

| **Recommended Resources** |
|---|

1. Larry Keeley Brian Quinn Ryan Pikkel. Ten types of innovation -the discipline of building breakthroughs, John Wiley& Sons, Inc; 2013
2. Eric Ries. The lean startup how constant innovation creates radically successful businesses, Penguin Books
3. Bruce R. Barringer, R. Duane Ireland. Entrepreneurship Successfully Launching New Ventures, Pearson; 2020
4. Robert D. Hasrich, Dean A. Shepherd, Michael P. Peters, Entrepreneurship, McGraw Hill, 2020
5. Siva Prasad N. Design Thinking : Techniques And Approaches, Ane Books, New Delhi; 2023

**Learning Assessment (Theory)**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | End Semester Exam (50%) |
|---|---|---|---|---|---|
| | | CLA-1 (10%) | CLA-2 (20%) | Mid-term (20%) | |
| Level 1 | Remember | 90% | 50% | 60% | 40% |
| | Understand | | | | |
| Level 2 | Apply | 10% | 50% | 40% | 60% |
| | Analyse | | | | |
| Level 3 | Evaluate | | | | |
| | Create | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** |

**Course Designers**

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# Linear Algebra and Differential Equation

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Code | FIC 117 | Course Category | FIC | L-T/D-P/Pr-C | 3 | 0 | 0 | 3 |
| Total Contact Hours | | 45 | Total Learning Hours | | 90 | | | |
| Pre-Requisite Course(s) | FIC103 | Co-Requisite Course(s) | NA | Progressive Course(s) | NA | | | |
| Course Offering Department | Mathematics | Professional / Licensing Standards | | | | | | |

**Course Objectives**:

**Objective 1:** Develop a comprehensive set of skills and knowledge to solve complex systems of linear equations and utilizing matrix operations by introducing determinants, vector spaces, and their applications in real-world scenarios.

**Objective 2:** To gain proficiency in understanding and manipulating linear transformations, eigenvalues, and eigenvectors, enabling them to analyse and interpret diverse mathematical models.

**Objective 3:** To develop practical techniques for solving first and higher-order differential equations, employing methods like reduction of order and variation of parameters
to tackle real-world problems involving dynamic systems.

**Course Outcomes (COs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **CO 1** | Proficiently solve linear equations and perform matrix operations. Understand special matrix types, determinants, and vector spaces. | 2 | 75% | 80% |
| **CO 2** | Define and analyze linear transformations. Apply eigenvalue concepts and understand diagonalization. | 3 | 70% | 65% |
| **CO 3** | Establish the existence, uniqueness, and classification of solutions. Solve various types of first-order differential equations, including separable and linear. | 3 | 75% | 70% |
| **CO 4** | Explore homogeneous equations with constant coefficients and Euler-Cauchy equations with solution methods like undetermined coefficients and variation of parameters. | 3 | 70% | 65% |
| **CO 5** | Transform higher-order equations into systems, emphasizing critical points and stability. Address nonhomogeneous linear systems using methods like undetermined coefficients and variation of parameters. | 4 | 70% | 65% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Team work Skills | Communication Skills | Project Management and Finance | Self-Directed and Lifelong Learning | PSO1 | PSO2 | PSO3 |
| **Outcome 1** | 2 | 3 | 2 | 2 | | | | | | | | | | | |
| **Outcome 2** | 2 | 3 | 2 | 2 | | | | | | | | | | | |
| **Outcome 3** | 2 | 3 | 2 | 2 | | | | | | | | | | | |
| **Outcome 4** | 2 | 3 | 3 | 2 | | | | | | | | | | | |
| **Outcome 5** | 2 | 3 | 3 | 3 | | | | | | | | | | | |
| **Course Average** | **2** | **3** | **2** | **2** | | | | | | | | | | | |

**Course Unitization Plan**

| Unit No. | Description of Topic | Contact Hours Required | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit I** | **Unit I: Linear Equations, Matrices, Determinants and Vector Spaces** | **9 Hours** | | |
| | Systems of Linear Equations, Algebraic Properties of Matrix Operations | 1 | **CO 1** | 1 |
| | Special Types of Matrices, Echelon Form of a Matrix, Rank of a matrix | 2 | **CO 1** | 1 |

| | | | | |
|---|---|---|---|---|
| | Solving Linear Systems, Elementary Matrices, Finding $A^{-1}$. | 1 | **CO 1** | 1 |
| | Determinants, Properties of Determinants | 2 | **CO 1** | 1,3 |
| | Vectors in the Plane and in 3-Space, Vector Spaces | 1 | **CO 1** | 1,3 |
| | Subspaces, Span, Linear Independence, Basis and Dimensions | 2 | **CO 1** | 1,3 |
| | **Unit II: Linear Transformations, Eigenvalues and Eigenvectors** | **9 Hours** | | |
| **Unit II** | Definition and Examples of Linear Transformations, | 1 | **CO 2** | 1,3 |
| | Kernel and Range of a Linear Transformation, | 2 | **CO 2** | 1,3 |
| | Matrix of a Linear Transformation, | 1 | **CO 2** | 1,3 |
| | Eigenvalues and Eigenvectors, Diagonalization and Similar Matrices, | 2 | **CO 2** | 1,3 |
| | Diagonalization of Symmetric Matrices | 1 | **CO 2** | 1,3 |
| | Spectral Decomposition and Singular Value Decomposition. | 2 | **CO 2** | 1,3 |
| | **Unit III: First order differential equations** | **9 Hours** | | |
| **Unit III** | Geometrical meaning of first order differential equations, | 1 | **CO 3** | 2 |
| | Existence and uniqueness of solution, | 2 | **CO 3** | 2 |
| | Classification of ODEs, | 1 | **CO 3** | 2 |
| | Separable differential equations, Exact differential equations, | 2 | **CO 3** | 2 |
| | Linear differential equations, | 1 | **CO 3** | 2 |
| | Bernoulli differential equations, Initial value problems. | 2 | **CO 3** | 2 |
| | **Unit IV: Second or higher order linear differential equations** | **9 Hours** | | |
| **Unit IV** | Method of reduction of order (when one solution is known) | 1 | **CO 4** | 2 |
| | Wronskian | 2 | **CO 4** | 2 |
| | Homogeneous differential equations with constant coefficients | 1 | **CO 4** | 2 |
| | Homogeneous Euler-Cauchy differential equations | 2 | **CO 4** | 2 |
| | Method of undetermined coefficients | 1 | **CO 4** | 2 |
| **Unit V** | Method of variation of parameters. | 2 | **CO 4** | 2 |
| | **Unit V: System of first order differential equations** | **9 Hours** | | |
| | Solution of homogeneous constant coefficient system of differential equations | 2 | **CO 5** | 2 |
| | Converting higher order differential equations into system of equations | 1 | **CO 5** | 2 |
| | Critical points and stability | 1 | **CO 5** | 2 |
| | Nonhomogeneous Linear Systems of ODEs. | 1 | **CO 5** | 2 |
| | Method of undetermined coefficients | 1 | **CO 5** | 2,4 |
| | Method of variation of parameters | 2 | **CO 5** | 2 |
| | Linearization of Nonlinear Systems. | 1 | **CO 5** | 2,4 |
| **Total** | | **45** | | |

**Recommended Resources**

1. Linear Algebra and Its Applications, Gilbert Strang, Nelson Engineering, 4th Edition, 2007.
2. Advanced Engineering Mathematics, Erwin Kreyszig 10th Edition, Wiley-India.
3. Elementary Linear Algebra with Applications**.** David Hill and Bernard Kolman, 9th Edition | By Pearson 2019.
4. Elementary Differential Equations and Boundary Value Problems, William Boyce and Richard DiPrima, 11th Edition, Wiley-India.

**Learning Assessment (Macro)**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (60%) | | | | End Semester Assessments (40%) |
|---|---|---|---|---|---|---|
| | | CLA-1 (10%) | Mid-1 (20%) | CLA-2 (10%) | CLA-3 (10%) | |
| Level 1 | Remember | 30% | 25% | 10% | 20% | 25% |
| | Understand | 30% | 30% | 30% | 30% | 30% |
| Level 2 | Apply | 20% | 25% | 30% | 30% | 25% |
| | Analyse | 20% | 20% | 30% | 20% | 20% |
| Level 3 | Evaluate | | | | | |
| | Create | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers:**


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# Principles of Economics and Management

| Course Code | FIC 105 | Course Category | | L-T/D-P/Pr-C | 3 | 0 | 0 | 3 |
|---|---|---|---|---|---|---|---|---|
| Total Contact Hours 45 | | | Total Learning Hours | | | | | |
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | Economics and Management | Professional / Licensing Standards | | | | | | |

**Course Objectives**

**Objective 1:** To understand fundamental concepts of economics with practical applications.
**Objective 2:** To understand consumer's choice and preference when price, income, and taste change.
**Objective 3:** To understand the concepts of costs and producer's behaviour in the short-run and long run.
**Objective 4:** To understand the functioning of macroeconomy and its fundamental problems.

**Course Outcomes (COs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **CO 1** | State, explain and apply economic principles such as supply and demand, and market structures. | 3 | 70 | 70 |
| **CO 2** | Application of Interdisciplinary concepts of economics and management | 3 | 70 | 70 |

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Lifelong Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | **3** | **3** | | | **1** | **1** | | | | | | **2** | | | |
| Outcome 2 | **3** | **3** | | | | | | | | | | **2** | | | |
| Outcome 3 | | | | | | | | | | | | | | | |
| Outcome 4 | | | | | | | | | | | | | | | |
| **Course Average** | **3** | **3** | | | **1** | **1** | | | | | | **2** | | | |

**Course Utilization Plan**

| **Unit No.** | **Unit Name** | **Required Contact Hours** | **CLOs Addressed** | **References** |
|---|---|---|---|---|
| **Unit 1** | **Introduction to Economics** | **05 hrs** | | |
| | Definition of Economics | 01 | 01 | 01,03 |

| | | | | |
|---|---|---|---|---|
| | Nature and Scope of Economics | 01 | 01 | 01,03 |
| | Models and Assumptions in Economics | 02 | 01,03 | 01,03 |
| | fundamental problems in economics- Scarcity and Choice | 01 | 01,03 | 01,03 |
| **Unit II** | **Consumer's Behaviour** | **09 hrs** | | |
| | Demand and law of Demand | 1 ½ | 02 | 01, 02 |
| | Determinants of Individual demand and market demand | 1 ½ | 02 | 01, 02 |
| | Exceptions to the law of demand | 01 | 02 | 01, 02 |
| | Supply and its various determinants | 1 ½ | 02 | 01, 02 |
| | Individual supply and market supply; Determination of equilibrium price and quantity | 1 ½ | 02,03 | 01, 02 |
| | Elasticity and its computation (Price, Income and Cross). | 02 | 02,03 | 01, 02 |
| **Unit III** | **Cost, Production and Market** | **08 hrs** | | |
| | Production in short and long run | 01 | 01,03 | 01, 02 |
| | Cost of Production- long run and short run | 01 | 01,03 | 01, 02 |
| | Introduction to Market Structures | 01 | 01,03 | 01, 02 |
| | Perfect Competition | 01 | 01,03 | 01, 02 |
| | Monopoly | 1 ½ | 01,03 | 01, 02 |
| | Monopolistic Competition | 1 ½ | 01,03 | 01, 02 |
| | Oligopoly | 01 | 01,03 | 01, 02 |
| **Unit IV** | **Macro Concepts** | **08 hrs** | | |
| | Basic concepts of National Income accounting | 1 ½ | 01 | 01, 04 |
| | Measurement of National Income Value Added Method and Expenditure Method | 1 ½ | 01, 03 | 01, 04 |
| | National Income and Economic Welfare | 01 | 01, 03 | 01, 04 |
| | Inflation: meaning, types and measurement | 1 ½ | 01, 03 | 01, 04 |
| | Unemployment: meaning, types and causes | 1 ½ | 01, 03 | 01, 04 |

**Learning Assessment (Macro) - Theory**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (60%)** | | | | **End Semester Assessments (40%)** |
|---|---|---|---|---|---|---|
| | | **CLA-1 (15%)** | **Mid-1 (15%)** | **CLA-2 (15%)** | **CLA-3 (15%)** | |
| Level 1 | Remember | 80 | 75 | 60 | -- | 75 |
| | Understand | | | | | |
| Level 2 | Apply | 20 | 25 | 40 | -- | 25 |
| | Analyse | | | | | |
| Level 3 | Evaluate | | | | | |
| | Create | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** |

**SRM University – AP, Andhra Pradesh**
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**Fundamentals of Electrical Circuits**

| Course Code | **ECE 101** | Course Category | **Core Course (CC)** | L-T-P-C | **3** | **0** | **1** | **4** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To remember different laws and understand the electrical circuits.

**Objective 2:** To understand and analyse the response of electrical circuits to different types of signals.

**Objective 3:** To understand the frequency response and Q-factors of different electrical components .

**Objective 4:** To design electrical systems and analyse their parameters

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Study different laws and understand the electrical circuits | 2 | 80% | 70% |
| **Outcome 2** | Apply the laws to understand the response of electrical circuits to different signals | 3 | 70% | 70% |
| **Outcome 3** | Understand the frequency response and Q-factor of electrical components | 4 | 65% | 70% |
| **Outcome 4** | Design electrical systems and verify their functioning | 4 | 65% | 65% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Life Long Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 3 | 3 | 1 | | | | | | | | | 1 | 2 | 3 | 1 |
| Outcome 2 | 3 | 3 | 1 | | | | | | | | | 1 | 2 | 3 | 1 |
| Outcome 3 | 3 | 2 | 3 | 2 | | | | | | | | 1 | 2 | 3 | 1 |
| Outcome 4 | 3 | 1 | 2 | 3 | | | | | | | | 1 | 1 | 2 | 3 |
| **Course Average** | **3** | **3** | **2** | **3** | | | | | | | | **1** | **2** | **3** | **1** |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Basic laws and circuit theorems** | **7** | | |
| | Review of Kirchhoff's Laws | 1 | 1 | 1, 2 |
| | Circuit Analysis - Nodal and Mesh | 1 | 1 | 1, 2 |
| | Linearity and Superposition | 1 | 1 | 1, 2 |
| | Source Transformations | 2 | 1 | 1, 2 |
| | Thevenin and Norton Equivalents | 2 | 1 | 1, 2 |
| **Unit 2** | **Capacitors and inductors with first order and second order circuits** | **7** | | |
| | Review of Inductor and Capacitor as Circuit Elements | 1 | 2 | 2 |
| | Source-free RL and RC Circuits | 2 | 2 | 2 |
| | Transient Response, Unit-Step Forcing | 2 | 2 | 2 |
| | Forced Response, RLC Circuit | 2 | 2 | 2 |
| **Unit 3** | **Sinusoids and phasors with steady state analysis** | **12** | | |
| | Sinusoidal Forcing, Complex Forcing | 2 | 3 | 1, 2 |
| | Phasors, and Complex Impedance | 2 | 3 | 1,2 |
| | Sinusoidal Steady State Response | 2 | 3 | 1, 2 |
| | Nodal and Mesh Revisited | 2 | 3 | 1, 2 |
| | Average Power, RMS | 2 | 3 | 1, 2 |
| | Introduction to Polyphase Circuits | 2 | 3 | 1, 2 |
| **Unit 4** | **Magnetically coupled circuits** | **8** | | |
| | Mutual Inductance | 1 | 4 | 2 |
| | Linear and Ideal Transformers | 1 | 4 | 2 |
| | Circuits with Mutual Inductance | 2 | 4 | 2 |
| | Frequency Response of Series/Parallel Resonances | 2 | 4 | 2 |
| | High-Q Circuits | 2 | 4 | 2 |
| **Unit 5** | **Frequency response** | 11 | | |
| | Complex Frequency | 1 | 4 | 2 |
| | s-Plane, Poles and Zeros | 2 | 4 | 2 |
| | Response Function | 2 | 4 | 2 |
| | Bode Plots | 2 | 4 | 2 |
| | Two Port Networks, Admittance, Impedance | 2 | 4 | 2 |
| | Hybrid and Transmittance Parameters | 2 | 4 | 2 |
| **Total Contact Hours** | | **45** | | |

**Course Unitization Plan - Lab**

| Exp No. | Experiment Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| 1 | Study of components of a circuit and Verification of KCL and KVL. | 1 | 1 | 1 |
| 2. | Verification of mesh and nodal analysis for AC circuits | 1 | 2 | 1 |
| 3. | Verification of Superposition, Thevenin's & Norton theorems for AC circuits. | 1 | 2 | 1 |

| | | | | |
|---|---|---|---|---|
| 4. | Verification of maximum power transfer theorem for AC circuits | 1 | 2 | 1 |
| 5. | Study of DC transients in RL, RC and RLC circuits | 1 | 2 | 1 |
| 6. | To study frequency response of various 1st order RL & RC networks | 1 | 2 | 2 |
| 7. | To study the transient and steady state response of a 2 nd order circuit by varying its various parameters and studying their effects on responses. | 1 | 3 | 2 |
| 8. | Find the Q Factor and Bandwidth of a Series and Parallel Resonance circuit. | 2 | 3 | 2 |
| 9. | Determination of open circuit (Z) and short circuit (Y) parameters | 2 | 4 | 2 |
| 10. | Determination of hybrid (H) and transmission (ABCD) parameters | 2 | 4 | 2 |
| 11. | To measure two port parameters of a twin-T network and study its frequency response. | 2 | 4 | 2 |
| **Total Contact Hours** | | **15** | | |

**Recommended Resources**

1. Network Analysis – ME Van Valkenburg, Prentice Hall of India, revised 3rd Edition, 2019.
2. Engineering Circuit Analysis by William H. Hayt, Jack Kemmerly, Jamie Phillips, Steven M. Durbin, 9 th Edition 2020.

**Learning Assessment (Integrated course)**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (50%)** | | | | | | | | **End Semester Exam (50%)** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **CLA-1 (10%)** | | **Mid-1 (15%)** | | **CLA-2 (10%)** | | **CLA-3 (15%)** | | | |
| | | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** |
| Level 1 | Remember | 60% | | 40% | 10% | 70% | 20% | 70% | 20% | 30% | 80% |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 40% | | 60% | 90% | 30% | 80% | 30% | 80% | 70% | 20% |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designers**

*Dr. Rituparna Choudhury, Assistant Professor, Department of Electronics & Communication Engineering, SRM University - AP.*

**SRM University – AP, Andhra Pradesh**
Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

**Microelectronic Devices and Circuits**

| Course Code | **ECE 102** | Course Category | **Speciality Stream Courses (C)** | L-T-P-C | **3** | **0** | **1** | **4** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | **ENG 111 ECE 205** | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** Learn the various linear application of op-amp.
**Objective 2:** Understand the various non-linear application of op-amp.
**Objective 3:** Gain knowledge of filter circuits using op-amp.
**Objective 4:** Learn oscillators and multivibrator circuits using op-amp.
**Objective 5:** Understand the various application of 555 timer.
**Objective 6:** Gain knowledge of performance of oscillators and multivibrators using PSPICE.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Identify linear application of op-amp | 2 | 70% | 65% |
| **Outcome 2** | Identify non-linear application of op-amp | 2 | 70% | 65% |
| **Outcome 3** | Discuss filter circuits using op-amp | 2 | 70% | 65% |
| **Outcome 4** | Discuss oscillators and multivibrator circuits using op-amp | 3 | 70% | 65% |
| **Outcome 5** | Illustrate the applications of 555 timer | 2 | 70% | 65% |
| **Outcome 6** | Demonstrate oscillators and multivibrators circuits using PSPICE | 3 | 70% | 65% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Life Long Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 1 | 1 | 2 | | | | | | | | | | 1 | 2 | 2 |
| Outcome 2 | 1 | 1 | 2 | 1 | 3 | | | | | | | 1 | 3 | 2 | 2 |
| Outcome 3 | 1 | 2 | 2 | 2 | 3 | | | | | | | 1 | 3 | 3 | 3 |
| Outcome 4 | 1 | 2 | 2 | 2 | 3 | | | | | | | 1 | 3 | 3 | 3 |
| Outcome 5 | 2 | 2 | 3 | 2 | 3 | | | | | | | 1 | 3 | 3 | 3 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outcome 6 | 2 | 2 | 2 | 2 | 3 | | | | 2 | | | 1 | 3 | 3 | 3 |
| **Course Average** | **2** | **2** | **2** | **2** | **3** | | | | **2** | | | **1** | **3** | **3** | **3** |

**Course Unitization Plan- Theory**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit I** | **BJT biasing and Single Stage Amplifiers** | **9** | | |
| 1. | BJT Device Structure and Physical Operation | 2 | 1 | 1,4 |
| 1. | BJT Current Voltage characteristics | 1 | 1 | 1,4 |
| 1. | BJT Circuits at DC | 1 | 2 | 1,4 |
| 1. | Amplifier Basic Principles | 1 | 3 | 1,4 |
| 1. | Circuit Models for Amplifier | 1 | 2 | 1,4 |
| 1. | Small Signal Models for BJT | 1 | 2 | 1,4 |
| 1. | BJT Biasing | 1 | 2 | 1,4 |
| 1. | Analysis of CE, CB. CC Amplifiers | 1 | 2 | 1,4 |
| **Unit II** | **MOSFET Biasing and Single Stage Amplifiers** | **9** | | |
| 1. | MOSFET Device Structure and Physical Operation | 2 | 1 | 1,4 |
| 1. | MOSFET Current Voltage characteristics | 2 | 1 | 1,4 |
| 1. | MOSFETS Circuits at DC | 1 | 2 | 1,4 |
| 1. | MOSFET Biasing | 1 | 3 | 1,4 |
| 1. | Small Signal models for MOSFET | 1 | 2 | 1,4 |
| 1. | Analysis of CG, CS | 1 | 2 | 1,4 |
| 1. | CD Amplifiers. | 1 | 2 | 1,4 |
| **Unit III** | **Differential Amplifiers and Frequency Response of single stage Amplifiers** | **9** | | |
| 16. | MOS Current Mirror | 1 | 2 | 1,2 |
| 17. | Analysis of MOS Differential Pair | 1 | 2 | 1,2 |
| 18. | Common Mode Rejection Ratio | 1 | 2 | 1,2 |
| 19. | DC Offset | 1 | 2 | 1,2 |
| 1. | MOS Differential Amplifier with current mirror load | 1 | 2 | 1,2 |
| 1. | Low frequency response of CS amplifier | 1 | 2 | 1,2 |
| 2. | High frequency response of CS amplifier | 1 | 2 | 1,2 |
| 3. | Millers Theorem | 1 | 2 | 1,2 |

| | | | | |
|---|---|---|---|---|
| 4. | High frequency response of CMOS Differential Amplifier | 1 | 2 | 1,2 |
| **Unit IV** | **Feedback Amplifiers, Signal Generators and wave shaping circuits** | **9** | | |
| 25. | General Feedback structure | 1 | 3 | 1,2 |
| 26. | Negative feedback | 1 | 3 | 1,2 |
| 27. | Feedback amplifier types | 1 | 3 | 1,2 |
| 28. | Stability problem | 1 | 4 | 1,2 |
| 29. | frequency compensation | 1 | 4 | 1,2 |
| 30. | Basic principles of sinusoidal oscillators | 1 | 3 | 1,2 |
| 31. | Op-amp RC oscillator | 1 | 4,5,6 | 1,2 |
| 32. | Wein Bridge oscillator | 1 | 4,5,6 | 1,2 |
| 33. | MOSFET Crystal oscillators, Bistable multivibrators, 555 timer IC and applications | 1 | 4,5,6 | 1,2 |
| **Unit V** | **Power Amplifiers and Active Filters** | **9** | | |
| 34. | Classification of output stages | 1 | 4 | 1,2 |
| 35. | Class A output stage | 1 | 4 | 1,2 |
| 36. | Class B output stage | 1 | 4 | 1,2 |
| 37. | Class AB output stage | 1 | 4 | 1,2 |
| 38. | Class C output stage, Class D and S power amplifiers | 1 | 3 | 1,2 |
| 39. | Filter Transmission, Types and specifications | 1 | 3 | 1,2 |
| 40. | Filter Transfer function | 1 | 4 | 1,2 |
| 41. | Butterworth and Chebyshev filters | 1 | 4 | 1,2 |
| 42. | First order and second order Filter functions | 1 | 4 | 1,2 |
| **Total Contact Hours** | | **45** | | |

**Course Unitization Plan - Lab**

| Session No. | Description of Experiments | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| 1. | Analysis of Feedback circuits with Op-amps. | 1 | 2 | 4,5 |
| 2. | Analysis of Feedback circuits with MOSFETs. | 1 | 3 | 4,5 |
| 3. | Design and Analysis of RC phase shift, LC oscillators. | 1 | 3,5,6 | 4 |
| 4. | Design and Analysis of Wien Bridge oscillator. | 1 | 3,5,6 | 4 |
| 5. | Design and Analysis of 555 timer based Astable and Monostable Multivibrators. | 2 | 3,5,6 | 4 |
| 6. | Design and Analysis of MOSFET based Class A, Class B, Class AB Power amplifier. | 2 | 3 | 4,5 |
| 7. | Design and Analysis of Op-amp based Active filters. | 2 | 3 | 5 |
| 8. | Design and Analysis of Voltage regulator circuits. | 1 | 4 | 4,5 |
| 9. | Design and Analysis of Voltage reference circuits. | 1 | 4 | 4 |
| 10. | Design and Analysis of ADCs, DACs-I. | 1 | 4 | 4,5 |

| | | | | |
|---|---|---|---|---|
| 11. | Design and Analysis of ADCs, DACs-II. | 1 | 4 | 4,5 |
| 12. | Course project. | 1 | 4 | 5 |
| **Total Contact Hours** | | **15** | | |

**Recommended Resources**

1. Microelectronic Circuits: Theory and Applications, Adel S. Sedra and K . C. Smith, 7th Edition, Oxford University press
2. BezhadRizavi "*Fundamentals of Microelectronics"*, Wiley, (2006)
3. Integrated Electronics, Jacob Millman, Christos C Halkias, McGraw Hill Education.
4. Electronic Devices and Circuits theory– Robert L. Boylestead, Louis Nashelsky, 11th Edition, 2009, Pearson.
5. Electronic Devices: Thomas L. Floyd, Edition 9, illustrated, Prentice Hall, 2012.

**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (50%)** | | | | | **End Semester Exam (50%)** | |
|---|---|---|---|---|---|---|---|---|
| | | **Theory (30%)** | | | | **Practical (20%)** | | |
| | | **CLA-1 (5%)** | **Mid-1 (10%)** | **CLA-2 (5%)** | **Mid-2 (10%)** | | **Th** | **Prac** |
| Level 1 | Remember | 60% | 40% | 60% | 40% | 50% | 30% | 40% |
| | Understand | | | | | | | |
| Level 2 | Apply | 40% | 60% | 40% | 60% | 50% | 70% | 60% |
| | Analyse | | | | | | | |
| Level 3 | Evaluate | | | | | | | |
| | Create | | | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers**

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# SEMESTER - III

**SRM University – AP, Andhra Pradesh**
Neerukonda, Mangalagiri Mandal
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# Analytical Skills for Engineers

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | AEC 105 | **Course Category** | | **L-T-P-C** | 1 | 0 | 1 | 2 |
| **Pre-Requisite Course(s)** | SEC 101 | **Co-Requisite Course(s)** | | **Progressive Course(s)** | | | | |
| **Course Offering Department** | Mathematics | **Professional / Licensing Standards** | | | | | | |

**Course Objectives**

1. To categorize, apply and use thought process to distinguish between concepts of quantitative methods.
2. To prepare and explain the fundamentals related to various possibilities.
3. To critically evaluate numerous possibilities related to puzzles.
4. Explore and apply key concepts in logical thinking to business problems.

**Course Outcome (COs)**

| CO's | At the end of the course the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **1** | Use logical thinking and analytical abilities to solve quantitative aptitude questions from company specific and other competitive tests. | 1 | 70% | 60% |
| **2** | Solve questions related to Time and Distance and Time and work from company specific and other competitive tests. | 3 | 65% | 70% |
| **3** | Understand and solve puzzle questions from specific and other competitive tests | 1 | 60% | 60% |
| **4** | Make sound arguments based on mathematical reasoning and careful analysis of data. | 1 | 65% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Engineering Knowledge** | **Problem** | **Design and Development** | **Analysis, Design and** | **Modern Tool and ICT** | **Society and Multicultural** | **Environment and** | **Moral, and Ethical** | **Individual and Teamwork** | **Communication Skills** | **Project Management** | **Self-Directed and Life Long** | **PSO 1** | **PSO 2** | **PSO 3** |
| Outcome 1 | | **2** | **2** | **2** | 1 | | | | **2** | | | | | | |
| Outcome 2 | | 2 | **1** | **2** | **1** | | | | | | | | | | |
| Outcome 3 | | 3 | **2** | **2** | | | | | 2 | | | | | | |
| Outcome 4 | | 3 | **1** | **2** | | | | | | | | | | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Average** | | **3** | **2** | **2** | **1** | | | | **2** | | | | | | |

**Course Unitization Plan**

| Unit No. | Syllabus Topics | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit No. 1** | Data interpretation – Introduction | 2 | 1,4 | 1,3 |
| | Basics to solve data interpretation | 2 | 1,4 | 1,3 |
| | Data interpretation line graphs | 2 | 1,4 | 1,3 |
| | Data interpretation bar graph. | 2 | 1,4 | 1,3 |
| **Unit No. 2** | Data interpretation – Pie charts, | 2 | 1,4 | 1,3 |
| | Data interpretation – Tabular, Data interpretation – case lets. | 2 | 1,4 | 1,3 |
| **Unit No. 3** | Statistics – Descriptive Statistics – Mean, median, Mode | 2 | 1,2 | 2,3 |
| | Variance, Standard Deviation, Normal distribution, Boxplot | 2 | 1,2 | 2,3 |
| | Application of Descriptive statistics in data analysis. | 2 | 1,2 | 2,3 |
| **Unit No. 4** | Functions and graphs | 3 | 1,2 | 1,2 |
| | Graph theory with respect to coding | 2 | 1,2 | 1,2 |
| | Math graph theory and coding problems | 2 | 2,3 | 2,3 |
| | Discrete planar theory and coding problems. | 3 | 1,2 | 2,4 |

**Recommended Resources**

1. Arun Sharma – How to prepare for Quantitative Aptitude, Tata McGraw Hill.
2. R.S. Agarwal – Reasoning. Reasoning for competitive exams – Agarwal.
3. Quantitative Aptitude for CAT, By Nishit K. Sinha

**Recommended Online Resources**

1. Geeks for Geeks
2. Indiabix.
3. M4maths.com

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50 %) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (10%) | | CLA-2 (15%) | | CLA-3 (10%) | | Mid Term (15%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 40% | | 50% | | 40% | | 50% | | 50% | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 60% | | 50% | | 60% | | 50% | | 50% | |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designers**

a. *Mr. Naresh Adapa, Quantitative Aptitude Trainer, Department of CR&CS SRM University-AP.*
b. *Mr. Shaik Mohammed Musa Kaleemullah, Verbal Ability Trainer, Department of CR&CS, SRM University-AP.*
c. *Dr. Fouzul Atik, Assistant Professor, Department of Mathematics, SRM University-AP.*

**SRM University – AP, Andhra Pradesh**
Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

# Data Structures

| Course Code | **SEC 115** | Course Category | **Professional Core (C)** | L-T-P-C | **2** | **0** | **1** | **3** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **CSE** | Professional / Licensing Standards | - | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To understand the basic concepts such as abstract data types, linear and non-linear data structures.

**Objective 2:** To understand the behaviour of data structures such as arrays, linked lists, stacks, queues, trees, hash tables, search trees, graphs, and their representations.

**Objective 3:** To provide an independent view of data structures, including its representation and operations performed on them, which are then linked to sorting, searching and indexing methods to increase the knowledge of usage of data structures in an algorithmic perspective.

**Objective 4:** To **c**hoose an appropriate data structure for a specified application.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Compare and contrast the algorithms for linked list, stack and queue operations. | 4 | 77% | 70% |
| **Outcome 2** | Illustrate algorithms for Binary Search Trees and AVL Trees. | 4 | 75% | 70% |
| **Outcome 3** | Analyze Graph traversal and minimum cost spanning tree algorithms. | 4 | 72% | 70% |
| **Outcome 4** | Distinguish searching and sorting techniques. | 3 | 78% | 80% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Life Long Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 3 | 3 | 2 | - | - | - | - | - | - | - | - | 1 | 3 | 3 | 3 |
| Outcome 2 | 3 | 3 | 2 | 1 | - | - | - | - | - | - | - | 1 | 3 | 3 | 3 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outcome 3 | 3 | 3 | 2 | 1 | - | - | - | - | - | - | - | 1 | 3 | 3 | 3 |
| Outcome 4 | 3 | 3 | 1 | - | - | - | - | - | - | - | - | 1 | 3 | 3 | 3 |
| **Course Average** | **3** | **3** | **2** | **1** | - | - | - | - | - | - | - | **1** | **3** | **3** | **3** |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Introduction to Data Structures** | **9** | | |
| | Abstract Data Type (ADT), Time and space requirements of algorithms | 1 | 1 | 1 |
| | Array ADT, Representing polynomials | 1 | 1 | 1,2 |
| | Sparse matrix using arrays and its operations | 1 | 1 | 1 |
| | **Stacks:** representation and application, implementation of stack operations using C. | 1 | 1 | 1 |
| | Example applications on Stacks | 1 | 1 | |
| | **Queues:** representation and application, implementation of queue operations using C. | 1 | 1 | 1,2 |
| | Example applications on Queues | 1 | 1 | 1,2 |
| | **Week 1 & 2: Simulate the following operations:**<br>**a.** Conversion of infix expression to postfix expression<br>**b.** Evaluation of expressions<br>**c.** **Assignment-1:** Tower of Hanoi is a mathematical puzzle where we have three rods and n disks. The objective of the puzzle is to move the entire stack to another rod, obeying the following simple rules:<br>Only one disk can be moved at a time.<br>Each move consists of taking the upper disk from one of the stacks and placing it on top of another stack i.e. a disk can only be moved if it is the uppermost disk on a stack.<br>No disk may be placed on top of a smaller disk<br>You can choose to use the function ***move (4, 1, 3, 2)***, where 4 represents the number of disks. 1 represents disks on source shaft, 3 represents the destination shaft which holds the disks after the move and finally 2 represents the intermediate support shaft – temporary storage. Write a C program to simulate the given problem and: Perform the algorithmic complexity analysis for the solution you propose.<br>**Resources:**<br>https://www.youtube.com/watch?v=YstLjLCGmgg | 1 | 1 | 1,6 |
| | **Week 3 & 4: Simulate the following tasks:**<br>**a.** Implementation the following operations: enqueue, dequeue and finding an element:<br>Linear Queue using arrays<br>Circular queue arrays<br>Priority queue singly linked list.<br>b. **Assignment-2:** The "*4-Queens Problem*" consists of placing four queens on a 4 x 4 chessboard so that no two queens can capture each other. That is, no two queens are allowed to be | 1 | 1 | 1,6 |

| | | | | |
|---|---|---|---|---|
| | placed on the same row, the same column or the same diagonal (both primary and secondary diagonals). Write a C program to simulate the given problem and perform the algorithmic complexity analysis for the solution you propose. | | | |
| **Unit 2** | **Linked lists** | **9** | | |
| | **Linked lists**: Single linked lists representation | 1 | 1 | 1,2 |
| | Implementation of linked list various operation using C | 1 | 1 | 1 |
| | Doubly linked list representation and Implementation of doubly linked list various operation using C | 2 | 1 | 5 |
| | Implementation of Circular linked list various operation using C | 2 | 1 | 4,5 |
| | **Week 5 &6: Demonstrate the following though simulation:**<br>a. Create a singly linked list and perform the following operations:<br>Add an element at the end of the list<br>Delete an element from the beginning of the list<br>Find the middle element of the list<br>Search the given key form the list<br>Polynomial addition using linked list<br>Sparse matrix operations using linked list<br>b. **Assignment-3:** Let us consider a small but busy airport with only one run-way (shown in figure). In each time unit, one plane can land or one plane can take off, but not both. Planes arrive ready to land or to take off at random times, so at any given unit of time, the runway may be idle or a plan may be landing or taking off, and there may be several planes waiting either to land or take off. We therefore need two queues, called *landing* and *takeoff*, to hold these planes. It is better to keep a plane waiting on the ground than in the air, so a small airport allows a plane to take off only if there are no planes waiting to land. Hence, after receiving requests from new planes to land or take off, our simulation will first service the head of the queue of planes waiting to land, and only if the landing queue is empty will it allow a plane to take off. We shall wish to run the simulation through many units of time, and therefore, we embed the main action of the program in a loop that runs for cur-time (denoting current time) from 1 to a variable end-time.<br>Simulate the given scenario using and write the output for different inputs. | 3 | 1 | 1,6 |
| **Unit 3** | **Trees** | **9** | | |
| | Tree terminology | 1 | 2 | 1 |
| | Binary tree, Representation of Binary Trees using Arrays and Linked lists | 1 | 2 | 1 |
| | Binary search tree | 1 | 2 | 1 |
| | Binary Search Trees- Basic Concepts, BST Operations: Insertion, Deletion | 1 | 2 | 1 |
| | Tree Traversals, Construction of tree using traversals | 1 | 2 | |
| | Applications, Expression tree | 1 | 2 | 1 |
| | General tree | 1 | 2 | 1 |

| | | | | |
|---|---|---|---|---|
| | Heap Sort, Balanced Binary Trees, AVL Trees, Insertion, Deletion and Rotations. | 1 | 2 | 1 |
| | **Week 7 & 8: Write code to perform the following operations:**<br>a. Develop a code to test whether the given tree is binary tree or not.<br>b. Implementation of Binary tree traversals techniques – pre-order, in-order, and post-order.<br>c. Implementation of AVL tree and its operations<br>d. Assignment-4: Given a mathematical expression, evaluate it using appropriate tree structure. | 1 | 2 | 5 |
| **Unit 4** | **Graphs** | **9** | | |
| | Graph terminology, Representation of graphs, path matrix | 1 | 3 | 3 |
| | BFS (breadth first search) | 1 | 3 | 3 |
| | DFS (depth first search) | 1 | 3 | 3 |
| | Topological sorting | 1 | 3 | 3 |
| | Priority Queues: Heap structures | 1 | 3 | 5 |
| | Binomial heaps, leftist heaps | | 3 | 2 |
| | Shortest path algorithms. | 1 | 3 | 2 |
| | Implementation of shortest path algorithm using C | 1 | 3 | 2 |
| | **Week 9:** Write a C program for implementation of Graph traversals techniques (BFS and DFS). | 1 | 3 | 1,6 |
| | **Week 10:** The **Dijkstra's algorithm** is an algorithm that gives the shortest path between two given vertices of a graph. In this problem we are given a directed graph with each edge having a non-negative weight. Thus, a solution requires a path of many other that costs least. We can think of the problem as like this: think graph G as a map of the airline routes, each node of the graph as the cities and the weights on each edge as the cost of flying from one city to another city. The solution we have to find a routing from a city v to city w such that the total cost is minimum. Write a C program to simulate the given problem. That is find the shortest path between node A and node F in the given graph. | 1 | 3 | 1,6 |
| **Unit 5** | **Sorting and Searching techniques** | **9** | | |
| | Bubble sort,selection sort and their algorithm analysis | 1 | 4 | 2 |
| | Insertion sort and its algorithm analysis | | 4 | 2 |
| | Quick sort and its algorithm analysis | 1 | 4 | 2,3 |
| | Merge sort and its algorithm analysis | | 4 | 3 |
| | Heap sort and its algorithm analysis | 1 | 4 | 3 |
| | Radix sort and its algorithm analysis | | 4 | 5 |
| | Linear and binary search methods and its algorithm analysis. | 1 | 4 | 5 |
| | Hashing techniques and hash functions | 1 | 4 | 5 |
| | **Week 11:** Write a C program for Linear search and Binary search algorithms. What is the best case and worst-case time complexity of those searching algorithms? | 1 | 4 | 2 |

| | | | | |
|---|---|---|---|---|
| | **Week 12:** Write a C program for bubble sort algorithm. What is the best case and worst-case time complexity of Bubble sort algorithm? Write a C program for Selection sort algorithm. What is the worst case or average case time complexity of selection sort algorithm? | 1 | 4 | 2 |
| | **Week 13:** Write a C program for Insertion sort algorithm. What is the worst case or average case time complexity of Insertion sort algorithm? | 1 | 4 | 2 |
| | **Week 14:** Write a C program for Quick sort algorithm. What is the worst case or average case time complexity of Quick sort algorithm? | 1 | 4 | 3 |
| | **Week 15:** Write a C program for Merge sort algorithm. What is the worst case or average case time complexity of Merge sort algorithm? | 1 | 4 | 3 |
| **Total Contact Hours** | | **45** | | |

**Recommended Resources**

1. "**Data structure using C**", Aaron M. Tenenbaum, Y Langsam and Mosche J. Augenstein, Pearson publication.
2. **"Data structures and Algorithm Analysis in C"**, Mark Allen Weiss, Pearson publications, Second Edition.
3. **"Fundamentals of data structure in C"** Horowitz, Sahani & Anderson Freed, Computer Science Press.
4. **"Fundamental of Data Structures"**, (Schaums Series) Tata-McGraw-Hill.
5. **"Data Structures and Algorithms: Concepts, Techniques & Algorithm"** G.A.V.Pai: Tata McGraw Hill.
6. **"Data Structures and Program Design in C"** Robert Kruse, C L Tondo, Bruce Leung and Shashi Mogalla. For pseudocode

**Other Resources**

1. **"Programming with C"**, Byron Gottfried, Mcgraw hill Education, Fourteenth reprint,2016
2. **"Programming in C"**. P. Dey and M Ghosh, Second Edition, Oxford University Press.

**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (50%)** | | | | | **End Semester Exam (50%)** | |
|---|---|---|---|---|---|---|---|---|
| | | **Theory (30%)** | | | | **Practical (20%)** | | |
| | | **CLA-1 (5%)** | **Mid-1 (10%)** | **CLA-2 (5%)** | **Mid-2 (10%)** | | **Th** | **Prac** |
| Level 1 | Remember | 70% | 60% | 30% | 30% | 50% | 60% | 50% |
| | Understand | | | | | | | |
| Level 2 | Apply | 30% | 40% | 70% | 70% | 50% | 40% | 50% |
| | Analyse | | | | | | | |
| Level 3 | Evaluate | | | | | | | |
| | Create | | | | | | | |
| **Total** | | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

**Course Designers**

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# Digital Design with HDL

| Course Code | **ECE 201** | Course Category | **Core Course (CC)** | L-T-P-C | **3** | **0** | **1** | **4** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | **ECE 211, Digital Electronics** | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To familiarize students with industry standard HDL based FPGA design flow and introduction to one of the HDL such as Verilog.

**Objective 2:** To review combinational logic circuits and circuit design using Verilog

**Objective 3:** To review sequential logic circuits, FSMs and circuit design using Verilog

**Objective 4:** To familiarize students with state of the art Xilinx FPGA architectures and implement digital circuits on Xilinx FPGA

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Demonstrate industry standard HDLs, Verilog for given designs | 2 | 80% | 70% |
| **Outcome 2** | Apply combinational logic design concepts and able to design using Verilog | 3 | 80% | 65% |
| **Outcome 3** | Apply sequential logic design concepts and FSM design concepts to design using Verilog | 3 | 70% | 65% |
| **Outcome 4** | Design and implement digital circuits on Xilinx FPGA | 3 | 70% | 60% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and | Self-Directed and Life Long | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 3 | 2 | | 2 | | | | | 2 | | | 2 | 1 | 3 | 2 |
| Outcome 2 | 3 | | 2 | 2 | 2 | | | 2 | 2 | 2 | | 2 | | 3 | 1 |
| Outcome 3 | | 2 | 2 | | | | | 2 | | | | 2 | 2 | | 2 |
| Outcome 4 | 3 | 2 | 2 | 2 | 2 | | | | 2 | 2 | | 2 | 2 | 3 | |
| **Course Average** | **3** | **2** | **2** | **2** | **2** | | | **2** | **2** | **2** | | **2** | **2** | **3** | **2** |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **INTRODUCTION TO LOGIC DESIGN USING VERILOG HDL** | **7** | | |
| | Introduction to HDL | 1 | 1 | 1, 2 |
| | Expressions, Modules and Ports, Built-in Primitives, User-Defined Primitives | 2 | 1 | 1, 2 |
| | Dataflow Modelling, Behavioural Modelling, Structural Modelling | 1 | 1 | 1, 2 |
| | Tasks and Functions | 2 | 1 | 1, 2 |
| | Testbenches | 1 | 1 | 1, 2 |
| **Unit 2** | **COMBINATIONAL AND SEQUENTIAL LOGIC DESIGN USING VERILOG HDL** | **6** | | |
| | Adder, subtractor, multiplexer | 1 | 2 | 2 |
| | Priority encoder, magnitude comparator | 1 | 2 | 2 |
| | ALU sequential logic, latches, flipflops | 2 | 2 | 2, 3 |
| | Counters, registers | 2 | 2 | 2, 3 |
| **Unit 3** | **FIELD PROGRAMMABLE GATE ARRAYS** | **9** | | |
| | FPGA Evolution, Programmable Logic Devices, Field Programmable Gate Arrays, FPGA Design Techniques | 2 | 3 | 1, 2 |
| | Design Constraints using FPGAs | 1 | 3 | 1, 2 |
| | Design Automation of FPGAs | 1 | 3 | 1, 2 |
| | Simulation, Synthesis, RTL Design Flow | 1 | 3 | 1, 2 |
| | Physical Design Flow | 1 | 3 | 1, 2 |
| | Place and Route, Timing Analysis | 2 | 3 | 1, 2 |
| | Design pitfalls | 1 | 3 | 1, 2 |
| **Unit 4** | **BEST PRACTICES FOR SUCCESSFUL FPGA DESIGN** | 14 | | |
| | Three Steps to Successful FPGA design, The Role of Project Management, Design Specification: Communication Is Key to Success | 2 | 4 | 2, 3 |
| | Engineering Resources, Device Selection, FPGA design environment | 2 | 4 | 2, 3 |
| | Challenges That FPGAs Create for Board Design, Key Factors in Accurate Power Estimation | 2 | 4 | 2, 3 |
| | Recommended Team Based Design Flow | 2 | 4 | 2, 3 |
| | RTL Design for FPGA devices, Writing Effective HDL | 2 | 4 | 2, 3 |
| | RTL Coding Styles for Synthesis, Analysing the RTL Design | 2 | 4 | 2, 3 |
| | Timing Closure Challenges, Design Sign-off | 2 | 4 | 2, 3 |
| **Unit 5** | **HDL COMPLEX DESIGN EXAMPLES AND FPGA APPLICATIONS-FSM design** | 9 | | |
| | Moore and Mealy FSM design examples1- 3 or more consecutive 1s detector | 2 | 4 | 2 |
| | Moore and Mealy FSM design examples2- Vending machine FSM | 2 | 4 | 2 |
| | Design of Computer Arithmetic Designs- Floating-Point Addition. | 2 | 4 | 2 |

| | | | | |
|---|---|---|---|---|
| | Design of Computer Arithmetic Designs- Floating-Point multiplier | 3 | 4 | 2 |
| **Total Contact Hours** | | **45** | | |

**Course Unitization Plan - Lab**

| Exp No. | Experiment Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| 1. | Verilog HDL Implementation, Simulation and Synthesis of Logic gates, 1-bit Adder, subtractors | 3 | 1 | 1, 4 |
| 2. | Verilog HDL Implementation, Simulation and Synthesis of Decoders, Multiplexers and Magnitude comparators | 3 | 2 | 1, 4 |
| 3. | Verilog HDL Implementation, Simulation and Synthesis of 4- bit adder, subtractors. | 3 | 2 | 1, 4 |
| 4. | Verilog HDL Implementation, Simulation and Synthesis of Latches and Flip-flops | 3 | 2 | 1, 4 |
| 5. | Verilog HDL Implementation, Simulation and Synthesis of 4-bit Register, Counter, Shift register, universal shift register | 3 | 2 | 1, 4 |
| 6. | Verilog HDL Implementation, Simulation and Synthesis of FSMs | 3 | 2 | 3, 4 |
| 7. | FPGA Introduction and Implementation of above simple Designs. | 3 | 3 | 3, 4 |
| 8. | FPGA Introduction and Implementation of above complex Designs. | 3 | 3 | 3, 4 |
| 9. | Course Project | 6 | 4 | 1, 3, 4 |
| **Total Contact Hours** | | **30** | | |

**Recommended Resources**


1. Joseph Cavanagh, Verilog HDL Design Examples, Taylor and Francis, CRC press, 2018.
2. Peter Wilson - Design Recipes for FPGAs using Verilog and VHDL [2nd ed.]-Elsevier (2016).
3. Philip Andrew Simpson (auth.) - FPGA Design_ Best Practices for Team-based Reuse-Springer International Publishing (2015).
4. Pong P. Chu - FPGA Prototyping Using Verilog Examples, Springer.
5. Douglas J Smith-HDL Chip Design: A Practical Guide for Designing, Synthesizing and Simulating ASICs and FPGAs using VHDL or Verilog, Doone Publications.


**Learning Assessment (Integrated course)**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (5%) | | Mid-1 (10%) | | CLA-2 (10%) | | Mid-2 (20%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 20% | | 40% | | 20% | | 20% | 30% | 40% | 25% |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 80% | | 60% | | 80% | | 80% | 70% | 60% | 75% |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designers**


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# Signals and Systems

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Code | **ECE 202** | Course Category | **Core Course (CC)** | L-T-P-C | **3** | **0** | **1** | **4** |
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** Understand the mathematical representation of continuous and discrete time signals and systems.
**Objective 2:** Learn to build input/output relationship for linear shift invariant system; understand the convolution operator for continuous and discrete time system.
**Objective 3:** Understand and resolve the signals in frequency domain using Fourier series and Fourier transforms.
**Objective 4:** Understand the limitations of Fourier transform; Understands the necessity of Laplace and Z transform.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Classify the given signal and system | 2 | 80% | 75% |
| **Outcome 2** | Discuss the LTI system and compute its output | 2 | 80% | 70% |
| **Outcome 3** | Compute the frequency components in the given signal and the bandwidth of signal and system | 3 | 80% | 65% |
| **Outcome 4** | Design the stable system based on the given parameters | 4 | 80% | 60% |

**Course Articulation Matrix**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and | Modern Tool and ICT Usage | Society and Multicultural | Environment and | Moral, and Ethical | Individual and Teamwork | Communication Skills | Project Management | Self-Directed and Life Long | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 3 | 2 | 1 | 2 | 1 | | | | | 1 | | | | 2 | 2 |
| Outcome 2 | | | 3 | 3 | 3 | | | | | | | | | 3 | |
| Outcome 3 | | 3 | | | | | | | | 1 | | 3 | 2 | | 3 |
| Outcome 4 | 3 | 3 | 3 | 3 | 3 | | | | | 1 | | 3 | 2 | | |
| **Course Average** | **3** | **3** | **3** | **3** | **3** | | | | | **1** | | **3** | **2** | **3** | **3** |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| Unit 1 | **Signals classification, transformations, representation** | **9** | | |
| | Classification of signals: continuous-time/discrete-time. | 2 | 1 | 1,2 |
| | Even odd | 1 | 1 | |
| | Periodic-aperiodic, energy-power, random-deterministic. | 1 | 1 | |
| | Standard signals: impulse, step | 1 | 1 | |
| | Ramp, exponential and sinusoids | 1 | 1 | |
| | Transformations of the independent variable: shifting | 1 | 1 | |
| | Scaling and reversal. Representation of periodic signals using Fourier series | 2 | 1 | |
| | **Lab Experiment / Practical / Programming** | 12 | 1 | |
| | Plotting even and odd components of continuous-time signals | 2 | 1 | |
| | Plotting even and odd components of discrete-time signals | 2 | 1 | |
| | Time period calculation of continuous time signals | 2 | 1 | |
| | Time period calculation of discrete time signals | 2 | 1 | |
| | Shifting, scaling and reflection of discrete time signals | 2 | 1 | |
| | Energy and power of signals | 2 | 1 | |
| Unit 2 | **Systems: classification and time domain analysis** | **9** | | |
| | Classification of systems: linear-nonlinear | 1 | 2 | 1, 2 |
| | Time-invariant/time-variant | 1 | 2 | |
| | Memory, causal | 1 | 2 | |
| | Continuous-time/discrete-time | 1 | 2 | |
| | LTI System properties: causality, memory | 1 | 2 | |
| | Stability, and invertibility | 1 | 2 | |
| | Impulse response | 1 | 2 | |
| | Linear convolution and discrete-time convolution | 1 | 2 | |
| | Graphical method to solve convolution | 1 | 2 | |
| | **Lab Experiment / Practical / Programming** | 8 | 2 | |
| | Verification of Reciprocity theorem | 4 | 2 | |
| | Convolution between two discrete time signals | 4 | 2 | |
| Unit 3 | **Continuous & discrete time systems: frequency domain analysis** | **9** | | 1, 2 |
| | Introduction to Laplace transform and region of convergence | 2 | 3,4 | |
| | Properties of Laplace transform | 1 | 3,4 | |
| | Inverse Laplace transform | 1 | 3,4 | |
| | Initial and final value theorems | 1 | 3,4 | |
| | Introduction to Z-transform and its region of convergence | 1 | 3,4 | |
| | Properties of Z-transform | 1 | 3,4 | |
| | Inverse Z-transform | 1 | 3,4 | |
| | The unilateral Z-transform | 1 | 3,4 | |
| | **Lab Experiment / Practical / Programming** | 4 | | |
| | Finding of Laplace transform | 2 | 3,4 | |
| | Finding of Z-transforms | 2 | 3,4 | |
| Unit 4 | **Continuous & discrete time signals: Fourier analysis** | **9** | | 1, 2 |
| | Introduction to sampling and reconstruction | 1 | 3,4 | |
| | Aliasing | 1 | 3,4 | |
| | Continuous time Fourier transform (CTFT) | 1 | 3,4 | |
| | Properties of CTFT | 1 | 3,4 | |

| | | | | |
|---|---|---|---|---|
| | Convolution property | 1 | 3,4 | |
| | CTFT of periodic signals | 1 | 3,4 | |
| | Discrete time Fourier transform (DTFT) and its properties | 2 | 3,4 | |
| | DTFT of periodic signals | 1 | 3,4 | |
| | **Lab Experiment/Practical/Programming** | 2 | | |
| | Fourier series representation of periodic signals | 2 | 3,4 | |
| Unit 5 | **Discrete Fourier transform and fft** | **9** | | |
| | Introduction to discrete Fourier transform (DFT) and its relation to DTFT | 2 | 3,4 | |
| | Properties of DFT | 1 | 3,4 | |
| | Inverse DFT | 1 | 3,4 | |
| | Convolution using DFT | 1 | 3,4 | 1, 2 |
| | Computation of DFT using fast Fourier transform (FFT) | 2 | 3,4 | |
| | Decimation in time FFT | 1 | 3,4 | |
| | Decimation in frequency FFT | 1 | 3,4 | |
| | **Lab Experiment/Practical/Programming** | 4 | | |
| | Discrete Fourier Transform (DFT) and Inverse DFT | 4 | 3,4 | |
| **Total Contact Hours** | | **75** | | |

**Recommended Resources**

1. "Signals and Systems" by Oppenheim, Wilsky and Nawab, Prentice Hall, 2nd edition. ISBN: 9780138147570.
2. "Signals and Systems" by Simon Haykin and Berry van Veen, 2nd edition, ISBN: 9780471164746.

**Other Resources**

1. "Principles of Signal Processing and Linear Systems" by B P Lathi, 2nd edition, ISBN: 9780198062271.
2. "Signals and Systems using MATLAB" by Louis F Chaparro, 2014 edition, Academic Press, ISBN: 9780123948434.

**Learning Assessment (Integrated Course)**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (50%)** | | | | | | | | **End Semester Exam (50%)** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **CLA-1 (10%)** | | **Mid-1 (15%)** | | **CLA-2 (10%)** | | **Mid-2 (15%)** | | | |
| | | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** |
| Level 1 | Remember | 60% | 60% | 60% | 60% | 60% | 60% | 60% | 60% | 60% | 60% |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 40% | 40% | 40% | 40% | 40% | 40% | 40% | 40% | 40% | 40% |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers**

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# Probability and Random Processes

| Course Code | **ECE 203** | Course Category | **Core Course (CC)** | L-T-P-C | **3** | **0** | **0** | **3** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | **ECE 212** | Co-Requisite Course(s) | **MAT 142** | Progressive Course(s) | **ECE 416** | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** Appreciate the importance of probability and statistics in the field of communicati**on** and signal processing.
**Objective 2:** Model the channel noise and understand its effect on information that is being **t**ransmitted over the channel.
**Objective 3:** Gain simulation capability of probability and stochastic process in Matlab.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Discuss probability and statistics | 1 | 80% | 60% |
| **Outcome 2** | Solve Random Variables problems | 3 | 80% | 80% |
| **Outcome 3** | Design and develop stochastic processes | 4 | 80% | 70% |
| **Outcome 4** | Analysis, design and research in applied stochastic problems | 5 | 80% | 60% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Life Long Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | | 2 | 1 | 3 | 2 | | | | | | 3 | | 1 | | |
| Outcome 2 | 2 | 3 | | 3 | | | | | | | 3 | 1 | | 2 | |
| Outcome 3 | 2 | | 3 | | 3 | | | | | | | | | 2 | |
| Outcome 4 | | 3 | 3 | 3 | 3 | | | | 1 | | | 1 | 2 | | |
| **Course Average** | **2** | **3** | **3** | **3** | **3** | | | | **1** | | **3** | **1** | **2** | **2** | |

**Course Unitization Plan**

| **Unit No.** | **Unit Name** | **Required Contact** | **CLOs Addressed** | **References Used** |
|---|---|---|---|---|

| | | hours | | |
|---|---|---|---|---|
| | **UNIT I: Review of basic probability theory** | **9** | | 1,2 |
| **Unit 1** | Definition and axioms of probability. | 2 | 1 | 1,2 |
| | Probability spaces. | 1 | 1 | 1,2 |
| | Joint and conditional probabilities. | 2 | 1 | 1,2 |
| | Independent events. | 2 | 1 | 1,2 |
| | Total probability theorem – Bayes' theorem. | 2 | 1 | 1,2 |
| | **UNIT II– Random Variables** | **9** | | 1,2 |
| **Unit 2** | Introduction to the concept of random variables. | 1 | 1,2 | 1,2 |
| | Continuous and Discrete random variables. | 1 | 1,2 | 1,2 |
| | Probability (Cumulative) distribution function (CDF) | 1 | 1,2 | 1,2 |
| | Probability Distribution Function (PDF) | 1 | 1,2 | 1, |
| | Joint distribution function of two random variables. | 1 | 1,2 | 1,2 |
| | Conditional CDF and PDF. | 1 | 1,2 | 1,2 |
| | Independent random variables. | 1 | 1,2 | 1,2 |
| | Various Continuous and Discrete random distributions (Special focus is on Uniform, Gaussian, Poisson random variables). | 2 | 1,2 | 1,2 |
| | **UNIT III - Statistical Averages** | **9** | | |
| **Unit 3** | Introduction to the concept of statistical averages. | 2 | 1,2 | |
| | various statistical averages – Expectation. | 2 | 1,2 | 1,2 |
| | Variance. | 1 | 1,2 | 1,2 |
| | Mean square value etc. | 1 | 1,2 | 1,2 |
| | Chebyshev inequality. | 2 | 1,2 | 1,2 |
| | Central limit theorem. | 1 | 1,2 | 1,2 |
| | **UNIT IV: Random Processes: Time domain analysis** | **9** | | |
| **Unit 4** | Introduction to the concept of random process. | 2 | 1,2,3 | 1,2 |
| | Classification of random processes. | 1 | 1,2,3 | 1,2 |
| | Stationary random processes. | 1 | 1,2,3 | 1,2 |
| | Ergodic random processes. | 1 | 1,2,3 | 1,2 |
| | Correlation functions and their properties | 1 | 1,2,3 | 1,2 |
| | Gaussian and Poisson random process. | 1 | 1,2,3 | 1,2 |
| | Sample t-tests. | 1 | 1,2,3 | 1,2 |
| | Analysis of statistical means | 1 | 1,2,3 | 1,2 |
| | **UNIT V: Random Processes: Frequency domain analysis** | **9** | | |
| **Unit 5** | Introduction to the concept of Power Spectral Density. | 2 | 1,2,3, 4 | 1,2 |
| | Relation between Power spectral density and auto correlation function – Wiener Kinchine Theorem. | 2 | 1,2,3, 4 | 1,2 |
| | Noise: White and Colored. | 2 | 1,2,3, 4 | 1,2 |
| | Linear Time Invariant (LTI) systems with random processes as inputs. | 2 | 1,2,3, 4 | 1,2 |
| | Noise equivalent bandwidth. | 1 | 1,2,3, 4 | 1,2 |
| | **Total Contact Hours** | **45** | | |

**Recommended Resources**

1. Probability, Random variables and Stochastic processes – A Papoulis and Unnikrishnan Pillai, 4th Edition, Mc Grahill Publisher.
2. Communication Systems, Simon Haykin, 4th Edition, John Wiley & Sons

**Other Resources**

1. Probability and Random Processes for Electric and Computer Engineers, John A Gubner, 1st Edition, CAMBRIDGE University press

| | |
|---|---|
| **2.** | Probability theory, Random variables and Random signal principles, Peebles, 4th Edition, TMH |

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (10%) | | Mid-1 (15%) | | CLA-2 (10%) | | Mid-2 (15%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 60% | | 50% | | 60% | | 60% | | 40% | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 40% | | 40% | | 40% | | 30% | | 30% | |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | 10% | | | | 10% | | 30% | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designers**

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# Design and Analysis of Analog, Mixed Signal Circuits

| Course Code | **ECE 204** | Course Category | **Core Course (CC)** | L-T-P-C | **3** | **0** | **1** | **4** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | **ECE 205** | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** Learn various feedback structures and frequency compensation techniques.

**Objective 2:** Gain Knowledge of various oscillations, multivibrators, and timer circuits using op-amp.

**Objective 3:** Learn about various filter circuits using op-amp and tuned amplifiers.

**Objective 4:** Understand the output stages of the power amplifier.

**Objective 5:** Understand the voltage reference circuits, power supply, and data converters circuits.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Identify various feedback structures with the knowledge of frequency compensation techniques | 2 | 70% | 65% |
| **Outcome 2** | Demonstrate oscillators, multivibrators, and timer circuits using PSPICE | 3 | 65% | 65% |
| **Outcome 3** | Discuss filter circuits using op-amp and tuned amplifier | 2 | 70% | 60% |
| **Outcome 4** | Discuss output stages of various power amplifier | 2 | 60% | 65% |
| **Outcome 5** | Illustrate the applications of voltage reference, power supply, and data converter circuits | 2 | 70% | 65% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural | Environment and | Moral, and Ethical | Individual and Teamwork | Communication Skills | Project Management | Self-Directed and Life Long | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 1 | | | | | | | | | | | | | 2 | 2 |
| Outcome 2 | 1 | | 2 | 1 | 2 | | | | | | | 1 | | 2 | 2 |
| Outcome 3 | | | 2 | 2 | | | | | | | | 1 | | | 2 |
| Outcome 4 | 2 | 2 | 2 | 2 | | | | | | | | 1 | 3 | | |
| Outcome 5 | 2 | 2 | 2 | 2 | 2 | | | | | | | 1 | 3 | 3 | |
| **Course Average** | **2** | **2** | **2** | **2** | **2** | | | | | | | **1** | **3** | **2** | **2** |

**Course Unitization Plan- Theory**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit I** | **Feedback Amplifiers** | **9** | | |
| 1. | General Feedback Structure | 2 | 1 | 1,2,4 |
| 0. | Negative Feedback | 1 | 1 | 1,2,4 |
| 0. | Feedback Amplifier Types | 2 | 1 | 1,2,4 |
| 0. | Stability Problem | 2 | 1 | 1,2,4 |
| 0. | Frequency Compensation | 2 | 1 | 1,3 |
| **Unit II** | **Signal Generation and Waveform Shaping Circuits** | **9** | | |
| 6 | Basic Principles of Sinusoidal Oscillators | 1 | 2 | 1,4 |
| 7 | Op-amp RC Oscillator | 2 | 2 | 1,4 |
| 8 | Wein Bridge Oscillator | 1 | 2 | 1,4 |
| 9 | MOSFET Crystal Oscillators | 1 | 2 | 1,4 |
| 10 | Bistable Multivibrators | 2 | 2 | 1,4 |
| 11 | 555 timer IC and Applications | 2 | 2 | 1,4 |
| **Unit III** | **Active Filter and Tuned Amplifiers** | **9** | | |
| 12. | Filter Transmission | 1 | 3 | 1,2 |
| 13. | Types and Specification | 1 | 3 | 1,2 |
| 14. | Filter Transfer Function | 1 | 3 | 1,2 |
| 15. | Butterworth and Chebyshev Filters | 1 | 3 | 1,2 |
| 16 | First order and second order Filter Functions | 2 | 3 | 1,2 |
| 17 | SC Filters, Gm-C Filters | 1 | 3 | 1,2 |
| 18 | Tuned Amplifiers | 1 | 3 | 1,2 |
| **Unit IV** | **Output Stages and Power Amplifiers** | **9** | | |
| 19. | Classification of output stages | 2 | 4 | 1,2,4 |
| 20. | Class A output stage | 2 | 4 | 1,2,4 |
| 21. | Class B output stage | 2 | 4 | 1,2,4 |
| 22. | Class C output stage | 2 | 4 | 1,2,4 |
| 23. | Class D Power Amplifiers | 1 | 4 | 1,2,4 |
| **Unit V** | **Voltage Reference Circuits and Data Converters** | **9** | | |
| 24. | Voltage Reference Circuits | 1 | 5 | 1,4 |
| 25. | Power Supplies: Ripple Removal and Regulation | 2 | 5 | 1,4 |
| 26. | Data Converters: Sample and Hold Circuits | 2 | 5 | 1,4 |
| 27. | ADCs | 2 | 5 | 1,4 |
| 28. | DACs | 2 | 5 | 1,4 |
| | | | | |
| **Total Contact Hours** | | **45** | | |

**Course Unitization Plan - Lab**

| Session No. | Description of Experiments | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| 1. | Analysis of Feedback circuits with Op-amps. | 2 | 2 | 4,5 |
| 2. | Analysis of Feedback circuits with MOSFETs. | 2 | 3 | 4,5 |
| 3. | Design and Analysis of RC phase shift, LC oscillators. | 1 | 3,5,6 | 4 |
| 4. | Design and Analysis of Wien Bridge oscillator. | 1 | 3,5,6 | 4 |

| | | | | |
|---|---|---|---|---|
| 5. | Design and Analysis of 555 timer-based Astable and Monostable Multivibrators. | 2 | 3,5,6 | 4 |
| 6. | Design and Analysis of MOSFET-based Class A, and Class C Power amplifier. | 2 | 3 | 4,5 |
| 7. | Design and Analysis of Op-amp-based Active filters. | 1 | 3 | 5 |
| 8. | Design and Analysis of Voltage regulator circuits. | 1 | 4 | 4,5 |
| 9. | Design and Analysis of Voltage reference circuits. | 1 | 4 | 4 |
| 10. | Design and Analysis of ADCs, DACs-I. | 1 | 4 | 4,5 |
| 11. | Design and Analysis of ADCs, DACs-II. | 1 | 4 | 4,5 |
| | | | | |
| **Total Contact Hours** | | **15** | | |

**Recommended Resources**

1. Microelectronic Circuits: Theory and Applications, Adel S. Sedra and K . C. Smith, 7th Edition, Oxford University press
2. BezhadRizavi "*Fundamentals of Microelectronics"*, Wiley, (2006)
3. Integrated Electronics, Jacob Millman, Christos C Halkias, McGraw Hill Education.
4. Electronic Devices and Circuits theory– Robert L. Boylestead, Louis Nashelsky, 11th Edition, 2009, Pearson.
5. Electronic Devices: Thomas L. Floyd, Edition 9, illustrated, Prentice Hall, 2012.

**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (60%)** | | | | | **End Semester Exam (40%)** | |
|---|---|---|---|---|---|---|---|---|
| | | **Theory (35%)** | | | | **Practical (25%)** | | |
| | | **CLA-1 (10%)** | **CLA-2 (5%)** | **CLA-3 (10%)** | **Mid-1(10 %)** | | **Th (25%)** | **Prac (15%)** |
| Level 1 | Remember | 60% | 40% | 60% | 40% | 50% | 40% | 40% |
| | Understand | | | | | | | |
| Level 2 | Apply | 40% | 60% | 40% | 60% | 50% | 60% | 60% |
| | Analyse | | | | | | | |
| Level 3 | Evaluate | | | | | | | |
| | Create | | | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers**

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# SEMESTER IV

**SRM University – AP, Andhra Pradesh**
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# Creativity and Critical Thinking Skills

| Course Code | AEC 104 | Course Category | Core | **L-T-P-C** | 1 | 0 | 1 | 2 |
|---|---|---|---|---|---|---|---|---|
| Total Contact Hours | | 30 | Total Learning Hours | | 60 | | | |
| Pre-Requisite Course(s) | Nil | Co-Requisite Course(s) | Nil | Progressive Course(s) | | | | |
| Course Offering Department | Literature & Languages | Professional / Licensing Standards | | | | | | |

**Course Objectives**:
To enhance students' creativity and critical thinking skills for effective real-life application, preparing them for advanced studies and diverse career opportunities, while fostering an understanding of global and regional socio-political and cultural contexts.

**Course Outcomes (COs)**

| COs | At the end of the course the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| 1 | Define and describe fundamental concepts and theories related to creativity and critical thinking. | 1 | 70% | 60% |
| 2 | Explain the significance of creativity and critical thinking in problem-solving and decision-making processes. | 2 | 65% | 60% |
| 3 | Implement critical thinking strategies to analyse and evaluate information and arguments effectively. | 3 | 70% | 60% |
| 4 | Analyse and assess the effectiveness of specific creative thinking methods in addressing real-world problems. | 4 | 70% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Scientific and Disciplinary Knowledge | Analytical Reasoning and Problem Solving | Critical and Reflective Thinking | Scientific Reasoning and Design Thinking | Research Related Skills | Modern Tools and ICT Usage | Environment and Sustainability | Moral, Multicultural and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Leadership Readiness Skills | Self-Directed and Lifelong Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | **3** | | 3 | **2** | **2** | | | **1** | **3** | **2** | | **1** | **2** | **1** | **3** |
| Outcome 2 | 3 | 3 | 3 | 3 | **2** | | | 3 | **3** | **2** | | 3 | 3 | 3 | **3** |
| Outcome 3 | 3 | 3 | 3 | 3 | 3 | | | 3 | **3** | **2** | **3** | 3 | 3 | 3 | **3** |
| Outcome 4 | 3 | 3 | 3 | 3 | 3 | | | 3 | **3** | 2 | **3** | 3 | 3 | 3 | 3 |
| **Course Average** | **3** | **3** | **3** | **2.75** | **2.5** | | | **2.5** | **3** | **2** | **3** | **2.5** | **2.75** | **2.5** | **3** |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Introduction to Creativity and Critical Thinking** | **7** | | |
| | Introduction to key concepts | | 1,3 | 1 |
| | Importance in personal and professional contexts | | 1,3 | 1,2 |
| | Understanding the differences | | 2,3 | 1,4 |
| | Real-world applications | | 1,3 | 1,3 |
| **Unit 2** | **Overcoming Mental Blocks** | **3** | | |
| | Identifying and addressing barriers | | 1 | 14 |
| | Exercises for mental flexibility | | 4 | 1,2 |
| **Unit 3** | **Critical Thinking Skills** | **7** | | |
| | Recognizing common pitfalls | | 1,3 | 1,2 |
| | Examples and group discussion | | 2,3 | 1,2 |
| | Techniques for assessing information credibility | | 1,3 | 1 |
| | Case studies and research exercises | | 1,3 | 3 |
| **Unit 4** | **Application of Creative Solutions** | **7** | | |
| | Practical problem-solving exercises | | 1,3 | 1,4 |
| | Group projects and case studies | | 2,3 | 2,3 |
| | Integrating ethics into creative and critical thinking | | 1,3 | 1 |
| | Discussions on ethical dilemmas and decision-making | | 1,3 | 3 |
| **Unit 5** | **Application of Creative Solutions** | **6** | | |
| | Quizzes on concepts and techniques | | 1,3 | 1,2 |
| | Individual and group assignments | | 2,3 | 1,2 |
| | Applying creativity and critical thinking to a real-world scenario | | 1,3 | 1 |
| | Presentation and peer evaluation | | 1,3 | 3 |
| **Total Contact Hours** | | **30** | | |

**Recommended Resources**


1. *Kelley, D., & Kelley, T. (2013). Creative Confidence: Unleashing the Creative Potential Within Us All. In Google Books. HarperCollins Publishers.*
2. *Fisher, A. (2001). Critical thinking : an introduction. Cambridge University Press.*
3. *Levitt, S. D., & Dubner, S. J. (2018). Think Like a Freak (Republish). Noura Books.*
4. *Nussbaum, B. (2014). Creative Intelligence: harnessing the power to create, connect, and inspire. HarperBusiness.*

**Learning Assessment (Macro)**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (75%) | | | |
|---|---|---|---|---|---|
| | | CLA-1 (20%) | CLA-2 (20%) | CLA-3 (20%) | Project Work (45%) |
| Level 1 | Remember | 30% | | 10% | |
| | Understand | | | | |
| Level 2 | Apply | 70% | 100% | 90% | 100 |
| | Analyse | | | | |
| Level 3 | Evaluate | | | | |
| | Create | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** |

**Course Designers**

*Dr. Srabani Basu*

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Guntur District, Mangalagiri, Andhra Pradesh 522240

## Hands on with Python and Raspberry Pi

| Course Code | SEC 116 | Course Category | **Professional Core** | L-T-P-C | **2** | **0** | **1** | **3** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | - | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** Understand the Raspberry Pi Hardware and software components.

**Objective 2:** Develop the Raspberry PI programs to interface the sensors and actuators.

**Objective 3:** Develop Raspberry PI based Python TCP/UDP networking programs.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Interface sensors, actuators with Raspberry Pi hardware. | 4 | 80% | 70% |
| **Outcome 2** | Develop programs using python basic constructs for Raspberry Pi peripheral interfacing | 4 | 80% | 70% |
| **Outcome 3** | Develop object oriented python programs. | 4 | 80% | 70% |
| **Outcome 4** | Develop python socket programs for TCP, UDP, and HTTP server/Client applications in Raspberry Pi. | 4 | 80% | 70% |
| **Outcome 5** | Write python GUI applications using existing libraries. | 4 | 80% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem | Design and Development | Analysis, Design and | Modern Tool and ICT | Society and Multicultural | Environment and | Moral, and Ethical | Individual and | Communication Skills | Project Management and Finance | Self-Directed and Lifelong | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 2 | 2 | 2 | 2 | 2 | 1 | | 1 | 2 | 2 | 1 | 2 | 1 | 1 | 1 |
| Outcome 2 | 2 | 2 | 3 | 2 | 2 | 1 | | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| Outcome 3 | 2 | 2 | 3 | 2 | 2 | 1 | | 1 | 2 | 2 | 1 | 2 | 3 | 3 | 3 |
| Outcome 4 | 2 | 2 | 3 | 2 | 2 | 1 | | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| Outcome 5 | 2 | 2 | 3 | 2 | 2 | 1 | | 1 | 2 | 2 | 1 | 2 | 3 | 3 | 3 |
| **Course Average** | **2** | **2** | **3** | **2** | **2** | **1** | | **1** | **2** | **2** | **2** | **2** | **2** | **2** | **2** |

**Course Unitization Plan -Theory**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Python Basics** | **10** | | |
| 1 | Introduction to Python | 1 | 2 | 6,4 |
| 2 | Data Types, Operators | 2 | 2 | 6,4 |
| 3 | Conditional statements | 2 | 2 | 6,4 |
| 4 | Loops - for, while | 2 | 2 | 6,4 |
| 5 | Strings, Lists and Dictionaries | 2 | 2 | 6,4 |
| 6 | Sets, Tuples | 1 | 2 | 6,4 |
| **Unit 2** | **Arrays, Functions and OOPS** | **10** | | |
| | Arrays | 2 | 2 | 6,4 |
| | Functions | 2 | 2 | 6,4 |
| | Exceptions | 1 | 2 | 6,4 |
| | Modules, Libraries | 2 | 2 | 6,4 |
| | Classes, Objects | 2 | 3 | 6,4 |
| | Inheritance | 1 | 3 | 6,4 |
| **Unit 3** | **GUI and Network Programming** | **10** | | |
| | Tkinter | 1 | 5 | 7 |
| | GUI Widgets, Simple GUI programs | 2 | 5 | 7 |
| | Introduction to Network Layers | 1 | 4 | 7 |
| | Socket programming – TCP Server/Client | 2 | 4 | 7 |
| | UDP Server/Client | 2 | 4 | 7 |
| | HTTP Server | 1 | 4 | 7 |
| | HTTP Client | 1 | 4 | 7 |
| | **Total Contact Hours** | **30** | | |
| | | | | |

**Course Unitization Plan - Lab**

| Session | Description of Experiment | Contact hours required | CLOs Addressed | Reference Used |
|---|---|---|---|---|
| 1. | Introduction to Raspberry Pi and Open-Source physical computing. | 1 | 1 | 1,5 |
| 2. | Introduction to Python | 1 | 2 | 4 |
| 3. | Network programming in python | 1 | 4 | 3,5 |
| 4. | Familiarization with Raspberry Pi and perform necessary software installation. | 2 | 1 | 1.5 |
| 5. | Interface LED/Buzzer with Raspberry Pi and write a program to turn ON LED for 1 sec after every 2 sec. | 1 | 1 | 1,5 |
| 6 | To interface Push button/Digital sensor (IR/LDR) with Raspberry Pi and write a program to turn ON LED when push button is pressed or at sensor detection. | 1 | 1 | 1,5 |
| 7 | To interface DHT11 sensor with Raspberry Pi and write a program to print temperature and humidity readings. | 1 | 1 | 1,5 |
| 8 | To Interface motor using relay with Raspberry | | 1 | 1,5 |

| | | | | |
|---|---|---|---|---|
| | Pi and write a program to turn ON motor when push button is pressed. | 1 | | |
| 9 | To interface Camera with Raspberry Pi and do the basic image processing. | 1 | 1 | 1,5 |
| 10 | Write a program on Raspberry Pi to upload temperature and humidity data to think speak cloud. | 2 | 1,4 | 1,5,7 |
| 11. | Write a program to create UDP server on Raspberry Pi and respond with humidity data to UDP client when requested. | 1 | 1,4 | 1,3,5,7 |
| 12 | Write a program to create TCP server on Raspberry Pi and respond with humidity data to TCP client when requested. | 1 | 1,4 | 1,3, 5,7 |
| 13 | Embedded Web Server on Raspberry Pi. | 1 | 1,4 | 7 |
| **Total Contact Hours** | | **15** | | |

**Recommended Resources**


1. Raspberry lab manuals
2. https://www.cisco.com/c/en/us/support/docs/smb/routers/cisco-rv-series-small-business-routers/smb5832-how-to-create-a-basic-voice-network-using-raspberry-pi.html
3. https://beej.us/guide/bgnet/
4. Learn complete python in simple way, Durgsoft Learning material (online available)
5. Derek Molly, "Exploring RaspberryPi, Interfacing the Real world with Embedded Linux", Wiley Publications, 2016
6. Simon Monk, "Programming the Raspberry Pi, Second Edition: Getting Started with Python", McGraw Hill TAB, 2015.
7. Brandon Rhodes, John Goerzen, "Foundations of Python Network Programming", Apress, 2014.


**Learning Assessment – Theory & Lab**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (50%)** | | | | **End Semester Exam (50%)** | |
|---|---|---|---|---|---|---|---|
| | | **Theory (35%)** | | | **Practical (25%)** | | |
| | | **CLA-1 (10%)** | **CLA-2 (5%)** | **Mid-1 (10%)** | | **Th (25%)** | **Prac (25%)** |
| Level 1 | Remember | 60% | 40% | 60% | 20% | 40% | 30% |
| | Understand | | | | | | |
| Level 2 | Apply | 40% | 60% | 40% | 80% | 60% | 70% |
| | Analyse | | | | | | |
| Level 3 | Evaluate | | | | | | |
| | Create | | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers**


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# Principles of Modern Communication Systems

| Course Code | **ECE 205** | Course Category | **Core Course (CC)** | L-T-P-C | **3** | **0** | **1** | **4** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | **ECE 203, ECE 204** | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To introduce the concept of modulation and different techniques and apply the concepts of stochastic process for performance evaluation of the different schemes.

**Objective 2:** To understand the concept of sampling and different baseband digital modulation schemes along with line coding and pulse shaping.

**Objective 3:** To apply the concept of modulation in the context of digital communication.

**Objective 4:** To understand the source and channel coding concept and their relevance to digital communication.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of this course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Compare and contrast AM, FM, and PM and use the relevant mathematical tools required to evaluate their noise performance. | 3 | 80% | 75% |
| **Outcome 2** | Apply the Sampling Theorem to discrete-time modulations and examine the importance of line coding and pulse shaping | 4 | 70% | 65% |
| **Outcome 3** | Illustrate the difference between passband and baseband digital modulations and their suitability for applications. | 3 | 70% | 65% |
| **Outcome 4** | Interpret the importance of Information Theory in Digital Communication | 3 | 70% | 65% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering | Problem | Design and | Analysis | Modern Tool | Society and | Environment | Moral, and | Individual and | Communicati | Project Manag | Self-Directe | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | | 2 | 1 | | 2 | | | | | | | 1 | 3 | | 3 |
| Outcome 2 | 3 | | 1 | 2 | | | | | | | | | | 2 | |
| Outcome 3 | | | 1 | 3 | 2 | | | | 3 | | | | 3 | 2 | |
| Outcome 4 | 3 | 2 | 1 | 3 | 2 | | | | 3 | | | | 3 | 2 | 3 |
| **Course Average** | **3** | **2** | **1** | **3** | **2** | | | | **3** | | | **1** | **3** | **2** | **3** |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **ANALOG COMMUNICATION** | **18** | | |
| | Baseband vs Carrier Communication | 1 | 1 | 1 |
| | Modulation | 1 | 1 | 1 |
| | Amplitude Modulation – DSB-SC, DSB | 2 | 1 | 1 |
| | Amplitude Modulation - SSB | 2 | 1 | 1 |
| | Angle Modulation - FM | 1 | 1 | 1 |
| | Angle Modulation - PM | 1 | 1 | 1 |
| | Superheterodyne Receivers | 1 | 1 | 1 |
| | Analyze and Test DSB and DSB-SC (Lab Experiment - 1) | 3 | 1 | 3 |
| | Analyze and Test SSB-SC (Lab Experiment - 2) | 3 | 1 | 3 |
| | Analyze and Test FM (Lab Experiment - 3) | 3 | 1 | 3 |
| **Unit 2** | **PERFORMANCE OF ANALOG MODULATION IN THE PRESENCE OF NOISE** | **10** | | |
| | Noise – Thermal, White, Filtered Noise, Noise Equivalent Bandwidth | 2 | 2 | 1 |
| | Baseband Noise – additive noise and Signal-to-Noise Ratio | 2 | 2 | 1 |
| | Bandpass Noise – System Models, Quadrature Components, Envelope and Phase | 2 | 2 | 1 |
| | Linear Continuous Wave Modulation with Noise– Analysis | 2 | 2 | 1 |
| | Angle Modulation with Noise – Analysis | 1 | 2 | 1 |
| | Performance comparison between amplitude and angle modulation | 1 | 2 | 1 |
| **Unit 3** | **PULSE AND BASEBAND DIGITAL MODULATION** | **25** | | |
| | Introduction to sampling theorem | 1 | 2 | 1 |
| | Pulse Amplitude Modulation (PAM), Pulse Width Modulation (PWM), Pulse Position Modulation (PPM) | 2 | 2 | 1 |
| | Quantization; Pulse Code Modulation (PCM) | 1 | 2 | 1 |

| | | | | |
|---|---|---|---|---|
| | Differential Pulse Code Modulation (DPCM), Delta Modulation (DM); Adaptive Delta Modulation (ADM) | 2 | 2 | 1 |
| | Line Coding | 1 | 2 | 1 |
| | Pulse Shaping Nyquist's First criterion for zero Intersymbol Interference (ISI) | 1 | 2 | 1 |
| | Raised Cosine Pulse, Partial Response Signaling | 2 | 2 | 1 |
| | Sampling Theorem Verification (Lab Experiment - 4) | 3 | 2 | 3 |
| | Analyze and Test PAM, PPM, and PWM (Lab Experiment - 5) | 3 | 2 | 3 |
| | Analyze and Test PCM and DPCM (Lab Experiment - 6) | 3 | 2 | 4 |
| | Analyze and Test DM (Lab Experiment – 7) | 3 | 2 | 4 |
| | Data Formatting (Lab Experiment - 8) | 3 | 2 | 4 |
| **Unit 4** | **DIGITAL PASSBAND MODULATION AND NOISE ANALYSIS** | **11** | | |
| | Binary and M-ary Signaling Features and Classification | 1 | 3 | 2 |
| | Carrier Modulations, Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK) | 2 | 3 | 2 |
| | Carrier Modulations, Minimum Shift Keying (MSK), Gaussian MSK (GMSK), Quadrature Phase Shift Keying (QPSK) and Quadrature Amplitude Modulation (QAM) | 2 | 3 | 2 |
| | Signal Space Introduction | 1 | 3 | 2 |
| | Generation and BER Calculation of Carrier Modulations | 1 | 3 | 2 |
| | Optimum Detector Matched Filter | 1 | 3 | 2 |
| | Analyze and Test ASK, FSK, and PSK (Lab Experiment - 9) | 3 | 3 | 4 |
| **Unit 5** | **INTRODUCTION TO INFORMATION THEORY** | **11** | | |
| | Information & Entropy, Conditional Entropy & Mutual Information | 1 | 4 | 2 |
| | Shannon's Source Coding Theorem, Huffman Coding, and Lempel-Ziv Algorithm | 2 | 4 | 2 |

| | | | | |
|---|---|---|---|---|
| | Shannon Hartley Theorem for Channel Capacity, Capacity of Binary Symmetric Channel, and Binary Erasure Channel | 2 | 4 | 2 |
| | Channel Coding Theorem, Forward Error Correction, Automatic Repeat Request (ARQ) | 1 | 4 | 2 |
| | Linear Block Codes and Cyclic Codes – CRC | 2 | 4 | 2 |
| | Analyze and Test Linear Block Codes (Lab Experiment - 10) | 3 | 4 | 4 |
| | **TOTAL CONTACT HOURS** | **75** | | |

**Recommended Resources**

1. B. P. Lathi, Z. Ding, "*Modern Digital and Analog Communication Systems"*, 4th Edition, Oxford University Press, 2017
2. A. B. Carlson, P. B. Crilly, "*Communication Systems: An Introduction to Signals and Noise in Electrical Communication"*, 5th Edition, McGraw Hill Higher Education
3. Physitech 60, 71 PD, 101, 133, 138, 139, 156, 157, 165, 422
4. Scientech 2152, 2153, 2154, 2155, 2156, 2157, 2113, 2121A, 2121B and 2807

**Other Resources**

1. H. Taub, D. L. Schilling, G. Saha, "Principles of Communication Systems", 4th Edition, McGraw Hill Higher Education
2. J. G. Proakis, M. Salehi, "Fundamentals of Communication Systems", 2nd Edition, Pearson Higher Education.

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (10%) | | Mid-1 (15%) | | CLA-2 (10%) | | Mid-2 (15%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 60% | 30% | 50% | 40% | 60% | 30% | 50% | 40% | 40% | 40% |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 40% | 70% | 50% | 60% | 40% | 70% | 50% | 60% | 60% | 60% |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers**

*Dr. Anirban Ghosh, Asst Professor, Dept of ECE, SRM University - AP*

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Neeru Konda, Mangalagiri Mandal
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# Digital Signal Processing

| Course Code | **ECE 206** | Course Category | **Core Course (CC)** | L-T-P-C | **3** | **0** | **1** | **4** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | **ECE 212** | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To familiarise the time domain signal processing techniques.

**Objective 2:** To analyze a given signal in the frequency domain.

**Objective 3:** To understand various analog filtering techniques.

**Objective 4:** To understand various digital filtering techniques.

**Objective 5:** To have a basic understanding of advanced signal processing algorithms.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Describe the response of an LTI system in both time and frequency domain. | 2 | 85% | 80% |
| **Outcome 2** | Apply and analyse transformation techniques | 4 | 80% | 75% |
| **Outcome 3** | Apply and verify analog filters for signal filtering applications | 3 | 85% | 70% |
| **Outcome 4** | Apply IIR and FIR digital filters that operate on discrete-time signals. | 3 | 80% | 70% |
| **Outcome 5** | Analyse multi-rate signal processing techniques. | 4 | 75% | 65% |

**Course Articulation Matrix: (CLO) to Program Learning Outcomes (PLO)**

| **CLO** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and | Modern Tool and ICT | Society and Multicultural | Environment and | Moral, and Ethical | Individual and | Communication Skills | Project Management | Self-Directed and Lifelong | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | 1 | 1 | 1 | 1 |
| Outcome 2 | 2 | 3 | 2 | 3 | 2 | | | | 2 | 1 | | 1 | 1 | 2 | 3 |
| Outcome 3 | 2 | 2 | 2 | 3 | 3 | | | | | | | | 1 | 2 | 2 |
| Outcome 4 | 2 | 3 | 3 | 3 | 3 | | | | 2 | 1 | | 1 | 2 | 3 | 3 |
| Outcome 5 | 3 | 3 | 2 | 3 | 3 | | | | 2 | 1 | | 2 | 2 | 2 | 2 |
| **Course Average** | **2** | **3** | **2** | **3** | **3** | | | | **2** | **1** | | **1** | **1** | **2** | **2** |

**Course Unitization Plan - Theory**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Introduction and Time Domain Processing** | **9** | | |
| | Review of signals and systems. | 1 | 1 | 1, 2 |
| | Differences between analog and digital signal processing. | 2 | 1 | 1, 2 |
| | Filtering in time domain: linear convolution. | 2 | 1 | 1, 2 |
| | Circular convolution. | 2 | 1 | 1, 2 |
| | Linear correlation and circular correlation; auto correlation and cross correlation of signals. | 2 | 1 | 1, 2 |
| **Unit 2** | **Frequency Domain Processing** | **9** | | |
| | Discrete Fourier transform (DFT). | 1 | 2 | 1, 2 |
| | Methods to compute DFT: Cooley-Tukey FFT algorithm, properties of FFT. | 3 | 2 | 1, 2 |
| | Decimation in time and decimation in frequency algorithms to compute DFT using FFT. | 3 | 2 | 1, 2 |
| | Rader's and Bluestein's FFT algorithms. | 2 | 2 | 1, 2 |
| **Unit 3** | **Analog Filters** | **9** | | |
| | Transfer function. | 1 | 3 | 1, 2 |
| | Design of Butterworth, elliptic. | 1 | 3 | 1, 2 |
| | Chebyshev, and Bessel filters. | 1 | 3 | 1, 2 |
| | Filter order and roll-off rate. | 1 | 3 | 1, 2 |
| | Lowpass, High pass. | 1 | 3 | 1, 2 |
| | Bandpass and band stop filters. | 1 | 3 | 1, 2 |
| | Higher order filters | 1 | 3 | 1, 2 |
| | Linear phase and its importance. | 1 | 3 | 1, 2 |
| | Phase delay and group delay of the filters. | 1 | 3 | 1, 2 |
| **Unit 4** | **Digital Filters** | **9** | | |
| | Finite impulse response (FIR) filters. | 1 | 4 | 2, 3 |
| | Infinite Impulse Response (IIR) filters. | 2 | 4 | 2, 3 |
| | Realization of digital filters: canonical form. | 2 | 4 | 2, 3 |
| | Direct form-I, form-II methods. | 1 | 4 | 2, 3 |
| | Converting analog filters to digital filers: bilinear transformation | 2 | 4 | 2, 3 |
| | All-pass filter and inverse filter. | 1 | 4 | 2, 3 |
| **Unit 5** | **Multi-rate Signal Processing** | **9** | | |
| | Decimation. | 1 | 5 | 2, 4 |
| | Interpolation. | 1 | 5 | 2, 4 |
| | Sampling rate conversion of non-integer factors; multistage implementation and polyphase implementation of decimation and interpolation. | 4 | 5 | 2, 4 |
| | Introduction to sub-band coding and multi-resolution analysis. | 3 | 5 | 2, 4 |
| **Total Contact Hours** | | **45** | | |

**Course Unitization Plan - Lab**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| 1 | Obtain DFT / IDFT of given Discrete Time signals. | 2 | 1 | 2, 4 |
| 2 | Obtain circular convolution of two finite length sequences. | 2 | 1 | 2, 4 |

| | | | | |
|---|---|---|---|---|
| 3 | Obtain linear correlation of two finite length sequences. | 2 | 1 | 2, 4 |
| 4 | Implementation of FFT of given sequence. | 2 | 2 | 2, 4 |
| 5 | Implementation of properties of FFT. | 2 | 2 | 2, 4 |
| 6 | Transfer function analysis | 2 | 2 | 2, 4 |
| 7 | Implementation of Butterworth Low Pass Filter. | 2 | 3 | 2, 4 |
| 8 | Implementation of Chebyshev Low Pass Filter | 2 | 3 | 2, 4 |
| 9 | Implementation of High Pass IIR filter for a given sequence. | 2 | 3 | 2, 4 |
| 10 | Implementation of Low Pass FIR filter for a given sequence. | 2 | 4 | 2, 4 |
| 11 | Implementation of Low Pass IIR filter for a given sequence. | 2 | 4 | 2, 4 |
| 12 | Implementation of band stop and band pass filters. | 2 | 4 | 2, 4 |
| 13 | Implementation of Decimation Procedure. | 2 | 5 | 2, 4 |
| 14 | Implementation of Interpolation Procedure. | 2 | 5 | 2, 4 |
| 15 | Implementation of sub-band coding and multi-resolution analysis | 2 | 5 | 2, 4 |
| **Total Contact Hours** | | **30** | | |

**Recommended Resources**


1. "Digital Signal Processing" by Tarun Kumar Rawat, Oxford Higher Education, 2017 edition.
2. "Discrete-time signal processing" by A. Oppenheim and R. W. Schafer, Pearson, 2014 edition.
3. "Principles of Signal Processing and Linear Systems" by B P Lathi, Oxford University Press, 2009 edition
4. "Digital Signal Processing" by J. G. Proakis and D. G. Manolakis, 2007 edition, Pearson India.


**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (50%)** | | | | | | | | **End Semester Exam (50%)** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **CLA-1 (10%)** | | **Mid-1 (15%)** | | **CLA-2 (10%)** | | **Mid-2 (15%)** | | | |
| | | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** |
| Level 1 | Remember | 40% | 40% | 60% | 70% | 40% | 40% | 60% | 70% | 30% | 40% |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 60% | 60% | 40% | 30% | 60% | 60% | 40% | 30% | 70% | 60% |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designer(s)**


*Dr. Inbarasan Muniraj. Asst. Professor. Dept. Of ECE. SRM University - AP*

**SRM University – AP, Andhra Pradesh**
Neeru Konda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

# Control Systems

| Course Code | **ECE 207** | Course Category | **Core Course (CC)** | L-T-P-C | **2** | **1** | **0** | **3** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | **Signals and Systems** | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To provide a basic understanding of the concepts and techniques involved in the design of control schemes for dynamic systems

**Objective 2:** To understand and modify a system based on time response analysis

**Objective 3:** To understand and modify a system based on frequency response analysis

**Objective 4:** To design compensators and controllers for the practical control systems

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Discuss control system classifications | 2 | 90% | 95% |
| **Outcome 2** | Represent a system in terms of equations and block diagrams | 3 | 80% | 80% |
| **Outcome 3** | Analyse the system behaviour with time and frequency variations | 4 | 70% | 80% |
| **Outcome 4** | Evaluate the stability and relative stability with different methods | 5 | 60% | 70% |
| **Outcome 5** | Design a stable control system with compensators and controllers | 5 | 50% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering | Problem Analysis | Design and Developm | Analysis, Design and | Modern Tool and | Society and | Environment and | Moral, and Ethical | Individual and | Communication Skills | Project Manageme | Self-Directed | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | | | | | 2 | | | | | | | 3 | | | 2 |
| Outcome 2 | | 3 | 2 | 2 | | | | | | | | 1 | | 2 | 3 |
| Outcome 3 | 2 | 3 | 2 | 3 | 2 | | | | | | | 2 | | 3 | 3 |
| Outcome 4 | 3 | 3 | 3 | 3 | 3 | | | | | | | 3 | | 3 | 3 |
| Outcome 5 | 3 | 3 | 3 | 3 | 3 | | | | 3 | | | 3 | | 3 | 3 |

| Course Average | 3 | 3 | 3 | 3 | 3 | | | | 3 | | | 3 | | 3 | 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

**Course Unitization Plan- Theory**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit I** | **Introduction to Control Systems** | **10** | | |
| 1. | Concept of feedback and automatic control | 1 | 1 | 1,2,3 |
| 2. | Effects of feedback, Objectives of control system. | 1 | 1 | 1,2,3 |
| 3. | Types of Control Systems, Definition of linear and nonlinear systems. | 1 | 1 | 1,2,3 |
| 4. | Mathematical modelling of Physical Systems –Mechanical Systems | 1 | 2 | 2 |
| 5. | Electrical Systems, Electromechanical systems, Analogous Systems. | 1 | 2 | 2 |
| 6. | Transfer function concept, Properties of Transfer function. | 2 | 2 | 1,2 |
| 7. | Block diagram representation of closed loop systems. | 1 | 2 | 1,2 |
| 8. | Block diagram algebra | 1 | 2 | 2 |
| 9. | Signal Flow graphs, Mason's gain formula. | 1 | 2 | 2 |
| **Unit II** | **Time Response of Feedback Control Systems** | **10** | | |
| 10. | Need of test signals, Standard test signals. | 1 | 3 | 1,2,3 |
| 11. | Step response of First Order Systems and its time domain specifications. | 1 | 3 | 1,2,3 |
| 12. | Step response of Second Order Systems and its time domain analysis- Concept of undamped natural frequency. | 2 | 3 | 1,2,3 |
| 13. | Damping, overshoot, rise time and settling time. | 1 | 3 | 1,2,3 |
| 14. | Dependence of time domain performance parameters on natural frequency and damping ratio. | 1 | 3 | 1,2,3 |
| 15. | Effects of Pole and Zeros on transient response, pole dominance. | 1 | 3,4 | 1,2,3 |
| 16. | approximation of higher order systems | 1 | 3 | 1,2,3 |
| 17. | Error Analysis-Steady state errors in control systems due to step, Ramp, and parabolic inputs. | 1 | 3 | 1,2,3 |
| 18. | Concepts of system types and error constants. | 1 | 3 | 1,2,3 |
| **Unit III** | **Stability Analysis** | **10** | | |
| 19. | Concepts of stability. | 1 | 4 | 1,2,3 |
| 20. | Necessary conditions for Stability. | 1 | 4 | 1,2,3 |
| 21. | Routh stability criterion. | 1 | 4 | 1,2,3 |
| 22. | Relative stability analysis. | 1 | 4 | 1,2,3 |
| 23. | Introduction to Root-Locus Techniques. The root locus concepts. | 2 | 4 | 1,2,3 |
| 24. | Construction of root loci. | 1 | 4 | 1,2,3 |
| 25. | Introduction to lead, lag and lead-lag compensating networks | 2 | 4,5 | 1,2,3 |
| 26. | Compensator design with Root locus. | 1 | 4,5 | 1,2,3 |
| **Unit IV** | **Frequency Domain Analysis and Stability** | **10** | | |
| 27. | Correlation between time and frequency response. | 1 | 1,3 | 1,2,3 |
| 28. | Introduction to polar and inverse polar plots, | 1 | 1,3 | 1,2,3 |
| 29. | Nyquist stability criterion. | 1 | 3,4 | |
| 30. | Assessment of relative stability: gain margin and phase margin. | 1 | 4 | 1,2,3 |
| 31. | Bode Plots, Determination of stability with Bode plots. | 2 | 4 | 1,2,3 |
| 32. | Examples of Bode Plot | 2 | 4 | 1,2,3 |
| 33. | Experimental determination of transfer function | 1 | 4 | |
| 34. | Compensator design with Bode plots. | 1 | 5 | 1,2,3 |

| | | | | |
|---|---|---|---|---|
| **Unit V** | **Controller Design** | **5** | | |
| 35. | Introduction to Controllers, Classification Controller. | 1 | 5 | 2,4 |
| 36. | Need and properties of controllers | 2 | 5 | 2,4 |
| 37. | Proportional Control Mode, Integral Control Mode, Derivative Control Mode, Proportional-integral (PI) controller, Proportional-derivative (PD) controller, Proportional-integral-derivative (PID) controller | 1 | 5 | 2,4 |
| 38. | Tuning rules of Ziegler-Nichols method. | 1 | 5 | 4 |
| **Total Contact Hours** | | **45** | | |

**Recommended Resources**


1. Norman S. Nise, Control Systems Engineering, 6th Edition, John Wiley & Sons Inc, 2010.
2. M Gopal, Control Systems: Principles and Design, McGraw Hill Education; 4th Edition, 2012.
3. K. Ogata, Modern Control Engineering, Prentice Hall India, 2006.
4. J. R. Leigh, Control Theory – A guided tour, IET Control Engineering Series 72, 3rd Edition, 2012


**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (60%) Theory (60%)** | | | | **End Semester Exam (40%)** |
|---|---|---|---|---|---|---|
| | | **Mid – 1 (15%)** | **CLA -1 (15%)** | **CLA-2 (15%)** | **CLA-3 (15%)** | **Theory (40%)** |
| Level 1 | Remember | 50% | 40% | 30% | 10% | 20% |
| | Understand | | | | | |
| Level 2 | Apply | 40% | 50% | 50% | 30% | 40% |
| | Analyse | | | | | |
| Level 3 | Evaluate | 10% | 10% | 20% | 60% | 40% |
| | Create | | | | | |
| **Total** | | 100% | 100% | 100% | 100% | 100% |

**Course Designers**


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**AI/ML For Electronics Engineers**

| Course Code | **ECE 208** | Course Category | **Core Course (CC)** | L-T-P-C | **3** | **0** | **1** | **4** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | **MAT 211, MAT 112** | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To familiarise the domains of supervised and unsupervised learning.

**Objective 2:** To understand and apply various binary classifiers.

**Objective 3:** To understand and apply clustering methods.

**Objective 4:** To understand and analyse Feedforward neural networks.

**Objective 5:** To have a basic understanding of CNNs and Reinforcement Learning.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Familiarise supervised and unsupervised learning | 1 | 85% | 80% |
| **Outcome 2** | Apply the concepts of binary classifiers for given scenarios | 3 | 80% | 75% |
| **Outcome 3** | Apply clustering methods for given problem statements | 3 | 85% | 70% |
| **Outcome 4** | Evaluate Feedforward neural networks | 2 | 80% | 70% |
| **Outcome 5** | Summarize CNNs and Reinforcement learning | 1 | 75% | 65% |

**Course Articulation Matrix: (CLO) to Program Learning Outcomes (PLO)**

| **CLO** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and | Modern Tool and ICT | Society and Multicultural | Environment and | Moral, and Ethical | Individual and | Communication Skills | Project Management | Self-Directed and Lifelong | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 1 | | | | 1 | | | | | | | 1 | | 1 | 1 |
| Outcome 2 | 2 | 3 | 2 | 2 | 2 | | | | 2 | 1 | | 1 | 1 | 2 | |
| Outcome 3 | 2 | 2 | 2 | 3 | 3 | | | | 2 | 1 | | 1 | 1 | 2 | 2 |
| Outcome 4 | 1 | 3 | 3 | 3 | 3 | | | | 2 | 1 | | 1 | 2 | | 3 |
| Outcome 5 | | | | | 3 | | | | 2 | 1 | | 2 | 2 | 2 | 2 |
| **Course Average** | **2** | **3** | **2** | **3** | **3** | | | | **2** | **1** | | **1** | **1** | **2** | **2** |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Introduction** | **15** | | |
| | Introduction to machine learning | 2 | 1 | 1, 2 |
| | Supervised learning | 1 | 1 | 1, 2 |
| | Unsupervised learning | 1 | 1 | 1, 2 |
| | Linear regression | 2 | 1 | 1, 2 |
| | Logistic regression | 1 | 1 | 1, 2 |
| | Generalized linear models | 2 | 1 | 1, 2 |
| | LE 1: Implement Linear Regression on the given dataset using python/MATLAB | 3 | 1 | 1, 2, 3 |
| | LE 2:Implement Logistic Regression on the given dataset using python/MATLAB | 3 | 1 | 1, 2, 3 |
| **Unit 2** | **Classifiers** | **30** | | |
| | Gaussian discriminant analysis (GDA) | 2 | 2 | 1, 2 |
| | Naive Bayes | 2 | 2 | 1, 2 |
| | Support Vector Machines | 2 | 2 | 1, 2 |
| | K-Nearest Neighbor | 3 | 2 | 1, 2 |
| | Decision Trees | 2 | 2 | 1, 2 |
| | Random forest | 2 | 2 | 1, 2 |
| | LE 3:Implement Naïve Bayes classifier using Python/MATLAB | 2 | 2 | 1, 2, 3 |
| | LE 4:Implement SVM algorithm using Python/MATLAB | 3 | 2 | 1, 2, 3 |
| | LE 5:Implement Decision tree classifier using python/MATLAB | 3 | 2 | 1, 2, 3 |
| | LE 6:Implement Random Forest classifier using python/MATLAB | 3 | 2 | 1, 2, 3 |
| | LE 7:Implement K-means algorithm for clustering the data using python/MATLAB | 3 | 3 | 1, 2, 3 |
| | LE 8:Implement K-Nearest Neighbour classifier using python/MATLAB | 3 | 2 | 1, 2, 3 |
| **Unit 3** | **Clustering** | **10** | | |
| | Clustering in machine learning | 2 | 3 | 1, 2 |
| | Different types of clustering algorithms | 2 | 3 | 1, 2 |
| | K-Means clustering | 2 | 3 | 1, 2 |
| | Gaussian mixture models | 2 | 3 | 1, 2 |
| | Bias-variance trade off | 2 | 3 | 1, 2 |
| **Unit 4** | **Feedforward neural networks** | **7** | | |
| | Introduction to Neural Networks | 1 | 4 | 1, 2 |
| | Feed-forward Network | 1 | 4 | 1, 2 |
| | Gradient descent optimization | 1 | 4 | 1, 2 |
| | Error Back propagation | 1 | 4 | 1, 2 |
| | Evaluation of error-function derivatives | 1 | 4 | 1, 2 |
| | Efficiency of back propagation | 1 | 4 | 1, 2 |
| | Under and over fitting | 1 | 4 | 1, 2 |
| **Unit 5** | **Deep Learning** | **13** | | |
| | Introduction to convolutional neural network (CNN) | 1 | 5 | 1, 2 |
| | Backpropagation in CNN | 1 | 5 | 1, 2 |
| | Sparse Kernel Machines | 1 | 5 | 1, 2 |

| | | | | |
|---|---|---|---|---|
| | Markov Chain Monte Carlo | 1 | 5 | 1, 2 |
| | Introduction to Reinforcement learning | 1 | 5 | 1, 2 |
| | LE 9:Emulate logic gates using neural network using python | 4 | 4 | 1, 2, 3 |
| | LE 10:Implement Convolution Neural Network for image/data analysis using Python/MATLAB | 4 | 5 | 1, 2, 3 |
| **Total Contact Hours** | | **75** | | |

**Recommended Resources**

1. Christopher M. Bishop, "Pattern Recognition and Machine Learning" by Springer, 2007.
2. Tom M. Mitchell, "Machine Learning", First Edition by Tata McGraw-Hill Education, 2013.
3. EthemAlpaydin, "Introduction to Machine Learning" 2nd Edition, The MIT Press, 2009

**Other Resources**

1. Google Colab
2. MATLAB
3. Scikit-Learn

**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (50%)** | | | | | | | | **End Semester Exam (50%)** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **CLA-1 (10%)** | | **Mid-1 (15%)** | | **CLA-2 (10%)** | | **CLA-3 (15%)** | | | |
| | | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** |
| Level 1 | Remember | 60% | 60% | 60% | 60% | 60% | 60% | 60% | 60% | 60% | 60% |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 40% | 40% | 40% | 40% | 40% | 40% | 40% | 40% | 40% | 40% |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designer(s)**

*Dr. Sudhakar Tummala. Asst. Professor. Dept. Of ECE. SRM University – AP*

# SEMESTER V

# SRM University – AP, Andhra Pradesh

Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

## ARM Programming

| Course Code | SEC XXX | Course Category | Professional Core (C) | L-T-P-C | 2 | 0 | 1 | 3 |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | Microprocessors and Microcontrollers | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | ECE | Professional / Licensing Standards | | | | | | |

**Course Objectives**

**Objective 1:** Understand the basics of Embedded software design.

**Objective 2:** Learn to develop C programs for interfacing the peripherals.

**Objective 3:** Understand the ARM interrupts and its programming.

**Objective 4:** Learn to apply low power programming techniques.

**Course Outcomes**

| | At the end of the course, the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **Outcome 1** | Understand and explain the basics of Embedded Software Design. | 2 | 80% | 70% |
| **Outcome 2** | Develop ARM mixed Assembly & C programming. | 4 | 80% | 70% |
| **Outcome 3** | Understand the interrupts and do programs using it. | 4 | 80% | 70% |
| **Outcome 4** | Develop programs for the internal peripherals like GPIO, Timers, UART and ADC. | 4 | 80% | 70% |
| **Outcome 5** | Understand and apply ARM low power programming | 4 | 80% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and | Modern Tool and ICT | Society and Multicultural | Environment and | Moral, and Ethical | Individual and | Communication Skills | Project Management | Self-Directed and Life | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 3 | 2 | 2 | 2 | 1 | | | | 1 | | 1 | 1 | 1 | 1 | 1 |
| Outcome 2 | 3 | 3 | 3 | 3 | 1 | | | | 1 | | 2 | 2 | 2 | 2 | 2 |
| Outcome 3 | 3 | 3 | 3 | 3 | 1 | | | | 1 | | 2 | 2 | 2 | 2 | 2 |
| Outcome 4 | 3 | 2 | 1 | 2 | 1 | | | | 1 | | 1 | 1 | 2 | 2 | 2 |
| Outcome 5 | 3 | 3 | 1 | 2 | 1 | | | | 1 | | 2 | 2 | 2 | 2 | 2 |
| **Course Average** | **3** | **2** | **1** | **2** | **1** | | | | **1** | | **1** | **2** | **2** | **2** | **2** |

**Course Unitization Plan - Theory**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| | **ARM Cortex M Programming** | | | |
| 1 | Introduction to Embedded System Design | 1 | 1 | 1,2 |
| 2 | Software Design Basics | 2 | 1 | 1,2,3 |
| 3 | ARM Cortex M Processor | 2 | 2 | 1,2,3 |
| 4 | ARM Cortex M Instruction set | 2 | 2 | 1,2,3 |
| 5 | ARM – C to Assembly, ARM Procedure Call Standard | 2 | 2 | 1,2,4 |
| 6 | Interrupts, Nested Vectored Interrupt Controller | 2 | 3 | 1,3,4 |
| 7 | General purpose Input Output (GPIO) Interfacing | 2 | 3,4 | 1,3,4,6 |
| 8 | Analog to Digital Converter | 2 | 3,4 | 1,2,6 |
| 9 | Digital to Analog Converter | 2 | 3,4 | 1,2,6 |
| 10 | Timers, PWM | 2 | 3,4 | 1,2,6 |
| 11 | Asynchronous Serial Communication | 2 | 3,4 | 1,2,6 |
| 12 | Synchronous Serial Communication | 2 | 3,4 | 1,2,6 |
| 13 | Direct Memory Access | 2 | 3,4 | 1,2,6 |
| 14 | Low Power Programming Techniques | 3 | 5 | 1,2,6 |
| 15 | Multi-channel Data acquisition System | 2 | 2,3,4 | 2,5,6 |
| | **Total Contact Hours** | **30** | | |

**Course Unitization Plan - Lab**

| Session | Description of Experiment | Contact hours required | CLOs Addressed | Reference Used |
|---|---|---|---|---|
| 1. | ARM Programming Environment - Introduction | 1 | 1 | 1 |
| 2. | ARM Cortex M - Clock Configuration | 1 | 4 | 1,2 |
| 3. | Mixed C and Assembly Programming | 2 | 2 | 1,2 |
| 4. | GPIO Interfacing | 1 | 3,4 | 1,2,6 |
| 5. | External Interrupt | 2 | 3,4 | 1,2,6 |
| 6 | Analog to Digital Converter with Interrupt | 2 | 3,4 | 1,2,6 |
| 7 | Timers | 2 | 3,4 | 1,2,6 |
| 8 | Serial Communication | 1 | 3,4 | 1,2,6 |
| 9 | Low Power Programming | 2 | 5 | 1,2,6 |
| 10 | Mini Capstone Project | 1 | - | 5,6 |
| **Total Contact Hours** | | **15** | | |

**Recommended Resources**


1. ARM Education, Efficient Embedded Systems Design Education Kit Repository: https://github.com/arm-university/Efficient-Embedded-Systems-Design-Education-Kit
2. Rob Toulson, Tim Wilmshurst, Fast and Effective Embedded Systems Design: Applying the ARM mbed, Newnes, 2016.
3. Ata Elahi, Trevor Arjeski, "ARM Assembly Language with Hardware Experiments", Springer, 2015.
4. A.N.Sloss *et al*., "*ARM System Developer's Guide*", Morgan Kaufmann Publishers, 2004
5. LPC176x Datasheet. https://www.nxp.com/docs/en/data-sheet/LPC1769_68_67_66_65_64_63.pdf

6. LPC176x User Manual. https://www.nxp.com/webapp/Download?colCode=UM10360

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|
| | | Theory (35%) | | | | Practical (15%) | | |
| | | CLA-1 (10%) | CLA-2 (5%) | CLA-3 (5%) | Mid-1(15 %) | | Th (35%) | Prac (15%) |
| Level 1 | Remember | 60% | 40% | 60% | 60% | 20% | 40% | 30% |
| | Understand | | | | | | | |
| Level 2 | Apply | 40% | 60% | 40% | 40% | 80% | 60% | 70% |
| | Analyse | | | | | | | |
| Level 3 | Evaluate | | | | | | | |
| | Create | | | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers**

*Dr Ramakrishnan M, Associate Professor, Department of Electronics and Communication Engineering, SRM University - AP*

**SRM University – AP, Andhra Pradesh**
Neeru Konda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

# Basic CMOS VLSI Design

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Code | **ECE 301** | Course Category | **Core Course (CC)** | L-T-P-C | **3** | **0** | **1** | **4** |
| Pre-Requisite Course(s) | **ENG 211** | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To understand IC Fabrication Process & teach the VLSI design flow.

**Objective 2:** To gain knowledge of CMOS technology-specific layout rules in the placement and routing of and interconnect and to inform the functionality, timing, power, and parasitic effects.

**Objective 3:** To understand CMOS Inverter based logic gates and its transfer characteristics analysis.

**Objective 4:** To learn VLSI chip design concept of constructing gate based Datapath to integrate it into larger complex system.

**Objective 5:** To learn design and testing of VLSI circuits using CAD tools.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Implement MOS IC fabrication process and VLSI design ow to FPGA | 2 | 80% | 70% |
| **Outcome 2** | Apply CMOS technology-specific layout rules in placement & routing of transistors, interconnect and to verify the functionality, timing, power, & parasitic effects. | 3 | 70% | 60% |
| **Outcome 3** | Analyse the transfer characteristics of logic gates based on CMOS inverter | 4 | 80% | 70% |
| **Outcome 4** | Design integrated circuits based on PLDs and CMOS testing techniques | 4 | 70% | 60% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering | Problem Analysis | Design and Development | Analysis, Design and | Modern Tool and | Society and Multicultur | Environment and | Moral, and Ethical | Individual and | Communication Skills | Project Manageme | Self-Directed | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 3 | 2 | 1 | 2 | | | | | 2 | | 1 | | | 1 | 2 |
| Outcome 2 | 3 | 3 | 2 | 2 | 1 | | | | 3 | | | | 1 | 3 | 2 |
| Outcome 3 | 3 | 3 | 3 | 3 | 1 | | | | 2 | | | | 1 | 3 | 3 |
| Outcome 4 | 3 | 3 | 3 | 3 | | | | | 3 | | 3 | | 1 | 3 | 3 |

| Course Average | 3 | 3 | 3 | 3 | 1 | | | | 3 | | 1 | | 1 | 3 | 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Introduction to IC Technology** | **9** | | |
| | Basic Electrical Properties of MOS Circuits | 1 | 1 | 1, 2 |
| | Basic Electrical Properties of CMOS Circuits | 1 | 1 | 1, 2 |
| | $I_{ds}$-$V_{ds}$ relationships | 1 | 1 | 1, 2 |
| | MOS transistor threshold Voltage | 1 | 1 | 1, 2 |
| | gm, gds, & Figure of merit $\omega$o | 1 | 1 | 1, 2 |
| | Pass transistor | 1 | 1 | 1, 2 |
| | NMOS Inverter | 1 | 1 | 1, 2 |
| | Various pull ups, CMOS Inverter analysis and design | 1 | 1 | 1, 2 |
| | Bi-CMOS Inverters | 1 | 1 | 1, 2 |
| **Unit 2** | **VLSI Circuit Design Processes** | **9** | | |
| | VLSI Design Flow | 1 | 2 | 2 |
| | MOS Layers | 1 | 2 | 2 |
| | Stick Diagrams | 1 | 2 | 2, 3 |
| | Design Rules and Layout | 1 | 2 | 2, 3 |
| | 2 $\mu$m CMOS Design rules for wires, Contacts | 1 | 2 | 1, 2, 3 |
| | Transistors Layout Diagrams for NMOS | 1 | 2 | 1, 2, 3 |
| | Transistors Layout Diagrams CMOS Inverters | 1 | 2 | 3 |
| | Transistors Layout Diagrams Gates | 1 | 2 | 3 |
| | Scaling of MOS circuits | 1 | 2 | 2,3 |
| **Unit 3** | **Gate Level Design** | **9** | | |
| | Logic Gates | 1 | 3 | 1, 2 |
| | Other complex gates | 1 | 3 | 1, 2 |
| | Switch logic | 1 | 3 | 1, 2 |
| | Alternate gate circuits | 1 | 3 | 1, 2 |
| | Time delays | 1 | 3 | 1, 2 |
| | Driving large capacitive loads | 1 | 3 | 1, 2 |
| | Wiring capacitance | 1 | 3 | 1, 2 |
| | Fan in, Fan out | 1 | 3 | 1, 2 |
| | Choice of layers | 1 | 3 | 1, 2 |
| **Unit 4** | **Datapath Subsystems** | **9** | | |
| | Subsystem Design | 1 | 4 | 2, 3 |
| | Shifters, Adders | 1 | 4 | 2, 3 |
| | ALUs, Multipliers | 1 | 4 | 2, 3 |
| | Parity generators | 1 | 4 | 2, 3 |
| | Comparators | 1 | 4 | 2, 3 |
| | Zero/One Detectors | 1 | 4 | 2, 3 |
| | Counters | 1 | 4 | 2, 3 |
| | Array Subsystems: SRAM, DRAM | 1 | 4 | 2, 3 |
| | ROM, Serial Access Memories | 1 | 4 | 2, 3 |
| **Unit 5** | **Programmable Logic Device** | **9** | | |
| | PLAs, FPGAs | 1 | 4 | 2 |
| | CPLDs, Standard Cells | 1 | 4 | 2 |
| | Programmable Array Logic | 1 | 4 | 2 |
| | Design Approach | 1 | 4 | 2 |
| | Parameters in sequencing low power design | 1 | 4 | 2 |
| | CMOS Testing | 1 | 4 | 2 |

| | | | | |
|---|---|---|---|---|
| | Need for testing, Test Principles | 1 | 4 | 2 |
| | Design Strategies for test | 1 | 4 | 2 |
| | Chip level Test Techniques | 1 | 4 | 1, 2, 3 |
| **Total Contact Hours** | | **45** | | |

**Course Unitization Plan - Lab**

| Exp No. | Experiment Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| 1. | HDL code to realize all the logic gates | 3 | 3 | 1, 4 |
| 2. | Design of 2-to-4 decoder & Design of 8-to-3 encoder (without and with priority) | 3 | 3 | 1, 4 |
| 3. | Design of 8-to-1 multiplexer and 1-to-8 demultiplexer | 3 | 4 | 1, 4 |
| 4. | Design of 4 bit binary to gray code converter | 2 | 4 | 1, 4 |
| 5. | Design of 4-bit comparator | 3 | 4 | 1, 4 |
| 6. | Design of Full adder using 3 modelling styles | 3 | 4 | 3, 4 |
| 7. | Design of flip fops: SR, D, JK, T | 3 | 4 | 3, 4 |
| 8. | Design of 4-bit binary, BCD counters (synchronous/ asynchronous reset) or any sequence counter | 3 | 4 | 3, 4 |
| 9. | Finite State Machine Design | 3 | 4 | 1, 3, 4 |
| 10. | CMOS inverter design | 4 | 1 | 1, 2, 5 |
| **Total Contact Hours** | | **30** | | |

**Recommended Resources**


1. Sung-Mo (Steve) Kang, Yusuf Leblebici, CMOS Digital Integrated Circuits, 3rdEdition, MHE, 2002, ISBN-10: 0070530777.
2. F Neil H. E Weste, David Harris, Ayan Banerjee, CMOS VLSI Design a Circuits and Systems Perspective, 4th Edition, Addison-Wesley, 2010, ISBN 10: 0-321-54774-8.
3. Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikoli, "Digital Integrated Circuits: A Design Perspective", 2 nd Edition, Pearson, 2003, ISBN-10: 0130909963.
4. Michael D. Ciletti, Advanced Digital Design with the Verilog HDL, 2e, Pearson, 2010.
5. John P. Uyemura, CMOS Logic Circuit Design, Wiley, 2005.


**Other Resources**


1. Kamran Eshraghian, Dougles A. Pucknell & Sholeh Eshraghian "Essentials of VLSI circuits and systems", 1st Edition, PHI,2005, ISBN-10-9788120327726.


**Learning Assessment (Integrated course)**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (10%) | | Mid-1 (15%) | | CLA-2 (10%) | | Mid-2 (15%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 80% | 30% | 50% | 30% | 20% | 30% | 20% | 30% | 20% | 30% |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 20% | 70% | 50% | 70% | 80% | 70% | 80% | 70% | 80% | 70% |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers**


a. *Dr. Pradyut Kumar Sanki, Assistant Professor, Department of Electronics & Communication Engineering, SRM University - AP.*
b. *Prof. Goutam Saha, Professor, Department of E & ECE, IIT Kharagpur, India.*

**SRM University – AP, Andhra Pradesh**
Neeru Konda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

# Wireless Communications

| Course Code | **ECE 302** | Course Category | **Core Course (CC)** | L-T-P-C | **3** | **0** | **1** | **4** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | **MAT 221, ECE 311, ECE 323** | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To understand the fundamentals of wireless communications and modelling the wireless channel.

**Objective 2:** To understand the concepts of diversity, beamforming, and interferences.

**Objective 3:** To have a basic understanding in TDMA, FDMA, CDMA and AWGN channel capacity.

**Objective 4:** To study MIMO & OFDMA and its use in the advanced wireless communication systems.

**Objective 5:** To have a basic understanding of challenging research topics in wireless networks.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Describe the existing and future wireless communications systems. | 2 | 85% | 80% |
| **Outcome 2** | Analyse the path loss models like free space propagation, ray tracing, log normal and log shadowing. | 4 | 80% | 75% |
| **Outcome 3** | Design a wireless channel. | 4 | 85% | 70% |
| **Outcome 4** | Implement the multiple access technologies like FDMA, TDMA, CDMA and OFDMA in modern communication systems. | 3 | 80% | 70% |
| **Outcome 5** | Illustrate the 5G communications systems and the technologies involved. | 2 | 75% | 65% |

**Course Articulation Matrix: (CLO) to Program Learning Outcomes (PLO)**

| **CLO** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and | Modern Tool and | Society and Multicultur | Environment and | Moral, and Ethical | Individual and | Communication Skills | Project Management | Self-Directed | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | 1 | 1 | 1 | 1 |
| Outcome 2 | 2 | 3 | 2 | 3 | 2 | | | | 2 | 1 | | 1 | 1 | 2 | 3 |
| Outcome 3 | 2 | 2 | 2 | 3 | 3 | | | | | | | | 1 | 2 | 2 |
| Outcome 4 | 2 | 3 | 3 | 3 | 3 | | | | 2 | 1 | | 1 | 2 | 3 | 3 |
| Outcome 5 | 3 | 3 | 2 | 3 | 3 | | | | 2 | 1 | | 2 | 2 | 2 | 2 |
| **Course Average** | **2** | **2** | **2** | **3** | **2** | | | | **2** | **1** | | **1** | **1** | **2** | **2** |

**Course Unitization Plan- Theory**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Introduction to Wireless Communications** | **9** | | |
| | Physical Modeling for Wireless Channels | 2 | 1 | 1, 2 |
| | Input/output model of wireless channel | 2 | 1 | 1, 2 |
| | Time and Frequency Coherence | 1 | 1 | 1, 2 |
| | Statistical Channel models | 1 | 1 | 1, 2 |
| | Time diversity | 1 | 1 | 1, 2 |
| | Antenna diversity | 1 | 1 | 1, 2 |
| | Frequency diversity | 1 | 1 | 1, 2 |
| **Unit 2** | **Wireless Channel Modeling** | **9** | | |
| | Uplink/Downlink Fading channels | 2 | 2 | 1, 2 |
| | Doppler Fading, Jakes modeling | 2 | 2 | 1, 2 |
| | RMS delay spread, Autocorrelation | 1 | 2 | 1, 2 |
| | SNR and BER Performance | 2 | 2 | 1, 2 |
| | Noise and Interference | 2 | 2 | 1, 2 |
| **Unit 3** | **CDMA** | **9** | | |
| | Narrowband Cellular Systems | 2 | 3 | 1, 2 |
| | Wideband systems: CDMA | 1 | 3 | 1, 2 |
| | Wideband systems: OFDM | 2 | 3 | 1, 2 |
| | AWGN channel capacity | 2 | 3 | 1, 2 |
| | Capacity of fading channels | 2 | 3 | 1, 2 |
| **Unit 4** | **MIMO, OFDM Systems** | **9** | | |
| | Introduction to MIMO, MIMO channel capacity | 2 | 4 | 1, 2 |
| | SVD and Eigen modes of MIMO Channel | 1 | 4 | 1, 2 |
| | MIMO spatial multiplexing | 2 | 4 | 1, 2 |
| | MIMO diversity, Beamforming | 2 | 4 | 1, 2 |
| | OFDM, multicarrier modulation, PAPR | 2 | 4 | 1, 2 |
| **Unit 5** | **Wireless Networks and Advanced Topics** | **9** | | |
| | Spread spectrum, direct sequence spread spectrum | 2 | 5 | 3, 4 |
| | Wide Area Network, GSM | 2 | 5 | 1, 3 |
| | Long term Evolution- Advanced | 2 | 5 | 1,4 |
| | Wi-Fi | 1 | 5 | 2,4 |
| | WiMAX & mm wave communications | 2 | 5 | 2,3 |
| **Total Contact Hours for Theory** | | **45** | | |

**Course Unitization Plan – Lab**

| Exp. No. | Experiment Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| 1 | Rayleigh and Rician Channel fading model | 3 | 1,2 | 1,2 |
| 2 | Jakes Channel model | 3 | 1,2 | 1,2 |
| 3 | Path loss model – Free space, and Ray tracing | 3 | 1,3 | 1,2 |
| 4 | Log distance and log normal shadowing model | 3 | 1,3 | 1,2 |
| 5 | Filtered White Gaussian Noise | 3 | 1,3 | 1,2,3 |
| 6 | MIMO Channel Capacity | 3 | 3,4 | 1,2,4 |
| 7 | MIMO Beamforming | 3 | 3,4 | 1,3,4 |
| 8 | OFDM Channel Capacity | 3 | 3,4 | 1,2,4 |

| | | | | |
|---|---|---|---|---|
| 9 | IEEE 802.11 Wireless LAN | 3 | 4,5 | 2,3,4 |
| 10 | IEEE 802.16 Wi-Max | 3 | 4,5 | 1,2,3 |
| **Total Contact Hours for Lab** | | **30** | | |

**Recommended Resources**


1. Tse, David, and Pramod Viswanath. *Fundamentals of Wireless Communication*. Cambridge, UK: Cambridge University Press, 2005.
2. Rappaport Theodore S., Wireless Communications, Principles and Practice, 2/e, Prentice Hall of India, 2003.
3. Goldsmith, Andrea. Wireless communications. Cambridge university press, 2005.
4. Haykin, S., Moher M., Modern Wireless Communications,1/e, Pearson Education, 2011.


**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (10%) | | Mid-1 (15%) | | CLA-2 (10%) | | Mid-2 (15%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 40% | 20% | 60% | 30% | 40% | 30% | 60% | 30% | 30% | 30% |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 60% | 80% | 40% | 70% | 60% | 70% | 40% | 70% | 70% | 70% |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designer(s)**

*Dr. Sunil Chinnadurai. Asst. Professor. Dept. Of ECE. SRM University – AP*

**SRM University – AP, Andhra Pradesh**
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Guntur District, Mangalagiri, Andhra Pradesh 522240

# Microprocessors and Microcontrollers

| Course Code | **ECE 303** | Course Category | **Core Course (CC)** | L-T-P-C | **3** | **0** | **1** | **4** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | **ECE 211** | Co-Requisite Course(s) | | Progressive Course(s) | **ECE 411** | | | |
| Course Offering Department | **ECE / EEE** | Professional / Licensing Standards | - | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** Analyse the internal organization, addressing modes and instruction sets of 8085 and 8086 processors.

**Objective 2:** Study the various functional units of 8051 microcontroller

**Objective 3:** Analyse the various peripheral devices such as 8255, 8279, 8251, 8253, 8259 and 8237.

**Objective 4:** Understand microcontroller-based system design for various applications.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Develop an ALP in 8085 and 8086 microprocessors using the internal organization for the given specification. | 3 | 80% | 70% |
| **Outcome 2** | Describe the architecture and functional block of 8051 microcontroller. | 3 | 80% | 70% |
| **Outcome 3** | Explain peripherals devices such as 8255, 8279, 8251, 8253, 8259 and 8237 among others. | 3 | 80% | 70% |
| **Outcome 4** | Demonstrate microcontroller application and architecture of PIC, ARM and ATMEGA processors on MP Lab. | 4 | 80% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem | Design and Development | Analysis, Design and | Modern Tool and ICT | Society and Multicultural | Environment and | Moral, and Ethical | Individual and | Communication Skills | Project Management | Self-Directed and Lifelong | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | | 2 | | 2 | 2 | 1 | | | 2 | | | 2 | | 1 | |
| Outcome 2 | 2 | | 1 | 2 | 2 | | | 1 | | | 1 | 2 | | 1 | 1 |
| Outcome 3 | 2 | 2 | 1 | 2 | | 1 | | 1 | 2 | | 1 | 2 | 1 | | 1 |
| Outcome 4 | 3 | 3 | 3 | 3 | 3 | 1 | | 1 | 1 | | 3 | 1 | 1 | 1 | 1 |
| **Course Average** | **2** | **2** | **2** | **2** | **2** | **1** | | **1** | **2** | | **2** | **2** | **1** | **1** | **1** |

**Course Unitization Plan - Theory**

| Unit No | Unit Name | Required Contact hours | CLOs Addressed | Reference Used |
|---|---|---|---|---|
| | **UNIT I: 8086 MICROPROCESSORS** | **9** | | |
| 1. | 8086 architecture- Functional Diagram. | 1 | 1 | 1, 2 |
| 2. | Register Organization, Memory segmentation, Memory addresses. | 2 | 1 | 1, 2 |
| 3. | physical memory organization, Signal descriptions of 8086-common function signals. | 2 | 1 | 1, 2 |
| 4. | Minimum and Maximum mode signals, Read Write cycles. | 2 | 1 | 1, 2 |
| 5. | Timing diagrams, Interrupt structure of 8086. | 2 | 1 | 1, 2 |
| | **UNIT II– ASSEMBLY LANGUAGE PROGRAMMING OF 8086** | **9** | | |
| 6. | Instruction formats, addressing modes, instruction set, assembler directives. | 2 | 1 | 1, 2 |
| 7. | Simple programs involving logical. | 2 | 1 | 1, 2 |
| 8. | Branch and call instructions. | 2 | 1 | 1, 2 |
| 9. | Sorting, evaluating arithmetic expressions | 2 | 1 | 1, 2 |
| 10. | String manipulations. | 1 | 1 | 1, 2 |
| | **UNIT III - PERIPHERAL INTERFACING WITH 8086 MICROPROCESSORS** | **9** | | |
| 11. | 8255 PPI, Keyboard, display controllers, Stepper motor. | 2 | 3 | 1, 2 |
| 12. | A/D & D/A Converter Interfacing with 8086 microprocessors. | 1 | 3 | 1, 2 |
| 13. | Static and Dynamic memories, Vector interrupt table. | 1 | 3 | 1, 2 |
| 14. | Interrupt service routine, Introduction to DOS & BIOS interrupts. | 1 | 3 | 1, 2 |
| 15. | Programmable Interrupt Controller 8259. | 2 | 3 | 1, 2 |
| 16. | DMA controller 8257 Interfacing with 8086 microprocessors. | 2 | 3 | 1, 2 |
| | **UNIT IV: COMMUNICATION INTERFACE** | **9** | | |
| 17. | Serial communication standards. | 2 | 3 | 1, 2 |
| 18. | serial data transfer schemes. | 2 | 3 | 1, 2 |
| 19. | 8251 USART architecture and Interfacing. | 2 | 3 | 1, 2 |
| 20. | RS232. | 1 | 3 | 1, 2 |
| 21. | prototyping and trouble shooting. | 2 | 3 | 1, 2 |
| | **UNIT V: INTRODUCTION TO MICROCONTROLLERS** | **9** | | |
| 22. | Overview of 8051 microcontroller. | 2 | 2, 4 | 1, 2, 3 |
| 23. | Architecture. | 2 | 2, 4 | 1, 2, 3 |
| 24. | I/O ports and Memory organization. | 2 | 2, 4 | 1, 2, 3 |
| 25. | Addressing modes and instruction set of 8051, Simple programs. | 3 | 2, 4 | 1, 2, 3 |
| **Total Contact Hours** | | **45** | | |

**Course Unitization Plan - Lab**

| Session | Description of Experiment | Contact hours required | CLOs Addressed | Reference Used |
|---|---|---|---|---|
| 1. | 16-bit addition, subtraction and multiplication | 2 | 1 | 1, 2 |
| 2. | 32- Bit Division. | 2 | 1 | 1, 2 |
| 3. | Program for addition of two numbers and display it on LCD. | 2 | 1 | 1, 2 |
| 4. | Moving data form 500 memory locations to 600 memory locations. Searching a number in given array. | 2 | 1 | 1, 2 |
| 5. | Program for comparing two strings | 2 | 1 | 1, 2 |

| | | | | |
|---|---|---|---|---|
| 6 | To ADD two Binary numbers each 8 Bytes long | 2 | 1 | 1, 2 |
| 7 | To find the maximum no. in a given string (16 Bytes long) and store it in location 0510. | 2 | 1 | 1, 2 |
| 8 | To sort a string of a no. of bytes in descending order. | 2 | 1 | 1, 2 |
| 9 | To multiply an ASCII string of eight numbers by a single ASCII digit. | 2 | 1,2 | 1, 2 |
| 10 | To Divide a String of Unpacked ASCII Digits | 2 | 1,2 | 1, 2 |
| 11 | BCD Addition of two bytes. | 2 | 1,2 | 1, 2 |
| 12 | BCD Subtraction of two bytes. | 2 | 1,2 | 1, 2 |
| 13 | Find whether a no is even or odd. | 2 | 1,2 | 1, 2 |
| 14 | Find whether a no is positive or negative. | 2 | 1,2 | 1, 2 |
| 15 | Logical Operations (AND, OR, NOT, XOR) | 2 | 1,2 | 1, 2 |
| **Total Contact Hours** | | **30** | | |

**Recommended Resources**


1. Ramesh S Gaonkar, "Microprocessor Architecture, Programming and Applications with the 8085", 6th edition, Penram.
2. D V Hall, "Microprocessors and Interfacing", MGH, 2nd edition.
3. The 8051 Microcontroller, Kenneth. J. Ayala, Cengage Learning, 3rd Edition.


**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (10%) | | Mid-1 (15%) | | CLA-2 (10%) | | Mid-2 (15%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 50% | 30% | 50% | 60% | 60% | 30% | 60% | | 60% | 30% |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 50% | 70% | 50% | 40% | 40% | 70% | 40% | | 40% | 70% |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | | **100%** | **100%** |

**Course Designers**


*a. Dr Sreenivasulu Tupakula, Assistant Professor, Department of ECE, SRM University-AP*
*b. Prof T Srinivas, Professor, Department of ECE, IISc*
*c. Prof Goutam Saha, Professor, Department of ECE, IIT, Kharagpur*

**SRM University – AP, Andhra Pradesh**
Neeru Konda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

# Electromagnetic and Wave Propagation

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Code | **ECE 304** | Course Category | **Core Course (CC)** | L-T-P-C | **3** | **0** | **0** | **3** |
| Pre-Requisite Course(s) | **MAT 112 MAT 121** | Co-Requisite Course(s) | **MAT 131** | Progressive Course(s) | **ECE 314** | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | - | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To impart concepts related to static electric and magnetic fields in material space along with boundary conditions.

**Objective 2:** To impart concepts of Faraday's law, induced emf and Maxwell's equations

**Objective 3:** To impart the concepts of EM wave propagation and Poynting's theorem

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Apply the concepts of static electric and derive boundary conditions over material space | 3 | 80% | 70% |
| **Outcome 2** | Apply the concepts of static magnetic fields to solve problems and derive boundary conditions over material space | 3 | 80% | 70% |
| **Outcome 3** | Apply Maxwell's equations for given scenarios | 3 | 80% | 70% |
| **Outcome 4** | Analyse EM wave propagation through material space and solve given power constraint problems | 3 | 80% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Lifelong Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 2 | 2 | 1 | 2 | 2 | | | | | | 1 | 2 | 2 | | |
| Outcome 2 | 2 | | | 2 | 2 | | | | | | 1 | | | | 3 |
| Outcome 3 | | 2 | 1 | | | 1 | | 1 | 2 | | 1 | 2 | 2 | | 2 |
| Outcome 4 | 3 | 3 | 3 | 3 | 3 | 1 | | 1 | 1 | | 3 | 1 | 1 | | 1 |
| **Course Average** | **2** | **2** | **2** | **2** | **2** | **1** | | **1** | **2** | | **2** | **2** | **2** | | **2** |

**Course Unitization Plan - Theory**

| Unit No | Unit Name | Required Contact hours | CLOs Addressed | Reference Used |
|---|---|---|---|---|
| | **UNIT I: Electrostatics and Magnetostatics** | **9** | | |
| 1. | Review of Electro statics and Magneto statics: Basic laws. | 2 | 1 | 1,2 |
| 2. | Maxwell's equations for static fields. | 2 | 1 | 1,2 |
| 3. | Electric fields in material space: Properties of materials. | 2 | 1 | 1,2 |
| 4. | Continuity equation. | 2 | 1 | 1,2 |
| 5. | Electric and Magnetic boundary conditions. | 1 | 1 | 1,2 |
| | **UNIT II– Time varying Electromagnetic fields** | **10** | | |
| 6. | Faradays law. | 1 | 1,2 | 1,2 |
| 7. | Displacement current. | 1 | 1,2 | 1,2 |
| 8. | Maxwell's equations (final form) | 1 | 1,2 | 1,2 |
| 9. | Time varying fields – Maxwell's equations. | 1 | 1,2 | 1,2 |
| 10. | Time harmonic fields – Maxwell's equations. | 1 | 1,2 | 1,2 |
| 11. | Waves in general- various parameters of wave. | 1 | 1,2 | 1,2 |
| 12. | EM wave propagation in lossy dielectric media. | 1 | 1,2 | 1,2 |
| 13. | Planewave in lossless dielectric media. | 1 | 1,2 | 1,2 |
| 14. | Plane waves in free space | 1 | 1,2 | 1,2 |
| 15. | Plane waves in good conductors. | 1 | 1,2 | 1,2 |
| | **UNIT III: Power Consideration of EM Wave** | **8** | | |
| 16. | Power of EM wave. | 1 | 1,2,3, 4 | 1,2 |
| 17. | Poynting's vector. | 1 | 1,2,3, 4 | 1,2 |
| 18. | Poynting's theorem. | 1 | 1,2,3, 4 | 1,2 |
| 19. | EM wave at boundary between two different media: Reflection of plane wave at normal incidence. | 1 | 1,2,3, 4 | 1,2 |
| 20. | Reflection of plane wave at oblique incidence: Parallel polarization. | 2 | 1,2,3, 4 | 1,2 |
| 21. | Perpendicular polarization. Illustrative Problems. | 2 | 1,2,3, 4 | 1,2 |
| | **UNIT IV: Transmission Lines Theory and Parameters** | **9** | | |
| 22. | Transmission Lines Types, Parameters, Transmission Line Equations. | 2 | 1,2,3, 4 | 1 |
| 23. | Primary & Secondary Constants, Expressions for Characteristics Impedance. | 2 | 1,2,3, 4 | 1 |
| 24. | Propagation Constant, Phase and Group Velocities, Infinite Line Concepts. | 2 | 1,2,3, 4 | 1 |
| 25. | Losslessness/Low Loss Characterization. | 1 | 1,2,3, 4 | 1 |
| 26. | Distortion - Condition for Distortionlessness and Minimum Attenuation | 1 | 1,2,3, 4 | 1 |
| 27. | Loading - Types of Loading, Illustrative Problems. | 1 | 1,2,3, 4 | 1 |
| | **UNIT - V: Impedance Matching in High Frequency Transmission-lines** | **9** | | |
| 28. | Transmission Lines - II: Input Impedance Relations. | 2 | 1,2,3 | 1 |
| 29. | SC and OC Lines, Reflection Coefficient. | 2 | 1,2,3 | 1 |
| 30. | VSWR. UHF Lines as Circuits Elements; λ/4, λ /2, λ /8 Lines - Impedance Transformations. | 2 | 1,2,3 | 1 |
| 31. | Significance of $Z_{min}$ and $Z_{max}$, Smith Chart. | 1 | 1,2,3 | 1 |
| 32. | Configuration and Applications, Single and Double Stub Matching. | 1 | 1,2,3 | 1 |
| 33. | Illustrative Problems. | 1 | 1,2,3 | 1 |
| **Total Contact Hours** | | **45** | | |

**Recommended Resources**

1. Mathew N.O. Sadiku, "Elements of Electromagnetics", 3rd edition, Oxford University press.
2. William Hayt , Buck, "Engineering Electromagnetics", 8th edition, TMH.

**Other Resources**

- K D Prasad, "Antenna and Wave propagation", Satya Prakashan, New Delhi
- E C Jordan and Balmain, "Electromagnetic waves and Radiating systems", Pearson Education

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (10%) | | Mid-1 (15%) | | CLA-2 (10%) | | Mid-2 (15%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 50% | | 50% | | 60% | | 60% | | 40% | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 50% | | 50% | | 40% | | 40% | | 60% | |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designers**

*a. Dr Sreenivasulu Tupakula, Assistant Professor, Department of ECE, SRM University AP*
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**SRM University – AP, Andhra Pradesh**
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# Internet of Things

| Course Code | **ECE 305** | Course Category | **Core Course (CC)** | L-T-P-C | **2** | **0** | **1** | **3** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To acquire knowledge on sensors, actuators used in IoT and its interfacing.

**Objective 2:** To IoT Architecture and the communication protocols

**Objective 3:** To design secured IoT projects using cloud platforms

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Discuss sensors, actuators used in IoT and its interfacing. | 2 | 80% | 75% |
| **Outcome 2** | Summarize IoT Architecture and the communication protocols used in it | 2 | 80% | 70% |
| **Outcome 3** | Demonstrate IoT cloud platform | 3 | 75% | 65% |
| **Outcome 4** | Demosntrate IoT security mechanisms | 3 | 75% | 65% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Life Long Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | | 2 | | | 1 | | | | | | | | | 1 | |
| Outcome 2 | 2 | | | | 1 | | | | | | | 1 | | 2 | |
| Outcome 3 | 2 | 2 | 3 | 2 | 3 | | | | | | | 2 | 3 | 2 | |
| Outcome 4 | 2 | 3 | 3 | 3 | 3 | | | | | | | 2 | 3 | 2 | |
| **Course Average** | **2** | **2** | **2** | **2** | **2** | | | | | | | **2** | **3** | **2** | |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Sensors, actuators & its interfacing** | **13** | | |
| | Temperature, Humidity Sensor | 1 | 1 | 1 |
| | Accelerometer, Barometer | 1 | 1 | 1 |
| | Gyro Sensor | 1 | 1 | 1 |
| | Sensor – Analog and Digital Interfacing | 1 | 1 | 1 |
| | DC Motor (Brushed, Brushless), Stepper motor, Servo Drive | 2 | 1 | 1 |
| | Solenoids, Valves and Pumps | 1 | 1 | 1 |
| | LE 1: Analog/Digital sensor interfacing | 3 | 1 | 1 |
| | LE 2: Actuators interfacing – Motor/Relay interface | 3 | 1 | 1 |
| **Unit 2** | **IoT Architecture and Protocols** | **12** | | |
| | IoT Architecture | 1 | 2 | 2,3 |
| | Zigbee, Zwave, Dash7 | 1 | 2 | 2,3 |
| | Bluetooth Low Energy | 1 | 2 | 2,3 |
| | IEEE 802.11, TCP, UDP, CoAP | 2 | 2 | 2,3 |
| | 6LowPAN, RPL | 1 | 2 | 2,3 |
| | LE 3: Wi-Fi Embedded Web Server | 3 | 2 | 1 |
| | LE 4: Wi-Fi TCP Server/Client | 3 | 2 | 1 |
| **Unit 3** | **IoT Thing/Gateway- Cloud connectivity** | **11** | | |
| | MQTT | 1 | 2 | 2,3 |
| | Hyper Text Transfer Protocol (HTTP) | 1 | 2 | 2,3 |
| | REST | 1 | 2 | 2,3 |
| | Network Layer-IPv4, IPv6 | 1 | 2 | 2,3 |
| | AMCP, web sockets | 1 | 2 | 2,3 |
| | LE 5: Wi-Fi – UDP Communication | 3 | 2 | 2 |
| | LE 6: HTTP Server with REST API | 3 | 2 | 3 |
| **Unit 4** | **Cloud Platform (AWS)** | **11** | | |
| | Various Cloud platforms | 1 | 3 | 2 |
| | MQTT communication /Data Retrieval | 1 | 3 | 2 |

| | | | | |
|---|---|---|---|---|
| | Database storage | 1 | 3 | 2 |
| | SMS/Email Alert services | 1 | 3 | 2 |
| | Data Analytics using algorithm/Serverless computing | 1 | 3 | 2 |
| | LE7:MQTT Publish Subscribe Client with AWS/Mosquitto Broker - Python | 3 | 2,4 | 5 |
| | LE 8: CoAP Server/Client - Arduino - Browser Add on) | 3 | 2 | 4 |
| **Unit 5** | **IoT Security** | **13** | | |
| | Private, Public key Encryption | 1 | 4 | 3 |
| | Advanced Encryption Standard (AES) | 1 | 4 | 3 |
| | Hash Algorithms, Digital signature | 1 | 4 | 3 |
| | TLS/DTLS | 1 | 4 | 3 |
| | LE 9: Bluetooth Low Energy - Notify example with nRF Connect app - (Arduino ESP32) | 3 | 3 | 6 |
| | LE 10: IOT Cloud platform Connectivity -MQTT | 3 | 2,3,4 | 1 |
| | LE 11: IoT Cloud Platform – SMS/Email alerts, DB Storage and serverless computing. | 3 | 3,4 | 1 |

**Recommended Resources**


1. D. Patranabis, “Sensors and Transducers”, PHI Learning Private Limited.
2. Agus Kurniawan, “Learning AWS IoT Effectively Manage Connected Devices on the AWS Cloud Using Services Such as AWS Greengrass, AWS Button, Predictive Analytics and Machine Learning”, Packt Publisher, 2018
3. Ammar Rayes and Samer Salam, "Internet of Things from Hype to Reality - The Road to Digitization", Springer, Second Edition.


**Other Resources**


1. Agus Kurniawan, “Internet of Things Projects with ESP32”, Packt Press, 2019
2. Neil Cameron, “Electronics Projects with the ESP8266 and ESP32”, APress, 2020
3. https://www.w3schools.com/php/php_mysql_intro.asp
4. https://flask-restful.readthedocs.io/en/latest/
5. https://www.arduino.cc/reference/en/libraries/coap-simple-library/
6. http://www.steves-internet-guide.com/into-mqtt-python-client/
7. Kevin Townsend, Carles Cufí, Akiba, Robert Davidson, “Getting Started with Bluetooth Low Energy”, O'Reilly Media, Inc, 2014.

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (10%) | | Mid-1 (15%) | | CLA-2 (10%) | | Mid-2 (15%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 20% | 30% | 40% | 25% | 20% | 30% | 20% | 30% | 40% | 25% |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 80% | 70% | 60% | 75% | 80% | 70% | 80% | 70% | 60% | 75% |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers**

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# SEMESTER VI

**SRM University – AP, Andhra Pradesh**
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# System Verilog

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | | **Course Category** | | **L-T-P-C** | 2 | 0 | 1 | 3 |
| **Pre-Requisite Course(s)** | | **Co-Requisite Course(s)** | | **Progressive Course(s)** | | | | |
| **Course Offering Department** | ECE | **Professional / Licensing Standards** | | | | | | |

**Course Objectives**

1. To understand the historical context and evolution of System Verilog from Verilog.
2. To design combinational and sequential logic circuits using System Verilog.
3. To Implement assertion-based verification to enhance the robustness of digital designs and Apply object-oriented programming principles within System Verilog for design and verification.
4. To understand the importance of functional coverage in the verification process and understand UVM components such as agents, drivers, monitors, and sequencers.

**Course Outcome (COs)**

| CO's | At the end of the course the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **1** | Design and verify complex digital systems using System Verilog. | **2** | **90%** | **90%** |
| **2** | Write and utilize System Verilog assertions for robust verification. | **3** | **80%** | **75%** |
| **3** | Apply object-oriented programming concepts within System Verilog for efficient verification. | **3** | **80%** | **75%** |
| **4** | Develop comprehensive verification plans and manage verification projects effectively. | **3** | **70%** | **70%** |
| **5** | Utilize UVM to build reusable and scalable verification environments. | **2** | **80%** | **75%** |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and | Modern Tool and ICT | Society and | Environment | Moral, and | Individual and Teamwork | Communication Skills | Project Management | Self-Directed and Life Long | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 3 | **2** | **1** | **1** | **2** | **-** | - | - | **2** | **2** | **2** | 2 | 1 | 1 | 1 |
| Outcome 2 | 2 | 2 | **2** | **2** | **2** | **-** | - | - | **2** | **2** | **2** | 2 | 2 | 2 | 1 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outcome 3 | 2 | **1** | **1** | **2** | **2** | **-** | - | **-** | **2** | **1** | **1** | 1 | 1 | 2 | 2 |
| Outcome 4 | 2 | 1 | **2** | **2** | **2** | **-** | - | **-** | **2** | **2** | **2** | 2 | 2 | 2 | 1 |
| Outcome 5 | 2 | 1 | **2** | **2** | **2** | **-** | - | **-** | **2** | **2** | **2** | 2 | 1 | 1 | 2 |
| **Course Average** | **2.20** | **1.40** | **1.60** | **1.80** | **2.00** | **-** | - | **-** | **2.00** | **1.80** | **1.80** | **1.80** | 1.40 | 1.60 | 1.50 |

**Course Unitization Plan**

| Unit No. | Syllabus Topics | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit No. 1** | **Introduction to System Verilog and System Verilog Language Basics** | **9** | | |
| | Overview of Hardware Description Languages (HDLs) | **2** | **1** | **1,2** |
| | Evolution of System Verilog from Verilog | **2** | **1,2** | **1,2** |
| | Design and Verification with System Verilog | **2** | **1,2** | **1,2** |
| | Data Types and Operators | **1** | **1** | **1,2** |
| | Modules and Ports, Continuous Assignments, Procedural Blocks and Timing Control | **2** | **1,2** | **1,2** |
| **Unit No. 2** | **RTL Design with System Verilog and Advanced System Verilog Constructs** | **11** | | |
| | Combinational and Sequential Logic Design | **2** | **2** | **1,2** |
| | Synthesizable Constructs | **1** | **2,3** | **1,2** |
| | Designing Finite State Machines (FSMs) | **2** | **2** | **1,2** |
| | Writing Testbenches for RTL Design | **2** | **2** | **1,2** |
| | Interfaces and Modports | **1** | **2** | **1,2** |
| | System Verilog Arrays | **1** | **2,3** | **1,2** |
| | Packed and Unpacked, Structures, Unions, and Typedefs, Enumerations and Constants | **2** | **2** | **1,2** |
| **Unit No. 3** | **System Verilog Assertions (SVA) and Object-Oriented Programming (OOP) in System Verilog** | **9** | | |
| | Introduction to Assertions | 1 | 3 | **1,2** |
| | Immediate and Concurrent Assertions | 1 | 3,4 | **1,2** |

| | | | | |
|---|---|---|---|---|
| | Temporal Operators and Sequences | 1 | 3,4 | **1,2** |
| | Assertion-Based Verification Methodology | 2 | 3,4 | **1,2** |
| | Classes and Objects, Inheritance and Polymorphism | 2 | 3 | **1,2** |
| | Virtual Methods and Abstract Classes, Packages and Libraries | 2 | 3,4 | **1,2** |
| **Unit No. 4** | **Functional Coverage and Constrained Random Verification** | **9** | | |
| | Coverage Driven Verification, Cover groups and Cover points | **2** | **1,4** | **1,2** |
| | Cross Coverage, Coverage Collection and Analysis | **2** | **1,4** | **1,2** |
| | Randomization in System Verilog | **1** | **4** | **1,2** |
| | Constraints and Constraint Solving, Random Sequence Generation | **2** | **1,4** | **1,2** |
| | Directed vs. Random Testing | **2** | **1,4** | **1,2** |
| **Unit No. 5** | **UVM (Universal Verification Methodology), Building and Running UVM Environments** | **7** | | |
| | Overview of UVM, UVM Components | **1** | **5** | **2,3** |
| | Agents, Drivers, Monitors, and Sequencers | **1** | **2,5** | **2,3** |
| | Writing UVM Testbenches | **1** | **2,5** | **2,3** |
| | Verification Planning and Management | **1** | **2,5** | **2,3** |
| | Test Planning and Testbench Architecture | **1** | **1,2,5** | **2,3** |
| | Regression Testing and Automation | **2** | **2,5** | **2,3** |
| | Debugging Techniques, Code and Functional Coverage Analysis | **2** | **1,2,5** | **2,3** |
| | **Total** | **45** | | |

**Course Unitization Plan (Lab)**

| Exp No. | Experiment Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| 1 | Writing and simulating basic SystemVerilog modules | 4 | 1,2 | 1,2 |
| 2 | Designing and verifying combinational and sequential circuits | 4 | 1,2 | 1,2 |
| 3 | Implementing assertions and coverage models | 4 | 2,3 | 1,2 |
| 4 | Building UVM testbenches and performing random testing | 4 | 1,4 | 2,3 |
| | | **16** | | |

**References**


1. Sutherland, Stuart, Simon Davidmann, and Peter Flake. "SystemVerilog for design: A guide to using systemverilog for hardware design." *Cham, Switzerland: Springer* (2013).
2. Tumbush, Greg. *Systemverilog for Verification-a Guide to Learning the Testbench Language*. Springer-verlag New York Incorporated, 2012.
3. Spear, Chris. *SystemVerilog for verification: a guide to learning the testbench language features*. Springer Science & Business Media, 2008.


**Recommended Online Resources**

1. IEEE Standard for SystemVerilog
2. Tutorials from platforms like Coursera, edX, and Udemy

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (5%) | | Mid-1 (20%) | | CLA-2 (15%) | | CLA-3 (10%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 70% | 50% | 50% | 20% | 45% | 40% | 50% | 40% | 60% | 40% |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 30% | 50% | 30% | 60% | 45% | 60% | 50% | 40% | 30% | 40% |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | - | - | 20% | 20% | 10% | - | - | 20% | 10% | 20% |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designer(s)**


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## FPGA based Advanced Digital System Design

| Course Code | **ECE 306** | Course Category | **Core Course (CC)** | L-T-P-C | **2** | **0** | **1** | **3** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | **ECE202** | Co-Requisite Course(s) | Digital system design | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To understand and apply advanced concepts in HDLs.

**Objective 2:** To understand and analyze the secure coding practices for HDLs

**Objective 3:** To understand and analyze industry-relevant case studies to demonstrate the application of advanced HDL concepts in real-world projects.

**Objective 4:** To understand the fundamentals of FPGA technology and familiarize with FPGA development tools from vendors like Xilinx or Altera

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Define and understand the basic of advanced concepts in HDLs. | 2 | 85% | 80% |
| **Outcome 2** | Understand, analyze and design the coding practices for HDLs | 3 | 80% | 75% |
| **Outcome 3** | Understand the industry-relevant case studies to demonstrate the application of advanced HDL concepts in real-world projects. | 3 | 80% | 75% |
| **Outcome 4** | Apply the knowledge gained in the course to real-world applications and work on practical projects | 4 | 75% | 70% |

**Course Articulation Matrix: (CLO) to Program Learning Outcomes (PLO)**

| **CLO** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Lifelong Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 2 | 3 | 1 | 2 | 2 | | | | 1 | 2 | 1 | 3 | 2 | 2 | 2 |
| Outcome 2 | 2 | 3 | 2 | 3 | 2 | | | | 2 | 2 | | 3 | 2 | 3 | 3 |
| Outcome 3 | 3 | 3 | 2 | 3 | 2 | | | | 2 | 2 | | 3 | 2 | 3 | 3 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outcome 4 | 2 | 2 | 2 | 2 | 2 | | | | 3 | 3 | 2 | 3 | 3 | 3 | 3 |
| **Course Average** | **2** | **3** | **2** | **3** | **2** | | | | **2** | **2** | **1** | **3** | **2** | **3** | **3** |

**Course Unitization Plan (Theory)**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References |
|---|---|---|---|---|
| **Unit 1** | **Introduction of VHDL & Logic synthesis** | **9** | | |
| | Concepts of Hardware Description Languages | 2 | 1 | 1,2 |
| | VHDL objects, types, subtypes, operators, packages | 2 | 1 | 1,2 |
| | Design cycle synthesis, | 1 | 1 | 1, 2 |
| | Types of synthesizers, design optimization techniques | 2 | 1 | 1, 2 |
| | Technology mapping, design organization | 2 | 1 | 1, 2 |
| **Unit 2** | **Combinational Logic & Sequential logic design** | **11** | | |
| | Design units, entities and architectures | 2 | 2,4 | 1,2 |
| | Simulation and synthesis model, signals and ports | 1 | 2,4 | 1,2,3 |
| | Simple signal assignments, conditional signal assignments, selected signal assignment | 2 | 2,4 | 1,2,3 |
| | Processes, variables, sequential statements | 1 | 2,4 | 1,2,3 |
| | Registers: Simulation and synthesis model of register, register templates, clock types, gated registers, resettable registers, | 2 | 2,4 | 1,2,3 |
| | Simulation model of asynchronous reset, asynchronous reset templates, registered variables | 2 | 2,4 | 1,2,3 |
| | FSM: Moore and Mealy machine modelling | 1 | 2,4 | 1,2,5 |
| **Unit 3** | **Hierarchy & Sub programs** | **8** | 2,4 | 1,2,5 |
| | Components, component instances, component declaration, generate statements | 2 | 2,4 | 1,2,5 |
| | Configuration specifications, default binding, binding process, component packages. | 2 | 2,4 | 1,2,5 |
| | Sub programs functions, procedures | 2 | 2,4 | 1,2,5 |
| | Declaring subprograms. | 2 | 2,4 | 1,2,5 |
| **Unit 4** | **Test Benches & Verilog** | **9** | | |
| | Test benches, verifying responses | 2 | 3,4 | 1,2,5 |
| | Printing response values, reading data files | 2 | 3,4 | 1,2,5 |
| | Overview of Digital Design with Verilog HDL | 1 | 3,4 | 1,2,5 |
| | Basic Concepts, Modules and Ports, Basics of Gate-Level Modeling | 2 | 3,4 | 1,2,5 |
| | Dataflow Modeling, Behavioral Modeling. | 2 | 3,4 | 1,2,5 |
| **Unit 5** | **FPGA** | **8** | | |
| | Introduction, Logic Block Architecture, Routing Architecture, Programmable, Interconnection, | 2 | 1,4 | 1,2,5 |
| | Design Flow, Xilinx Virtex-II , Artix-7 (Architecture) | 2 | 1,4 | 1,2,5 |
| | Boundary Scan, Programming FPGA's | 2 | 1,4 | 1,2,5 |
| | Interface of FPGA board with input and output devices. | 2 | 1,4 | 1,2,5 |
| | **Total** | **45** | | |

**Course Unitization Plan (Lab)**

| Exp No. | Experiment Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| 1 | Write Verilog code to realize all the logic gates | 2 | 1,4 | 1,2 |

| | | | | |
|---|---|---|---|---|
| 2 | Write a Verilog program for the following combinational designs<br>a. 2 to 4 decoder<br>b. 8 to 3 (encoder without priority & with priority)<br>c. 8 to 1 multiplexer.<br>d. 4 bit binary to gray converter<br>e. Multiplexer, de-multiplexer, comparator. | 2 | 1,4 | 1,2 |
| 3 | Write a VHDL and Verilog code to describe the functions of a Full Adder using three modeling styles. | 2 | 1,4 | 1,2 |
| 4 | Write a Verilog code to model 32 bit ALU | 4 | 1,4 | 1,2 |
| 5 | Develop the Verilog code for the following flip-flops, SR, D, JK and T. | 2 | 2,4 | 1,2,3 |
| 6 | Design a 4 bit binary, BCD counters (Synchronous reset and Asynchronous reset ) and "any sequence" counters, using Verilog code. | 2 | 2,4 | 1,2,3 |
| 7 | Write a Verilog code to design a clock divider circuit that generates 1/2, 1/3$^{rd}$ and 1/4$^{th}$ clock from a given input clock. Port the design to FPGA and validate the functionality through oscilloscope | 2 | 2,4 | 1,2,3 |
| 8 | Interface a DC motor to FPGA and write Verilog code to change its speed and direction | 2 | 2,4 | 1,2,3 |
| 9 | Interface a Stepper motor to FPGA and write Verilog code to control the Stepper motor rotation which in turn may control a Robotic Arm. External switches to be used for different controls like rotate the Stepper motor (i) +N steps if Switch no.1 of a Dip switch is closed (ii) +N/2 steps if Switch no. 2 of a Dip switch is closed (iii) –N steps if Switch no. 3 of a Dip switch is closed etc. | 2 | 3,4 | 1,2,3,4 |
| 10 | Interface a DAC to FPGA and write Verilog code to generate Sine wave of frequency F KHz (eg. 200 KHz) frequency. Modify the code to down sample the frequency to F/2 KHz. Display the Original and Down sampled signals by connecting them to an oscilloscope | 2 | 1,4 | 1,2,5 |
| **Total Contact Hours** | | **20** | | |

**Recommended Resources**


1. Charles H. Roth, Digital System Design Using VHDL , Jr.,Thomson, (2008)2nd Ed.
2. Bhaskar, J., A VHDL Primer, Pearson Education/ Prentice Hall (2006)3rd Ed.
3. Ashenden, P., The Designer's Guide To VHDL, Elsevier (2008) 3rd Ed.
4. David C. Black and Jack Donovan, SystemC: From the Ground Up, Springer, (2014) 2$^{nd}$ Ed.
5. Rushton, A., VHDL for Logic Synthesis, Wiley (1998) 2ed.
6. Samir Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Prentice Hall PTR (2003) 2nd Ed.

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (5%) | | Mid-1 (20%) | | CLA-2 (15%) | | CLA-3 (10%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 50% | | 45% | 20% | 45% | 45% | 50% | 40% | 40% | 40% |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 45% | | 45% | 60% | 50% | 55% | 50% | 40% | 40% | 50% |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | 5% | | 10% | 20% | 5% | | | 20% | 20% | 10% |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designer(s)**

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# Antenna Design

| Course Code | **ECE 307** | Course Category | **Core Course (CC)** | L-T-P-C | **2** | **0** | **1** | **3** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To provide the fundamental concepts of generation of radiation and basic parameters of antenna characterization

**Objective 2:** To provide comprehensive knowledge of different design and performance parameters of antenna.

**Objective 3:** To impart knowledge on the design and operation of antenna-arrays

**Objective 4:** To provide the overall idea about various existing antennas and different advance antennas presently in practice.

**Objective 5:** To impart knowledge on the concepts of parallel plate & Rectangular waveguides and corresponding important parameters

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Understand the fundamental concepts of radiation | 2 | 85% | 85% |
| **Outcome 2** | Apply the basic concepts in antenna design and understand various characteristic parameters | 2 | 85% | 80% |
| **Outcome 3** | To understand the operation of antenna-arrays and its radiation | 2 | 80% | 75% |
| **Outcome 4** | To provide principle of design, operation, analysis and application of different practical antennas such as micro-strip, yagi-Uda, horn, and Helical antennas etc | 5 | 85% | 80% |
| **Outcome 5** | Understand the design concepts and radiation characteristics of antenna-arrays | 2 | 85% | 80% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Life Long Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 3 | 1 | 3 | 2 | | | 1 | | 1 | | | 1 | 1 | | |
| Outcome 2 | 3 | 1 | 2 | 2 | 1 | | 1 | | 1 | | | 1 | 2 | 1 | |
| Outcome 3 | 3 | 1 | 2 | 2 | 2 | | 1 | | 1 | | | 1 | 1 | | |
| Outcome 4 | 3 | 3 | 3 | 3 | 3 | | 3 | | 2 | | 1 | 3 | 2 | 2 | 1 |
| Outcome 5 | 2 | 1 | 2 | 2 | 3 | | | | 2 | | | 1 | 2 | 2 | |
| **Course Average** | **3** | **2** | **3** | **2** | **2** | | **2** | | **2** | | **2** | **2** | **2** | **2** | **2** |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Fundamental of Radiation** | **9** | | |
| | Definition and functions of an antenna | 1 | 1,2 | 1,2 |
| | Comparison between an antenna & Transmission line | 1 | 1,2 | 1,2 |
| | Radio communication link with transmitting antenna and a receiving antenna | 1 | 1,2,4 | 1,2 |
| | Radiation fundamentals | 1 | 2,4 | 1,2 |
| | Radiation from a current element & Radiation from quarter wave monopole | 1 | 1,2,3 | 1,2 |
| | Radiation from quarter wave monopole and half wave dipoles | 1 | 1,2 | 1,2 |
| | Derivation for radiation resistance, application of reciprocity | 1 | 1,2 | 1,2 |
| | Directional properties of dipole antennas, antenna feeding methods | | | |
| | Tutorial Classes (Numerical Problems related to the unit) | 2 | 1,2, 3 | 1,2,4,5 |
| **Unit 2** | **Antenna Parameters and definitions** | **9** | | |
| | Antenna-parameters, Bandwidth, Beam area, beam width-Half-Power Beam width (HPBW)and First Null Beam | 1 | 1,2,4 | 1,2,3 |
| | Radiation Intensity, Beam Efficiency | 1 | 2,4 | 1,2,3 |
| | Radiation resistance, Radiation efficiency | 1 | 2,4 | 1,2,4 |
| | Resolution, Antenna aperture-physical and effective apertures | 1 | 2,4 | 1,2,4 |
| | Effective height | 1 | 3, 4 | 1,2,4 |
| | Friss-free transmission formula | 1 | 3, 4 | 1,2 |
| | Antenna field zones | 1 | 1,2,4,5 | 1,2 |
| | Tutorial Classes (Numerical Problems related to the unit) | 2 | 1,2,4 | 1,2,5 |
| **Unit 3** | **Arrays of point sources** | **9** | | |
| | Antenna Arrays: Point Sources | 1 | 3, 4 | 1,2,3 |

| | | | | |
|---|---|---|---|---|
| | Definition, Pattern, arrays of 2 Isotropic Sources | 1 | 3, 4 | 1,2,3 |
| | Different cases of arrays of 2 Isotropic Sources | 1 | 1,2, 3, 4 | 1,2,3 |
| | Principle of Pattern Multiplication | 1 | 1,2, 3, 4 | 1,2,3 |
| | Uniform Linear Arrays – Broadside Arrays | 1 | 1,2, 3, 4 | 1,2,3 |
| | EFA with Increased Directivity | 1 | 1,3,4 | 1,2,3 |
| | Derivation of their Characteristics and Comparison | 1 | 1,3,4 | 1,2,3 |
| | BSAs with Non- UNIT form Amplitude Distributions, General Considerations and Binomial Arrays | 1 | 3,4,5 | 1,2,3 |
| | Tutorial Classes (Numerical Problems related to the unit) | 2 | 1,3,5 | 1,2,3 |
| **Unit 4** | **Types of Antennas** | **9** | | |
| | Loop Antenna | 1 | 4,5 | 1,2 |
| | Slot antenna | 1 | 4,5 | 1,2 |
| | Micro-strip (Patch) antennas | 1 | 3, 4 | 1,2 |
| | Yagi-Uda antenna | 1 | 3, 4 | 1,2 |
| | Log periodic antenna | 1 | 3 | 1,2 |
| | Helical antenna | 1 | 3, 4 | 1,2 |
| | Horn antenna | 1 | 1,3,4 | 1,2 |
| | Parabolic reflector antenna | 1 | 1,3,5 | 1,2 |
| | Tutorial Classes (Numerical Problems related to the unit) | 2 | 1,3,5 | 1,2 |
| **Unit 5** | **Waveguides** | **12** | | |
| | General Wave behaviours along uniform Guiding structures | 1 | 1,5 | 1,2,3 |
| | TE wave, TM wave, Transverse Electromagnetic waves | 1 | 1,5 | 1,2 |
| | TM and TE waves between parallel plates | 1 | 1,5 | 1,2 |
| | TM and TE waves in rectangular wave guides | 1 | 4,5 | 1,2 |
| | Bessel's differential equation and Bessel function in circular waveguide | 1 | 4,5 | 1,2,3 |
| | Rectangular and circular cavity Resonators. | 1 | 4,5 | 1,2,3 |
| | Tutorial Classes (Numerical Problems related to the unit) | 2 | 4,5 | 1,2,3 |

| | |
|---|---|
| **Total Contact Hours for Theory** | **45** |

**Course Unitization Plan - Lab**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Exp.1** | Characterization of dipole antenna. | 3 | 1,2,3 | 1,2,4 |
| **Exp.2** | Characterization of Yagi-Uda antenna. | 3 | 1,2,3 | 1,2,4 |
| **Exp.3** | Design of Micro strip patch antenna with the help of CST MWS/Ansys HFSS | 3 | 1, 3, 4 | 1,2,4 |
| **Exp. 4** | Characterization of Micro strip patch antenna. | 3 | 3,4 | 1,2,3 |
| **Exp. 5** | Characterization of ring resonator. | 3 | 1,5 | 1,2,3 |
| **Exp.6** | Characterization of parallel coupler | 3 | 1, 5 | 1,2,3 |
| **Exp. 7** | Characterization of a two-way power divider. | 3 | 1, 5, 6 | 1,2,3 |
| **Exp.8** | Characterization of a RF passive detector. | 3 | 1, 5 | 1,2.3 |
| **Exp. 9** | Radiation Pattern & Gain of Yagi-Uda Antenna. | 3 | 1,2,3 | 1,2,3 |

| | | | | |
|---|---|---|---|---|
| **Exp.10** | Study of Vector Network Analyzer. | 3 | 5,6 | 1, 2 |
| **Total Contact Hours** | | **30** | | |

**Recommended Resources**

1) Antenna Theory – C.A. Balanis, John Wiley & Sons, 3rd Ed., 2005.
2) Antennas and Wave Propagation – K.D. Prasad, Satya Prakashan, Tech India Publications, New Delhi.
3) Antenna Theory and Applications -H.J. Visser, Wiley Publications, 2012
4) Microwave Engineering & Passive circuits, Peter A Rizzi
5) NPTEL lectures on "Antennas" by Prof. Girish Kumar IIT Bombay

**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (50%)** | | | | | | | | **End Semester Exam (50%)** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **CLA-1 (10%)** | | **Mid-1 (15%)** | | **CLA-2 (10%)** | | **CLA-3 (15%)** | | | |
| | | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** |
| Level 1 | Remember | 40% | 40% | 30% | 40% | 30% | 40% | 30% | | 40% | 40% |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 60% | 60% | 50% | 60% | 40% | 60% | 40% | | 40% | 60% |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | 20% | | 30% | | 30% | | 20% | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designers**

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# Embedded System for Design

| Course Code | **ECE 308** | Course Category | **Core Course (CC)** | L-T-P-C | **3** | **0** | **1** | **4** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | **Microprocessors** | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To cover the basic and essential aspects of embedded systems design.

**Objective 2:** To understand the design process and design considerations of different processors.

**Objective 3:** To understand the interfacing of various devices with microprocessors.

**Objective 4:** To understand the communication protocols used in Embedded Systems.

**Objective 5:** To understand the fundamental working and application of a real time operating system.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Differentiate between different processor architectures and selection of appropriate processor | 2 | 80% | 70% |
| **Outcome 2** | Design a single purpose processor for a specific application | 2 | 60% | 60% |
| **Outcome 3** | Understand the PIC Architecture, Instruction set and do the programming with MPLAB. | 3 | 70% | 70% |
| **Outcome 4** | Use communication protocols to interface PIC microcontroller with peripheral devices, like LCD display, memories, and sensors. | 3 | 70% | 60% |
| **Outcome 5** | Compare and contrast scheduling algorithms in RTOS to run multiple Tasks. | 3 | 60% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering | Problem Analysis | Design and | Analysis, Design | Modern Tool and | Society and | Environment and | Moral, and | Individual and | Communication | Project Manage | Self-Directed | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | | 2 | 2 | 2 | 1 | | | | 1 | | 1 | 1 | 1 | | 1 |
| Outcome 2 | | 3 | 3 | 3 | 1 | | | | 1 | | 1 | 2 | 2 | 3 | 2 |
| Outcome 3 | 2 | | 1 | | 3 | | | | 2 | | | 1 | 1 | | 2 |
| Outcome 4 | 2 | 2 | 3 | 2 | 3 | | | | 2 | | | 2 | 2 | 3 | 2 |
| Outcome 5 | 2 | 3 | 3 | 3 | 3 | | | | 3 | | 1 | 2 | 2 | 3 | 2 |

| Course Average | 2 | 3 | 2 | 3 | 2 | | | | 2 | | 1 | 2 | 2 | 3 | 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

**Course Unitization Plan (Theory)**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Introduction** | **7** | | |
| 1 | Introduction to embedded systems, examples of embedded systems, | 1 | 1 | 1,2 |
| 2 | Components of embedded systems hardware | 1 | 1 | 1,2 |
| 3 | Design process in embedded system | 1 | 1 | 1,2 |
| 4 | Design metrics, design metrics optimization | 1 | 1 | 1,2 |
| 5 | Time to market, The NRE and unit cost design metrics, The performance design metrics | 1 | 1 | 1,2 |
| 6 | Von Neumann and Harvard Architecture, CISC and RISC architectures | 1 | 1 | 1,2 |
| 7 | Introduction to different controllers: Atmel 89C52, ATMEGA 32, Microchip PIC16F877, ARM 7. | 1 | 1 | 1,2,3 |
| **Unit 2** | **Custom Processor Designs** | **11** | | |
| 8 | Processor technology – General-purpose processor, single-purpose processor, and application specific processors | 1 | **2** | 1 |
| 9 | IC Technology – PLD, semi-custom, full custom. | 1 | 2 | 1 |
| 10 | Design Technology – RT Synthesis. RT-level combinational and sequential components. | 1 | 2 | 1 |
| 11 | Finite state machine with data (FSMD) | 1 | 2 | 1 |
| 12 | Finite state machines (FSM) | 1 | 2 | 1 |
| 13 | controller and data path design | 1 | 2 | 1 |
| 14 | Optimization of design | 2 | 2 | 1 |
| 15 | Operation of general-purpose processors – Instruction execution, pipelining, superscalar and VLIW architectures. | 1 | 2 | 1 |
| 16 | Design of Soda Vending machine | 1 | 2 | 1 |
| 17 | Design of Elevator controller | 1 | 2 | 1 |
| **Unit 3** | **PIC MICROCONTROLLER – ARCHITECTURE AND INTERFACING** | **13** | | |
| 18 | Baseline, Mid-range and High-performance PIC devices | 1 | 3 | 6,7 |
| 19 | PIC Architecture, Memory Organization | 1 | 3 | 6,7 |
| 20 | Instruction Set - Branch, Call, Time Delay Loop | 3 | 3 | 6,7 |
| 21 | Arithmetic logical instructions | 1 | 3 | 6,7 |
| 22 | Assembly Language Programs | 1 | 3 | 6,7 |
| 23 | Bank Switching, Table processing, Macros and Modules | 1 | 3 | 6,7 |
| 24 | Development tools –MPLAB – Cross compilers, PIC I/O Ports | 2 | 3 | 6,7 |
| 25 | Timers and Counters, Capture Compare, PWM Modules | 1 | 3 | 6,7 |
| 26 | Interrupts, Watch Dog Timer | 2 | 3 | 6,7 |
| **Unit 4** | **Communication Protocols** | **6** | | |
| 27 | Concept of protocols. Study of serial and parallel communication protocols – UART, SPI, | 1 | 4 | 1,2,6 |

| | | | | |
|---|---|---|---|---|
| 28 | SCI, I2C, CAN, USB, PCI, Ethernet | 2 | 4 | 1,2,6,7 |
| 29 | Study of wireless protocols - IrDA, Bluetooth, IEEE802.11, | 1 | 4 | 6,7 |
| 30 | Zigbee, RF modules, GSM modem for AT command study. | 2 | 4 | 6,7 |
| **Unit 5** | **Basics of Real-Time Operating System** | **8** | | |
| 31 | Need of RTOS in Embedded system software, RTOS services in contrast with computer OS. Features of µCOS II. | 1 | 5 | 4 |
| 32 | Foreground/Background systems, Kernel architecture, | 1 | 5 | 4,5 |
| 33 | Task, Task scheduler, context switching. | 1 | 5 | 4,5 |
| 34 | Scheduling algorithms – First come first serve, Round Robin, Round Robin with Priority, Shortest job first. | 1 | 5 | 4 |
| 35 | Multitasking, Interrupt service routine (ISR), | 1 | 5 | 4 |
| 36 | Semaphores, Mutexes, Events | 1 | 5 | 4 |
| 37 | Inter process communication (IPC) - mailbox, message queues, | 1 | 5 | 4,7 |
| 38 | Pipes, timers, memory management. | 1 | 5 | 4, 7 |
| | **Total Contact Hours** | **45** | | |

**Course Unitization Plan - Lab**

| Session | Description of Experiment | Contact hours required | CLOs Addressed | Reference Used |
|---|---|---|---|---|
| 1. | Assembly language programming for PIC microcontrollers.<br>Arithmetic Operations<br>Port I/O Programming | 4 | 3 | 6 |
| 2. | Timers and Counter Programming and usage of CCP module. | 4 | 3,4 | 6 |
| 3. | ADC and Data EEPROM Programming. | 4 | 4 | 6, 7 |
| 4. | Asynchronous Serial Communication UART Programming. | 2 | 3,4 | 6 |
| 5. | Peripheral Interfacing using synchronous serial communication (SPI/ I2C) | 2 | 3,4 | 6,7 |
| 6 | Program for making PIC's USB as virtual COM Device (CDC class device) | 2 | 4 | 7 |
| 7 | Controller Area Network (CAN) Interface. | 2 | 4 | 7 |
| 8 | RTOS program to demonstrate Task management. | 2 | 5 | 4 |
| 9 | RTOS program to demonstrate Inter task communication and inter task synchronization. | 4 | 5 | 4 |
| 10 | Mini Capstone Project. | 4 | 3,4,5 | 4,6,7 |
| **Total Contact Hours** | | **30** | | |

**Recommended Resources**


1. Vahid and Givargis,"*Embedded system design : A unified hardware/software introduction*", John Wiley & Sons, Inc. 2002.
2. Raj Kamal, "Embedded Systems : Architecture, Programming, and Design", The McGraw-Hill Companies, Edition 2, 2008.
3. Steve Furber, "*ARM System-on-chip architecture*", Addison-Wesley Publications, 2nd Ed., 2000.
4. Jean J. Labrosse, "MicroC/OS-II : The Real-Time Kernel", CMP Books, Edition 2, 2002.
5. S.V. Iyer and P. Gupta, "Embedded Realtime Systems Programming", The McGraw-Hill Companies, 2004.

6. Muhammad Ali Mazidi, Rolin D. Mckinlay, Danny Causey "PIC Microcontroller and Embedded Systems using Assembly and C for PIC18', Pearson Education 2008.
7. Dogan Ibrahim, "Advanced PIC Microcontroller Projects in C: From USB to RTOS with PIC18F Series", Newnes, 2008.

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (15%) | | Mid-1 (10%) | | CLA-2 (15%) | | Mid-2 (10%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 60% | 50% | 40% | 50% | 70% | 60% | 40% | | 50% | 50% |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 40% | 50% | 60% | 50% | 30% | 40% | 60% | | 50% | 50% |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designers**

*Dr. Ramakrishnan M,* Associate Professor, Department of Electronics and Communication Engineering, SRM University - AP

# SEMESTER VIII

**SRM University – AP, Andhra Pradesh**
Neeru Konda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

**Major Project**

| Course Code | **ECE 402** | Course Category | **RDIP (RD)** | L-T-P-C | **0** | **0** | **12** | **12** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To find own research problem

**Objective 2:** In depth study of the topic under consideration

**Objective 3:** Application of knowledge gained in building up to a system that solves real life problems

**Objective 4:** Understanding the social, economic, and environmental constraints in making of a new project

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Conduct a literature survey in the field of interest / proposed topic of the work and identify a problem to solve. | 4 | 60% | 80% |
| **Outcome 2** | Design and conduct a Modelling / Simulation / /Experiment | 6 | 65% | 80% |
| **Outcome 3** | Present finding and analysis to a review committee | 5 | 90% | 90% |
| **Outcome 4** | Submit a paper / patent | 6 | 90% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Life Long Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 2 | 3 | | | | 2 | 2 | 3 | 3 | | 2 | 3 | | | 1 |
| Outcome 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | | 3 | 3 | 3 | 3 | 3 |
| Outcome 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Outcome 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | | 1 |
| **Course Average** | **3** | **3** | **3** | **3** | **3** | **3** | **3** | **3** | **3** | **3** | **3** | **3** | **2** | **3** | **2** |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Literature Survey** | **35** | | |
| | Do a thorough literature survey in the domain of interest and conceive an idea | 10 | 1 | 1 |
| | Continue the literature survey specifically related to the idea conceived and determine your contribution | 10 | 1 | 1 |
| | Make an abstract of the proposed idea | 5 | 1 | 1 |
| | Preparation of biweekly reports | 10 | 1 | 1 |
| **Unit 2** | **Methodology** | **35** | | |
| | Device project plan. | 5 | 2 | 1 |
| | Acquire necessary components, software, dataset etc requirements. | 10 | 2 | 1 |
| | Testing the existing algorithms, tools, or components | 10 | 2 | 1 |
| | Preparation of biweekly reports and test plans | 10 | 2 | 1 |
| **Unit 3** | **Results** | **55** | | |
| | Development of complete methodology | 20 | 2 | 1 |
| | Prototype building | 20 | 2 | 1 |
| | Preparation of biweekly reports and test plans | 15 | 2 | 1 |
| **Unit 4** | **Dissertation and demonstration of the project** | **36** | | |
| | Completion of project dissertation | 24 | 3 | 1 |
| | Demonstration of the project | 12 | 3 | 1 |
| **Unit 5** | **Writing and submitting a research article/patent** | **19** | | |
| | writing of a technical paper / patent | 8 | 4 | 1 |
| | Writing and submission of a journal research paper | 11 | 4 | 1 |
| | **Total Contact Hours** | **180** | | |

**Recommended Resources**

**1.** As deem appropriate by the student under guidance of project faculty guide.

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (10%) | | Mid-1 (15%) | | CLA-2 (10%) | | Mid-2 (15%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | | 70% | | 50% | | 20% | | 10% | | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | | 30% | | 30% | | 40% | | 50% | | 30% |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | 20% | | 40% | | 40% | | 70% |
| | Create | | | | | | | | | | |
| **Total** | | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** |

**Course Designers**

a. *Dr. Anuj Deshpande, Assistant Professor, Department of Electronics and Communication Engineering*

b. *Prof. Siva Sankar Y, Professor, Department of Electronics and Communication Engineering*

# Specialization: Embedded System and IOT

# SRM University - AP, Andhra Pradesh

Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

## Embedded Programming

| Course Code | ECE 421 | Course Category | Professional Core (C) | L-T-P-C | 2 | 0 | 1 | 3 |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | Microprocessors and Microcontrollers | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | ECE | Professional / Licensing Standards | | | | | | |

**Course Objectives**

**Objective 1:** Understand the basics of Embedded Systems.

**Objective 2:** Learn the ARM architecture, instruction set and its assembly programming.

**Objective 3:** Learn to develop C programs for ARM processors and interfacing the peripherals.

**Objective 4:** Understand the software architectures used in Embedded Systems.

**Course Outcomes**

| | At the end of the course, the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **Outcome 1** | Understand and explain the basics of Embedded Systems. | 2 | 80% | 70% |
| **Outcome 2** | Understand the ARM Cortex M Architecture, instruction set and do ARM assembly & C programming. | 3 | 80% | 70% |
| **Outcome 3** | Develop ARM assembly & C programs. | 2 | 80% | 70% |
| **Outcome 4** | Understand the architecture used in Embedded Software. | 2 | 80% | 70% |
| **Outcome 5** | Understand the RTOS concepts and develop RTOS applications for ARM Microcontrollers. | 3 | 80% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Resea | Modern Tool and IC | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Team work Skills | Communication Skills | Project Management and Finance | Self-Directed and Life Lo | PSO1 | PSO2 | PSO3 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | rch | TUsage | | | | | | | ngLearning | | | |
| Outcome 1 | 3 | 2 | 2 | 2 | 1 | | | | 1 | | 1 | 1 | 1 | 1 | 1 |
| Outcome 2 | 3 | 3 | 3 | 3 | 1 | | | | 1 | | 2 | 2 | 2 | 2 | 2 |
| Outcome 3 | 3 | 3 | 3 | 3 | 1 | | | | 1 | | 2 | 2 | 2 | 2 | 2 |
| Outcome 4 | 3 | 2 | 1 | 2 | 1 | | | | 1 | | 1 | 1 | 2 | 2 | 2 |
| Outcome 5 | 3 | 3 | 1 | 2 | 1 | | | | 1 | | 2 | 2 | 2 | 2 | 2 |
| **Course Average** | **3** | **2** | **1** | **2** | **1** | | | | **1** | | **1** | **2** | **2** | **2** | **2** |

**Course Unitization Plan - Theory**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **OVERVIEW** | **9** | | |
| 1 | Embedded System Case Studies | 2 | 1 | 1,3 |
| 2 | Introduction to Embedded Systems | 2 | 1 | 1,3,4 |
| 3 | Getting to Know the Hardware | 2 | 1 | 1,3,4 |
| 4 | Learn How to Communicate | 1 | 1 | 1,3,4 |
| 5 | Getting to Know the Processor | 1 | 1 | 1,3,4 |
| 6 | Study the External Peripherals | 1 | 1 | 1,3,4 |
| **Unit 2** | **ARM REFERENCE ARCHITECTURE** | **13** | | |
| 7 | ARM Processor Architecture | 1 | **2** | 6,4 |
| 8 | ARM Software Development | 1 | 2 | 6,4 |
| 9 | ARM Instruction Sets | 2 | 2 | 6,4 |
| 10 | Getting Started with Embedded Software Development (Tools, Packages, Platforms, etc.) | 1 | 3 | 1,6,4 |
| 11 | Your First Embedded Program-Hello, ARM! | 1 | 3 | 1,6,4 |
| 12 | The Blinking LED Program | 1 | 3 | 1,6,4 |

| | | | | |
|---|---|---|---|---|
| 13 | The Role of the Infinite Loop | 1 | 3 | 1,6,4 |
| 14 | Compiling, Linking, and Locating | 1 | 3 | 1,6,4 |
| 15 | The Build Process | 1 | 3 | 1,6,4 |
| 18 | Embedded Software Architecture | 3 | 3 | 3 |
| **Unit 4** | **EMBEDDED OPERATING SYSTEM** | **8** | | |
| 27 | Real-Time Operating Systems | 2 | 4 | 2,7 |
| 29 | Tasks and Task States, its transition | 2 | 4 | 2,7 |
| 30 | Task scheduling | 2 | 4 | 2,7 |
| 28 | Interrupt Routines in an RTOS Environment | 2 | 4 | 2,7 |
| | **Total Contact Hours** | **30** | | |

**Course Unitization Plan - Lab**

| Session | Description of Experiment | Contact hours required | CLOs Addressed | Reference Used |
|---|---|---|---|---|
| 1. | ARM Assembly language program for doing arithmetic operation. | 1 | 3 | 5 |
| 2. | ARM assembly language program for Memory operations | 1 | 3 | 5 |
| 3. | ARM Assembly - Interfacing memory mapped peripherals<br>1. Binary Counter with LEDs<br>2. Real Time Clock<br>3. Analog to Digital converter<br>4. Digital to Analog Converter | 2 | 3 | 5 |
| 4 | C Program for peripheral interfacing<br>1. GPIO<br>2. Real Time Clock<br>3. Analog to Digital Converter<br>4. Digital to Analog Converter | 2 | 3 | 5 |
| 5. | C Program for Asynchronous and synchronous serial communication<br>1. UART<br>2. I2C/SPI | 2 | 3 | 5 |
| 6 | Timer programming with Interrupt | 1 | 3 | 5 |
| 7 | LCD/Keypad Interface | 2 | 3 | 5 |
| 8 | RTOS Task Management | 1 | 4 | 7 |
| 9 | RTOS Inter Task Synchronization and Inter Task communication | 2 | 4 | 7 |
| 10 | Mini Capstone Project | 1 | 2,3 | |
| **Total Contact Hours** | | **15** | | |

## Recommended Resources

1. Barr, Michael, and Anthony Massa. Programming embedded systems: with C and GNU development tools. " O'Reilly Media, Inc.", 2006.
2. Simon, David E. An embedded software primer. Vol. 1. Addison-Wesley Professional, 1999.
3. Edward A. Lee and Sanjit A. Seshia, Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, MIT Press, ISBN 978-0-262-53381-2, 2017.
4. Wolf, Wayne (2008), Computers as components : principles of embedded computing system design. 2 edition. Amsterdam : Elsevier (507 p).
5. Ata Elahi, Trevor Arjeski, "ARM Assembly Language with Hardware Experiments", Springer, 2015.
6. A.N.Sloss *et al*., "*ARM System Developer's Guide*", Morgan Kaufmann Publishers, 2004
7. Richard Barry, "Mastering the FreeRTOS™ Real Time Kernel", Real Time Engineers Ltd 2016

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|
| | | Theory (35%) | | | | Practical (15%) | | |
| | | CLA-1 (10%) | CLA-2 (5%) | CLA-3 (5%) | Mid-1(15%) | | Th (35%) | Prac (15%) |
| Level 1 | Remember | 60% | 40% | 60% | 60% | 20% | 40% | 30% |
| | Understand | | | | | | | |
| Level 2 | Apply | 40% | 60% | 40% | 40% | 80% | 60% | 70% |
| | Analyse | | | | | | | |
| Level 3 | Evaluate | | | | | | | |
| | Create | | | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers**

*Dr Ramakrishnan M, Associate Professor, Department of Electronics and Communication Engineering, SRM University - AP*

# SRM University – AP, Andhra Pradesh

Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

## RTOS

| Course Code | ECE 422 | Course Category | Professional Core (C) | L-T-P-C | 2 | 0 | 1 | 3 |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | Microprocessor/ Microcontroller | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | ECE | Professional / Licensing Standards | | | | | | |

**Course Objectives**

**Objective 1:** To understand the basics of operating systems.

**Objective 2:** To understand and appreciate the RTOS based firmware development.

**Objective 3:** To understand the internals of RTOS and apply it for the firmware development.

**Objective 4:** To design an RTOS based system using microcontroller to solve the specific problem

**Course Outcomes**

| | At the end of the course, the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| Outcome 1 | Describe the basic operating systems and RTOS concepts. | 2 | 80% | 70% |
| Outcome 2 | Apply the FreeRTOS scheduling algorithms and other task system calls. | 4 | 60% | 60% |
| Outcome 3 | Apply FreeRTOS inter task synchronization means for synchronizing tasks. | 4 | 60% | 60% |
| Outcome 4 | Write FreeRTOS program with interrupts and software timers | 4 | 70% | 60% |
| Outcome 5 | Apply FreeRTOS memory management and inter task communication concepts | 4 | 60% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICTU | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Team work Skills | Communication Skills | Project Management and Finance | Self-Directed and Life Long | PSO1 | PSO2 | PSO3 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **sage** | | | | | | | **Learning** | | | |
| Outcome 1 | 3 | 2 | 2 | 2 | 1 | | | | | | | 2 | 1 | | 1 |
| Outcome 2 | 3 | 3 | 3 | 3 | 3 | | | | 2 | 1 | 1 | 2 | 2 | 3 | 2 |
| Outcome 3 | 3 | 3 | 3 | 3 | 3 | | | | 2 | 1 | 1 | 2 | 1 | | 2 |
| Outcome 4 | 3 | 3 | 3 | 3 | 3 | | | | 2 | 1 | 1 | 2 | 2 | 3 | 2 |
| Outcome 5 | 3 | 2 | 3 | 3 | 3 | | | | 3 | 1 | 1 | 2 | 2 | 3 | 2 |
| **Course Average** | **3** | **3** | **3** | **3** | **3** | | | | **2** | 1 | **1** | **2** | **2** | **3** | **2** |

**Course Unitization Plan**

| Unit No. | Syllabus Topics | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| | **UNIT I: INTRODUCTION** | **7** | | |
| Unit I | Basics of Operating Systems Threads and Processes. | 1 | 1 | 1,5,6 |
| | Scheduling - Inter process synchronization Inter process communication. | 2 | 1 | 1,5,6 |
| | Memory Management File System – Introduction to Real Time Systems. | 2 | 1 | 1,5,6 |
| | RTOS Vs General purpose OS Types of RTOS. | 1 | 1 | 1,2 |
| | Firmware development approaches When to use RTOS. | 1 | 1 | 1,2 |
| | **UNIT II : TASK MANAGEMENT** | **6** | | |
| Unit II | Task -Task states -Task State Transition. | 1 | 2 | 3 |
| | Task creation Task Priorities Idle Task. | 1 | 2 | 3 |
| | Task scheduling | 2 | 2 | 3 |

| | | | | |
|---|---|---|---|---|
| | Task Context Task Context switch. | 2 | 2 | 3 |
| | **UNIT III: INTER TASK SYNCHRONIZATION AND COMMUNICATION** | **9** | | |
| Unit III | Inter Task Synchronization – Semaphores Types of semaphores. | 2 | 3 | 3 |
| | Mutexes, System Calls for Task synchronization, Critical sections. | 2 | 3 | 3 |
| | Priority inversion, Priority Inheritance, Deadlocks. | 2 | 3 | 3 |
| | Events - Event groups Inter Task Communication. | 1 | 3 | 3 |
| | Message queues, Queue creation, Queue Send/Receive System Calls. | 2 | 5 | 3 |
| | **UNIT IV: RESOURCE MANAGEMENT AND INTERRUPTS** | **8** | | |
| Unit IV | Memory Management, Dynamic Memory Allocation. | 2 | 5 | 3 |
| | Heap, Stack Overflow detection -Software Timers. | 2 | 5 | 3 |
| | Attributes, States, Context, and system calls. | 1 | 2 | 3 |
| | Interrupt Management - Interrupt Safe System Calls. | 2 | 4 | 3 |
| | Deferred Interrupt Processing. | 1 | 4 | 3 |
| | **Total Contact Hours** | **30** | | |

**Course Unitization Plan - Lab**

| Session No. | Description of Experiments | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| 1. | RTOS Configuration, Task creation and Task management API | 2 | 2 | 3 |
| 2. | Task scheduling Priority based pre-emptive / Round Robin Scheduling | 2 | 2 | 3 |
| 3. | Cooperative scheduling & co routines | 1 | 2 | 3 |
| 4. | Inter Task synchronization Semaphores, Mutexes and Events | 2 | 3 | 3 |
| 5. | Priority Inversion & Priority inheritance | 2 | 3 | 3 |
| 6. | Program to demonstrate Inter Task Communication using message queues. | 2 | 5 | 3 |
| 7. | One shot and auto reload software timers | 1 | 4 | 3 |
| 8. | Profiling: Viewing Run Time and task state information | 2 | 2 | 3 |
| 10. | Mini Capstone Project | 1 | 5 | 3,4,5 |
| **Total Contact Hours** | | | **15** | |

**Recommended Resources**


1. Abraham Silberschatz, Peter B Galvin, Greg Gagne, "Operating System concepts",9th edition, John Wiley & Sons Inc, 2018
2. Raj Kamal, "Embedded Systems- Architecture, Programming and Design", 3rd edition, McGraw Hill Education, 2017.
3. Richard Barry, "Mastering the FreeRTOS Real Time Kernal", Real Time Engineers Ltd, 2016.
4. Brian Amos, “Hands-on RTOS with Microcontrollers”, Packet Publishing, 2020.
5. www.freertos.org

6. Robert Love, “Linux System Programming”, 2nd edition, O’Reily Publications, 2013.

**Learning Assessment**

| Bloom’s Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|
| | | Theory (35%) | | | | Practical (15%) | | |
| | | CLA-1 (10%) | CLA-2 (5%) | CLA-3 (5%) | Mid-1(15%) | | Th (35%) | Prac (15%) |
| Level 1 | Remember | 60% | 40% | 60% | 60% | 20% | 40% | 30% |
| | Understand | | | | | | | |
| Level 2 | Apply | 40% | 60% | 40% | 40% | 80% | 60% | 70% |
| | Analyse | | | | | | | |
| Level 3 | Evaluate | | | | | | | |
| | Create | | | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers**

a. *Dr. Ramakrishnan M, Associate Professor, Department of Electronics and Communication Engineering, SRM University - AP*
b. *Dr. Anuj Deshpande, Assistant Professor, Department of Electronics and Communication Engineering, SRM University - AP*

# SRM University – AP, Andhra Pradesh

Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

## Embedded Networking

| Course Code | ECE 423 | Course Category | Professional Core (C) | L-T-P-C | 2 | 0 | 1 | 3 |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | Microprocessors and Microcontrollers | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | ECE | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** Application Development using USB and CAN bus with microcontrollers.

**Objective 2:** Understand the lightweight TCP/IP protocol and its usage.

**Objective 3:** Understand the MODBUS RTU and MODBUS TCP protocols.

**Objective 4:** Application development for 6LoWPAN network on Contiki OS.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | At the end of the course, the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| Outcome 1 | Understand Embedded Communication Protocols like UART, RS232, RS485, SPI, I2C. | 2 | 80% | 70% |
| Outcome 2 | Understand USB BUS interface and develop USB device applications. | 2 | 80% | 70% |
| Outcome 3 | Understand and apply the Controller Area Network | 3 | 80% | 70% |
| Outcome 4 | Develop Embedded TCP/IP applications. | 3 | 80% | 70% |
| Outcome 5 | Understand and develop application using Modbus RTU and Modbus TCP | 3 | 80% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usa | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Team work Skills | Communication Skills | Project Management and Finance | Self-Directed and Lifelong L | PSO1 | PSO2 | PSO3 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ge | | | | | | | earning | | | |
| Outcome 1 | 3 | 2 | 2 | 2 | 2 | | | | 2 | 2 | 1 | 2 | 1 | 1 | 1 |
| Outcome 2 | 3 | 3 | 3 | 3 | 3 | | | | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| Outcome 3 | 3 | 3 | 3 | 3 | 3 | | | | 2 | 2 | 1 | 2 | 3 | 3 | 3 |
| Outcome 4 | 3 | 3 | 3 | 3 | 3 | | | | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| Outcome 5 | 3 | 3 | 3 | 3 | 3 | | | | 2 | 2 | 1 | 2 | 3 | 3 | 3 |
| **Course Average** | **3** | **3** | **3** | **3** | **3** | | | | **2** | **2** | **2** | **2** | **2** | **2** | **2** |

**Course Unitization Plan -Theory**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **EMBEDDED COMMUNICATION PROTOCOLS** | **6** | | |
| 1 | Embedded Networking - Introduction | 1 | 1 | 1,3 |
| 2 | Serial/Parallel Communication | 1 | 1 | 1,3 |
| 3 | Serial communication protocols - RS232 standard – RS485 | 1 | 1 | 1,3 |
| 4 | Synchronous Serial Protocols -Serial Peripheral Interface (SPI) | 1 | 1 | 1,3 |
| 5 | Inter Integrated Circuits (I2C) | 1 | 1 | 1,3 |
| 6 | PC Parallel port programming | 1 | 1 | 2 |
| **Unit 2** | **USB AND CAN BUS** | **8** | | |
| | USB bus – Introduction | 1 | 2 | 1,3 |
| | Speed Identification on the bus, USB States | 1 | 2 | 3 |
| | USB bus communication: Packets –Data flow types, Enumeration –Descriptors | 1 | 2 | 3 |

| | | | | |
|---|---|---|---|---|
| | USB Device Classes (CDC,MSC, HID) and USB Host | 1 | 2 | 3 |
| | CAN Bus – Introduction | 1 | 3 | 3 |
| | Frames –Bit stuffing –Types of errors – Nominal Bit Timing | 1 | 3 | 3 |
| | A simple application with CAN | 1 | 3 | 3 |
| **Unit 3** | **EMBEDDED TCP/IP** | **9** | | |
| | Light Weight TCP/IP - Introduction | 1 | 4 | 7,8,9 |
| | Process model, Memory management and Network Interfaces | 1 | 4 | 7,8,9 |
| | IP Processing | 2 | 4 | 7,8,9 |
| | UDP, TCP Processing | 2 | 4 | 7,8,9 |
| | Interfacing the stack – API | 1 | 4 | 7,8,9 |
| | TCP/UDP Server Client | 1 | 4 | 7,8,9 |
| | HTTP Server, SSI and CGI | 1 | 4 | 7,8,9 |
| **Unit 4** | **MODBUS** | **7** | | |
| | Modbus RTU - Introduction | 1 | 5 | 5 |
| | Protocol Description – Data Encoding – Data Model – Address Model | 1 | 5 | 5 |
| | MODBUS Transaction – Function code categories | 1 | 5 | 5 |
| | Function code descriptions | 2 | 5 | 5 |
| | Modbus Exception Responses | 1 | 5 | 5 |
| | Modbus TCP/IP – Protocol Description | 1 | 5 | 5,6 |
| | **Total Contact Hours** | **30** | | |

**Course Unitization Plan – Lab**

| Session | Description of Experiment | Contact hours required | CLOs Addressed | Reference Used |
|---|---|---|---|---|
| 1. | I2C/SPI Communication | 1 | 1 | 1,3 |
| 2. | RS485 Bus Communication – Modbus RTU | 2 | 1 | 1,3,5 |
| 3. | Embedded TCP Client/Server | 2 | 3 | 3,8 |
| 4. | Embedded UDP application | 2 | 3 | 3,8 |
| 5. | Modbus TCP | 2 | 4 | 3,8 |
| 6. | Embedded HTTP | 1 | 3 | 3,8 |
| 7. | USB -CDC Class Device | 2 | 2 | 3 |
| 8. | USB - HID Class Device | 2 | 2 | 3 |
| 9. | CAN communication | 1 | 2 | 3 |
| **Total Contact Hours** | | **15** | | |

**Recommended Resources**

1. Frank Vahid, Givargis ‘Embedded Systems Design: A Unified Hardware/Software Introduction’, Student Edition, Wiley Publications, 2006.

2. Jan Axelson, 'Parallel Port Complete: Programming, Interfacing, & Using the PC's Parallel Printer', First Edition, Penram publications, 1997.
3. Dogan Ibrahim, 'Advanced PIC microcontroller projects in C', Elsevier 2008
4. Microchip Technology, "AN2059 LIN Basics and Implementation of the MCC LIN Stack Library on 8-Bit PIC® Microcontrollers", http://ww1.microchip.com/downloads/en/appnotes/00002059b.pdf.
5. Modbus.org, "MODBUS APPLICATION PROTOCOL SPECIFICATION V1.1b3", https://www.modbus.org/docs/Modbus_Application_Protocol_V1_1b3.pdf
6. Modbus.org, "MODBUS MESSAGING ON TCP/IP IMPLEMENTATION GUIDE V1.0b", https://www.modbus.org/docs/Modbus_Messaging_Implementation_Guide_V1_0b.pdf
7. Adam Dunkels, "Design and Implementation of the lwIP", https://www.artila.com/download/RIO/RIO-2010PG/lwip.pdf
8. Microchip Technology, Microchip TCP/IP Lite Stack, https://ww1.microchip.com/downloads/en/Appnotes/Microchip-AN1921-8-bit-PICMCU-TCP-IP-LiteStack-ApplicationNote-00001921D.pdf2
9. Edward Insam, "TCP/IP Embedded Internet Applications", Newnes, 2003

**Learning Assessment – Theory & Lab**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|
| | | Theory (35%) | | | | Practical (15%) | | |
| | | CLA-1 (10%) | CLA-2 (5%) | CLA-3 (5%) | Mid-1(15%) | | Th (35%) | Prac (15%) |
| Level 1 | Remember | 60% | 40% | 60% | 60% | 20% | 40% | 30% |
| | Understand | | | | | | | |
| Level 2 | Apply | 40% | 60% | 40% | 40% | 80% | 60% | 70% |
| | Analyse | | | | | | | |
| Level 3 | Evaluate | | | | | | | |
| | Create | | | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers**

*Dr Ramakrishnan M, Associate Professor, Department of Electronics and Communication Engineering, SRM University - AP*

# SRM University – AP, Andhra Pradesh

Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

## IoT Architecture and Protocols

| Course Code | ECE 424 | Course Category | Core (C) | L-T-P-C | 2 | 0 | 1 | 3 |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | ECE | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** Understand the Architectural Overview of IoT

**Objective 2:** Understand the IoT Reference Architecture and Real World Design Constraints

**Objective 3:** Understand the various IoT Protocols (Datalink, Network, Transport, Session, Service) and its security aspects.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | At the end of the course, the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **Outcome 1** | Understand the various IoT Architectures | 2 | 80% | 70% |
| **Outcome 2** | Understand IoT wireless networking standards. | 2 | 80% | 70% |
| **Outcome 3** | Understand and use the IoT network and transport layer protocols. | 4 | 80% | 70% |
| **Outcome 4** | Understand and use the IoT application layer protocols. | 4 | 80% | 70% |
| **Outcome 5** | Understand and use IoT Security at different layers. | 4 | 80% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Conduct Investigations of Complex Problems | Design and Development | Modern Tools Usage | The Engineer and Society | Environment and Sustainability | Ethics | Individual and Teamwork Skills | Communication Skills | Life Long Learning | PSO1 | PSO2 | PSO3 |
| Outcome 1 | 3 | 2 | 2 | 1 | | | | 1 | 1 | 1 | 1 | 1 | 1 |
| Outcome 2 | 3 | 2 | 3 | 3 | | | | 1 | 1 | 2 | 3 | 2 | 2 |
| Outcome 3 | 3 | 3 | 3 | 3 | | | | 1 | 1 | 1 | 3 | 2 | 2 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outcome 4 | 3 | 3 | 3 | 3 | | | | 1 | 1 | 2 | 3 | 2 | 2 |
| Outcome 5 | 3 | 3 | 3 | 3 | | | | 1 | 1 | 2 | 3 | 2 | 2 |
| **Course Average** | **3** | **2** | **3** | **3** | | | | **1** | **1** | **2** | **3** | **2** | **2** |

**Course Unitization Plan - Theory**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **OVERVIEW** | **7** | | |
| 1 | IoT Architecture – Different layers | 2 | 1 | 1,3 |
| 2 | Sensors and Actuators | 1 | 1 | 1,3 |
| 3 | Gateways | 1 | 1 | 1,3 |
| 4 | Analytics and Data services | 1 | 1 | 1,3 |
| 5 | Application layer, Communication Models | 1 | 1 | 1,3 |
| 6 | IoT Architecture - Case Study | 1 | 1 | 1,3 |
| **Unit 2** | **Lower Layer Protocols/Standards** | **8** | | |
| 7 | Zigbee, Zwave, Dash7 | 2 | **2** | 2 |
| 8 | Bluetooth Low Energy | 2 | 2 | 2,4 |
| 9 | IEEE 802.11, IEEE 802.15.4, TCP, UDP | 2 | 2,3 | 2 |
| 10 | Network Layer-IPv4, IPv6,6LoWPAN, RPL | 1 | 3 | 2 |
| 11 | Cellular IoT -NB-IoT, LTE-m | 1 | 2 | 6 |
| **Unit 3** | **IoT –Application Layer Protocols** | **9** | | |
| 12 | MQTT | 2 | 4 | 2 |
| 13 | Hyper Text Transfer Protocol (HTTP) | 1 | 4 | 2 |
| 14 | Web sockets, REST | 2 | 4 | 2 |
| 15 | CoAP | 2 | 4 | 2 |
| 16 | AMCP, XMPP | 2 | 4 | 2 |
| **Unit 4** | **IoT Security** | **6** | | |
| 17 | IoT Device/Embedded Security | 1 | 5 | 7 |
| 18 | Encryption – Private and Public key Encryption | 1 | 5 | 7 |
| 19 | Hash Algorithms, Digital Signature | 1 | 5 | 7 |
| 20 | Transport Layer Security - TLS/DTLS | 2 | 5 | 7 |
| 21 | Network Layer Security | 2 | 5 | 7 |
| | **Total Contact Hours** | **30** | | |

**Course Unitization Plan - Lab**

| Session | Description of Experiment | Contact hours required | CLOs Addressed | Reference Used |
|---|---|---|---|---|
| 1. | TCP Server - Single Client Socket Program (C) | 1 | 3 | 2 |
| 2. | TCP Server - Multi Client Socket Program (C) | 1 | 3 | 2 |

| | | | | |
|---|---|---|---|---|
| 3. | UDP Server - Client Communication (C) | 1 | 3 | 2 |
| 4. | HTTP Server (Apache Server) - Web Page and Server side script for MySQL Connectivity (PHP - MySQL) | 2 | 4 | 2 |
| 5. | HTTP Server with REST API | 1 | 4 | 2 |
| 6. | MQTT Publish Subscribe Client with AWS/Mosquitto Broker - Python | 2 | 1,4 | 5 |
| 7. | CoAP Server/Client - Arduino - Browser Add on) | 2 | 4 | 1,2 |
| 8. | Bluetooth Low Energy - Notify example with nRF Connect app - (Arduino ESP32) | 2 | 2 | 4 |
| 9. | IPV6 TCP Client-Server communication program (C) | 1 | 3 | 2 |
| 10. | Contiki /Cooja Demonstration | 2 | 1,2 | 8 |
| **Total Contact Hours** | | **15** | | |

## Recommended Resources


1. Arsheep Bahga, Vijay Madisetti, "INTERNET OF THINGS - A HANDS-ON APPROACH", 1st Edition, Orient Blackswan Private Limited, New Delhi, 2015.
2. Simone Cirani, Gianluigi Ferrari, Marco Picone, Luca Veltri, " Internet of Things: Architectures, Protocols and Standards", Wiley Publishers, 2018
3. Dieter Uckelmann, Florian Michahelles, Mark Harrison, "Architecting the Internet of Things", Springer Berlin Heidelberg, 2011.
4. Kevin Townsend, Carles Cufí, Akiba, Robert Davidson, "Getting Started with Bluetooth Low Energy: Tools and Techniques for Low-Power Networking", 1st Edition, O'Reilly Media, 2014.
5. Agus Kurniawan, "Learning AWS IoT", Packt Publishing, 2018.
6. Cameron Coursey, “The Practitioner's Guide to Cellular IoT”, Artech House, 2020.
7. Russell, Brian, and Drew Van Duren. Practical Internet of Things Security, 1 st edition, Packt Publishing Ltd, 2016.
8. Agus Kurniawan, “Practical Contiki-NG, Programming for Wireless Sensor Networks”, Apress, 2018


**Learning Assessment – Theory**

| Bloom’s Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|
| | | Theory (35%) | | | | Practical (15%) | | |
| | | CLA-1 (10%) | CLA-2 (5%) | CLA-3 (5%) | Mid-1(15%) | | Th (35%) | Prac (15%) |
| Level 1 | Remember | 60% | 40% | 60% | 60% | 20% | 40% | 30% |
| | Understand | | | | | | | |
| Level 2 | Apply | 40% | 60% | 40% | 40% | 80% | 60% | 70% |
| | Analyse | | | | | | | |
| Level 3 | Evaluate | | | | | | | |
| | Create | | | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers**


*Dr Ramakrishnan M, Associate Professor, Department of Electronics and Communication Engineering, SRM University - AP*

# SoC Design for IoT

| Course Code | ECE 426 | Course Category | Professional Core (C) | L-T-P-C | 3 | 0 | 0 | 3 |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | Microprocessors and Microcontrollers | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | Electronics and Communication Engineering | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** Understand the basics of SoC Design.

**Objective 2:** Learn the techniques to choose a processor for SoC Implementation.

**Objective 3:** Learn different type of memory blocks used in SoC Design.

**Objective 4:** Understand the bus architecture and Custom SoC Design.

**Objective 5:** Learn the designing methods for customized SoC Design using hardware and software co-design.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | At the end of the course, the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **Outcome 1** | Understand and explain the basics of SoC Design. | 2 | 80% | 70% |
| **Outcome 2** | Understand the techniques in choosing a best processor for SoC implementation. | 3 | 80% | 70% |
| **Outcome 3** | Understand the memory blocks used in SoC Design. | 2 | 80% | 70% |
| **Outcome 4** | Understand various bus architecture in designing Custom SoCs. | 3 | 80% | 70% |
| **Outcome 5** | Understand various terminologies using hardware and software co-design for designing customized SoC using suitable Processor. | 2 | 80% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Conduct Investigations of Complex Problems | Design and Development | Modern Tool Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Life Long Learning | PSO1 | PSO2 | PSO3 |
| Outcome 1 | 3 | 2 | 2 | 1 | | | | 1 | | 1 | 1 | 1 | 1 |
| Outcome 2 | 3 | 3 | 3 | 2 | | | | 1 | | 2 | 2 | 2 | 2 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outcome 3 | 3 | 2 | 2 | 1 | | | | 1 | | 1 | 2 | 2 | 2 |
| Outcome 4 | 3 | 3 | 2 | 1 | | | | 1 | | 2 | 2 | 2 | 2 |
| Outcome 5 | 3 | 2 | 2 | 2 | | | | 1 | | 2 | 2 | 2 | 2 |
| **Course Average** | **3** | **2** | **2** | **1** | | | | **1** | | **2** | **2** | **2** | **2** |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **SYSTEM ARCHITECTURE: OVERVIEW** | **9** | | |
| 1 | Components of the system, Processor architectures | 2 | 1 | 1,3 |
| 2 | Processor architectures, Memory and addressing – system level interconnection. | 2 | 1 | 1,3,4 |
| 3 | SoC design requirements and specifications, Design integration – design complexity. | 2 | 1 | 1,3,4 |
| 4 | Cycle time, die area and cost, Ideal and practical scaling. | 1 | 1 | 1,3,4 |
| 5 | Design integration – design complexity, Area-time-power tradeoff in processor design. | 1 | 1 | 1,3,4 |
| 6 | Configurability. | 1 | 1 | 1,3,4 |
| **Unit 2** | **PROCESSOR SELECTION FOR SOC** | **9** | | |
| 7 | Overview – soft processors. | 1 | **2** | 1,3,4 |
| 8 | Processor core selection. | 1 | 2 | 1,3,4 |
| 9 | Basic concepts – instruction set, branches. | 1 | 2 | 1,3,4 |
| 10 | Interrupts and exceptions. | 1 | 2 | 1,3,4 |
| 11 | Basic elements in instruction handling. | 1 | 2 | 1,3,4 |
| 12 | Minimizing pipeline delays | 1 | 2 | 1,3,4 |
| 13 | Reducing the cost of branches – Robust processors | 1 | 2 | 1,3,4 |
| 14 | Vector processors, VLIW processors | 1 | 2 | 1,3,4 |
| 15 | Superscalar processors. | 1 | 2 | 1,3,4 |
| **Unit 3** | **MEMORY DESIGN** | **9** | | |
| 16 | SoC external memory, SoC internal memory | 1 | 3 | 3 |
| 17 | Scratch pads and cache memory | 1 | 3 | 3 |
| 18 | Cache organization and write policies | 1 | 3 | 2, 3, 4 |
| 19 | Srategies for line replacement at miss time | 1 | 3 | 2,3 |
| 20 | Split I- and D- | 1 | 3 | 3,4 |
| 21 | Caches – multilevel caches | 1 | 3 | 3 |
| **22** | SoC memory systems | **1** | 3 | 1,4 |

| | | | | |
|---|---|---|---|---|
| 23 | Board based memory systems | 1 | 3 | 2 |
| 24 | Simple processor/memory interaction. | 1 | 3 | 2 |
| **Unit 4** | **INTERCONNECT ARCHITECTURES ANDSOCCUSTOMIZATION** | 9 | | 2 |
| 25 | Bus architectures – SoC standard buses. | 1 | 4 | 2 |
| 26 | AMBA, Core Connect. | 1 | 4 | 2,3 |
| **27** | Processor customization approaches. | **1** | 4 | 2,3 |
| 28 | Reconfigurable technologies. | 1 | 4 | 2 |
| 29 | Mapping designs onto reconfigurable devices. | 1 | 4 | 2 |
| 30 | FPGA based design. | 1 | 4 | 2 |
| 31 | Architecture of FPGA. | **1** | 4 | 2 |
| 32 | FPGA interconnect technology. | 1 | 4 | 2,4 |
| 33 | FPGA memory, Floor plan and routing | 1 | 4 | 2,3,4 |
| **Unit 5** | | 9 | | |
| 34 | Hardware software task partitioning – FPGA fabric Immersed Processors | 1 | 5 | 1,2 |
| 35 | Soft Processors and Hard Processors | 1 | 5 | 2,3,4 |
| 36 | Tool flow for Hardware/Software Co-design | 1 | 5 | 2,3 |
| 37 | Interfacing Processor with memory and peripherals | 1 | 5 | 2,3 |
| 38 | Types of On-chip interfaces – Wishbone interface | 1 | 5 | 2,3 |
| 39 | Avalon Switch Matrix. | 1 | 5 | 2,3,4 |
| 40 | OPB Bus Interface | 1 | 5 | 2,3 |
| 41 | Creating a Customized Microcontroller | 1 | 5 | 1,4 |
| 42 | FPGA-based Signal Interfacing and Conditioning. | 1 | 5 | 2,3,4 |
| | **Total Contact hours** | **45** | | |

## Recommended Resources


1. Michael J. Flynn and Wayne Luk**,** "Computer System Design: System-on-Chip", John Wiley and sons,2011.
2. Rahul Dubey, "Introduction to Embedded System Design Using Field Programmable Gate Arrays", Springer Verlag London Ltd.,2009.
3. Sudeep Pasricha and Nikil Dutt, On-Chip Communication Architectures - System on Chip Interconnect, Elsevier, 2008.
4. Steve Furber, System-on-chip Architecture, Addison-Wesley, 2000.


**Learning Assessment**

| **Bloom's Level of Cognitive Task** | **Continuous Learning Assessments (50%)** | | | | | | | | **End Semester Exam (50%)** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **CLA-1 (10%)** | | **Mid-1 (20%)** | | **CLA-II (10%)** | | **CLA-III (10%)** | | | |
| | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Level 1 | Remember | 40% | | 30% | | 40% | | 40% | | 50% | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 60% | | 70% | | 60% | | 60% | | 50% | |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | 100% | | 100% | | 100% | | 100% | | 100% | |

**Course Designers**

*Dr Saswat Kumar Ram. Assistant Professor, Department of Electronics and Communication Engineering, SRM University - AP*

| Course Code | ECE 428 | Course Category | Technical Elective | L-T-P-C | 2 | 0 | 1 | 3 |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | ECE | Professional / Licensing Standards | *VIVADO* | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To introduce the internal architecture of programmable logic with focus on FPGA.
**Objective 2:** To provide knowledge in FPGA design flow at the architectural and system design.
**Objective 3:** To impart a good background in block-based design using standard system level tools.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | At the end of the course the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **Outcome 1** | Ability to understand the structure of the fabric of programmable logic | 2 | 80% | 75% |
| **Outcome 2** | Implement ideas on Placement and Partitioning of Circuits | 3 | 80% | 75% |
| **Outcome 3** | Identify concepts and Algorithms of Floor planning and Routing | 3 | 80% | 75% |
| **Outcome 4** | Develop circuit level techniques and apply in logic Synthesis | 3 | 80% | 75% |
| **Outcome 5** | Working on High Level Synthesis of Circuits | 4 | 80% | 75% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Life Long Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 3 | 3 | 3 | 3 | 1 | | 2 | 1 | | | | 3 | 3 | 1 | 2 |
| Outcome 2 | 3 | 3 | 3 | 3 | 2 | 1 | 2 | 1 | 3 | | | 2 | 3 | 2 | 2 |
| Outcome 3 | 3 | 3 | 3 | 3 | 2 | | 2 | 1 | 3 | | | 3 | 3 | 2 | 2 |
| Outcome 4 | 3 | 3 | 3 | 3 | 2 | 1 | 2 | 1 | 3 | | | 2 | 3 | 2 | 2 |
| Outcome 5 | 3 | 3 | 3 | 3 | 2 | 1 | 2 | 1 | 2 | | | 2 | 3 | 2 | 2 |
| **Course Average** | **3** | **3** | **3** | **3** | **2** | **1** | **2** | **1** | **3** | | | **2** | **3** | **2** | **2** |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Programmable Logic Devices** | **10** | | |
| | PROM - PAL - PLA - CPLD - Gate Arrays - MPGA | 1 | 1 | 1 |
| | FPGA - Programming Technologies - EPROM - EEPROM - FLASH - SRAM - FPGA Fabric | 2 | 1 | 1 |
| | Configurable Logic Block - LUT - Slice - Slicem | 1 | 1 | 1 |
| | Programmable Interconnects - Input Output Blocks - Keeper Circuit - Xilinx 7 Series Architecture. | 2 | 1 | 1 |
| | Introduction to Edge Zynq SoC FPGA Development Board. (Lab Experiment - 1) | 2 | 1 | 4 |
| | Controlling LED in Edge Zynq SoC FPGA Development Board. (Lab Experiment - 2) | 2 | 1 | 4 |
| **Unit 2** | **FPGA Design Flow and Abstraction Levels** | **10** | | |
| | Verilog Design for Synthesis | 1 | 2 | 1 |
| | One Hot Encoding - Memory Blocks - Block Memory Generator (BRAM/BROM) | 2 | 2 | 1 |
| | Single Port Memory - Dual Port Memory | 1 | 2 | 2 |
| | FIFO - Distributed RAM - Synthesis Pitfalls - Latch Inference | 2 | 2 | 2 |
| | Designing Combinational Logic circuits Edge Zynq SoC FPGA Development Board. (Lab Experiment - 3) | 2 | 2 | 5 |
| | Designing Sequential Logic circuits Edge Zynq SoC FPGA Development Board. (Lab Experiment - 4) | 2 | 2 | 5 |
| **Unit 3** | **Static Timing Analysis** | **14** | | |
| | Speed Performance - Timing Constraints | 2 | 3 | 2 |
| | Clock Management - Clock Buffers. | 3 | 3 | 2 |
| | Clock Tree Routing | 3 | 3 | 2 |
| | Control relay using switch on the Edge Zynq Board. (Lab Experiment - 5) | 2 | 3 | 5 |
| | Produce sound at piezo Buzzer at regular interval on Edge Zynq Board. (Lab Experiment - 6) | 2 | 3 | 5 |

| | | | | |
|---|---|---|---|---|
| | LDR Interface using ADC. (Lab Experiment - 7) | 2 | 3 | 5 |
| **Unit 4** | **Introduction to SoC Design** | **10** | | |
| | Hard Macros - Multipliers - DSP Block | 2 | 4 | 3 |
| | Hard Core Processors - Interface Circuits | 2 | 4 | 3 |
| | Configuration Chain - JTAG Interface - Zynq7000 Architecture | 2 | 4 | 3 |
| | 2x16 Liquid Crystal Display Interface. (Lab Experiment - 8) | 2 | 4 | 4 |
| | 4-bit BCD to Seven Segment Display. (Lab Experiment - 9) | 2 | 4 | 4 |
| **Unit 5** | **Timing Simulation and Programming** | **10** | | |
| | Timing Simulation using Modelsim/Icarusverilog, | 2 | 5 | 3 |
| | Programming using JTAG, System Level testing and debugging | 1 | 5 | 3 |
| | Debugging techniques | 1 | 5 | 3 |
| | Debugging using chip scope and Logic analyzers, Protocols on FPGA | 2 | 5 | 3 |
| | Seven Segment Display Counter. (Lab Experiment - 10) | 2 | 5 | 3 |
| | Displays 128x160 pixel image on the SPI TFT Display interfaced to Edge board. (Lab Experiment - 11) | 2 | 5 | 4 |
| | Project | | | |

**Recommended Resources**

. 1. Amano, Hideharu, Principles and Structures of FPGAs, First Edition, Springer, 2018.
2. Readler, Blaine C., Verilog by example: a concise introduction for FPGA design, Full Arc Press, 2011.
3. ZainalabedinNavabi, Embedded Core Design with FPGAs, First Edition, McGraw Hill, 2008.
4. Xilinx Inc, Vivado Design Suite User Guide, 2021.

**Learning Assessment**

| Bloom's Level of Cognitive Task | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | CLA-1 (10%) | | Mid-1 (15%) | | CLA-2 (10%) | | CLA3 (15%) | | | |
| | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Level 1 | Remember | 60% | 30% | 50% | 40% | 60% | 30% | 50% | 40% | 50% | 50% |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 40% | 50% | 50% | 50% | 40% | 60% | 50% | 50% | 40% | 40% |
| | Analyze | | | | | | | | | | |
| Level 3 | Evaluate | | 20% | | 10% | | 10% | | 10% | 10% | 10% |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers**

*Dr. Saswat Kumar Ram, Assistant Professor, Dept of ECE, SRM University - AP*



# Embedded Systems for Electric Vehicles

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | ECE 429 | **Course Category** | Elective | **L-T-P-C** | 3 | 0 | 0 | 3 |

| | | | | | |
|---|---|---|---|---|---|
| **Pre-Requisite Course(s)** | ECE 303 | **Co-Requisite Course(s)** | | **Progressive Course(s)** | |
| **Course Offering Department** | ECE | **Professional / Licensing Standards** | | | |

**Course Objectives**

5. To understand the fundamental concepts of embedded systems and electric vehicles.
6. To know the advanced versions of the microcontrollers and microprocessors
7. To understand the integration of hardware and software from the electric vehicles' perspective
8. To design embedded systems for electric vehicles

**Course Outcome (COs)**

| CO's | At the end of the course the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| 1 | Explain the basics of embedded systems and electric vehicles | 2 | 70% | 65% |
| 2 | Know the usage of the latest microcontrollers and microprocessors | 2 | 65% | 65% |
| 3 | Integrate hardware and software through communication protocols | 3 | 70% | 60% |
| 4 | Know how to design embedded systems for electric vehicles | 2 | 60% | 65% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Engineering Knowledge** | **Problem** | **Design and Development** | **Analysis, Design and** | **Modern Tool and ICT** | **Society and Multicultural** | **Environment and** | **Moral, and Ethical** | **Individual and Teamwork** | **Communication Skills** | **Project Management** | **Self-Directed and Life Long** | **PSO 1** | **PSO 2** | **PSO 3** |
| Outcome 1 | 3 | | | | | | | | | | | | | | |
| Outcome 2 | 3 | 1 | | **1** | | | | | | | | 1 | | | |
| Outcome 3 | 3 | **2** | **2** | **2** | | | | | | | | 1 | 2 | 3 | 2 |
| Outcome 4 | 3 | 3 | **3** | **3** | **3** | | | | | | | 1 | 3 | 3 | 2 |
| **Course Average** | **3** | **2** | **2** | **2** | **3** | | | | | | | **1** | **2** | **3** | **2** |

**Course Unitization Plan**

| Unit No. | Syllabus Topics | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| Unit No. 1 | **INTRODUCTION TO EMBEDDED SYSTEMS AND ELECTRIC VEHICLES** | **7** | 1 | 1,2 |
| | Importance of embedded systems | 1 | 1 | 1,2 |
| | Microcontrollers vs. microprocessors, Real-time systems and applications | 2 | 1 | 1,2 |
| | Glance of electric vehicle technology, Types of electric vehicles – BEV, PHEV, HEV | 2 | 1 | 7 |
| | Constituents of electric vehicles – batteries, motors, controllers | 2 | 1 | 7 |
| Unit No. 2 | **MICROCONTROLLERS AND MICROPROCESSORS** | **11** | 2 | 5,6 |
| | Basic architecture of microcontrollers in EVs | 1 | 2 | 5,6 |
| | Brief of microcontrollers used in EVs – TI C2000 series, Infineon AURIX series, NXP S32K and MPC series, Renesas RH850 series, Microchip PIC32 and dsPIC series, STMicroelectronics STM32 series | 6 | 2 | 5,6 |
| | Interfacing microcontrollers | 4 | 2 | 5,6 |
| Unit No. 3 | **HARDWARE IN ELECTRIC VEHICLES** | **10** | 2 | 7 |
| | Power Electronics - Basics of power electronics, DC-DC converters, inverters, and rectifiers, Motor control techniques and algorithms | 3 | 2 | 7 |
| | Battery Management System - Battery chemistry and characteristics, Constituents of BMS, State of Charge (SoC), and State of Health (SoH) estimation | 4 | 2 | 7 |
| | Electronic motors and control strategies | 3 | 2 | 7 |
| Unit No. 4 | **COMMUNICATION PROTOCOLS IN ELECTRIC VEHICLES** | **9** | 3 | 1,2,3 |
| | Importance of communication protocols in EVs, Evolution of EV communication standards | 2 | 3 | 1,2,3 |
| | Understanding Controller Area Network (CAN), CAN protocol layers and message structure | 3 | 3 | 1,2,3 |
| | EV Charging communication protocols, OCPP, ISO 15118 (Plug and charge) | 3 | 3 | 1,2,3 |
| | Vehicle-to-Grid (V2G) communication, Vehicle-to-Vehicle (V2V) communication, Vehicle-to-Infrastructure (V2I) communication | 1 | 3 | 1,2,3 |
| Unit No. | **EMBEDDED SYSTEM DESIGN FOR ELECTRIC VEHICLES** | **8** | 4 | 4,7 |

| | | | | |
|---|---|---|---|---|
| **5** | Hardware design considerations | 2 | 4 | 4,7 |
| | Software design and development | 2 | 4 | 4,7 |
| | Real-time operating systems (RTOS) and their applications in EVs | 4 | 4 | 4,7 |

**Recommended Resources**


2. Vahid and Givargis,"*Embedded system design: A unified hardware/software introduction*", John Wiley & Sons, Inc. 2002.
3. Raj Kamal, *"Embedded Systems: Architecture, Programming, and Design"*, The McGraw-Hill Companies, Edition 2, 2008.
4. Steve Furber, "*ARM System-on-chip architecture*", Addison-Wesley Publications, 2nd Ed., 2000.
5. Jean J. Labrosse, *"MicroC/OS-II: The Real-Time Kernel"*, CMP Books, Edition 2, 2002.
6. Ramesh S Gaonkar, *"Microprocessor Architecture, Programming and Applications with the 8085",* 6th edition, Penram.
7. D V Hall, *"Microprocessors and Interfacing",* MGH, 2nd edition.
8. Per Enge, Nick Enge, Stephen Zoepf, *"Electric Vehicle Engineering"*, McGraw Hill, 1st edition, 2021.


**Recommended Online Resources**

3. https://skill-lync.com/plus/embedded/embedded-systems-for-ev-applications
4. https://www.udemy.com/course/cortex-m/?couponCode=ST9MT71624

**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (60 %)** | | | | | | | | **End Semester Exam (40 %)** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **CLA-1 (10 %)** | | **CLA-2 (10 %)** | | **CLA-3 (10 %)** | | **Mid Term (30 %)** | | | |
| | | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** |
| Level 1 | Remember | 60% | | 60% | | 60% | | 50% | | 50% | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 30% | | 30% | | 30% | | 30% | | 30% | |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | 10% | | 10% | | 10% | | 20% | | 20% | |
| | Create | | | | | | | | | | |
| **Total** | | 100% | | 100% | | 100% | | 100% | | 100% | |

**Course Designer(s)**

*Dr. Sujith Kalluri, Associate Professor, Dept. Of ECE, SRM University – AP*

# Specialization: VLSI Design

# SRM University – AP, Andhra Pradesh

Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

## VLSI Physical Design

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | ECE 431 | **Course Category** | Technical Elective | **L-T-P-C** | 3 | 0 | 0 | 3 |
| **Pre-Requisite Course(s)** | VLSI Design | **Co-Requisite Course(s)** | | **Progressive Course(s)** | | | | |
| **Course Offering Department** | ECE | **Professional / Licensing Standards** | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To understand the requirements of VLSI automation Tools.
**Objective 2:** To understand the requirements Proper placement and Routing of Circuits.
**Objective 3:** To familiarize with methods and algorithms for efficient Floor Planning and Routing
**Objective 4:** To understand different circuit level techniques for logic synthesis.
**Objective 5:** To understand how high-level synthesis is carried out for proper allocation, scheduling and assignment.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Describe various VLSI Automation Tools | 2 | 70% | 65% |
| **Outcome 2** | Implement ideas on Placement and Partitioning of Circuits | 3 | 70% | 65% |
| **Outcome 3** | Identify concepts and Algorithms of Floor planning and Routing | 3 | 70% | 65% |
| **Outcome 4** | Develop circuit level techniques and apply in logic Synthesis | 3 | 70% | 65% |
| **Outcome 5** | Working on High Level Synthesis of Circuits | 4 | 70% | 65% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Team work Skills | Communication Skills | Project Management and Finance | Self-Directed and Life Long Learning | PSO1 | PSO2 | PSO3 |
| Outcome 1 | 3 | 3 | 3 | 2 | 1 | | 2 | | | | | 3 | 3 | 1 | 2 |
| Outcome 2 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | | 3 | | | 2 | 3 | 2 | 2 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outcome 3 | 3 | 3 | 3 | 2 | 2 | | 2 | | 3 | | | 3 | 3 | 2 | 2 |
| Outcome 4 | 3 | 3 | 3 | 3 | 2 | 1 | 2 | | 3 | | | 2 | 3 | 2 | 2 |
| Outcome 5 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | | 2 | | | 2 | 3 | 2 | 2 |
| **Course Average** | **3** | **3** | **3** | **2** | **2** | **1** | **2** | | **3** | | | **2** | **3** | **2** | **2** |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **VLSI DESIGN AUTOMATION TOOLS** | **16** | | |
| | Algorithms and system design, Structural and logic design | 2 | 1 | 1 |
| | Transistor level design, Layout design | 2 | 1 | 1 |
| | Verification methods | 1 | 1 | 1 |
| | Design management tools | 1 | 1 | 1 |
| | Layout compaction | 2 | 2 | 1 |
| | placement and routing, Pin Assignment | 2 | 2 | 1 |
| | Design rules, symbolic layout, Applications of compaction | 2 | 2 | 2 |
| | Formulation methods, Algorithms for constrained graph compaction | 2 | 2 | 2 |
| | Circuit representation, Wire length estimation, Placement algorithms, Partitioning algorithms | 2 | 2 | 2 |
| **Unit 3** | **FLOOR PLANNING AND ROUTING** | **10** | | |
| | Floor planning concepts | 2 | 3 | 1,2 |
| | Shape functions and floor planning sizing | 2 | 3 | 1,2 |
| | Local routing, Area routing | 2 | 3 | 1,2 |
| | Channel routing | 2 | 3 | 1,2 |
| | Global routing and its algorithms. | 2 | 3 | 1,2 |
| **Unit 4** | **SIMULATION AND LOGIC SYNTHESIS** | **10** | | |

| | | | | |
|---|---|---|---|---|
| | Gate level and switch level modelling and simulation | 1 | 4 | 2,3 |
| | Introduction to combinational logic synthesis | 1 | 4 | 2,3 |
| | STA | 2 | 4 | 2,3 |
| | ROBDD principles, Implementation, construction and manipulation | 2 | 4 | 2,3 |
| | Two level logic synthesis. | 2 | 4 | 3,4 |
| | Timing Closure | 2 | 4 | 3,4 |
| **Unit 5** | **HIGH-LEVEL SYNTHESIS** | **11** | | |
| | Hardware model for high level synthesis | 2 | 5 | 3,4 |
| | Internal representation of input algorithms | 1 | 5 | 3,4 |
| | Allocation, assignment, and scheduling | 2 | 5 | 3,4 |
| | Scheduling algorithms, Aspects of assignment | 1 | 5 | 3,4 |
| | High level transformations | 1 | 5 | 3,4 |

**Recommended Resources**


1. S.H. Gerez, "Algorithms for VLSI Design Automation", John Wiley ,1998.
2. N.A.Sherwani , "Algorithms for VLSI Physical Design Automation", (3/e), Kluwer,1999..
3. S.M. Sait , H. Youssef, "VLSI Physical Design Automation", World scientific, 1999
4. cadence.com/content/dam/cadence-www/global/en_US/documents/tools/digital-design-signoff/innovus-implementation-system-ds.pdf


**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (60%) | | | | | | | | End Semester Exam (40%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (15%) | | Mid-1 (15%) | | CLA-2 (15%) | | Mid-2 (15%) | | | |
| | | **Th** | | Th | | **Th** | | **Th** | | **Th** | |
| Level 1 | Remember | 60% | | 50% | | 60% | | 50% | | 40% | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 40% | | 50% | | 40% | | 50% | | 60% | |
| | Analyze | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designers**


*Dr. Ramesh Vaddi, Associate Professor, Dept of ECE, SRM University – AP*

**SRM University – AP, Andhra Pradesh**
Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

# Advanced CMOS Digital IC Design

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | ECE 432 | **Course Category** | Elective | **L-T-P-C** | 3 | 0 | 0 | 3 |
| **Pre-Requisite Course(s)** | ECE 320 | **Co-Requisite Course(s)** | TEC | **Progressive Course(s)** | | | | |
| **Course Offering Department** | ECE | **Professional / Licensing Standards** | | | | | | |

**Course Objectives**

1. To study advanced concepts of CMOS Digital Design. It will be helpful for the students when they work in VLSI industries or R&D's.
2. To cover crucial real world system design issues such as signal integrity, power dissipation, interconnect packaging, timing and synchronization.
3. To provide unique coverage of the latest design methodologies and tools.
4. To learn Low-power design concepts and voltage-frequency scaling.

**Course Outcome (COs)**

| CO's | At the end of the course the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| 1 | To understand the fundamental principles of CMOS technology, including the operation of MOS transistors, logic gates, and basic building blocks. | 2 | 75% | 65% |
| 2 | Modelling and estimation of R, C, and L parasitic, effect of technology scaling, sheet resistance, techniques to cope with ohmic drop and capacitive cross talk, estimating RC delay, and inductive effects. | 1 | 75% | 65% |
| 3 | Several lab team assignments to design actual VLSI subsystems from high-level specifications, culminating in a course project involving the software design of a modest complexity chip. | 3 | 75% | 65% |
| 4 | Several homework assignments based on core concepts and reinforcing analytical skills learned in class. | 3 | 75% | 65% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Engineering Knowledge** | **Problem** | **Design and Development** | **Analysis, Design and** | **Modern Tool and ICT** | **Society and Multicultural** | **Environment and** | **Moral, and Ethical** | **Individual and Teamwork** | **Communication Skills** | **Project Management** | **Self-Directed and Life Long** | **PSO 1** | **PSO 2** | **PSO 3** |
| Outcome 1 | 3 | 2 | 3 | 3 | 2 | - | - | - | - | - | 3 | 3 | 2 | 1 | 2 |
| Outcome 2 | 3 | 3 | 3 | 3 | 2 | 3 | 1 | - | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| Outcome 3 | 3 | 2 | 1 | 1 | 1 | - | - | - | 1 | - | 2 | 3 | 1 | 1 | 1 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outcome 4 | 3 | 2 | 1 | 2 | 2 | - | - | - | 1 | - | 2 | 3 | 1 | 1 | 3 |
| **Course Average** | **3** | **2** | **3** | **2** | **2** | **3** | **1** | **-** | **3** | **2** | **3** | **3** | **2** | **2** | **3** |

**Course Unitization Plan**

| Unit No. | Syllabus Topics | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| Unit No. 1 | **INTRODUCTION, THE WIRE, COPING WITH INTERCONNECT** | **9** | | |
| | Impact of Interconnect Parasitic | 2 | 1,2 | 1,2 |
| | Impact of Resistance, | 2 | 1 | 1 |
| | Impact of Capacitance, Crosstalk | 2 | 1,2 | 1 |
| | Reducing RC-delay | 1 | 1 | 1 |
| | Dealing with inductance | 2 | 1,2 | 1,3 |
| Unit No. 2 | **DESIGNING SEQUENTIAL LOGIC CIRCUITS** | **12** | | |
| | Self-Timed Circuit Design, Self-Timed Signaling, Muller-C Element, Two Phase Handshake Protocol, Self-Resetting CMOS, Synchronizer | 2 | 1 | 1,2,3 |
| | Designing Latch and Edge triggered Register using different approaches, Clock Overlaps, C2MOS Logic, TSPC Logic | 2 | 1,2 | 2,3 |
| | Specialized edge-triggered TSPCR | 2 | 1,2 | 1 |
| | Pulse Registers, Pipelining | 2 | 1,2 | 1,3 |
| | Designing Schmitt Trigger and multi-vibrators, | 2 | 1,2 | 2,3 |
| | Design Techniques for large Fan in, Sizing combinational circuits for minimum delay, | 2 | 3 | 1,2 |
| Unit No. 3 | **RATIOED LOGIC** | **6** | | |
| | DCVSL | 2 | 1 | 1,2,3 |
| | Pass transistor Logic | 2 | 1,2 | 2,3 |
| | Differential Pass Transistor Logic | 2 | 1,2 | 1 |
| Unit No. 4 | **ARITHMETIC CIRCUITS** | **9** | | |
| | Adders- Ripple-Carry Adder, Complimentary Static CMOS FullAdder, | 1 | 1,2 | 3,4 |
| | Mirror Adder, Transmission Gate Full Adder | 1 | 1 | 4 |
| | Carry-Bypass Adder, Carry-Select Adder | 2 | 1 | 4 |
| | Logarithmic Look-Ahead Adder, Tree Adders | 2 | 1,2 | 4 |
| | Multipliers (Array Multiplier, Wallace-Tree Multiplier, Booths Multiplier Algo) | 2 | 1,2 | 3,4 |
| | Shifters (Barrel Shifter, Logarithmic Shifter). | 1 | 3 | 3,4 |
| Unit No. 5 | **SEMICONDUCTOR MEMORIES** | **9** | | |
| | Memory Timing, Memory Architecture, Read-Only Memory Cells | 1 | 4 | 1,5 |
| | MOS OR ROM, MOS NOR ROM, MOS NAND ROM | 2 | 4 | 2,5 |
| | Dual Data rate Synchronous Dynamic RAM | 2 | 4 | 5 |
| | DRAM Timing, Sources of Power Dissipation in Memories, Data Retention in SRAM | 2 | 4 | 5 |
| | Suppressing Leakage in SRAM, Data Retention in DRAM | 2 | 4 | 3,5 |

**Recommended Resources**


1. J. Rabaey, A. Chandrakasan and Nikolic, B., Digital Integrated Circuits – A Design perspective, Pearson Education (2007) 2nd ed.
2. John P. Uyemura; "Introduction to VLSI Circuits and Systems", John Wiley & Sons, Inc, 2002.
3. Kang, S. and Leblebici, Y., CMOS Digital Integrated Circuits – Analysis and Design, Tata McGraw Hill
4. Weste, N.H.E. and Eshraghian, K., CMOS VLSI Design: A Circuits and Systems Perspective, eddision Wesley (1998) 2nd ed.
5. Baker, R.J., Lee, H. W. and Boyce, D. E., CMOS Circuit Design, Layout and Simulation, Wiley - IEEE Press (2004) 2nd ed.


**Web Resources**

1. URL1:- http://nptel.ac.in/courses/117106092/
2. URL2:- http://nptel.ac.in/courses/117106093/

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (60 %) | | | | | | | | End Semester Exam (40 %) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (10 %) | | CLA-2 (10 %) | | CLA-3 (10 %) | | Mid Term (30 %) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 60% | | 60% | | 60% | | 50% | | 50% | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 30% | | 30% | | 30% | | 30% | | 30% | |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | 10% | | 10% | | 10% | | 20% | | 20% | |
| | Create | | | | | | | | | | |
| **Total** | | 100% | | 100% | | 100% | | 100% | | 100% | |

**Course Designer(s)**


*Dr. Pradyut Kumar Sanki, Associate Professor, Dept. Of ECE, SRM University – AP*

# SRM University – AP, Andhra Pradesh

Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

## CMOS RFIC Design

| Course Code | ECE 433 | Course Category | CC | L-T-P-C | 3 | 0 | 0 | 3 |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | ECE301 | Co-Requisite Course(s) | VLSI Analog IC Design | Progressive Course(s) | | | | |
| Course Offering Department | ECE | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To understand the fundamentals of RFIC design and its applications in wireless communication systems.

**Objective 2:** To learn CMOS technology basics and its suitability for RF applications.

**Objective 3:** To gain proficiency in designing and optimizing RF building blocks such as amplifiers, mixers, oscillators, and filters.

**Objective 4:** To develop skills in simulation and verification of RFIC designs using CAD tools.

**Objective 5:** To explore advanced topics in RFIC design, including noise analysis, linearity, and power management.

**Objective 6:** To Apply design methodologies to achieve desired specifications for wireless transceivers.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | At the end of the course, the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **Outcome 1** | Understand the fundamental of analog IC Design, including the single-stage amplifiers and Differential Amplifiers | 1,2 | 85% | 80% |
| **Outcome 2** | Design operational amplifiers and performance of various Op-Amp topologies | 3 | 80% | 75% |
| **Outcome 3** | Create layout designs for operational amplifier circuits and understand the stability in feedback system and noise performance | 3 | 85% | 70% |
| **Outcome 4** | Apply theoretical knowledge to real-world analog and digital converter IC design projects | 3 | 80% | 70% |
| **Outcome 5** | Explore emerging trends in RFIC design including mm-wave and high-frequency applications. | 3 | 80% | 70% |
| **Outcome 6** | Collaborate in teams to solve design challenges and implement solutions in RFIC design projects. | 3 | 80% | 70% |

**Course Articulation Matrix: (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Design / Development of | Conduct Investigations of | Modern Tool Usage | The Engineer and Society | Environment and Sustainability | Ethics | Individual and Team Work | Communication | Life-long Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 3 | 2 | 2 | 2 | 2 | -- | -- | -- | -- | 3 | 3 | 2 | 2 |
| Outcome 2 | 3 | 3 | 3 | 2 | 2 | -- | -- | -- | -- | 3 | 2 | 3 | 2 |
| Outcome 3 | 3 | 3 | 3 | 3 | 2 | -- | -- | 2 | -- | 2 | 3 | 3 | 2 |
| Outcome 4 | 3 | 3 | 3 | 3 | 2 | -- | -- | 3 | -- | 3 | 3 | 3 | 3 |
| Outcome 5 | | | | | | | | | | | | | |
| Outcome 6 | | | | | | | | | | | | | |
| **Course Average** | **3.00** | **2.75** | **2.75** | **2.50** | **2.00** | **--** | **--** | **1.25** | **--** | **2.75** | **2.75** | **2.75** | **2.25** |

**Course Unitization Plan -Theory**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References |
|---|---|---|---|---|
| **Unit 1** | **Introduction to RFIC Design** | **10** | | |
| | Overview of RF systems and applications | 2 | 1 | 1,2 |
| | Challenges in RFIC design and performance metrics | 2 | 1 | 1,2 |
| | CMOS Technology Basics for RFICs | 2 | 1 | 1,2 |
| | Overview of CMOS process technology | 2 | 1 | 1,2 |
| | Impact of technology scaling on RF performance | 2 | 1,3 | 1,2 |
| **Unit 2** | **RFIC Building Blocks and Passive RF Components** | **9** | | |
| | Low Noise Amplifiers (LNAs) | 1 | 1 | 1,2 |
| | Mixers and frequency synthesizers | 2 | 1 | 1,2 |
| | Power amplifiers (PAs) and modulators | 2 | 1 | 1,2 |
| | Inductors, capacitors, and transmission lines in CMOS | 2 | 1 | 1,2 |
| | Modeling and layout considerations for passive components | 2 | 2,3 | 1,2 |
| **Unit 3** | **RFIC Design Methodologies, Simulation and Characterization** | **9** | | |
| | Design specifications and trade-offs | 1 | 2 | 1,2 |
| | Transistor-level design techniques (e.g., cascode, current mirrors) | 2 | 1,2 | 1,2 |
| | CAD tools for RFIC design (e.g., ADS, Cadence Virtuoso) | 3 | 2 | 1,2 |
| | Noise analysis, linearity, and stability analysis | 3 | 2 | 1,2 |
| **Unit 4** | **Advanced RFIC Design, Testing and Validation** | **9** | | |
| | Frequency planning and synthesis | 1 | 1 | 1,2 |
| | Phase-locked loops (PLLs) and clock generation circuits | 2 | 1,2 | 1,2 |
| | Nonlinear distortion and intermodulation analysis | 2 | 2 | 1,2,3 |
| | Test methodologies and measurement techniques | 2 | 2,3 | 1,2,3 |

| | | | | |
|---|---|---|---|---|
| | Yield analysis and reliability considerations | 2 | 3 | 1,2,3 |
| **Unit 5** | **Case Studies and Applications** | **8** | | |
| | Design examples of RF front-end circuits (e.g., for wireless communication standards) | 4 | 3,4 | 2,3 |
| | Emerging trends in RFIC design (e.g., IoT, mm-wave applications) | 4 | 3,4 | 2,3 |
| | **Total** | **45** | | |

**Recommended Texts and References**


1. Razavi, B., & Behzad, R. (2012). RF microelectronics (Vol. 2, pp. 255-333). New York: Prentice hall.
2. Yuan, J. S. (2016). CMOS RF Circuit Design for Reliability and Variability. Springer.
3. Research papers and application notes from semiconductor manufacturers


**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (50%)** | | | | **End Semester Exam (50%)** |
|---|---|---|---|---|---|---|
| | | **CLA-1 (10%)** | **Mid-1 (15%)** | **CLA-2 (15%)** | **CLA-3 (10%)** | |
| Level 1 | Remember | 60% | 50% | -- | 50% | 40% |
| | Understand | | | | | |
| Level 2 | Apply | 40% | 50% | 60% | 30% | 40% |
| | Analyse | | | | | |
| Level 3 | Evaluate | -- | -- | 40% | 20% | 20% |
| | Create | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designer(s)**


*Dr. M. Durga Prakash, Associate Professor, Dept. Of ECE. SRM University - AP*

**SRM University – AP, Andhra Pradesh**
Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

# Design Verification and Testing

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | ECE 436 | **Course Category** | **Technical Elective (TE)** | **L-T-P-C** | **3** | **0** | **0** | **3** |
| **Pre-Requisite Course(s)** | ENG 211<br>ECE 320 | **Co-Requisite Course(s)** | | **Progressive Course(s)** | | | | |
| **Course Offering Department** | ECE | **Professional / Licensing Standards** | | | | | | |

**PURPOSE:** To provide necessary knowledge and skills to ensure the successful design, manufacturing, and deployment of highly reliable and efficient integrated circuits in modern electronic devices

**COURSE OBJECTIVES / COURSE LEARNING RATIONALES (CLRS):**

**Objective 1 (To ensure Quality and Reliability):** As VLSI circuits become more complex and denser, the likelihood of defects and errors increases. Testing and verification techniques are employed to ensure that the fabricated chips meet the desired specifications and are free from manufacturing defects. This is crucial to ensure the overall quality and reliability of the integrated circuits used in various electronic devices.

**Objective 2 (To detect and Fix Design Errors):** During the design phase of VLSI circuits, errors and bugs can be introduced inadvertently. Proper testing and verification processes help identify these design errors early in the development cycle. This allows designers to correct the mistakes before the chips are manufactured; thus, saving time and costs associated with rework.

**Objective 3 (Functional Verification):** VLSI circuits are designed to perform specific functions. This subject is focused on verifying that these functions are correctly implemented and that the chip behaves as intended under various operating conditions.

**Objective 4 (Performance Analysis):** VLSI Testing and Verification also involve assessing the performance of the integrated circuits. This includes verifying that the chips meet the required speed, power, and area constraints specified during the design phase.

**Objective 5 (To know about the Test Methodologies and Techniques):** This subject will also cover various test methodologies and techniques used to evaluate the performance and functionality of VLSI circuits. This includes design for testability (DFT), built-in self-test (BIST), automatic test pattern generation (ATPG), and scan-based testing, among others.

**Objective 6 (Fault Models and Test Coverage):** Understanding and dealing with different fault models are essential for designing effective tests to identify potential defects in VLSI circuits. This subject will cover various fault models and techniques to achieve high test coverage.

**Objective 7 (Manufacturability and Yield Enhancement):** Testing and verification are critical for assessing the manufacturability of VLSI circuits and improving yield during the chip fabrication process. A higher yield means fewer defective chips, leading to cost savings and better overall productivity.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | At the end of the course, the learner will | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **Outcome 1** | have a solid understanding of testing methodologies, verification techniques, and design-for-testability principles | 2 | 80% | 70% |
| **Outcome 2** | acquire confidence to work on real-world projects, use industry-standard tools, and simulate various testing scenarios | 3 | 80% | 70% |
| **Outcome 3** | gain insights into the current trends and challenges in VLSI Testing and Verification, such as dealing with increased complexity, power constraints, and manufacturing defects | 4 | 75% | 65% |
| **Outcome 4** | be able to explore career opportunities in the semiconductor industry, particularly in roles related to design verification, validation, and test engineering | 4 | 70% | 60% |

**Course Articulation Matrix: (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Design / Development of | Conduct Investigations of | Modern Tool Usage | The Engineer and Society | Environment and Sustainability | Ethics | Individual and Team Work | Communication | Life-long Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 3 | 2 | 2 | 3 | 2 | 2 | 1 | 3 | 3 | 3 | 2 | 3 | 2 |
| Outcome 2 | 3 | 3 | 2 | 3 | 2 | 2 | 1 | 2 | 2 | 3 | 2 | 3 | 2 |
| Outcome 3 | 3 | 3 | 2 | 3 | 2 | 2 | 1 | 3 | 2 | 3 | 2 | 3 | 2 |
| Outcome 4 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 3 | 2 | 3 | 2 | 3 | 3 |
| **Course Average** | **3** | **2.5** | **2** | **2.75** | **2** | **2** | **1** | **2.75** | **2.25** | **3** | **2** | **3** | **2.25** |

**Course Unitization Plan**

| Unit No. | Description of Topic | Required Contact Hours | CLOs addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **INTRODUCTION TO TESTING AND VERIFICATION** | **7** | 1, 3 | 1, 2 |
| | VLSI design flow | 1 | | |
| | Overview of Verification and Testing | | | |
| | Need of pre-silicon verification | | | |
| | Need of post-silicon validation and debug | | | |
| | VLSI Testing needs and challenges | 1 | | |
| | Possible Outcome of Testing | | | |
| | Stages of IC Product | | | |

| | | | | |
|---|---|---|---|---|
| | Types of Testing: Implicit, Explicit | | | |
| | Production Test | 1 | | |
| | Characterization Test | 1 | | |
| | Reliability Test | 1 | | |
| | Test Quality Measures | 1 | | |
| | Yield and defects | | | |
| | Scope of testing and verification in VLSI design process | 1 | | |
| | Issues in test and verification of complex chips | | | |
| **Unit 2** | **FAULT MODELING AND FAULT SIMULATION** | **12** | | |
| | Overview of Defect, Fault, Error, Failure | 1 | 1, 3 | 3, 4, 7, 8 |
| | Random and Systematic defects | | | |
| | Overview of Test pattern, Test Set, Test Length, Fault Coverage | | | |
| | Importance of Fault modeling | | | |
| | Introduction to Fault models | 1 | | |
| | Single stuck-at-fault model | | | |
| | Fanout stem and branch for Stuck-at-fault model | | | |
| | Multiple stuck at fault | 1 | | |
| | Bridging faults | | | |
| | Bridging fault models: Wired-OR, Wired-AND, A-Dominant | 2 | | |
| | Feedback bridging faults | 2 | | |
| | Fanout Stem and Branch for Bridge Fault | | | |
| | Permanent and Transient Bridge Fault | | | |
| | Delay fault and its detection | 2 | | |
| | Delay fault models Introduction | | | |
| | Path delay fault: Falling transition, Rising transition | | | |
| | Transition delay fault: Slow-to-rise (STR) and slow-to-fall (STF) | 1 | | |
| | Overview of Transistor level or Switch level fault model | 1 | | |
| | Stuck-open fault | | | |
| | Stuck-short fault | | | |
| | Fault Simulation Overview | 1 | | |
| | Yield and Fault Equivalence | | | |
| **Unit 3** | **TESTABILITY MEASURES AND ANALYSIS** | **6** | | |
| | Introduction and need of testability measures | 1 | 1, 3, 4 | 2, 7 |
| | Testability Components: Controllability and Observability | | | |
| | Overview of Testability Analysis | | | |
| | Topology-based Analysis | 2 | | |
| | SCOAP: Combinational Controllability and Combinational Observability | | | |
| | Probability-based Analysis | 2 | | |

| | | | | |
|---|---|---|---|---|
| | COP: Combinational Controllability and Combinational Observability | | | |
| | High-level Analysis | 1 | | |
| **Unit 4** | **ATPG AND DESIGN FOR TESTABILITY METHODS** | **14** | 1, 2, 3 | 5, 6, 7, 8, 9 |
| | Test pattern generation Overview: Random and Deterministic | 1 | | |
| | Automatic test pattern generation: Complete and Incomplete ATPG | | | |
| | Combinational ATPG Introduction | 2 | | |
| | Boolean Difference Method | | | |
| | SAT | 1 | | |
| | Path-sensitization Method | 2 | | |
| | Single Path Sensitization | | | |
| | Multiple Path Sensitization | | | |
| | D Algorithm | 1 | | |
| | PODEM | 1 | | |
| | FAN | 1 | | |
| | Sequential ATPG Introduction | 3 | | |
| | Scan design | | | |
| | Issues in Scan Design | | | |
| | Test interface and boundary scan | | | |
| | Iddq testing | | | |
| | Delay fault testing | 2 | | |
| | Built-in Self-Test | | | |
| **Unit 5** | **DESIGN VERIFICATION** | **6** | 3, 4 | 7, 8, 10 |
| | Design verification techniques: Introduction | 1 | | |
| | Techniques based on simulation approach | | | |
| | Techniques based on analytical approach | 1 | | |
| | Techniques based on formal approach | 1 | | |
| | Functional verification | 3 | | |
| | Timing verification | | | |
| | Formal verification | | | |
| **Total Contact Hours: 45** | | | | |

| **TEXTBOOKS/REFERENCE BOOKS** | |
|---|---|
| 1 | L.T. Wang, C.W. Wu, and X. Wen, "*VLSI Test Principles and Architectures*", Morgan Kaufmann, 2006 |
| 2 | M.L. Bushnell and V.D. Agrawal, *"Essentials of electronic testing,"* Kluwer Academic Publishers, 2000 |
| 3 | George W. Zobrist, VLSI Fault Modeling and Testing Techniques (VLSI Design Automation Series), Praeger Publishers Inc, 1993 |

| | |
|---|---|
| 4 | RL Wadsack, "Fault modeling and logic simulation of CMOS and MOS integrated circuits" Bell System Technology, 1978 |
| 5 | Hideo Fujiwara, Logic testing and design for testability, MIT Press, 1985 |
| 6 | M. Abramovici, M. A. Breuer and A.D. Friedman, "*Digital systems testing and testable design*," IEEE Press,1994 |
| 7 | P. K. Lala, "Digital Circuits Testing and Testability", Academic Press |
| 8 | Stephan Eggersgluss and Rolf Drechsler, High Quality Test Pattern Generation and Boolean Satisfiability, Springer, 2012 |
| 9 | P.H. Bardell, W.H. McAnney, and J. Savior, "Built-in Test for VLSI: Pseudorandom Techniques," Wiely Interscience, 1987 |
| 10 | Khosrow Golshan, Physical Design Essentials: An ASIC Design Implementation Perspective, Springer, 2007 |

**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (60%)** | | | | **End Semester Exam (40%)** |
|---|---|---|---|---|---|---|
| | | **CLA-1 (15%)** | **Mid-1 (15%)** | **CLA-2 (10%)** | **CLA-3 (20%)** | |
| Level 1 | Remember | 65% | 50% | 45% | 60% | 50% |
| | Understand | | | | | |
| Level 2 | Apply | 35% | 50% | 55% | 40% | 50% |
| | Analyse | | | | | |
| Level 3 | Evaluate | | | | | |
| | Create | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designer**

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Guntur District, Mangalagiri, Andhra Pradesh 522240

# Nanoelectronics

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | ECE 437 | **Course Category** | CE/SE | **L-T-P-C** | **3** | **0** | **0** | **3** |
| **Pre-Requisite Course(s)** | Basic Electronics, Microelectronic Devices and Circuits | **Co-Requisite Course(s)** | - | **Progressive Course(s)** | Quantum Mechanics | | | |
| **Course Offering Department** | ECE | **Professional / Licensing Standards** | IEEE, COMSOL, Microsoft | | | | | |

**Course Objectives**

1. To gain an in-depth understanding of design techniques of nanoscale transistors and the effect of nanoscale phenomena on the behavior of electronic devices.
2. To understand and analyze various fabrication and characterization methods for nanoscale electronic devices.
3. To explore the challenges and strategies involved in integrating nanoscale devices into existing microelectronics and nanotechnology platforms.
4. To gain the knowledge and skills needed to contribute to cutting-edge research, technology development, and innovation in the rapidly evolving field of semiconductor devices and nanoelectronics.

**Course Learning Outcome (CLOs)**

| CO's | At the end of the course the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **1** | Understand the design techniques of nanoscale transistors and effect of nanoscale phenomena on the behavior of electronic devices. | **3** | 80% | 75% |
| **2** | Understand and analyze various fabrication and characterization techniques for nanoscale electronic devices. | **2** | 80% | 70% |
| **3** | Explore the challenges and strategies involved in integrating nanoscale devices into existing microelectronics and nanotechnology platforms. | **2** | 85% | 70% |
| **4** | Gain the knowledge and skills needed to contribute to cutting-edge research, technology development, and innovation in the rapidly evolving field of semiconductor devices and nanoelectronics. | **2** | 75% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem | Design and Development | Analysis, Design and | Modern Tool and ICT | Society and Multicultural | Environment and | Moral, and Ethical | Individual and Teamwork | Communication Skills | Project Management | Self-Directed and Life Long | PSO 1 | PSO 2 | PSO 3 |
| **Outcome 1** | 3 | 3 | 2 | 3 | 2 | | 1 | | 2 | 3 | 1 | 2 | 1 | 1 | 2 |
| **Outcome 2** | 3 | 2 | 1 | 1 | 2 | | 1 | | 2 | 2 | 2 | 2 | 1 | 2 | 2 |
| **Outcome 3** | 2 | 2 | 1 | 2 | 1 | | 1 | | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **Outcome 4** | 2 | 2 | 1 | 2 | 1 | | 1 | | 2 | 2 | 2 | 3 | 2 | 2 | 2 |
| **Course Average** | **3** | **2** | **1** | **2** | **2** | | **1** | | **2** | **2** | **2** | **2** | **2** | **2** | **2** |

**Course Unitization Plan**

| Unit No. | Syllabus Topics | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | CMOS Scaling Theory | 1 | 1,4 | 2,3,4 |
| | Short Channel Effects | 1 | 1,4 | 2,3,4 |
| | Subthreshold Conduction & Drain Induced Barrier Lowering | 1 | 1,4 | 2,3,4 |
| | Channel and Source Drain Engineering | 1 | 1,4 | 2,3,4 |
| | CMOS Process Flow | 2 | 1,4 | 2,3,4 |
| | Gate Oxide Scaling and Reliability | 1 | 1,4 | 2,3,4 |
| | Metal Gate Transistor | 1 | 1,4 | 2,3,4 |
| | Industrial CMOS Technology | 2 | 1,4 | 2,3,4 |
| **Unit 2** | Ideal MOS C-V Characteristics | 1 | 1,3,4 | 2,3,4 |
| | Effect of Non Idealities on C-V | 1 | 1,3,4 | 2,3,4 |
| | MOS Parameter Extraction from C-V and I-V Characteristics | 1 | 1,3,4 | 2,3,4 |

| | | | | |
|---|---|---|---|---|
| | MOS Parameter Extraction from I-V Characteristics | 1 | 1,3,4 | 2,3,4 |
| | Interface State Density Effects on Short Channel Effects and Drain-Induced Barrier Lowering | 2 | 1,3,4 | 2,3,4 |
| | Velocity Saturation, Ballistic Transport and Velocity Overshoot Effects | 2 | 1,3,4 | 2,3,4 |
| **Unit 3** | Need for Metal-Semiconductor contact Source/Drain Junction in Nanoscale MOSFETs | 1 | 1,3,4 | 1,2,4 |
| | Rectifying and Ohmic Contacts and Challenges in Source-Drain MOSFET Technology | 1 | 1,3,4 | 1,2,4 |
| | Effect of Interface States and Fermi Level Pinning on MS Contacts | 2 | 1,3,4 | 1,2,4 |
| | Challenges in Germanium Technology | 1 | 1,3,4 | 1,2,4 |
| | Natural Language Processing (NLP) in Healthcare | 1 | 1,3,4 | 1,2,4 |
| | Compound Semiconductors and Heterojunction FETs for High Performance | 2 | 1,3,4 | 1,2,4 |
| | Heterojunctions and High Electron Mobility Transistors | 2 | 1,3,4 | 1,2,4 |
| **Unit 4** | Basic Principles of Quantum Mechanics | 4 | 1,3,4 | 1,2,4 |
| | Energy Bands in Crystalline Solids | 4 | 1,3,4 | 1,2,4 |
| | Quantum Structure and Devices | 4 | 1,3,4 | 1,2,4 |
| **Unit 5** | Crystal Growth and Nanocrystals | 2 | 2,4 | 1,2,4 |
| | Nanocrystals and Nanostructured Thin Films | 2 | 2,4 | 1,2,4 |
| | Nanowires and Other Nanostructures | 2 | 2,4 | 1,2,4 |
| | Chemical Vapour Deposition (CVD) and Atomic Layer Deposition (ALD) | 2 | 2,4 | 1,2,4 |
| | Characterization of Nanomaterials | 2 | 2,4 | 1,2,4 |
| **Total Hours** | | **50** | | |

**Recommended Resources**

1. "Fundamentals of Modern VLSI Devices" by Taur and Ning, Cambridge University Press.
2. "Solid State Electronic Devices" by Streetman and Banerjee.
3. "Fundamentals of Electronic Devices" by Achutan and Bhat, McGraw Hill.
4. "MOS Physics and Technology" by E.H. Nicollian and J.R. Brews, Wiley Publishers.

**Other Resources**

1. Silicon VLSI Technology: Fundamentals, Practice and Modelling by James D. Plummer, Michael D. Deal, Peter B. Griffin.
2. Advanced Semiconductor Fundamentals, Second Edition, by Robert F. Pierret, Pearson Education, Inc. (1983).

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | End Semester Exam (50%) |
|---|---|---|---|---|---|---|
| | | CLA-1 (20%) | Mid-1 (20%) | CLA-2 (5%) | CLA-3 (5%) | |
| Level 1 | Remember | 70 | 50 | 40 | 40 | 60 |
| | Understand | | | | | |
| Level 2 | Apply | 30 | 50 | 40 | 40 | 40 |
| | Analyse | | | | | |
| Level 3 | Evaluate | | | 20 | 20 | |
| | Create | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designer(s)**

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# Nanoelectronics

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | VLS 484 | **Course Category** | CE/SE | **L-T-P-C** | **3** | **0** | **0** | **3** |
| **Pre-Requisite Course(s)** | Basic Electronics, Microelectronic Devices and Circuits | **Co-Requisite Course(s)** | - | **Progressive Course(s)** | Quantum Mechanics | | | |
| **Course Offering Department** | ECE | **Professional / Licensing Standards** | IEEE, COMSOL, Microsoft | | | | | |

**Course Objectives**

1. To gain an in-depth understanding of design techniques of nanoscale transistors and the effect of nanoscale phenomena on the behavior of electronic devices.
2. To understand and analyze various fabrication and characterization methods for nanoscale electronic devices.
3. To explore the challenges and strategies involved in integrating nanoscale devices into existing microelectronics and nanotechnology platforms.

4. To gain the knowledge and skills needed to contribute to cutting-edge research, technology development, and innovation in the rapidly evolving field of semiconductor devices and nanoelectronics.

**Course Learning Outcome (CLOs)**

| CO's | At the end of the course the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **1** | Understand the design techniques of nanoscale transistors and effect of nanoscale phenomena on the behavior of electronic devices. | **3** | 80% | 75% |
| **2** | Understand and analyze various fabrication and characterization techniques for nanoscale electronic devices. | **2** | 80% | 70% |
| **3** | Explore the challenges and strategies involved in integrating nanoscale devices into existing microelectronics and nanotechnology platforms. | **2** | 85% | 70% |
| **4** | Gain the knowledge and skills needed to contribute to cutting-edge research, technology development, and innovation in the rapidly evolving field of semiconductor devices and nanoelectronics. | **2** | 75% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem | Design and Development | Analysis, Design and | Modern Tool and ICT | Society and Multicultural | Environment and | Moral, and Ethical | Individual and Teamwork | Communication Skills | Project Management | Self-Directed and Life Long | PSO 1 | PSO 2 | PSO 3 |
| **Outcome 1** | 3 | 3 | 2 | 3 | 2 | | 1 | | 2 | 3 | 1 | 2 | 1 | 1 | 2 |
| **Outcome 2** | 3 | 2 | 1 | 1 | 2 | | 1 | | 2 | 2 | 2 | 2 | 1 | 2 | 2 |
| **Outcome 3** | 2 | 2 | 1 | 2 | 1 | | 1 | | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **Outcome 4** | 2 | 2 | 1 | 2 | 1 | | 1 | | 2 | 2 | 2 | 3 | 2 | 2 | 2 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Average** | **3** | **2** | **1** | **2** | **2** | | **1** | | **2** | **2** | **2** | **2** | **2** | **2** | **2** |

**Course Unitization Plan**

| Unit No. | Syllabus Topics | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | CMOS Scaling Theory | 1 | 1,4 | 2,3,4 |
| | Short Channel Effects | 1 | 1,4 | 2,3,4 |
| | Subthreshold Conduction & Drain Induced Barrier Lowering | 1 | 1,4 | 2,3,4 |
| | Channel and Source Drain Engineering | 1 | 1,4 | 2,3,4 |
| | CMOS Process Flow | 2 | 1,4 | 2,3,4 |
| | Gate Oxide Scaling and Reliability | 1 | 1,4 | 2,3,4 |
| | Metal Gate Transistor | 1 | 1,4 | 2,3,4 |
| | Industrial CMOS Technology | 2 | 1,4 | 2,3,4 |
| **Unit 2** | Ideal MOS C-V Characteristics | 1 | 1,3,4 | 2,3,4 |
| | Effect of Non Idealities on C-V | 1 | 1,3,4 | 2,3,4 |
| | MOS Parameter Extraction from C-V and I-V Characteristics | 1 | 1,3,4 | 2,3,4 |
| | MOS Parameter Extraction from I-V Characteristics | 1 | 1,3,4 | 2,3,4 |
| | Interface State Density Effects on Short Channel Effects and Drain-Induced Barrier Lowering | 2 | 1,3,4 | 2,3,4 |
| | Velocity Saturation, Ballistic Transport and Velocity Overshoot Effects | 2 | 1,3,4 | 2,3,4 |
| **Unit 3** | Need for Metal-Semiconductor contact Source/Drain Junction in Nanoscale MOSFETs | 1 | 1,3,4 | 1,2,4 |
| | Rectifying and Ohmic Contacts and Challenges in Source-Drain MOSFET Technology | 1 | 1,3,4 | 1,2,4 |
| | Effect of Interface States and Fermi Level Pinning on MS Contacts | 2 | 1,3,4 | 1,2,4 |
| | Challenges in Germanium Technology | 1 | 1,3,4 | 1,2,4 |
| | Natural Language Processing (NLP) in Healthcare | 1 | 1,3,4 | 1,2,4 |
| | Compound Semiconductors and Heterojunction FETs for High Performance | 2 | 1,3,4 | 1,2,4 |

| | | | | |
|---|---|---|---|---|
| | Heterojunctions and High Electron Mobility Transistors | 2 | 1,3,4 | 1,2,4 |
| **Unit 4** | Basic Principles of Quantum Mechanics | 4 | 1,3,4 | 1,2,4 |
| | Energy Bands in Crystalline Solids | 4 | 1,3,4 | 1,2,4 |
| | Quantum Structure and Devices | 4 | 1,3,4 | 1,2,4 |
| **Unit 5** | Crystal Growth and Nanocrystals | 2 | 2,4 | 1,2,4 |
| | Nanocrystals and Nanostructured Thin Films | 2 | 2,4 | 1,2,4 |
| | Nanowires and Other Nanostructures | 2 | 2,4 | 1,2,4 |
| | Chemical Vapour Deposition (CVD) and Atomic Layer Deposition (ALD) | 2 | 2,4 | 1,2,4 |
| | Characterization of Nanomaterials | 2 | 2,4 | 1,2,4 |
| **Total Hours** | | **50** | | |

**Recommended Resources**

5. "Fundamentals of Modern VLSI Devices" by Taur and Ning, Cambridge University Press.
6. "Solid State Electronic Devices" by Streetman and Banerjee.
7. "Fundamentals of Electronic Devices" by Achutan and Bhat, McGraw Hill.
8. "MOS Physics and Technology" by E.H. Nicollian and J.R. Brews, Wiley Publishers.

**Other Resources**

3. Silicon VLSI Technology: Fundamentals, Practice and Modelling by James D. Plummer, Michael D. Deal, Peter B. Griffin.
4. Advanced Semiconductor Fundamentals, Second Edition, by Robert F. Pierret, Pearson Education, Inc. (1983).

**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (50%)** | | | | **End Semester Exam (50%)** |
|---|---|---|---|---|---|---|
| | | **CLA-1 (20%)** | **Mid-1 (20%)** | **CLA-2 (5%)** | **CLA-3 (5%)** | |
| Level 1 | Remember | 70 | 50 | 40 | 40 | 60 |
| | Understand | | | | | |
| Level 2 | Apply | 30 | 50 | 40 | 40 | 40 |
| | Analyse | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Level 3 | Evaluate | | | 20 | 20 | |
| | Create | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designer(s)**

*Dr. Patta Supraja. Asst. Professor. Dept. Of ECE. SRM University – AP*

**SRM University – AP, Andhra Pradesh**
Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

# CAD for VLSI IC Design

| **Course Code** | ECE 438 | **Course Category** | CE | **L-T-P-C** | 3 | 0 | 0 | 3 |
|---|---|---|---|---|---|---|---|---|
| **Pre-Requisite Course(s)** | | **Co-Requisite Course(s)** | | **Progressive Course(s)** | | | | |
| **Course Offering Department** | ECE | **Professional / Licensing Standards** | *IEEE, Microsoft, Cadence, Vivado* | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To study the various CAD tools and methodologies employed in the design of VLSI circuits.

**Objective 2:** To understand the RTL (Register-Transfer Level) design, logic synthesis, physical design, and simulation.

**Objective 3:** To learn design and testing of VLSI circuits using CAD tools.

**Objective 4:** To evaluate and enhance the performance of VLSI designs through CAD tools.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Learn industry-standard CAD tools, navigating schematic capture, layout design, and verification tools for VLSI circuits. | 2 | 80% | 70% |
| **Outcome 2** | Apply theoretical concepts into practical applications. | 3 | 70% | 60% |
| **Outcome 3** | Analyse, identify bottlenecks, optimize VLSI designs for Performance, Power, and Area (PPA) using CAD tools. | 4 | 80% | 70% |
| **Outcome 4** | Exhibit adaptability to evolving CAD technologies, ensuring they stay current with advancements in the dynamic field of VLSI design. | 4 | 70% | 60% |

## Course Articulation Matrix: (CLO) to Program Learning Outcomes (PLO)

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Life Long Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 3 | 2 | 1 | 2 | | | | | 2 | | 1 | | | 1 | 2 |
| Outcome 2 | 3 | 3 | 2 | 2 | | | | | 3 | | | | 1 | 3 | 2 |
| Outcome 3 | 3 | 3 | 3 | 3 | | | | | 2 | | | | 1 | 3 | 3 |
| Outcome 4 | 3 | 3 | 3 | 3 | | | | | 3 | | 3 | | 1 | 3 | 3 |
| **Course Average** | **3** | **3** | **3** | **3** | | | | | **3** | | **1** | | **1** | **3** | **3** |

## Course Unitization Plan -Theory

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References |
|---|---|---|---|---|
| **Unit 1** | **Introduction to VLSI Design and CAD Tools** | **9** | | |
| | Understand the stages of the VLSI design process, from conceptualization to fabrication. | 1 | 1 | 1,2 |
| | Trace the historical development of VLSI technology and its impact on computing. | 1 | 1 | 1,2 |
| | Examine key milestones and breakthroughs that shaped the VLSI landscape. | 1 | 1 | 1,2 |
| | Analyze the pivotal role of Computer-Aided Design (CAD) tools in VLSI design. | 1 | 1,2 | 1,2 |
| | Discuss how CAD tools enhance efficiency, accuracy, and productivity in VLSI workflows. | 1 | 1,2 | 1,2 |
| | Explore Electronic Design Automation (EDA) tools and their roles in the design flow. | 1 | 1,2 | 1,2 |

| | | | | |
|---|---|---|---|---|
| | Discuss the impact of CAD tools on reducing time-to-market and overall design cost. | 1 | 1,2 | 1,2 |
| | Introduce students to a basic CAD tool interface. | 1 | 1,2 | 1,2,4,6 |
| | Conduct introductory exercises to familiarize students with basic CAD operations. | 1 | 1,2 | 1,2,4,6 |
| **Unit 2** | **Digital Design Fundamentals** | **9** | | |
| | Apply Boolean algebra to simplify and manipulate logical expressions. | 1 | 2,3 | 1,2 |
| | Design and analyze combinational circuits using logic gates. | 1 | 2,3 | 1,2 |
| | Introduce sequential circuits, including flip-flops and latches. | 1 | 1,2,3 | 1,2 |
| | Discuss the concept of clocking and its importance in sequential circuit design. | 1 | 1,2,3 | 1,2 |
| | Define Register-Transfer Level (RTL) design and its role in VLSI. | 1 | 1,2,3 | 1,2 |
| | Demonstrate the translation of high-level design concepts into RTL descriptions. | 1 | 1,2,3 | 1,2 |
| | Engage students in practical RTL design exercises. | 1 | 2,3 | 1,2 |
| | Implement simple digital circuits using RTL design principles. | 1 | 2,3 | 1,2 |
| | Utilize simulation tools to validate the functionality of RTL designs. | 1 | 2,3 | 1,2 |
| **Unit 3** | **Schematic Capture and Simulation Tools** | **9** | | |
| | Introduce functional simulation using Verilog or VHDL. | 1 | 2,3,4 | 1,2,3 |
| | Create and simulate basic digital circuits to understand functional behavior. | 1 | 2,3,4 | 1,2,3 |
| | Optimize circuit designs for better performance using timing constraints | 1 | 2,3,4 | 1,2,3 |
| | Apply simulation tools to analyze and troubleshoot real-world digital circuits. | 1 | 2,3,4 | 1,2,3 |
| | Discuss the significance of simulation in identifying design flaws. | 1 | 2,3,4 | 1,2,3 |
| | Introduce advanced simulation techniques such as mixed-signal simulation. | 1 | 2,3 | 1,2,3 |
| | Explore co-simulation of analog and digital components. | 1 | 2,3,4 | 1,2,3 |
| | Conduct hands-on sessions for students to create and simulate circuits using schematic capture tools. | 1 | 2,3,4 | 1,2,3 |
| | Emphasize the practical application of simulation results in design refinement. | 1 | 2,3 | 1,2,3 |
| **Unit 4** | **Logic Synthesis and Optimization Techniques** | **9** | | |
| | Define logic synthesis and its role in transforming RTL descriptions into gate-level netlists. | 1 | 2,3,4 | 1,2,5 |
| | Discuss strategies for optimizing designs in terms of area, power, and performance (PPA). | 1 | 2,3,4 | 1,2,5 |
| | Introduce technology mapping as a critical step in the synthesis process. | 1 | 2,3,4 | 1,2,5 |
| | Cover advanced logic synthesis techniques, including retiming and resynthesis. | 1 | 2,3,4 | 1,2,5 |
| | Explore the impact of these techniques on design quality and efficiency. | 1 | 2,3,4 | 1,2,5 |
| | Demonstrate the application of logic synthesis techniques | 1 | 2,3,4 | 1,2,5 |

| | | | | |
|---|---|---|---|---|
| | through practical examples. | | | |
| | Guide students in optimizing designs for specific criteria. | 1 | 2,3,4 | 1,2,5 |
| | Discuss current challenges in logic synthesis. | 1 | 2,3,4 | 1,2,5 |
| | Explore emerging trends and future directions in logic synthesis research and development. | 1 | 2,3,4 | 1,2,5 |
| **Unit 5** | **Physical Design and Layout** | **9** | | |
| | Provide an overview of the physical design process, from initial floor planning to tape-out. | 1 | 3,4,5 | 1,2,5 |
| | Introduce floor planning as a critical step in physical design. | 1 | 2,3,4 | 1,2,5 |
| | Explain the global and detailed routing stages in the physical design flow. | 1 | 2,3,4 | 1,2,5 |
| | Discuss algorithms and techniques for efficient and effective routing. | 1 | 3,4,5 | 1,2,5 |
| | Cover the significance of physical verification in ensuring design correctness. | 1 | 2,3,4 | 1,2,5 |
| | Introduce Design Rule Checking (DRC) and its role in identifying layout violations. | 1 | 2,3,4 | 1,2,5 |
| | Conduct hands-on sessions for students to implement physical design principles. | 1 | 3,4,5 | 1,2,5 |
| | Guide students through the process of floorplanning, placement, and routing. | 1 | 2,3,4 | 1,2,5 |
| | Discuss advanced topics such as clock tree synthesis and power planning. | 1 | 2,3,4 | 1,2,5 |
| | **Total** | **45** | | |

**Recommended Resources**

**Textbooks:**


1. K. K. Parhi, "VLSI Digital Signal Processing Systems: Design and Implementation," Wiley, 1999.G. S. May, S. M. Sze, “Fundamentals of Semiconductor Fabrication” Wiley, 2003
2. J. M. Rabaey, A. Chandrakasan, and B. Nikolić, "Digital Integrated Circuits: A Design Perspective," 2nd ed. Prentice Hall, 2003.


**Reference Books:**


1. T. R. K. Chetty, M. Balakrishnan, and N. Kittipiyakul, "VLSI Design Methodology Development," IEEE Trans. Very Large Scale Integr. (VLSI) Syst., vol. 18, no. 6, pp. 890-902, Jun. 2010.
2. C. Mead and L. Conway, "Computer-Aided Design of VLSI Circuits and Systems," in Proc. IEEE Int. Symp. Circuits Syst., New York, NY, USA, 1980, pp. 468-471.
3. C. Mead and L. Conway, "Introduction to VLSI Systems," 2014. [Online]. Available: https://www.cim.mcgill.ca/~langer/273/3-introduction.pdf


**Other Resources**

1. NPTEL Video lecturer (https://archive.nptel.ac.in/courses/106/106/106106088/#)

**Learning Assessment (Integrated course)**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (10%) | | Mid-1 (15%) | | CLA-2 (10%) | | Mid-2 (15%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 80% | | 50% | | 20% | | 20% | | 20% | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 20% | | 50% | | 80% | | 80% | | 80% | |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designer(s)**

*Dr. Pradyut Kumar Sanki, Associate Professor, Dept. of ECE, SRM University – AP*

# SRM University – AP, Andhra Pradesh

Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

## Semiconductor Device Modeling

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | ECE 440 | **Course Category** | CC | **L-T-P-C** | 3 | 0 | 0 | 3 |
| **Pre-Requisite Course(s)** | FIC102 | **Co-Requisite Course(s)** | Engineering Physics | **Progressive Course(s)** | | | | |
| **Course Offering Department** | ECE | **Professional / Licensing Standards** | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To learn the basics of current flow though solid state semiconductor devices.
**Objective 2:** To Understand some elementary concepts of quantum- and statistical-mechanics.
**Objective 3:** To Gain the knowledge of electrostatics of P-N junction diodes.
**Objective 4:** To learn the design of Bipolar transistors and MOSFETs.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Define and understand the current flow though semiconductor devices | 2 | 70% | 65% |
| **Outcome 2** | Understand the concepts of quantum- and statistical-mechanics | 2 | 70% | 65% |
| **Outcome 3** | Understand and design the electrostatics of P-N junction diodes | 3 | 70% | 65% |
| **Outcome 4** | Understand the discuss BJT and MOSFET design | 3 | 75% | 65% |

**Course Articulation Matrix: (CLO) to Program Learning Outcomes (PLO)**

| **CLO** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and | Environment and | Moral, and Ethical | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Lifelong Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 2 | - | - | - | 2 | - | - | - | 1 | 2 | 1 | 3 | 2 | 2 | 2 |
| Outcome 2 | 2 | - | - | - | 2 | - | - | - | 2 | 2 | - | 3 | 2 | 3 | 3 |
| Outcome 3 | 3 | 1 | 1 | 2 | 2 | - | - | - | 2 | 2 | - | 3 | 2 | 3 | 3 |
| Outcome 4 | 2 | 2 | 1 | 2 | 2 | - | - | - | 3 | 3 | 2 | 3 | 3 | 3 | 3 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Average** | **2.00** | **0.75** | **0.50** | **1.00** | **2.00** | **-** | **-** | **-** | **2.00** | **2.00** | **0.75** | **3.00** | **2** | **3** | **3** |

**Course Unitization Plan (Theory)**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References |
|---|---|---|---|---|
| **Unit 1** | **Basic Semiconductor Properties & Elements of Quantum Mechanics** | **9** | | |
| | General Material Properties | 2 | 1 | 1,3 |
| | Crystal Structure, The Unit Cell Concept | 1 | 1 | 1,3 |
| | Simple 3-D Unit Cells | 1 | 2 | 1,3 |
| | Bravais Lattices and Crystal Systems | 1 | 3 | 1,3 |
| | Specific Semiconductor Lattices | 1 | 2 | 1,3 |
| | Miller Indices, Example Use of Miller Indices | 1 | 2 | 1,3 |
| | The Quantum Concept | 1 | 2 | 1,3 |
| | Basic Formalism, Simple Problem Solutions | 1 | 2 | 1,3 |
| | Miller Indices, Example Use of Miller Indices | 1 | 2 | 1,3 |
| **Unit 2** | **Energy Band Theory & Equilibrium Carrier Statistics** | **9** | | |
| | Preliminary Considerations, Approximate One-Dimensional Analysis | 2 | 1 | 1,4 |
| | Extrapolation of Concepts to Three Dimensions | 2 | 1 | 1,4 |
| | Density of States, Fermi Function | 1 | 2 | 1,4 |
| | Equilibrium Distribution of Carriers | 1 | 3 | 1,4 |
| | The Energy Band Diagram, Donors | 1 | 2 | 1,4 |
| | Acceptors, Band Gap Centers | 1 | 2 | 1,4 |
| | Equilibrium Concentration Relationships, Concentration and $E_F$ Calculations. | 1 | 2 | 1,4 |
| **Unit 3** | **Recombination-Generation Processes & Carrier Transport** | **9** | | |
| | Introduction | 1 | 2 | 2,3 |
| | Recombination-Generation Statistics | 2 | 2 | 2,3 |
| | Surface Recombination-Generation | 2 | 2 | 2,3 |
| | Supplemental R-G Information | 1 | 2 | 2,3 |
| | Drift | 1 | 2 | 2,3 |
| | Diffusion | 1 | 2 | 2,3 |
| | Equations of State | 1 | 2 | 2,3 |
| **Unit 4** | **Electrostatics of P-N Junction Diodes & Introduction to Bipolar Transistors** | **9** | | |
| | P-N Diode I-V Characteristics | 1 | 3 | 2,4 |
| | Non-ideal Effects | 1 | 3 | 2,4 |
| | AC Response | 1 | 3 | 2,4 |
| | Large Signal Response | 1 | 4 | 2,4 |
| | Schottky Diode I | 1 | 4 | 2,4 |
| | Schottky Diode II | 1 | 3 | 2,4 |
| | BJT Design I | 1 | 4,5,6 | 2,4 |
| | BJT Design II | 1 | 4,5,6 | 2,4 |
| | Heterojunction Bipolar Transistors | 1 | 4,5,6 | 2,4 |
| **Unit 5** | **MOS** | **9** | | |
| | MOS Electrostatics | 2 | 4 | 2,4 |
| | MOSCAP Frequency Response | 1 | 4 | 2,4 |

| | | | | |
|---|---|---|---|---|
| | MOSFET I-V Characteristics | 2 | 4 | 2,4 |
| | Nonideal Effects in MOSFET | 2 | 4 | 2,4 |
| | Modern MOSFET | 1 | 3 | 2,4 |
| | Reliability of MOSFET | 1 | 3 | 2,4 |
| | **Total** | **45** | | |

**Recommended Resources**


3. Advanced Semiconductor Fundamentals, Second Edition, by Robert F. Pierret, Pearson Education, Inc. (1983).
4. Semiconductor Device Fundamentals, Robert F.Perret, (1996).
5. Sze, S. M., & Ng, K. K. (2006). Physics of semiconductor devices. John wiley& sons.
6. B. G. Streetman, S. K. Banerjee, Solid State Electronic Devices, Pearson, (2016)
7. Arora, N. (2007). MOSFET modeling for VLSI simulation: theory and practice. World Scientific.


**Other Resources**

1. https://onlinecourses.nptel.ac.in/noc23_ee35/preview
2. https://archive.nptel.ac.in/courses/108/105/108105188/

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | End Semester Exam (50%) |
|---|---|---|---|---|---|---|
| | | CLA-1 (5%) | Mid-1 (20%) | CLA-2 (15%) | CLA-3 (10%) | |
| | | Th | Th | Th | Th | Th |
| Level 1 | Remember | 80% | 60% | 50% | 40% | 50% |
| | Understand | | | | | |
| Level 2 | Apply | 15% | 30% | 40% | 40% | 30% |
| | Analyse | | | | | |
| Level 3 | Evaluate | 5% | 10% | 10% | 20% | 20% |
| | Create | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designer(s)**


*Dr. M. Durga Prakash. Associate Professor. Dept. Of ECE. SRM University – AP*

# Specialization: Advanced Communication Systems

**SRM University – AP, Andhra Pradesh**
Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

# Advanced Wireless Communication Systems (5G/6G)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | ECE 441 | **Course Category** | CORE ELECTIVE | **L-T-P-C** | 2 | 0 | 1 | 3 |
| **Pre-Requisite Course(s)** | FIC 117 - Linear Algebra and Differential Equations.<br>ECE 205 – Principles of Modern Communication System.<br>ECE 302 – Wireless Communications. | **Co-Requisite Course(s)** | Nil | **Progressive Course(s)** | Nil | | | |
| **Course Offering Department** | ECE | **Professional / Licensing Standards** | | | | | | |

**Course Objectives**

1. To provide an understanding of the fundamentals of 5G technology and its evolution from 4G.
2. To impart comprehensive knowledge of 5G network architecture and components, including 5G radio access technology and the 5G core network.
3. To familiarize students with emerging technologies and trends in 5G, such as Intelligent Reflecting Surfaces (IRS), cell-free massive MIMO, and IoT.
4. To enable students to gain deeper insights into research challenges and opportunities in the field of 5G communications.
5. To prepare students to design, deploy, and manage 5G networks and services effectively.

**Course Outcome (COs)**

| CO's | At the end of the course the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **1** | Understand the fundamentals of 5G technology and its evolution from 4G | **1** | 85% | 80% |
| **2** | Comprehend 5G network architecture and components, 5G radio access technology, and the 5G core network | **2** | 80% | 75% |
| **3** | Familiarize with emerging technologies and trends in 5G such as IRS and cell-free massive MIMO | **1,2** | 85% | 75% |
| **4** | Understand research challenges and opportunities in the field of 5G communications | **3** | 80% | 70% |
| **5** | Design, deploy, and manage 5G networks and services effectively | **3** | 85% | 75% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Engineering Knowledge** | **Problem** | **Design and Development** | **Analysis, Design and** | **Modern Tool and ICT** | **Society and Multicultural** | **Environment and** | **Moral, and Ethical** | **Individual and Teamwork** | **Communication Skills** | **Project Management** | **Self-Directed and Life Long** | **PSO 1** | **PSO 2** | **PSO 3** |
| Outcome 1 | 1 | 1 | 1 | 1 | 1 | | | 1 | | | | 1 | 1 | 1 | 1 |
| Outcome 2 | 2 | 3 | 2 | 3 | 2 | | | **2** | 2 | 1 | | 1 | 1 | 2 | 3 |
| Outcome 3 | 2 | 2 | 2 | 3 | 3 | | | **1** | 2 | 1 | | 1 | 1 | 2 | 2 |
| Outcome 4 | 2 | 3 | 3 | 3 | 3 | | | **1** | 2 | 1 | | 1 | 2 | 3 | 3 |
| Outcome 5 | 3 | 3 | 2 | 3 | 3 | | | **1** | 2 | 1 | | 2 | 2 | 2 | 2 |
| **Course Average** | **2** | **3** | **2** | **3** | **3** | | | | **2** | **1** | | **1** | **1** | **2** | **2** |

**Course Unitization Plan**

| Unit No. | Syllabus Topics | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit No. 1** | Overview of 5G Technology | 1 | 1 | 1,2 |
| | Key features and benefits of 5G | 1 | 1,2 | 1,2 |
| | Evolution of mobile communication systems from 1G to 5G | 1 | 1 | 1,2 |
| | 5G architecture and components, Radio access and core network technologies in 5G and 5G frequency bands and spectrum usage. | 2 | 1 | 1,3 |
| | L1: A 2x2 MIMO Communication System using the NI USRP module in the LabVIEW platform. | 2 | 1 | 1,2 |
| | L2: Amplitude and Phase Amplitude Modulation Using LABVIEW | 2 | 1 | 1,2 |
| **Unit No. 2** | 5G New Radio. | 1 | 1 | 1,2 |
| | 5G milli meter (mm) wave technology. | 1 | 1,2 | 1,2 |
| | 5G Beamforming and Beam management. | 1 | 2 | 1,2 |
| | 5G Carrier Aggregation and Inter-band Carrier Aggregation. 5G Radio Resource Management | 2 | 1 | 1,2 |

| | | | | |
|---|---|---|---|---|
| | L3: Single-sideband and Double-sideband suppressed-carrier transmission using LabVIEW. | 2 | 1,2 | 1,2 |
| | L4: Phase Shift keying using LABVIEW | 2 | 1,2 | 1,2 |
| **Unit No. 3** | Introduction to Intelligent Reflecting Surfaces | 1 | 3 | 1,2 |
| | IRS Components and Architecture | 1 | 3 | 1,2 |
| | Channel Modeling and Analysis | 1 | 1,2 | 1,2 |
| | Optimization Techniques for IRS, Practical Deployment and Implementation | 2 | 3 | 1,2 |
| | L5: OFDM signal transmission and reception using MATLAB. | 2 | 3 | 1,2 |
| **Unit No. 4** | Introduction to Cell-Free Massive MIMO | 1 | 2 | 1,2,4 |
| | System Architecture and Design | 1 | 3 | 1,2,4 |
| | Channel Modeling and Analysis | 1 | 2 | 1,2,4 |
| | Resource Allocation and Scheduling, Interference Management | 2 | 3 | 1,2,4 |
| | L6: Analysis of Spectral efficiency with Relay, IRS, and Hybrid mode system. | 2 | 4 | 1,2,4 |
| | L7: Energy efficiency analysis by varying power with number of antennas using MATLAB. | 2 | 4 | 1,2,4 |
| **Unit No. 5** | 5G use cases in Telecommunications | 3 | 4 | 1,2,3 |
| | 5G Applications in various industries like Healthcare, Transportation, Energy and Agriculture. | 2 | 5 | 1,2,3 |
| | Impact of 5G on Society and Economy. | 2 | 4,5 | 1,2,3 |
| | Implementation, Challenges and Solutions in 5G. Future Developments in 5G. | 4 | 4,5 | 1,2,3 |
| | **Total Contact Hours** | **45** | | |

**Recommended Resources**


6. Trinh Van Chien, Emil Björnson, "Massive MIMO Communications," in 5G Mobile Communications, W. Xiang et al. (eds.), pp. 77-116, Springer, 2017.
7. Osseiran A, Monserrat JF, Marsch P, editors. 5G mobile and wireless communications technology. Cambridge University Press; 2016 Jun 2.

8. Yu, F. Richard, Chunming Qiao, and Sheng Chen. *5G Wireless Communications: Fundamentals, Devices, and Applications*. Cambridge University Press, 2016
9. Gursoy, Mustafa Cenk, Ozan K. Tonguz, and Ali Ghrayeb. *5G Mobile and Wireless Communications Technology*. Cambridge University Press, 2016.
10. MATLAB & LABVIEW.

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (10%) | | CLA-2 (15%) | | CLA-3 (10%) | | Mid Term (15%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 40% | 60% | 60% | 50% | 40% | 40% | 60% | 40% | 30% | 50% |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 60% | 40% | 40% | 50% | 60% | 60% | 40% | 60% | 70% | 50% |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designer(s)**

*Dr. Sunil Chinnadurai. Associate Professor. Dept. of ECE. SRM University - AP*

# SRM University – AP, Andhra Pradesh

Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

## Quantum Communications

| Course Code | ECE 442 | Course Category | Professional Core | L-T-P-C | 3 | 0 | 0 | 3 |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | ECE | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To understand Quantum computing and communication concepts.

**Objective 2:** To understand mathematical concepts and algorithms related to Quantum computing and Communications.

**Objective 3:** To explore towards research in Quantum computing and communications.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | At the end of the course, the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **Outcome 1** | To understand difference between bits and Qubits | 1,2 | 80% | 75% |
| **Outcome 2** | To understand Linear Operator, Hilbert spaces and Bloch sphere related to quantum concepts | 2,3,4 | 80% | 70% |
| **Outcome 3** | To understand quantum gates, | 2,3,4 | 75% | 65% |
| **Outcome 4** | To understand quantum algorithms, quantum Fourier transform and quantum error correction concepts, Quantum information processing | 2,3,4 | 75% | 65% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and | Self-Directed and Life Long Learning | PSO 1 | PSO 2 | PSO 3 |
| **Outcome 1** | 3 | 2 | 1 | 2 | 1 | | | | 1 | | | 2 | 1 | 3 | 3 |
| **Outcome 2** | 3 | 2 | 1 | 2 | 1 | | | | 1 | | | 2 | 1 | 3 | 3 |
| **Outcome 3** | 3 | 3 | 3 | 3 | 2 | | | | 3 | | | 3 | 1 | 3 | 3 |
| **Outcome 4** | 3 | 3 | 3 | 3 | 2 | | | | 3 | | | 3 | 3 | 2 | 3 |
| **Course Average** | **3** | **3** | **2** | **3** | **2** | | | | **2** | | | **3** | **2** | **3** | **3** |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **QUANTUM OPERATORS, STATES AND THEIR APPLICATIONS** | **9** | | |
| | Introduction to Quantum computing | 1 | 1,2 | 1,2 |
| | Quantum states & wave functions, Dirac notation(bra–ket notation) of states | 1 | 1,2 | 1,2 |
| | Basis vectors and orthogonality | 2 | 1,2 | 1,2 |
| | Linear operators and matrices in Hilbert spaces | 2 | 1,2 | 1,2 |
| | Qubits and Bloch sphere, Base states and superposition | 1 | 1,2 | 1,2 |
| | Structural randomness & Heisenberg's Uncertainty Principle | 1 | 1,2 | 1,2 |
| | Unitary operators and projectors | 1 | 1,2 | 1,2 |
| **Unit 2** | **QUANTUM LOGICS** | **10** | | |
| | Abramsky-Coecke semantics | 1 | 3 | 1,2 |
| | No-cloning theorem | 1 | 3 | 1,2 |
| | Quantum entanglement & Entangled states | 2 | 3 | 1,2 |
| | Bell states & Bell inequalities | 2 | 3 | 1,2 |
| | Pauli, Hadamard gates, CNOT, Toffoli gates | 2 | 3 | 1,2 |
| | Quantum teleportation | 1 | 3 | 1,2 |
| | Universality of two-qubit gates. | 1 | 3 | 1,2 |
| **Unit 3** | **QUANTUM ELECTRONICS USING OPTICS** | **9** | | |
| | Introduction to Photon and Laser pulses as quantum states | 1 | 4 | 1,2 |
| | Single photon (quanta) counting with avalanche photodiode | 1 | 4 | 1,2 |
| | HOM interference, Pure and mixed states | 1 | 4 | 1,2 |
| | Quantum states of single photons | 1 | 4 | 1,2 |
| | Optical Qubits and Optical Two-Qubit Gates (CNOT) | 1 | 4 | 1,2 |
| | Deutsch-Josza algorithm and applications | 1 | 4 | 1,2 |
| | Quantum Fourier transform | 2 | 4 | 1,2 |
| | Shor’s Algorithm – Periodicity | 1 | 4 | 1,2 |
| **Unit 4** | **QUANTUM INFORMATFION PROCESSING** | **10** | | |

| | | | | |
|---|---|---|---|---|
| | Quantum information processing features and basic mathematics | 3 | 4 | 2,3 |
| | Von Neumann entropy and Schumacher's noiseless quantum coding theorem | 3 | 4 | 2,3 |
| | Quantum channels | 4 | 4 | 2,3 |
| **Unit 5** | **QUANTUM COMPUTING AND COMMUNICATIONS** | **9** | | |
| | Density matrix and information propagations | 1 | 4 | 1,2 |
| | Quantum cryptography | 1 | 4 | 1,2 |
| | Communication across two-input quantum gate (C-NOT) and Teleportation | 2 | 4 | 1,2 |
| | Physical realization of quantum computation: ion trap | 1 | 4 | 1,2 |
| | Physical realization of quantum computation: cavity QED, Quantum key distribution | 1 | 4 | 1,2 |
| | Noise and decoherence: DiVincenzo's criteria | 1 | 4 | 1,2 |
| | Quantum error correction and examples | 1 | 4 | 1,2 |
| | Circuit for a quantum Fourier transform | 1 | 4 | 1,2 |

**Recommended Resources**


1. Phillip Kaye, Raymond Laflamme, and Michele Mosca (2007). An Introduction to Quantum Computing. Oxford University Press.
2. Michael A. Nielsen and Isaac L. Chuang (2000). Quantum Computation and Quantum Information. Cambridge University Press.
3. Ivan B. Djordjevic. Quantum Communication, Quantum Networks, and Quantum Sensing, Academic Press, Elsevier.


**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (10%) | | Mid-1 (15%) | | CLA-2 (10%) | | Mid-2 (15%) | | | |
| | | **Th** | **Prac** | Th | Prac | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** |
| Level 1 | Remember | 60% | | 50% | | 40% | | 50% | | 40% | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 40% | | 50% | | 60% | | 50% | | 60% | |
| | Analyze | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designers**

*Dr. V. Udaya Sankar, Asst Professor, Dept of ECE, SRM University – AP*

# SRM University – AP, Andhra Pradesh

Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

## Information Theory and Coding

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Code | **ECE 443** | Course Category | **Core Course (CC)** | L-T-P-C | **3** | **0** | **0** | **3** |
| Pre-Requisite Course(s) | **MAT 211, ECE 224** | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To review the basic principles of information theory.

**Objective 2:** To introduce the concept of source, channel coding, and channel capacity.

**Objective 3:** To impart knowledge on the concepts of data and voice coding.

**Objective 4:** To impart knowledge on the concepts of error control coding.

**Objective 5:** To impart knowledge on the concepts of audio and video coding.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Understand the basic principles of information theory | 2 | 85% | 85% |
| **Outcome 2** | Understand the concept of source, channel coding, and channel capacity | 2 | 85% | 80% |
| **Outcome 3** | Apply the concept of pulse modulation to data and voice coding | 3 | 80% | 75% |
| **Outcome 4** | Understand the concept of error control coding | 2 | 75% | 75% |
| **Outcome 5** | Apply the concept of source coding for data compression | 3 | 85% | 80% |
| **Outcome 6** | Analyze the concept of coding in audio and video coding | 4 | 55% | 65% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Life Long Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 3 | 1 | 3 | 2 | | | 1 | | 1 | | | 1 | 1 | | |
| Outcome 2 | 3 | 1 | 2 | 2 | 1 | | 1 | | 1 | | | 1 | 2 | 1 | |
| Outcome 3 | 3 | 1 | 2 | 2 | 2 | | 1 | | 1 | | | 1 | 1 | | |
| Outcome 4 | 3 | 3 | 3 | 3 | 3 | | 3 | | 2 | | 1 | 3 | 2 | 2 | 1 |
| Outcome 5 | 2 | 1 | 2 | 2 | 3 | | | | 2 | | | 1 | 2 | 2 | |
| Outcome 6 | 3 | 3 | 3 | 3 | 3 | | 3 | | 3 | | 2 | 3 | 3 | 2 | 3 |
| **Course Average** | **3** | **2** | **3** | **2** | **2** | | **2** | | **2** | | **2** | **2** | **2** | **2** | **2** |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **INFORMATION ENTROPY FUNDAMENTALS** | **8** | | |
| | Uncertainty, Information, Entropy | 1 | 1 | 1,2 |
| | Source coding Theorem, Huffman coding | 2 | 1,2 | 1,2 |
| | Shannon Fano coding | 2 | 1,2 | 1,2 |
| | Discrete Memoryless channels, Channel capacity | 1 | 1,2 | 1,2 |
| | Channel coding Theorem, Channel capacity Theorem | 2 | 1,2 | 1,2 |
| **Unit 2** | **DATA AND VOICE CODING** | **11** | | |
| | Pulse code Modulation | 2 | 1,3 | 1,2 |
| | Differential Pulse Code Modulation | 2 | 1,3 | 1,2 |
| | Adaptive Differential Pulse Code Modulation | 2 | 1,3 | 1,2 |
| | Adaptive sub-band coding | 1 | 1,3 | 1,2 |
| | Delta Modulation, Adaptive Delta Modulation | 2 | 1,3 | 1,2 |
| | Coding of speech signal at low bit rates | 1 | 1,3 | 1,2 |
| | Vocoders, Linear Prediction Coding | 1 | 1,3 | 1,2 |
| **Unit 3** | **ERROR CONTROL CODING** | **12** | | |
| | Linear Block codes | 1 | 2,4 | 1,2 |
| | Syndrome Decoding | 2 | 2,4 | 1,2 |
| | Minimum distance consideration | 1 | 2,4 | 1,2 |
| | Cyclic codes | 2 | 2,4 | 1,2 |
| | Generator Polynomial, Parity check polynomial | 2 | 2,4 | 1,2 |
| | Encoder for cyclic codes, Calculation of syndrome | 2 | 2,4 | 1,2 |
| | Convolutional codes | 2 | 2,4 | 1,2 |
| **Unit 4** | **COMPRESSION TECHNIQUES** | **7** | | |
| | Principles, Text compression | 1 | 2,5 | 1,2 |
| | Static Huffman Coding | 1 | 2,5 | 1,2 |
| | Dynamic Huffman coding | 2 | 2,5 | 1,2 |
| | Arithmetic coding | 1 | 2,5 | 1,2 |

| | | | | |
|---|---|---|---|---|
| | Image Compression, Graphics Interchange format, Tagged Image File Format | 1 | 2,5 | 1,2 |
| | Digitized documents and Introduction to JPEG standards | 1 | 2,5 | 1,2 |
| **Unit 5** | **AUDIO AND VIDEO CODING** | **7** | | |
| | Linear Predictive coding | 1 | 2,4,5,6 | 1,2 |
| | Code excited LPC | 1 | 2,4,5,6 | 1,2 |
| | Perceptual coding | 1 | 2,4,5,6 | 1,2 |
| | MPEG audio coders | 1 | 2,4,5,6 | 1,2 |
| | Dolby audio coders | 1 | 2,4,5,6 | 1,2 |
| | Video compression - Principles | 1 | 2,4,5,6 | 1,2 |
| | Introduction to H.261,MPEG Video standards | 1 | 2,4,5,6 | 1,2 |
| **Total Contact Hours for Theory** | | **45** | | |

**Recommended Resources**

1. Thomas M. Cover and Joy A Thomas, “Elements of Information Theory”, 2nd edition, Wiley.
2. Simon Haykin, “Communication Systems”, 4th edition, Wiley

**Recommended Online Resources**

1. https://nptel.ac.in/courses/117101053
2. https://nptel.ac.in/courses/117105077

**Learning Assessment (Theory only and integrated course)**

| **Bloom’s Level of Cognitive Task** | | **Continuous Learning Assessments (60%)** | | | | | | | | **End Semester Exam (40%)** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **CLA-1 (15%)** | | **Mid-1 (15%)** | | **CLA-2 (15%)** | | **CLA-3 (15%)** | | | |
| | | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** |
| Level 1 | Remember | 40% | | 50% | | 50% | | 40% | | 40% | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 60% | | 50% | | 50% | | 60% | | 60% | |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designers**

*Dr. Anirban Ghosh, Asst. Professor, Dept of ECE, SRM University – AP*

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# Optical Communication

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | ECE 444 | **Course Category** | TC | **L-T-P-C** | **3** | **0** | **0** | **3** |
| **Pre-Requisite Course(s)** | | **Co-Requisite Course(s)** | | **Progressive Course(s)** | | | | |
| **Course Offering Department** | ECE | **Professional / Licensing Standards** | | | | | | |

**Course Objectives**

1. Understanding Fundamentals: Grasp the basic principles of optical communication, including the behaviour of light, optical fibers, and the transmission of data through light waves.
2. System Components: Identify and explain the components of an optical communication system, such as optical transmitters, receivers, modulators, and amplifiers.
3. Optical Fiber Properties: Understand the properties of optical fibers, including types of fibers, modes of propagation, attenuation, dispersion, and non-linear effects.
4. Signal Transmission: Learn the techniques for efficient signal transmission in optical networks, including wavelength division multiplexing (WDM), time division multiplexing (TDM), and code division multiplexing (CDM).
5. Optical Networking: Explore the principles and architectures of optical networks, such as passive optical networks (PONs), synchronous optical networking (SONET), and optical transport networks (OTNs).

**Course Outcome (COs)**

| CO's | At the end of the course, the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **1** | demonstrate a thorough understanding of the fundamental principles of optical communication, including the nature of light and the basics of optical fibers. | **2** | 85% | 75% |
| **2** | understand the properties and types of optical fibers, and will be able to explain concepts such as attenuation, dispersion, and non-linear effects. | **3** | 75% | 70% |
| **3** | identify and describe the key components of an optical communication system, such as optical transmitters, receivers, and amplifiers. | **2** | 80% | 70% |
| **4** | gain proficiency in various signal transmission techniques, including Wavelength Division Multiplexing (WDM), Time Division Multiplexing (TDM), and Code Division Multiplexing (CDM). | **4** | 70% | 65% |
| **5** | understand the principles and architectures of different optical networks, including Passive Optical Networks (PONs), Synchronous Optical Networking (SONET), and Optical Transport Networks (OTNs) | **2** | 80% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** |
|---|---|

| | Engineering Knowledge | Problem | Design and Development | Analysis, Design and | Modern Tool and ICT | Society and Multicultural | Environment and | Moral, and Ethical | Individual and Teamwork | Communication Skills | Project Management | Self-Directed and Life Long | PSO 1 | PSO 2 | PSO 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outcome 1 | 3 | | | | | | | | | | | | 1 | 1 | 1 |
| Outcome 2 | 3 | 3 | | | | | | | | | | | 1 | 1 | 1 |
| Outcome 3 | 3 | 1 | | | | | | | | | | | 1 | 1 | 1 |
| Outcome 4 | 3 | 3 | **3** | **3** | **3** | | | | **1** | | | | 1 | 1 | 1 |
| Outcome 5 | 3 | 3 | **3** | **3** | **3** | | | | **2** | | | | 1 | 1 | 1 |
| **Course Average** | **3** | **2** | **3** | **3** | **3** | | | | **1** | | | | 1 | 1 | 1 |

**Course Unitization Plan**

| Unit No. | Syllabus Topics | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| | **Unit:01 Introduction** | **9 hrs** | | |
| **Unit No. 1** | Introduction to Telecommunications and fiber optics | **1** | **1** | **1** |
| | Evolution of Light wave Systems | **1** | **1** | **1** |
| | Need of Fiber Optic Communications | **1** | **1** | **1** |
| | point to point systems and Networks | **1** | **1** | **1** |
| | Information carrying capacity | **1** | **1** | **1** |
| | Basic block diagram of fiber optic communication systems: Optical Communication System | **1** | **1** | **1** |
| | Light wave System Component | **1** | **1** | **1** |
| | Optical Fibers as a Communication Channel | **1** | **1** | **1** |
| | Optical Transmitters, Optical Receivers | **1** | **1** | **1** |
| | **Unit:02 Optical Fibers** | **9 hrs** | | |
| **Unit No. 2** | Optical fiber description: How optical fiber conducts light, ore cladding, Total internal reflection, | **1** | **2** | **1** |

| | | | | |
|---|---|---|---|---|
| | Fiber Modes | **1** | **2** | **1** |
| | Dispersion in Single-Mode Fibers | **1** | **2** | **1** |
| | Modal dispersion | **1** | **2** | **1** |
| | Step-Index Fibers, Graded Index Fibers | **1** | **2** | **1** |
| | Understanding Numerical Aperture, Acceptance cone | **1** | **2** | **1** |
| | Attenuation, bending losses, scattering, absorption, total attenuation, | **1** | **2** | **1** |
| | Bit rate and bandwidth, | **1** | **2** | **1** |
| | Cables, Connectors and Splicing | **1** | **2** | **1** |
| | **Unit:03 Optical Sources and Detectors** | **9 hrs** | | |
| **Unit No. 3** | Basic Concepts; Emission and Absorption concept in p-n Junctions | **1** | **3** | **1** |
| | non-radiative Recombination | **1** | **3** | **1** |
| | Semi-conductor Materials, Light Emitting Diodes | **1** | **3** | **1** |
| | Light radiation by a semiconductor, Power-current Characteristics, LED Structures | **1** | **3** | **1** |
| | Semi-Conductor Lasers Diodes; Principle of action, DFB Lasers | **1** | **3** | **1** |
| | Coupled Cavity semiconductor Lasers, Vertical Cavity Semiconductor Lasers | **1** | **3** | **1** |
| | Laser Characteristics. Basic concepts of detectors, p-n Photo Diodes | **1** | **3** | **1** |
| | p-i-n Photo Diodes, Avalanche Photo Diode | **1** | **3** | **1** |
| | Receiver Design, Receiver Noise; Noise mechanism, Receiver sensitivity, Bit error rate, Minimum Receiver Power | **1** | **3** | **1** |
| | **Unit:4 Optical Communication Systems** | **8 hrs** | | |
| **Unit No. 4** | System Architecture | **1** | **4** | **1** |
| | Components of fiber optic Network | **1** | **4** | **1** |
| | point to point links | **1** | **4** | **1** |
| | Optical Amplifiers, Principle of operation | **1** | **4** | **1** |

| | | | | |
|---|---|---|---|---|
| | Wavelength Division Multiplexers and Demultiplexers | **1** | **4** | **1** |
| | Semiconductor optical amplifiers, Erbium doped fiber amplifiers, Dispersion limited Light wave systems | **2** | **4** | **1** |
| | Optical TDM Systems | **1** | **4** | **1** |
| | **Unit:5 Optical Networks** | **8 hrs** | | |
| **Unit No. 5** | principles and architectures of different optical networks | **2** | **5** | **1** |
| | Passive Optical Networks (PONs) | **2** | **5** | **1** |
| | Synchronous Optical Networking (SONET) | **2** | **5** | **1** |
| | Optical Transport Networks (OTNs). | **2** | **5** | **1** |
| | **Total Hours** | **43** | | |

**Recommended Resources**

1. Senior J. Optical Fiber Communications, Principles & Practice, PHI 1985.
2. Keiser G., Optical Fiber Communication, Mc Graw-hill 2008.
3. Govind P. Agrawal, Fiber Optics Communication Systems, John Wiley & Sons (Asia) Pvt. Ltd 1998.
4. Djafar K. Mynbeav, Fiber-Optics Communications Technology, Pearson 2001.

**Recommended Online Resources**

1. https://www.coursera.org/learn/introduction-optical-communication
2. https://ocw.mit.edu/courses/electrical-engineering

**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (50%)** | | | | **End Semester Exam (50%)** |
|---|---|---|---|---|---|---|
| | | **CLA-1 (20%)** | **Mid-1 (20%)** | **CLA-2 (5%)** | **CLA-3 (5%)** | |
| Level 1 | Remember | 70 | 70 | 40 | 40 | 60 |
| | Understand | | | | | |
| Level 2 | Apply | 30 | 30 | 60 | 60 | 40 |
| | Analyse | | | | | |
| Level 3 | Evaluate | | | | | |
| | Create | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designer(s)**

*Dr. Goutam Rana, Assistant Professor, Dept. of ECE, SRM University – AP*

# SRM University – AP, Andhra Pradesh

Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

## Computer Networks and Internet Protocols

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Code | ECE 472 | Course Category | Technical elective | L-T/D-P/Pr-C | 3 | 0 | 0 | 3 |
| Total Contact Hours | | 45 | Total Learning Hours | | | | | |
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | ECE | Professional / Licensing Standards | | | | | | |

**Course Objectives**

**Objective 1:** To Understand the computer network.

**Objective 2:** To Understand internet and protocols.

**Objective 3:** To Study how to apply internet protocols on IoT.

**Objective 4:** Understand the importance of protocols.

**Course Outcomes (COs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **CO 1** | Describe the basics and structures of Computer network | 2 | 75% | 70% |
| **CO 2** | Identifies the different types of network layers | 2 | 75% | 70% |
| **CO 3** | Identifies different protocols in the different layers | 2 | 75% | 70% |
| **CO 4** | Understand and build the skills on wireless technologies and Internet of things | 3 | 75% | 70% |

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Lifelong Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 1 | | 1 | | | | | | | | | | 1 | 2 | 2 |
| Outcome 2 | 2 | | 1 | 1 | 2 | | | | | | | 1 | 3 | 2 | 2 |
| Outcome 3 | 1 | 2 | 2 | 2 | 2 | | | | | | | 1 | 3 | 3 | 3 |
| Outcome 4 | 1 | 2 | 2 | 2 | 2 | | | | | | | 1 | 3 | 3 | 3 |
| **Course Average** | **2** | **2** | **2** | **2** | **2** | | | | | | | **1** | **3** | **3** | **3** |

**Course Unitization Plan- Theory**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit I** | **Introduction** | **9** | | |
| 1. | Introduction to Computer Networks | 2 | 1 | 1,2 |
| 2. | Data network | 2 | 1 | 1,2 |
| 3. | Circuit Switching Network | 2 | 2 | 1,2 |
| 4. | Packet Switching Network | 2 | 1 | 1,2 |
| 5. | TCP/IP Protocol Stack | 1 | 2 | 1,2 |
| **Unit II** | **Application Layer** | **8** | | 1,2 |
| 6. | Introduction to application layer | 2 | 2 | 1,2 |
| 7. | Introduction to HTTP, FTP | 2 | 3 | 1,2 |
| 8. | Email, DNS | 2 | 3 | 1,2 |
| 9. | World wide web | 2 | 3 | 1,2 |
| **Unit III** | **Transport Layer** | **9** | | |
| 10. | Introduction to Transport Layer Connection Establishment and Closure | 2 | 3 | 1,2 |
| 11. | Flow Control at the Transport Layer | 2 | 3 | 1,2 |
| 12. | Congestion Control | 2 | 3 | 1,2 |
| 13. | Transmission Control Protocol – Basic Features, TCP Congestion Control | 3 | 3 | 1,2 |
| **Unit IV** | **Recognition And Reconstruction** | **9** | | |
| 14. | Introduction to Transport layer | 2 | 2 | 1,2 |
| 15. | Intra Domain Routing Protocols | 2 | 3 | 1,2 |
| 16. | Inter Domain Routing Protocols (BGP) | 2 | 3 | 1,2 |
| 17. | Simple Network Management Protocol (SNMP) | 3 | 3 | 1,2 |
| **Unit V** | **Wireless LAN** | **10** | | |
| 18. | Introduction to IOT | 3 | 4 | 1,2 |
| 19. | Network security | 3 | 4 | 1,2 |
| 20. | WiMAX Broadband Wireless Access | 3 | 4 | 1,2 |
| 21. | WiMAX vs LTE | 1 | 4 | 1,2 |
| **Total Contact Hours** | | **45** | | |

**Recommended Resources**


1. Ames Kurose, Keith Ross “Computer Networking: A Top - Down Approach” Pearson; 7th edition, ISBN-10 : 9780133594140
2. Andrew S Tanenbaum “Computer Networks” Pearson Education India; 5th edition, ISBN-10 : 9332518742.

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (60%) | | | | End Semester Assessments (40%) |
|---|---|---|---|---|---|---|
| | | CLA-1 (15%) | Mid-1 (15%) | CLA-2 (15%) | CLA-3 (15%) | |
| Level 1 | Remember | 50% | 40% | 40% | 40% | 30% |
| | Understand | | | | | |
| Level 2 | Apply | 50% | 60% | 60% | 60% | 70% |
| | Analyse | | | | | |
| Level 3 | Evaluate | | | | | |
| | Create | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers**

*Dr. Karthikeyan E, Assistant Professor, Dept. of ECE. SRM University – AP*

# SRM University – AP, Andhra Pradesh

Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

## Detection and Estimation Theory

| Course Code | ECE 446 | Course Category | Elective (TE) | L-T-P-C | 3 | 0 | 0 | 3 |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | Nil | Co-Requisite Course(s) | Probability and Random Variables, Linear Algebra, Wireless Communications | Progressive Course(s) | Nil | | | |
| Course Offering Department | ECE | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To understand the importance of detection and estimation

**Objective 2:** To understand and design the various detectors

**Objective 3:** To understand and design various estimators

**Objective 4:** To understand how to apply detection and estimation algorithms to a particular situation

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | To understand the importance of detection and estimation | 3 | 85% | 80% |
| **Outcome 2** | To understand and design the various detectors | 3 | 80% | 75% |
| **Outcome 3** | To understand and design various estimators | 3 | 85% | 70% |
| **Outcome 4** | To understand how to apply detection and estimation algorithms to a particular situation. | 3 | 80% | 70% |

**Course Articulation Matrix: (CLO) to Program Learning Outcomes (PLO)**

| **CLO** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and | Modern Tool and ICT Usage | Society and Multicultural | Environment and | Moral, and Ethical | Individual and Teamwork | Communication Skills | Project Management | Self-Directed and Lifelong | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 1 | 1 | 1 | 1 | 1 | | | | 1 | 1 | | 3 | 1 | 1 | 1 |
| Outcome 2 | 2 | 3 | 3 | 3 | 2 | | | | 2 | 1 | | 3 | 1 | 2 | 3 |
| Outcome 3 | 2 | 3 | 3 | 3 | 2 | | | | 2 | 1 | | 3 | 1 | 2 | 2 |
| Outcome 4 | 3 | 3 | 3 | 3 | 3 | | | | 2 | 1 | | 3 | 2 | 3 | 3 |
| **Course Average** | **2** | **3** | **3** | **3** | **3** | | | | **2** | **1** | | **3** | **2** | **2** | **2** |

**Course Unitization Plan - Theory**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Introduction** | **8** | | |
| | Introduction to Detection and Estimation | 2 | 1 | 1, 2,3 |
| | Review of Probability | 2 | 1 | 1, 2,3 |
| | Review of Linear Algebra | 2 | 1 | 1, 2,3 |
| | Hypothesis Testing | 2 | 1 | 1, 2,3 |
| **Unit 2** | **Detection Theory** | **8** | | |
| | Neyman-Pearson Detector | 3 | 2 | 1, 2,3 |
| | Bayes detector | 2 | 2 | 1, 2,3 |
| | Matched Filters | 3 | 2 | 1, 2,3 |
| **Unit 3** | **Estimation Theory** | **8** | | |
| | Introduction to Estimation Theory | 1 | 3 | 1, 2,3 |
| | Minimum Variance Unbiased Estimation | 2 | 3 | 1, 2,3 |
| | CR Rao Lower Bound | 2 | 3 | 1, 2,3 |
| | General Minimum Variance Unbiased Estimator | 1 | 3 | 1, 2,3 |
| | Best Linear Unbiased Estimator | 2 | 3 | 1, 2,3 |
| **Unit 4** | **Estimation Theory (Contd..)** | **11** | | |
| | Maximum likelihood estimator | 2 | 4 | 1, 2,3 |
| | Linear Bayesian Estimator-Minimum Mean squared Estimator | 3 | 4 | 1, 2,3 |
| | Wiener and Kalman Filters | 4 | 4 | 1, 2,3 |
| **Unit 5** | **Applications of Detection and Estimation** | **8** | | |
| | Application to Detection Theory | 3 | 5 | 1, 2,3 |
| | Application to Estimation Theory | 5 | 5 | 1, 2,3 |
| **Total Contact Hours** | | **41** | | |

**Recommended Resources**

4. Fundamentals of Statistical Signal Processing, Volume I: Estimation Theory, S.M. Kay, Prentice Hall 1993, ISBN-13: 978-0133457117.
5. Fundamentals of Statistical Signal Processing, Volume II: Detection Theory, S.M. Kay, Prentice 1993, ISBN-13: 978-0135041352.
6. An Introduction to Signal Detection and Estimation, H.V. Poor, Springer, 2nd edition, 1998, ISBN-13: 978-0387941738.

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (10%) | | Mid-1 (15%) | | CLA-2 (10%) | | CLA-3 (15%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 40% | | 60% | | 40% | | 60% | | 30% | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 60% | | 40% | | 60% | | 40% | | 70% | |
| | Analyse | | | | | | | | | | |
| | Evaluate | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Level 3 | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designer(s)**

*Dr. V. Udaya Sankar, Asst. Professor, Department of ECE, SRM University-AP*

# SRM University – AP, Andhra Pradesh

Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

## Satellite Communication

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | ECE 447 | **Course Category** | Technical Elective (TE) | **L-T-P-C** | 3 | 0 | 0 | 3 |
| **Pre-Requisite Course(s)** | Wireless Communications | **Co-Requisite Course(s)** | | **Progressive Course(s)** | | | | |
| **Course Offering Department** | ECE | **Professional / Licensing Standards** | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** Comprehend the fundamental equations of motion governing satellite orbits and their application in tracking and orbit determination.

**Objective 2:** Master techniques for orbital correction and control to ensure optimal satellite positioning and functionality.

**Objective 3:** Demonstrate proficiency in utilizing FDMA, TDMA, CDMA, and random-access techniques in satellite communication systems.

**Objective 4:** Gain insight into spacecraft subsystems, emphasizing reliability considerations and the integration process in communication satellite design.

**Objective 5:** Understand the performance requirements and standards for satellite links and develop the skills to design effective satellite communication links, considering various satellite systems.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Apply orbital mechanics equations to accurately predict and determine satellite orbits, facilitating efficient tracking and management. | 2 | 85% | 80% |
| **Outcome 2** | Demonstrate proficiency in utilizing FDMA, TDMA, CDMA, and random-access techniques in satellite communication systems. | 4 | 80% | 75% |
| **Outcome 3** | Upon completion, students will demonstrate the application of FDMA, TDMA, CDMA, and random-access techniques | 3 | 75% | 70% |
| **Outcome 4** | Apply knowledge of spacecraft subsystems and reliability considerations to practically design and integrate communication satellites. | 3 | 80% | 70% |
| **Outcome 5** | Develop skills to design satellite communication links meeting standards across diverse satellite systems. | 4 | 85% | 75% |

**Course Articulation Matrix: (CLO) to Program Learning Outcomes (PLO)**

| CLO | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Lifelong Learning | PSO1 | PSO2 | PSO3 |
| Outcome 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | 1 | 1 | 1 | 1 |
| Outcome 2 | 2 | 3 | 2 | 3 | 2 | | | | 2 | 1 | | 1 | 1 | 2 | 3 |
| Outcome 3 | 2 | 2 | 2 | 3 | 3 | | | | | | | 1 | 1 | 2 | 2 |
| Outcome 4 | 2 | 3 | 3 | 3 | 3 | | | | 2 | 1 | | 1 | 2 | 3 | 3 |
| Outcome 5 | 3 | 3 | 2 | 3 | 3 | | | | 2 | 1 | | 2 | 2 | 2 | 2 |
| **Course Average** | **2** | **2** | **2** | **3** | **2** | | | | **2** | **1** | | **1** | **1** | **2** | **2** |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References |
|---|---|---|---|---|
| **Unit 1** | **ELEMENTS OF ORBITAL MECHANICS** | **9** | | |
| | Equations of motion. | 2 | 1 | 1, 2 |
| | Tracking and orbit Determination | 2 | 1 | 1, 2 |
| | Orbital correction/control | 2 | 1 | 1, 2 |
| | Satellite launch systems | 2 | 1 | 1, 2 |

| | | | | |
|---|---|---|---|---|
| | Multistage rocket launchers and their performance | 1 | 1 | 1, 2 |
| **Unit 2** | **ELEMENTS OF COMMUNICATION SATELLITE DESIGN** | **9** | | |
| | Spacecraft subsystems | 4 | 2 | 1, 3 |
| | Reliability considerations | 3 | 2 | 1, 3 |
| | Spacecraft integration | 2 | 2 | 1, 3 |
| **Unit 3** | **MULTIPLE ACCESS TECHNIQUES** | **9** | | |
| | FDMA | 2 | 3 | 2, 3 |
| | TDMA | 2 | 3 | 2, 3 |
| | CDMA | 2 | 3 | 2, 3 |
| | Random access techniques | 1 | 3 | 2, 3 |
| | Satellite onboard processing | 2 | 3 | 2, 3 |
| **Unit 4** | **SATELLITE LINK DESIGN** | **9** | | |
| | Performance requirements and standards | 2 | 4 | 1, 2 |
| | design of satellite links | 2 | 4 | 1, 2 |
| | DOMSAT, INSAT | 2 | 4 | 1, 2 |
| | INTELSAT and IMMaRSAT | 2 | 4 | 2, 3 |
| | Satellite-based personal communication | 1 | 4 | 2, 3 |
| **Unit 5** | **EARTH STATION DESIGN** | **9** | | |
| | Configurations | 3 | 5 | 1, 3 |
| | Antenna and tracking systems | 3 | 5 | 2, 3 |
| | Satellite broadcasting | 3 | 5 | 2, 3 |

**Recommended Resources**

1. Dennis Roddy, Satellite Communications, 4/e, Tata McGraw Hill, 2006
2. T. Pratt, S. W. Bostian, Satellite Communication, 2/e, John Wiley and Sons, 2006.
3. D. C. Agarwal, Satellite Communication, 1/e, Khanna Publishers, 1991.

**Other Resources**

1. Dharma Raj Cheruku, Satellite Communication, 1/e, IK International Publishing, 2010.

**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (50%)** | | | | | | | | **End Semester Exam (50%)** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **CLA-1 (10%)** | | **Mid-1 (15%)** | | **CLA-2 (10%)** | | **Mid-2 (15%)** | | | |
| | | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** |
| Level 1 | Remember | 35% | | 35% | | 35% | | 35% | | 35% | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 65% | | 65% | | 65% | | 65% | | 65% | |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designer(s)**

*Dr. Sunil Chinnadurai. Associate Professor. Dept. Of ECE. SRM University – AP.*

SRM UNIVERSITY AP
Andhra Pradesh

# Specialization : Advanced Signal Processing with AI/ML

# SRM University – AP, Andhra Pradesh

Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

## Advanced Signal Processing

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Code | ECE 451 | Course Category | Technical Elective | L-T-P-C | **3** | **0** | **0** | **3** |
| Pre-Requisite Course(s) | Signals and Systems, Digital Signal processing, Control System | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To understand the Linear Algebra in Modern Digital Signal processing.

**Objective 2:** To learn the principles of different type digital filter designs.

**Objective 3:** To understand the different Spectrum Estimation Algorithms.

**Objective 4:** Application of DSP in Real-World Problems

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Understand the techniques for analysing and processing signals in the presence of noise. | 2 | 90% | 95% |
| **Outcome 2** | Learn the principles of digital filter design. | 3 | 80% | 80% |
| **Outcome 3** | Analyse estimation theory, detection theory, and parameter estimation. | 4 | 70% | 80% |
| **Outcome 4** | Process the digital Signal using Statistical methods. | 5 | 60% | 70% |
| **Outcome 5** | Apply modern digital signal processing techniques to solve real-world problems in areas such as telecommunications, audio processing, or biomedical signal processing. | 6 | 50% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Lifelong Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 3 | 3 | | | 3 | | | | | | | 3 | | | 2 |
| Outcome 2 | 3 | 3 | 2 | 2 | | | | | | | | 2 | 3 | 2 | 3 |
| Outcome 3 | 3 | 3 | 2 | 3 | 2 | | | | | | | 2 | 3 | 3 | 3 |
| Outcome 4 | 3 | 3 | 3 | 3 | 3 | | | | | | | 3 | | 3 | 3 |
| Outcome 5 | 3 | 3 | 3 | 3 | 3 | | | | 3 | | | 3 | 3 | 3 | 3 |
| **Course Average** | **3** | **3** | **3** | **3** | **3** | | | | **3** | | | **3** | **3** | **3** | **3** |

**Course Unitization Plan- Theory**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| | **UNIT I: LINEAR ALGEBRA** | **12** | | |
| 1. | Vectors, linear independence, vector spaces and basis vectors, matrices, matrix inverse | 1 | 1,4 | 1,2 |
| 2. | The determinant and trace, linear equations, special matrix forms, quadratic and hermitian forms | 1 | 1,4 | 1,2 |
| 3. | Eigen values and eigen vectors | 1 | 1,4 | 1,2 |
| 4. | Discrete Time Random Process: Introduction, Random Variables: Ensemble averages, jointly distributed random variables, joint moments, independent, uncorrelated orthogonal random variables, linear mean square estimation | 3 | 1,4 | 1,2 |
| 5. | Gaussian random variables. Random processes: Ensemble averages, | 2 | 1,4 | 1,2 |
| 6. | Gaussian processes, stationary processes, auto covariance and auto correlation matrices, ergodicity, white noise, power spectrum, filtering random processes, special types of random processes (ARMA, MA, AR Harmonic processes). | 4 | 1,4 | 1,2 |
| | **UNIT II: OPTIMUM FILTERS** | **7** | | |
| 7. | About FIR Wiener Filter | 1 | 1-3 | 1,2 |
| 8. | Filtering, linear prediction | 2 | 1-3 | 1,2 |
| 9. | Noise cancellation | 1 | 1-3 | 1,2 |
| 10. | Lattice representation for the FIR Wiener filter | 2 | 1-3 | 1,2 |
| 11. | Causal linear prediction | 1 | 1-3 | 1,2 |
| | **UNIT III: ADAPTIVE FILTERS** | **8** | | |
| 12. | FIR Adaptive Filters: Steepest descent adaptive filter | 1 | 1-3 | 1-4 |
| 13. | LMS algorithm, convergence of LMS algorithm, normalized LMS | 2 | 1-3 | 1-4 |
| 14. | Application: Noise cancellation. | 1 | 1-3 | 1-4 |
| 15. | Other LMS based adaptive filters, gradient adaptive lattice filter, joint process estimator, channel equalization, adaptive recursive filters. | 2 | 1-3 | 1-4 |

| | | | | |
|---|---|---|---|---|
| 16. | Recursive Least squares: Exponentially weighted RLS, sliding window RLS | 2 | 1-3 | 1-4 |
| | **UNIT IV: SPECTRUM ESTIMATION- Part-A** | **7** | | |
| 17. | Non-Parametric Methods: Periodogram, performance of the periodogram, modified periodogram, | 2 | 3-5 | 1-4 |
| 18. | Bartlett's method: periodogram averaging. | 2 | 3-5 | 1-4 |
| 19. | Blackman-Tukey approach: periodogram smoothing. | 2 | 3-5 | 1-4 |
| 20. | Performance comparisons, minimum variance spectrum estimation, maximum entropy method | 1 | 3-5 | 1-4 |
| | **UNIT V: SPECTRUM ESTIMATION- Part-B** | **7** | | |
| 21. | Parametric Methods: AR, MA, ARMA spectrum estimation techniques | 2 | 3-5 | 2-5 |
| 22. | Frequency estimation: Eigen decomposition of the autocorrelation matrix, Pisarenko harmonic decomposition, music, other eigen decomposition methods. | 3 | 3-5 | 2-5 |
| 23. | Principal components spectrum estimation: Bartlett frequency estimation, minimum variance frequency estimation, autoregressive frequency estimation | 2 | 3-5 | 2-5 |
| **Total Contact Hours** | | **41** | | |

**Recommended Resources**


1. Monson H. Hayes, Statistical Digital Signal Processing and Modeling, 1/e, Wiley Student Edition, 1996.
2. Proakis, J. Gard, D.G.Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, 4/e, Pearson Education, 2006.
3. D. G. Manolakis, Vijay Ingle, Statistical and Adaptive Signal Processing, 1/e, Artech Book House, 2009.
4. A.V. Oppenheim, R.W.Schafer, Discrete Time Signal Processing, 2/e, Prentice Hall of India, 1999.
5. S.J. Orfanidis, Optimum Signal Processing, 2/e, McGraw Hill, 1989.


**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (60%)** | | | | **End Semester Exam (40%)** |
|---|---|---|---|---|---|---|
| | | **Theory (60%)** | | | | |
| | | **Mid – 1 (15%)** | **CLA -1 (15%)** | **CLA-2 (15%)** | **Mid – 2 (15%)** | **Theory (40%)** |
| Level 1 | Remember | 50% | 40% | 30% | 10% | 20% |
| | Understand | | | | | |
| Level 2 | Apply | 40% | 50% | 50% | 30% | 40% |
| | Analyse | | | | | |
| Level 3 | Evaluate | 10% | 10% | 20% | 60% | 40% |
| | Create | | | | | |
| **Total** | | 100% | 100% | 100% | 100% | 100% |

**Course Designers**


*Dr. Sibendu Samanta, Assistant Professor, Dept. of ECE, SRM University – AP*

# SRM University – AP, Andhra Pradesh

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Guntur District, Mangalagiri, Andhra Pradesh 522240

## Deep Learning

| Course Code | **ECE 452** | Course Category | **Elective (TE)** | L-T-P-C | **2** | **0** | **1** | **3** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | **Nil** | Co-Requisite Course(s) | **Nil** | Progressive Course(s) | **Nil** | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |
| Board of Studies Approval Date | | Academic Council Approval Date | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To familiarise the domain of fully connected neural networks.

**Objective 2:** To understand and design convolutional neural networks.

**Objective 3:** To understand and design recurrent neural networks.

**Objective 4:** To understand autoencoders and generative models.

**Objective 5:** To have a basic understanding of applications of deep learning.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Design fully connected neural networks | 3 | 85% | 80% |
| **Outcome 2** | Apply and analyse convolutional neural networks | 3 | 80% | 75% |
| **Outcome 3** | Apply recurrent neural networks | 3 | 85% | 70% |
| **Outcome 4** | Apply autoencoders and generative models. | 3 | 80% | 70% |
| **Outcome 5** | Understand the applications of deep learning to Computer vision and NLP | 2 | 75% | 65% |

**Course Articulation Matrix: (CLO) to Program Learning Outcomes (PLO)**

| **CLO** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and | Modern Tool and ICT Usage | Society and Multicultural | Environment and | Moral, and Ethical | Individual and Teamwork | Communication Skills | Project Management | Self-Directed and Lifelong | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | 1 | 1 | 1 | 1 |
| Outcome 2 | 2 | 3 | 2 | 3 | 2 | | | | 2 | 1 | | 1 | 1 | 2 | 3 |
| Outcome 3 | 2 | 2 | 2 | 3 | 3 | | | | | | | | 1 | 2 | 2 |
| Outcome 4 | 2 | 3 | 3 | 3 | 3 | | | | 2 | 1 | | 1 | 2 | 3 | 3 |
| Outcome 5 | 3 | 3 | 2 | 3 | 3 | | | | 2 | 1 | | 2 | 2 | 2 | 2 |
| **Course Average** | **2** | **3** | **2** | **3** | **3** | | | | **2** | **1** | | **1** | **1** | **2** | **2** |

**Course Unitization Plan - Theory**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Introduction to neural network** | **18** | | |
| | Introduction to Neural network | 1 | 1 | 1, 2 |
| | Feedforward Neural networks | 1 | 1 | 1, 2 |
| | Gradient descent algorithm | 1 | 1 | 1, 2 |
| | Back propagation algorithm | 1 | 1 | 1, 2 |
| | Activation function | 1 | 1 | 1, 2 |
| | Training neural network | 1 | 1 | 1, 2 |
| | Risk minimization, loss function | 1 | 1 | 1, 2 |
| | Regularization and model selection | 1 | 1 | 1, 2 |
| | Optimization and hyperparameters | 1 | 1 | 1, 2 |
| | Shallow neural networks and Deep neural networks | 1 | 1 | 1, 2 |
| Expt 1 | Binary Classification using Fully connected neural network | 2 | 1 | 4 |
| Expt 2 | Regression using Fully connected neural network | 2 | 1 | 4 |
| Expt 3 | Multi-class classification using Fully connected neural network | 2 | 1 | 4 |
| Expt 4 | MNIST digit classification using fully connected neural network | 2 | 1 | 4 |
| **Unit 2** | **Convolutional neural networks** | **16** | | |
| | Introduction to CNN | 1 | 2 | 1, 2 |
| | Convolutions and Pooling | 1 | 2 | 1, 2 |
| | Invariance, stability | 1 | 2 | 1, 2 |
| | Understanding ConvNets via Visualization | 1 | 2 | 1, 2 |
| | ConvNet Architectures | 2 | 2 | 1, 2 |
| | CNN on ImageNet | 1 | 2 | 1, 2 |
| | Overfitting Bias/Variance trade-off | 1 | 2 | 1, 2 |
| | Deep Convolutional Neural Networks | 2 | 2 | 1, 2 |
| Expt 5 | MNIST digit classification using CNNs | 2 | 2 | 4 |
| Expt 6 | CIFAR10 classification using AlexNet | 2 | 2 | 4 |
| Expt 7 | CIFAR10 classification using Transfer Learning | 2 | 2 | 4 |
| **Unit 3** | **Recurrent neural networks** | **13** | | |
| | Introduction to Recurrent Networks | 1 | 3 | 1, 2 |
| | Back propagation through time | 1 | 3 | 1, 2 |
| | The problem of Exploding and Vanishing Gradients | 2 | 3 | 1, 2 |
| | Long Short Term Memory (LSTM) | 2 | 3 | 1, 2 |
| | Gated Recurrent Units (GRUs) | 1 | 3 | 1, 2 |
| | How LSTMs avoid the problem of vanishing gradients | 2 | 3 | 1, 2 |
| Expt 8 | Stock price prediction using RNNs | 2 | 3 | 4 |
| Expt 9 | Sentiment Analysis using RNNs | 2 | 3 | 4 |

| | | | | |
|---|---|---|---|---|
| **Unit 4** | **Autoencoders** | **11** | | |
| | Introduction to Autoencoders | 1 | 4 | 1, 2 |
| | Introduction to Encoder and Decoder models | 1 | 4 | 1, 2 |
| | Link between PCA and Autoencoders | 1 | 4 | 1, 2 |
| | Regularization in autoencoders | 1 | 4 | 1, 2 |
| | Denoising Autoencoders | 1 | 4 | 1, 2 |
| | Sparse Autoencoders | 1 | 4 | 1, 2 |
| | Introduction to Generative Adversarial Networks (GAN) | 2 | 4 | 1, 2 |
| | Introduction to Reinforcement Learning | 1 | 4 | 1, 2 |
| Expt 10 | Design of Autoencoders | 2 | 4 | 4 |
| **Unit 5** | **Applications of Deep Learning** | **8** | | |
| | Introduction | 2 | 5 | 1, 2,3 |
| | Computer vision applications | 3 | 5 | 1, 2,3 |
| | NLP Applications | 3 | 5 | 1, 2,3 |
| **Total Contact Hours** | | **66** | | |

**Recommended Resources**


7. Ravichandiran, S., 2019. Hands-On Deep Learning Algorithms with Python: Master deep learning algorithms with extensive math by implementing them using TensorFlow. Packt Publishing Ltd..
8. Goodfellow, I., Bengio, Y., Courville, A. and Bengio, Y., 2016. Deep learning (Vol. 1). Cambridge: MIT press.
9. Research Papers
10. TensorFlow


**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (50%)** | | | | | | | | **End Semester Exam (50%)** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **CLA-1 (10%)** | | **Mid-1 (15%)** | | **CLA-2 (10%)** | | **CLA-3 (15%)** | | | |
| | | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** |
| Level 1 | Remember | 40% | 50% | 60% | 40% | 40% | 50% | 60% | | 40% | 40% |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 60% | 50% | 40% | 60% | 60% | 50% | 40% | | 60% | 60% |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designer(s)**


a. *Dr. Sudhakar Tummala. Asst. Professor. Dept. Of ECE. SRM University - AP*
b. *Dr. V. Udaya Sankar, Asst. Professor, Department of ECE, SRM University-AP*

# SRM University – AP, Andhra Pradesh

Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

## Image Processing and Computer Vision

| Course Code | **ECE 453** | Course Category | **Elective (TE)** | L-T-P-C | **3** | **0** | **0** | **3** |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | **Digital Signal Processing** | Co-Requisite Course(s) | **Nil** | Progressive Course(s) | **Nil** | | | |
| Course Offering Department | **ECE** | Professional / Licensing Standards | | | | | | |
| Board of Studies Approval Date | | Academic Council Approval Date | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To understand the geometric relationships between 2D images and the real-world 3D objects.
**Objective 2:** To analyse the foundation of camera geometry, measurement, and analysis.
**Objective 3:** To apply various advanced computer vision techniques.
**Objective 4:** To understand standard image processing and computer vision algorithms.
**Objective 5:** To develop the practical skills necessary to build futuristic imaging systems.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Understand the geometric relationships between 2D images and the real-world 3D objects. | 1 | 85% | 80% |
| **Outcome 2** | Analyse the foundation of camera geometry, measurement, and analysis. | 2 | 80% | 75% |
| **Outcome 3** | ious advanced computer vision techniques. | 2 | 85% | 70% |
| **Outcome 4** | Understand standard image processing and computer vision algorithms. | 1 | 80% | 70% |
| **Outcome 5** | Create futuristic imaging systems. | 3 | 75% | 65% |

**Course Articulation Matrix: (CLO) to Program Learning Outcomes (PLO)**

| **CLO** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Lifelong Learning | PSO1 | PSO2 | PSO3 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outcome 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | 1 | 1 | 1 | 1 |
| Outcome 2 | 2 | 3 | 2 | 3 | 2 | | | | 2 | 1 | | 1 | 1 | 2 | 3 |
| Outcome 3 | 2 | 2 | 2 | 3 | 3 | | | | 2 | 1 | | 1 | 1 | 2 | 2 |
| Outcome 4 | 2 | 3 | 3 | 3 | 3 | | | | 2 | 1 | | 1 | 2 | 3 | 3 |
| Outcome 5 | 3 | 3 | 2 | 3 | 3 | | | | 2 | 1 | | 2 | 2 | 2 | 2 |
| **Course Average** | **2** | **3** | **2** | **3** | **3** | | | | **2** | **1** | | **1** | **1** | **2** | **2** |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Introduction to Image processing** | **10** | | |
| | Image acquisition, image sampling and quantization and image representation, spatial and intensity resolutions. | 1 | 1 | 1, 2 |
| | Intensity transformations, Histogram processing, Histogram equalization and modification. | 1 | 1 | 1, 2 |
| | Spatial filtering and convolution, smoothening and Sharpening filters, median filter. | 1 | 1 | 1, 2 |
| | 2D DFT and filtering in frequency domain | 2 | 1 | 1, 2 |
| | Image Restoration, Linear Degradation model, Inverse filtering, Wiener filter | 3 | 1 | 1, 2 |
| | Color image processing: Color fundamentals, color models. | 2 | 1 | 1, 2 |
| **Unit 2** | **Camera Geometry and Depth Estimation** | **10** | | |
| | Image formation: perspective projection. Cameras with lenses. | 1 | 2 | 1, 2 |
| | Rigid Transformations and Homogeneous coordinates, Intrinsic and extrinsic parameters | 2 | 2 | 1, 2 |
| | Geometric camera calibration | 1 | 2 | 1, 2 |
| | Binocular Camera Geometry and Epipolar constraint, Essential and fundamental matrices | 2 | 2 | 1, 2 |

| | | | | |
|---|---|---|---|---|
| | Binocular fusion: Local and Global Methods. | 2 | 2 | 1, 2 |
| | Multi- view stereo | 2 | 2 | 1, 2 |
| **Unit 3** | **Motion Estimation and Structure from Motion** | **10** | | |
| | Optical Flow, Horn-Shunck and Lucas-Kanade algorithms | 2 | 3 | 1, 2 |
| | Geometric Intrinsic calibration and pose estimation | 2 | 3 | 1, 2 |
| | Two- frame and Multi-frame SFMs | 4 | 3 | 1, 2 |
| | SLAM and applications | 2 | 3 | 1, 2 |
| **Unit 4** | **Feature Extraction and Image Segmentation** | **8** | | |
| | Edge and Line detection | 1 | 4 | 1, 2 |
| | Orientation Histograms, HOG, SIFT and SURF | 2 | 4 | 1, 2 |
| | Principal Component Analysis | 1 | 4 | 1, 2 |
| | Segmentation by region growing and region splitting | 2 | 4 | 1, 2 |
| | Segmentation using graph cuts | 2 | 4 | 1, 2 |
| **Unit 5** | **Applications** | **10** | | |
| | Computational Photography: HDR imaging, Super resolution, denoising and blur removal | 4 | 5 | 1, 2 |
| | Image-Based Rendering | 2 | 5 | 1, 2 |
| | Image classification, Face Recognition | 2 | 5 | 1, 2 |
| | Object Detection: Face detection, Pedestrian detection | 2 | 5 | 1, 2 |
| **Total Contact Hours** | | **45** | | |

**Recommended Resources**

| |
|---|
| 1. Digital Image Processing, by Rafael Gonzalez and Richard Woods. |
| 2. Computer Vision: A Modern Approach, by David Forsyth and Jean Ponce. Pearson Education. |
| 3. Multiple View Geometry in Computer Vision, by Richard Hartley and Andrew Zisserman. |
| 4. Computer Vision: Algorithms and Applications, by Richard Szeliski. |

**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (50%)** | | | | | | | | **End Semester Exam (50%)** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **CLA-1 (10%)** | | **Mid-1 (15%)** | | **CLA-2 (10%)** | | **CLA-3 (15%)** | | | |
| | | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** |
| Level 1 | Remember | 40% | | 60% | | 40% | | 60% | | 30% | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 60% | | 40% | | 60% | | 40% | | 70% | |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designer(s)**

*Dr. Sudhakar Tummala. Asst. Professor. Dept. Of ECE. SRM University - AP*

# SRM University – AP, Andhra Pradesh

Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

## Biomedical Signal Processing

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Code | **ECE 454** | Course Category | **Professional Core** | L-T-P-C | **3** | **0** | **0** | **3** |
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | **ECE / EEE** | Professional / Licensing Standards | - | | | | | |
| Board of Studies Approval Date | **BOS, 2022** | Academic Council Approval Date | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** Understand the physiological basis and origin of biomedical signals.

**Objective 2:** Familiarize with different types of biomedical signals and the challenges in their analysis.
**Objective 3:** Analyse EEG signals using advanced methods like autoregressive modeling and adaptive segmentation.

**Objective 4:** Learn ECG data acquisition and advanced techniques for ECG waveform analysis and apply adaptive filter techniques to enhance the accuracy and quality of biomedical signals.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Ability to understand the origin and physiological basis of biomedical signals. | 2 | 80% | 70% |
| **Outcome 2** | Ability to Identify and describe various types of biomedical signals and their analysis challenges. | 3 | 80% | 70% |
| **Outcome 3** | Ability to Analyse EEG signals using advanced techniques like autoregressive modelling. | 3 | 80% | 70% |
| **Outcome 4** | Ability to Acquire and process ECG data to detect and analyse waveforms and arrhythmias and apply adaptive filters to enhance the quality and accuracy of biomedical signals. | 4 | 80% | 70% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** |
|---|---|

| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Lifelong Learning | PSO 1 | PSO 2 | PSO 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outcome 1 | 2 | 2 | 1 | 2 | 2 | 1 | | 1 | 2 | | 1 | 2 | 1 | 1 | 1 |
| Outcome 2 | 2 | 2 | 1 | 2 | 2 | 1 | | 1 | 2 | | 1 | 2 | 1 | 1 | 1 |
| Outcome 3 | 2 | 2 | 1 | 2 | 2 | 1 | | 1 | 2 | | 1 | 2 | 1 | 1 | 1 |
| Outcome 4 | 3 | 3 | 3 | 3 | 3 | 1 | | 1 | 1 | | 3 | 1 | 1 | 1 | 1 |
| **Course Average** | **2** | **2** | **2** | **2** | **2** | **1** | | **1** | **2** | | **2** | **2** | **1** | **1** | **1** |

**Course Unitization Plan – Theory**

| Unit No. | Syllabus Topics | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| Unit No. 1 | **UNIT I: PHYSIOLOGY TO UNDERSTAND BIOMEDICAL SIGNAL ORIGIN** | **9** | | |
| | Cell and its structure – Resting and Action Potential | 1 | 1 | 1, 2 |
| | Nervous system and its fundamentals - Basic components of a biomedical system | 2 | 1 | 1, 2 |
| | Cardiovascular systems- Respiratory systems | 2 | 1 | 1, 2 |
| | Electrodes – Limb electrodes –floating electrodes | 2 | 1 | 1, 2 |
| | pregelled disposability electrodes - Micro, needle and surface electrodes | 2 | 1 | 1, 2 |
| Unit No. 2 | **UNIT II– FUNDAMENTALS OF BIOMEDICAL SIGNALS** | **9** | | |
| | Bioelectric signals- Electro-neurogram, Electro-oculogram, Electroencephalogram | 2 | 1 | 1, 2 |
| | Evoked potential, Electro-cardiogram, Electro-gastrogram, PPG, | 2 | 1 | 1, 2 |
| | Bio Impedance Signals, Mechanical Signals - Bioacoustics Signals, Biochemical Signals | 2 | 1 | 1, 2 |
| | Objectives Of Biomedical Signal Analysis, | 2 | 1 | 1, 2 |
| | Difficulties In Biomedical Signal Analysis | 1 | 1 | 1, 2 |
| **Unit No.** | **UNIT III - NEUROLOGICAL SIGNAL PROCESSING** | **9** | | |

| | | | | |
|---|---|---|---|---|
| **3** | EEG signal and its characteristics, EEG analysis, | 2 | 3 | 1, 2 |
| | Linear prediction theory-Autoregressive method, Moving average model, Autoregressive moving average mode | 1 | 3 | 1, 2 |
| | Estimation of AR, MA, ARMA parameters. | 1 | 3 | 1, 2 |
| | AR modelling of Seizure EEG | 1 | 3 | 1, 2 |
| | Spectral error measure | 2 | 3 | 1, 2 |
| | Adaptive segmentation | 2 | 3 | 1, 2 |
| **Unit No. 4** | **UNIT IV: CARDIOLOGICAL SIGNAL PROCESSING** | **9** | | |
| | Basic Electrocardiography, ECG data acquisition, ECG lead system | 2 | 3 | 1, 2 |
| | ECG signal characteristics (parameters and their estimation) | 2 | 3 | 1, 2 |
| | Power spectrum of the ECG, Analog filters, ECG amplifier, Event Detection: Example events (viz. P, QRS and T wave in ECG), | 2 | 3 | 1, 2 |
| | Derivative based Approaches for QRS Detection Pan Tompkins Algorithm for QRS Detection | 1 | 3 | 1, 2 |
| | ECG interpretation, ST segment analyser, Portable arrhythmia monitor | 2 | 3 | 1, 2 |
| **Unit No. 5** | **UNIT V: ADAPTIVE FILTERS FOR NOISE CANCELLATION IN BIOSIGNALS** | **9** | | |
| | Adaptive filter- principles, steepest descent algorithm, Widrow-Hoff least mean square adaptive algorithm, | 2 | 2, 4 | 1, 2, 3 |
| | Adaptive noise canceller-cancellation of 60Hz interference in ECG-cancelling donor heart interference in Heart-transplant | 2 | 2, 4 | 1, 2, 3 |
| | ECG-cancellation of ECG signals from electrical activity of chest muscles- cancelling of maternal ECG from fetal ECG-cancellation of high frequency noise in Electro-surgery. | 2 | 2, 4 | 1, 2, 3 |
| | Adaptive line enhancement of diastolic heart sound, Applications of adaptive noise cancelling method to enhance electro gastric measurements. | 3 | 2, 4 | 1, 2, 3 |

**Recommended Resources**


1. Rangaraj M. Rangayyan, Biomedical Signal Analysis: A Case-Study Approach, Publisher: Wiley India; 2009.
2. Eugene N. Bruce, Biomedical Signal Processing and Signal Modeling, Wiley-Inderscience; 1 edition, 2000.
3. John L. Semmlow, Biosignal and Biomedical Image Processing: MATLAB-based applications, CRC; 1 edition, 2004.
4. MetinAkay, Time Frequency and Wavelets in Biomedical Signal Processing, Wiley- IEEE Press; IEEE Press; 1 edition, 1997

**Learning Assessment - Theory**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (10%) | | Mid-1 (15%) | | CLA-2 (10%) | | Mid-2 (15%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 50% | | 50% | | 60% | | 60% | | 60% | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 50% | | 50% | | 40% | | 40% | | 40% | |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designers**

*Dr. KA Sunitha, Associate Professor, Department of ECE, SRM University AP*

# SRM University – AP, Andhra Pradesh

Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

## Detection and Estimation Theory

| Course Code | ECE 455 | Course Category | Elective (TE) | L-T-P-C | 3 | 0 | 0 | 3 |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | Nil | Co-Requisite Course(s) | Probability and Random Variables, Linear Algebra, Wireless Communications | Progressive Course(s) | Nil | | | |
| Course Offering Department | ECE | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To understand the importance of detection and estimation

**Objective 2:** To understand and design the various detectors

**Objective 3:** To understand and design various estimators

**Objective 4:** To understand how to apply detection and estimation algorithms to a particular situation

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | To understand the importance of detection and estimation | 3 | 85% | 80% |
| **Outcome 2** | To understand and design the various detectors | 3 | 80% | 75% |
| **Outcome 3** | To understand and design various estimators | 3 | 85% | 70% |
| **Outcome 4** | To understand how to apply detection and estimation algorithms to a particular situation. | 3 | 80% | 70% |

**Course Articulation Matrix: (CLO) to Program Learning Outcomes (PLO)**

| **CLO** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and | Modern Tool and ICT Usage | Society and Multicultural | Environment and | Moral, and Ethical | Individual and Teamwork | Communication Skills | Project Management | Self-Directed and Lifelong | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 1 | 1 | 1 | 1 | 1 | | | | 1 | 1 | | 3 | 1 | 1 | 1 |
| Outcome 2 | 2 | 3 | 3 | 3 | 2 | | | | 2 | 1 | | 3 | 1 | 2 | 3 |
| Outcome 3 | 2 | 3 | 3 | 3 | 2 | | | | 2 | 1 | | 3 | 1 | 2 | 2 |
| Outcome 4 | 3 | 3 | 3 | 3 | 3 | | | | 2 | 1 | | 3 | 2 | 3 | 3 |
| **Course Average** | **2** | **3** | **3** | **3** | **3** | | | | **2** | **1** | | **3** | **2** | **2** | **2** |

**Course Unitization Plan - Theory**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Introduction** | **8** | | |
| | Introduction to Detection and Estimation | 2 | 1 | 1, 2,3 |
| | Review of Probability | 2 | 1 | 1, 2,3 |
| | Review of Linear Algebra | 2 | 1 | 1, 2,3 |
| | Hypothesis Testing | 2 | 1 | 1, 2,3 |
| **Unit 2** | **Detection Theory** | **8** | | |
| | Neyman-Pearson Detector | 3 | 2 | 1, 2,3 |
| | Bayes detector | 2 | 2 | 1, 2,3 |
| | Matched Filters | 3 | 2 | 1, 2,3 |
| **Unit 3** | **Estimation Theory** | **8** | | |
| | Introduction to Estimation Theory | 1 | 3 | 1, 2,3 |
| | Minimum Variance Unbiased Estimation | 2 | 3 | 1, 2,3 |
| | CR Rao Lower Bound | 2 | 3 | 1, 2,3 |
| | General Minimum Variance Unbiased Estimator | 1 | 3 | 1, 2,3 |
| | Best Linear Unbiased Estimator | 2 | 3 | 1, 2,3 |
| **Unit 4** | **Estimation Theory (Contd..)** | **11** | | |
| | Maximum likelihood estimator | 2 | 4 | 1, 2,3 |
| | Linear Bayesian Estimator-Minimum Mean squared Estimator | 3 | 4 | 1, 2,3 |
| | Wiener and Kalman Filters | 4 | 4 | 1, 2,3 |
| **Unit 5** | **Applications of Detection and Estimation** | **8** | | |
| | Application to Detection Theory | 3 | 5 | 1, 2,3 |
| | Application to Estimation Theory | 5 | 5 | 1, 2,3 |
| **Total Contact Hours** | | **41** | | |

**Recommended Resources**

1. Fundamentals of Statistical Signal Processing, Volume I: Estimation Theory, S.M. Kay, Prentice Hall 1993, ISBN-13: 978-0133457117.
2. Fundamentals of Statistical Signal Processing, Volume II: Detection Theory, S.M. Kay, Prentice 1993, ISBN-13: 978-0135041352.
3. An Introduction to Signal Detection and Estimation, H.V. Poor, Springer, 2nd edition, 1998, ISBN-13: 978-0387941738.

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (10%) | | Mid-1 (15%) | | CLA-2 (10%) | | CLA-3 (15%) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 40% | | 60% | | 40% | | 60% | | 30% | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 60% | | 40% | | 60% | | 40% | | 70% | |
| | Analyse | | | | | | | | | | |
| | Evaluate | | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Level 3 | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designer(s)**

*Dr. V. Udaya Snakar, Asst. Professor, Department of ECE, SRM University-AP*

**SRM University – AP, Andhra Pradesh**
Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

# Digital Speech Processing

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | ECE 456 | **Course Category** | TE | **L-T-P-C** | **3** | **0** | **0** | **3** |
| **Pre-Requisite Course(s)** | Signals and Systems, DSP | **Co-Requisite Course(s)** | | **Progressive Course(s)** | | | | |
| **Course Offering Department** | ECE | **Professional / Licensing Standards** | | | | | | |

## Course Objectives

1. To understand the fundamentals of speech production and perception.
2. To analyse and synthesize speech signal
3. To implement speech and speaker recognition algorithms.
4. To develop robust speech coding and compression methods.
5. Exploring applications and emerging trends in speech technology.

## Course Outcome (COs)

| CO's | At the end of the course the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **1** | Demonstrate the basic concepts of speech production and perception, information source in the speech signal, applications of speech signal processing for the modern world. | **2** | 90% | 70% |
| **2** | Extract relevant information and enhancement of speech signals in the presence of different background noises | **3** | 80% | 70% |
| **3** | Implement the concepts pattern recognition system and different statistical modelling approaches for speech processing applications | **4** | 70% | 70% |
| **4** | Develop human-machine interactive systems using speech signals. | **6** | 60% | 70% |

## Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Engineering Knowledge** | **Problem** | **Design and Development** | **Analysis, Design and** | **Modern Tool and ICT** | **Society and Multicultural** | **Environment and** | **Moral, and Ethical** | **Individual and Teamwork** | **Communication Skills** | **Project Management** | **Self-Directed and Life Long** | **PSO 1** | **PSO 2** | **PSO 3** |
| Outcome 1 | 3 | 2 | 2 | 3 | | | | | | | | | 3 | 1 | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outcome 2 | 3 | 2 | 3 | 3 | | | | | | | | | 3 | 2 | |
| Outcome 3 | 3 | 2 | 3 | 3 | | | | | | | | | 3 | 3 | |
| Outcome 4 | 3 | | 3 | 3 | | | | | | | | | 3 | 3 | 3 |
| **Course Average** | 3 | 2 | 3 | 3 | | | | | | | | | 3 | 3 | 3 |

**Course Unitization Plan**

| Unit No. | Syllabus Topics | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| | **Unit 1: Introduction to Speech Processing** | **8** | | |
| **Unit No. 1** | Speech production and perception | 1 | 1 | 1 |
| | information sources in speech signal, linguistic aspect of speech, acoustic and articulatory phonetics | 2 | 1 | 1 |
| | nature of speech, models for speech analysis and perception | 1 | 1 | 1 |
| | short-term processing of speech | 1 | 1 | 1 |
| | time, frequency and time-frequency analysis | 1 | 1 | 1 |
| | development of short-term Fourier transform (STFT), transform and filter-bank views of STFT. | 2 | 1 | 1 |
| | **Unit 2: Analysis of speech** | **12** | | |
| **Unit No. 2** | Basis and development cesptrum analysis of speech | 2 | 1 | 1 |
| | real and complex cepstrum, pitch detection, formant estimation | 2 | 1,2 | 1 |
| | Mel-frequency cepstral coefficient (MFCC), delta and delta-delta MFCC | 2 | 1,2 | 1 |
| | Linear Prediction (LP) analysis, LP analysis of speech, | 3 | 1,2 | 1 |
| | solution of LP equation using Levinson-Durbin’s method, normalized error, LP spectrum, LP cepstrum, LP residual. | 3 | 1,2 | 1 |
| | **Unit 3: Speech Enhancement** | **6** | | |
| **Unit No. 3** | Speech enhancement: objective, issues | 1 | 2 | 1 |
| | enhancement of noisy speech | 2 | 2 | 1 |
| | reverberant speech and multi-speaker speech using time, frequency and time-frequency approaches | 2 | 2 | 1 |

| | | | | |
|---|---|---|---|---|
| | **Unit 4: Speech recognition** | **10** | | |
| **Unit No. 4** | Basic concepts of pattern recognition: feature extraction, modeling, testing, Objective, issues | 2 | 3 | 1 |
| | block diagram description of automatic speech recognition (ASR) system | 2 | 3 | 1 |
| | development of ASR system using vector quantization (VQ) | 2 | 3 | 1 |
| | dynamic time warping (DTW) | 2 | 3 | 1 |
| | Hidden Markov Model (HMM) | 1 | 3 | |
| | Neural networks (NN) | 1 | 3 | |
| | **Unit 5: Speaker Recognition** | **9** | | |
| **Unit No. 5** | Objective, issues | 1 | 3,4 | 1 |
| | block diagram description of speaker recognition system | 1 | 3,4 | 1 |
| | classification of speaker recognition systems | 2 | 3,4 | 1 |
| | development of speaker recognition system using VQ | 2 | 3,4 | 1 |
| | Speaker recognition system using Gaussian mixture model (GMM), Adapted-GMM | 2 | 3,4 | 1 |
| | Speaker recognition system using I-vetor | 1 | 3,4 | 2 |
| | **Total Hours** | **45** | | |

**Recommended Resources**

1. L. R. Rabiner, B. H. Jhuang and B. Yegnanarayana, “Fundamentals of speech recognition”, Pearson Education, 2009.

**2.** Selected research papers as recommended by the course instructor.

**Reference Books:**


1. L. Rabiner and R. W. Schafer, Digital Processing of Speech Signals, Prentice Hall, 1978.
2. K. Sayood, Introduction to Data Compression, 2nd Ed, Morgan Kaufmann, 2000.
3. D. O'Shaughnessy, Speech Communications: Human and Machine, 2nd Ed, IEEE Press, 2000.
4. A. Gersho and R. M. Gray, Vector Quantization and Signal Compression, Kluwer Academic, 1991.

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (60%) | | | | End Semester Exam (40%) |
|---|---|---|---|---|---|---|
| | | CLA-1 (15%) | Mid-1 (15%) | CLA-2 (15%) | CLA-3 (15%) | |
| Level 1 | Remember | 75% | 25% | 30% | | 35 |
| | Understand | | | | | |
| Level 2 | Apply | 25% | 75% | 30% | 25% | 30 |
| | Analyse | | | | | |
| Level 3 | Evaluate | | | 40% | 75% | 35 |
| | Create | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers**

*Dr. Anuj Deshpande, Asst. Professor, Department of ECE, SRM University AP*

# SRM University – AP, Andhra Pradesh

Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

## Pattern Recognition

| Course Code | ECE 459 | Course Category | Elective | L-T-P-C | 2 | 0 | 1 | 3 |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | Signal Processing, Digital Signal Processing, Image Processing, Linear Algebra | Co-Requisite Course(s) | Nil | Progressive Course(s) | Nil | | | |
| Course Offering Department | ECE | Professional / Licensing Standards | | | | | | |

**Course Objectives / Course Learning Rationales (CLRs)**

**Objective 1:** To familiarise the domains of supervised and unsupervised learning.

**Objective 2:** To understand and apply various classifiers.

**Objective 3:** To understand and apply clustering methods.

**Objective 4:** To understand and analyse numerous techniques for feature extraction and selection.

**Objective 5:** To have a basic understanding of recent advances in pattern recognition.

**Course Outcomes / Course Learning Outcomes (CLOs)**

| | **At the end of the course, the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Familiarise supervised and unsupervised learning | 1 | 85% | 80% |
| **Outcome 2** | Implement and apply various classifiers | 1, 2 | 80% | 75% |
| **Outcome 3** | Understand and apply clustering methods | 1, 2 | 85% | 70% |
| **Outcome 4** | Learn and evaluate various techniques for feature extraction and selection | 3,4 | 80% | 70% |
| **Outcome 5** | Understand and implement the support vector machine (SVM) | 3 | 75% | 65% |

**Course Articulation Matrix: (CLO) to Program Learning Outcomes (PLO)**

| **CLO** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and | Modern Tool and ICT | Society and Multicultural | Environment and | Moral, and Ethical | Individual and | Communication Skills | Project Management | Self-Directed and Lifelong | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | 1 | 1 | 1 | 1 |
| Outcome 2 | 2 | 3 | 2 | 3 | 2 | | | | 2 | 1 | | 1 | 1 | 2 | 3 |
| Outcome 3 | 2 | 2 | 2 | 3 | 3 | | | | 2 | 1 | | 1 | 1 | 2 | 2 |
| Outcome 4 | 2 | 3 | 3 | 3 | 3 | | | | 2 | 1 | | 1 | 2 | 3 | 3 |
| Outcome 5 | 3 | 3 | 2 | 3 | 3 | | | | 2 | 1 | | 2 | 2 | 2 | 2 |
| **Course Average** | **2** | **3** | **2** | **3** | **3** | | | | **2** | **1** | | **1** | **1** | **2** | **2** |

**Course Unitization Plan**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Introduction and mathematical preliminaries** | **8+4** | | |
| | Principles of Pattern recognition | 1 | 1 | 1, 2 |
| | Clustering vs Classification; Supervised vs unsupervised | 1 | 1 | 1, 2 |
| | Relevant basics of Linear Algebra, vector spaces | 2 | 1 | 1, 2 |
| | Probability Theory basics and Basics of Estimation theory | 2 | 1 | 1, 2 |
| | Decision Boundaries, Decision region/ Metric spaces/ distances | 2 | 1 | 1, 2 |
| | L1: Implement Linear Regression on the given dataset using python/MATLAB | 2 | 1 | 4-6 |
| | L2: Implement Logistic Regression on the given dataset using python/MATLAB | 2 | 1 | 4-6 |
| **Unit 2** | **Classification** | **13+8** | | |
| | Bayes decision rule, Error probability | 1 | | |
| | Linear Discriminant Function (equal covariance matrices) | 1 | | |
| | Non-linear Decision Boundaries (unequal covariance matrices) | 2 | | |
| | K-Nearest Neighbor | 2 | 2 | 1, 2 |
| | Naive Bayes | 1 | 2 | 1, 2 |
| | Single Layer Perceptron | 1 | 2 | 1, 2,3 |
| | Multi-layer Perceptron | 1 | | |
| | Training set, test set; standardization and normalization | 1 | | |
| | Decision Trees, Random Forest | 3 | 2 | 1, 2 |
| | L3: Implement Naïve Bayes classifier using Python/MATLAB | 2 | 2 | 4-6 |
| | L4: Implement KNN algorithm using Python/MATLAB | 2 | 2 | 4-6 |
| | L5: Implement Decision tree classifier using python/ MATLAB | 2 | 2 | 4-6 |
| | L6: Implement Random Forest classifier using python/ MATLAB | 2 | 2 | 4-6 |
| **Unit 3** | **Clustering** | **5+4** | | |
| | Clustering in machine learning | 1 | 3 | 1, 2, 3 |
| | Different types of clustering algorithms | 1 | 3 | 1, 2, 3 |
| | K-Means clustering | 1 | 3 | 1, 2, 3 |
| | Gaussian mixture models | 1 | 3 | 1, 2 3 |
| | Bias-variance trade off | 1 | 3 | 1, 2 3 |
| | L7: Implement K-means algorithm for clustering the data using python/MATLAB | 2 | 3 | 4-6 |
| | L8: Implement K-Nearest Neighbour classifier using python/MATLAB | 2 | 3 | 4-6 |
| **Unit 4** | **Feature selection and Extraction** | **6+4** | | |
| | Problem statement and uses Algorithms - Branch and bound algorithm, sequential forward / backward selection algorithms | 2 | 4 | 1, 2 |
| | Probabilistic separability-based criterion functions, interclass distance-based criterion functions | 2 | 4 | 1, 2 |
| | PCA + Kernel PCA | 2 | | |
| | L9: Emulate logic gates using neural network using python | 2 | 4 | 4-6 |
| | L10: Implement PCA for image/data analysis using Python/MATLAB | 2 | 4 | 4-6 |

| | | | | |
|---|---|---|---|---|
| **Unit 5** | **Recent advances in Pattern Recognition** | **3** | | |
| | Structural Pattern recognition, SVM | 1 | 5 | 1, 2 3 |
| | FCM | 1 | 5 | 1, 2 3 |
| | Soft-computing and Neuro-fuzzy techniques, and real-life examples | 1 | 5 | 1, 2 |
| **Total Contact Hours** | | **55** | | |

**Recommended Resources**

1. Christopher M. Bishop, "Pattern Recognition and Machine Learning" by Springer, 2007.
2. Tom M. Mitchell, "Machine Learning", First Edition by Tata McGraw-Hill Education, 2013.
3. EthemAlpaydin, "Introduction to Machine Learning" 4th Edition, The MIT Press, 2020
4. Google Colab
5. MATLAB
6. Scikit-Learn

**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (60%)** | | | | | | | | **End Semester Exam (40%)** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **CLA-1 (15%)** | | **Mid-1 (15%)** | | **CLA-2 (15%)** | | **CLA-3 (15%)** | | | |
| | | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** |
| Level 1 | Remember | 40% | 60% | 60% | 50% | 40% | 30% | 30% | 20% | 30% | 30% |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 60% | 40% | 40% | 50% | 40% | 40% | 40% | 40% | 30% | 30% |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | | | 20% | 30% | 30% | 40% | 40% | 40% |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designer(s)**

a. *Dr. Sibendu Samanta. Asst. Professor. Dept. Of ECE. SRM University – AP*

b. *Dr. Anuj P. Deshpande, Asst. Professor. Dept. Of ECE. SRM University – AP*

# MINOR PROGRAM (DRONE TECHNOLOGY)

**SRM University – AP, Andhra Pradesh**
Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

# Drone Fabrication and Testing

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | ECE 241 | **Course Category** | OE | **L-T-P-C** | 3 | 0 | 0 | 3 |
| **Pre-Requisite Course(s)** | | **Co-Requisite Course(s)** | | **Progressive Course(s)** | | | | |
| **Course Offering Department** | ECE | **Professional / Licensing Standards** | | | | | | |

**Course Objectives**

9. To understand the fundamentals of drone technology and its applications.
10. To gain practical knowledge in designing, fabricating, and testing drones.
11. To learn about the various components and systems involved in drone construction.
12. To develop skills in troubleshooting and maintaining drones.

**Course Outcome (COs)**

| CO's | At the end of the course the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **1** | Explain the history, evolution, and classifications of drones. | **1** | **80%** | **80%** |
| **2** | Select appropriate materials and design frames for different types of drones (quadcopters, hexacopters, etc.). | **1,6** | **75%** | **70%** |
| **3** | Install and configure power systems, including batteries and power distribution boards. | **2,4** | **75%** | **70%** |
| **4** | Develop basic programs for drone control using relevant programming languages. | **2,3** | **80%** | **75%** |
| **5** | Conduct flight tests to evaluate drone performance, stability, and responsiveness. | **2,6** | **75%** | **70%** |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Engineering Knowledge** | **Problem Analysis** | **Design and Development** | **Analysis, Design and** | **Modern Tool and ICT** | **Society and** | **Environment** | **Moral, and Ethical** | **Individual and Teamwork** | **Communication Skills** | **Project Management** | **Self-Directed and Life Long** | **PSO 1** | **PSO 2** | **PSO 3** |
| Outcome 1 | 3 | - | 1 | 1 | 1 | - | - | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 |
| Outcome 2 | 3 | 2 | 3 | 3 | 2 | - | - | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 |
| Outcome 3 | 3 | 2 | 3 | 3 | 3 | - | - | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 2 |
| Outcome 4 | 2 | 1 | 2 | 2 | 2 | - | - | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Average** | **2.75** | **1.25** | **2.25** | **2.25** | **2.00** | **-** | **-** | **1.75** | **2.00** | **1.75** | **1.75** | **2.25** | 1.75 | 1.75 | 1.75 |

**Course Unitization Plan**

| Unit No. | Syllabus Topics | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit No. 1** | **Introduction to Drones** | **8** | | |
| | Overview of Drone Technology: History and evolution of drones, Types and classifications of drones, Applications of drones in various fields | 4 | **1** | **1,2** |
| | Basic Principles of Flight: Aerodynamics and flight dynamics, Principles of lift, drag, thrust, and weight, Stability and control of drones | 4 | **1** | **1,2** |
| **Unit No. 2** | **Drone Components and Systems** | **8** | | |
| | Frame and Structure: Materials used in drone frames, Types of frames: quadcopters, hexacopters, octocopters | 2 | **1,2** | **1,2** |
| | Propulsion System: Motors: brushed vs. brushless, Propellers: types and selection, Electronic Speed Controllers (ESCs) | 2 | **1,2** | **1,2** |
| | Power System Batteries: types, specifications, and management Power distribution boards and wiring | 2 | **1,2** | **1,2** |
| | Control System Flight controllers: architecture and functions, Sensors: accelerometers, gyroscopes, barometers, GPS, Radio transmitters and receivers | 2 | **1,2** | **1,2** |
| **Unit No. 3** | **Drone Design and Fabrication** | **8** | | |
| | Design Process: Conceptual design and requirements analysis, CAD modeling and simulation, Component selection and sourcing | 4 | **2,3** | **2,3** |
| | Fabrication Techniques: Assembly of frame and installation of components, Soldering and wiring techniques, Balancing and tuning the drone | 4 | **2,3** | **2,3** |
| **Unit No. 4** | **Drone Programming and Control** | **10** | | |
| | Introduction to Drone Programming: Basic programming concepts, Programming languages used in drone development | 2 | **3** | **2,3** |
| | Flight Control Software: Open-source flight control software (e.g., ArduPilot, PX4), Configuration and calibration of flight controllers, Tuning PID controllers for stable flight | 4 | **2,3** | **2,3** |
| | Autonomous Flight: Waypoint navigation and mission planning, Integration of GPS and other sensors for autonomous operation | 4 | **3** | **2,3** |
| **Unit No. 5** | **Drone Testing and Troubleshooting** | **10** | | |
| | Pre-flight Checks and Safety: Checklist for pre-flight inspection, Safety protocols and risk assessment | 2 | **2,4** | **2,3** |

| | | | | |
|---|---|---|---|---|
| | Flight Testing: Basic flight maneuvers and controls, Testing stability and responsiveness, Analyzing flight data and performance | 4 | **2,4** | **2,3** |
| | Troubleshooting: Common issues and their solutions, Diagnostic tools and techniques, Maintenance and repair of drones | 4 | **2,4** | **2,3** |
| | **Total** | **44** | | |

**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (50%)** | | | | | | | | **End Semester Exam (50%)** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **CLA-1 (10%)** | | **CLA-2 (15%)** | | **CLA-3 (5%)** | | **Mid Term (20%)** | | | |
| | | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** | **Th** | **Prac** |
| Level 1 | Remember | 80% | -- | 60% | -- | 30% | -- | 60% | -- | 50% | -- |
| | Understand | | -- | | -- | | -- | | -- | | -- |
| Level 2 | Apply | 20% | -- | 30% | -- | 40% | -- | 30% | -- | 30% | -- |
| | Analyse | | -- | | -- | | -- | | -- | | -- |
| Level 3 | Evaluate | -- | -- | 10% | -- | 30% | -- | 10% | -- | 20% | -- |
| | Create | -- | -- | | -- | | -- | | -- | | -- |
| **Total** | | **100%** | **--** | **100%** | **--** | **100%** | **--** | **100%** | **--** | **100%** | **--** |

**Recommended Resources**

1. DeFrangesco, Ralph, and Stephanie DeFrangesco. The big book of drones. CRC Press, 2022.
2. McGriffy, David. Make: drones: teach an Arduino to fly. Maker Media, Inc., 2016.
3. Baichtal, John. Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs. Que Publishing, 2015.

**Recommended Online Resources**

1. https://onlinecourses.nptel.ac.in/noc19_ae06/preview
2. https://onlinecourses.swayam2.ac.in/ntr24_ed12/preview
3. https://www.udemy.com/topic/drone/
4. https://www.coursera.org/courses?query=drone

**Course Designer(s)**

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**SRM University – AP, Andhra Pradesh**
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# Drone Security

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | ECE 242 | **Course Category** | OE | **L-T-P-C** | 3 | 0 | 0 | 3 |
| **Pre-Requisite Course(s)** | | **Co-Requisite Course(s)** | | **Progressive Course(s)** | | | | |
| **Course Offering Department** | ECE | **Professional / Licensing Standards** | | | | | | |

**Course Objectives**

13. To Understand type of drones and its applications
14. To Understand and reduce the risk to security
15. To Understand vulnerability assessments in drones
16. To Understand Penetration testing methodology and process in drones
17. To understand best practices for protecting against drone vulnerabilities and attacks

**Course Outcome (COs)**

| | **At the end of the course the learner will be able to** | **Bloom's Level** | **Expected Proficiency Percentage** | **Expected Attainment Percentage** |
|---|---|---|---|---|
| **Outcome 1** | Describe drone types and legal formalities | 2 | 70% | 65% |
| **Outcome 2** | Analyse security risks associated with drones | 3 | 70% | 65% |
| **Outcome 3** | Identify techniques for conducting vulnerability assessments on drone systems | 3 | 70% | 65% |
| **Outcome 4** | Analyse Techniques for conducting penetration testing on drone systems | 3 | 70% | 65% |
| **Outcome 5** | Analyse examples of real-world drone vulnerabilities and attacks | 4 | 70% | 65% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Teamwork Skills | Communication Skills | Project Management and Finance | Self-Directed and Life Long Learning | PSO 1 | PSO 2 | PSO 3 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outcome 1 | 3 | 3 | 3 | 2 | 1 | | 2 | | | | | 3 | 3 | 1 | 2 |
| Outcome 2 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | | 3 | | | 2 | 3 | 2 | 2 |
| Outcome 3 | 3 | 3 | 3 | 2 | 2 | | 2 | | 3 | | | 3 | 3 | 2 | 2 |
| Outcome 4 | 3 | 3 | 3 | 3 | 2 | 1 | 2 | | 3 | | | 2 | 3 | 2 | 2 |
| Outcome 5 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | | 2 | | | 2 | 3 | 2 | 2 |
| **Course Average** | **3** | **3** | **3** | **2** | **2** | **1** | **2** | | **3** | | | **2** | **3** | **2** | **2** |

**Course Unitization Plan**

| Unit No. | Syllabus Topics | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit No. 1** | Introduction to drones and their uses | **2** | **1** | **1** |
| | Overview of drone technology and applications | **2** | **1** | **1,2** |
| | Types of drones and their capabilities | **3** | **1** | **1,2** |
| | Legal and regulatory considerations for drones | **3** | **1** | **2** |
| **Unit No. 2** | The security risks associated with drones | **2** | **1** | **1,2** |
| | Threats to drone security, including hacking, spoofing, and physical attacks | **2** | **2** | **2,3** |
| | Risks to personal privacy and data security | **3** | **2** | **2** |
| | Consequences of drone security breaches | **3** | **2** | **2** |
| **Unit No. 3** | Techniques for conducting vulnerability assessments on drone systems | **3** | **3** | **1,3** |
| | Vulnerability assessment methodology and process | **3** | **3** | **2,3** |
| | Tools and techniques for identifying vulnerabilities in drone hardware and software | **4** | **3** | **2** |
| | Analyzing and reporting on vulnerabilities | **5** | **3** | **2** |
| **Unit No. 4** | Methods for identifying and exploiting vulnerabilities in drone hardware and software | **5** | **4** | **3** |
| | Exploitation methodology and process, Techniques for exploiting vulnerabilities in drone hardware and software | **5** | **4** | **2,3** |
| | Analyzing and reporting on exploitation results, Techniques for conducting penetration testing on drone systems | **5** | **4** | **1,2** |
| | Penetration testing methodology and process, Tools and techniques for conducting penetration testing on drone systems Analyzing and reporting on penetration testing results | **5** | **4** | **2,3** |

| | | | | |
|---|---|---|---|---|
| **Unit No. 5** | Countermeasures for protecting against drone vulnerabilities and attacks, case studies and examples of real-world drone vulnerabilities and attacks | **5** | **5** | **1,3** |
| | Best practices for protecting against drone vulnerabilities and attacks | **5** | **5** | **2,3** |
| | Deploying countermeasures and implementing security controls | **5** | **5** | **1,2,3** |
| | Case studies and examples of real-world drone vulnerabilities and attacks | **10** | **5** | **1,2,3** |

**Recommended Resources**

1. Suthikshn Kumar CR, "Artificial Intelligence Applications for Drone Cyber Security: Second Edition
2. Sachi Nandan Mohanty et al. Drone Technology, Wiley-Scrivener
3. Imdad Ali Shah, Noor Zaman Jhanjhi, Cybersecurity Issues and Challenges in the Drone Industry

**Recommended Online Resources**

1. Security analysis of drones systems: Attacks, limitations, and recommendations - ScienceDirect

**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (60%)** | | | | | | | | **End Semester Exam (40%)** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **CLA-1 (15%)** | | **Mid-1 (15%)** | | **CLA-2 (15%)** | | **Mid-2 (15%)** | | | |
| | | **Th** | | Th | | **Th** | | **Th** | | **Th** | |
| Level 1 | Remember | 60% | | 50% | | 60% | | 50% | | 40% | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 40% | | 50% | | 40% | | 50% | | 60% | |
| | Analyze | | | | | | | | | | |
| Level 3 | Evaluate | | | | | | | | | | |
| | Create | | | | | | | | | | |
| **Total** | | **100%** | | **100%** | | **100%** | | **100%** | | **100%** | |

**Course Designers**

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# Hands-on with Python and Raspberry PI for Drones

| Course Code | ECE 243 | Course Category | OE | L-T-P-C | 2 | 0 | 1 | 3 |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | Basis electronics | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | ECE | Professional / Licensing Standards | | | | | | |

## Course Objectives

5. To learn the installation of Raspberry Pi OS.
6. To learn Python programming language.
7. To develop the circuit design for sensor implementation.
8. To learn a basic understanding of Drones and their potential applications related to smart agriculture and so on.

## Course Outcome (COs)

| CO's | At the end of the course, the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| 1 | Students will be able to install and use Raspberry Pi. | 1 | 80% | 70% |
| 2 | Students will be able to use Python language and Raspberry Pi for developing circuits. | 1 | 70% | 60% |
| 3 | Students will be able to develop integrated system design | 2 | 60% | 60% |
| 4 | Students will be able to understand the application of drones. | 1 | 80% | 70% |

## Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Problem | Design and Development | Analysis, Design and | Modern Tool and ICT | Society and Multicultural | Environment and | Moral, and Ethical | Individual and Teamwork | Communication Skills | Project Management | Self-Directed and Life Long | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 2 | | | | | | | | 1 | | | | 1 | 1 | 1 |
| Outcome 2 | 1 | 2 | | | | | | | 1 | | | | 1 | 1 | 1 |
| Outcome 3 | 1 | 2 | 2 | | 2 | | 1 | | | 1 | 2 | 2 | 1 | 1 | 1 |
| Outcome 4 | | | 2 | 2 | 2 | | 1 | | | | 2 | 2 | 1 | 1 | 1 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Average** | **2** | **2** | **2** | **2** | **2** | | **1** | | **1** | **1** | **2** | **2** | **1** | **1** | **1** |

**Course Unitization Plan**

| Unit No. | Syllabus Topics | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| | **Unit:01 Introduction to Artificial Intelligence in Medicine** | **15 hrs** | | |
| **Unit No. 1** | Install Raspberry Pi OS | **3** | **1** | **1** |
| | Program with Python3- Variables and Functions | **3** | **2** | **1** |
| | Program with Python3-Conditions, Loops, Lists | **3** | **2** | **1** |
| | Build your first Raspberry Pi circuit | **3** | **2** | **1** |
| | Control Raspberry Pi's GPIOs with Python | **3** | **2** | **1** |
| | **Unit:02 AI in Medical Imaging and Diagnostics** | **15 hrs** | | |
| **Unit No. 2** | Detect movement with a PIR sensor | **2** | **2** | **3** |
| | Use the Terminal on Your Raspberry Pi | **2** | **2** | **3** |
| | Add Vision to Your Application with the Raspberry Pi Camera V2 Module | **2** | **2** | **3** |
| | Create Web Applications with the Raspberry Pi with Flask and Python | **2** | **2** | **3** |
| | Fundamentals of flight aerodynamics: Basis understanding of drone | **2** | **2** | **3** |
| | Introduction to flight simulator | **2** | **2** | **3** |
| | Advantages/Disadvantages of multi-rotor Drones | **2** | **2** | **3** |
| | ATC Procedures and Radio Telephony | **1** | **2** | **3** |
| | **Unit:03 Mini Project I** | **10 hrs** | | |
| **Unit No. 3** | Smart Agriculture | **10** | **3, 4** | **1,2,3** |
| | **Unit:4 Mini Project II** | **10 hrs** | | |
| **Unit No. 4** | Smart City | **10** | **3, 4** | **1,2,3** |

| | | | | |
|---|---|---|---|---|
| | **Unit:5 Mini Project III** | **10 hrs** | | |
| **Unit No. 5** | Smart Village | **10** | **3,4** | **1,2,3** |
| | **Total Hours** | **60** | | |

**Recommended Resources**


1. S. Yamanoor, S. Yamanoor, 2017. Python Programming with Raspberry Pi. Packt Publishing, ISBN: 9781786467577.
2. W. Donat. 2017. Learn Raspberry Pi Programming with Python. Publisher: Apress, ISBN: 9781430264248.
3. D. Nar, R. Kotecha 2021. Drone Technology for Beginners: Learn | Build | Fly Drones, Chapter 1-4.


**Recommended Online Resources**

4. Raspberry Pi and Python Tutorials: https://www.youtube.com/watch?v=RpseX2ylEuw&list=PLQVvvaa0QuDesV8WWHLLXW_avmTzHmJLv
5. Learn Python: https://www.youtube.com/watch?v=rfscVS0vtbw
6. Drone Programming Course: https://www.youtube.com/watch?v=TO7qa8oCACI&list=PLgiealSjeVyx3t4N9GroE29SbVwhYrOtL

**Learning Assessment**

| **Bloom's Level of Cognitive Task** | | **Continuous Learning Assessments (50%)** | | | | **End Semester Exam (50%)** |
|---|---|---|---|---|---|---|
| | | **CLA-1 (10%)** | **Mid-1 (20%)** | **CLA-2 (10%)** | **CLA-3 (10%)** | |
| Level 1 | Remember | 60% | 40% | 30% | 30% | 40% |
| | Understand | | | | | |
| Level 2 | Apply | 40% | 50% | 50% | 40% | 40% |
| | Analyse | | | | | |
| Level 3 | Evaluate | | 10% | 20% | 30% | 20% |
| | Create | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers**


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# Internet of Drones

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Course Code** | ECE 244 | **Course Category** | Minor | **L-T-P-C** | 3 | 0 | 0 | 3 |
| **Pre-Requisite Course(s)** | | **Co-Requisite Course(s)** | | **Progressive Course(s)** | | | | |
| **Course Offering Department** | ECE | **Professional / Licensing Standards** | | | | | | |

**Course Objectives**

1. To acquire knowledge on the various components of a drone.
2. To understand the dynamics and mechanism of flying.
3. To design basic types of drones with connectivity.

**Course Outcome (COs)**

| CO's | At the end of the course, the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **1** | To understand the various components of drone design. | 2 | 80% | 75% |
| **2** | To understand the mechanics and dynamics of a flying object | 2 | 80% | 70% |
| **3** | To analyze the different communication protocols and connectivity | 4 | 75% | 65% |
| **4** | To analyze various drone applications | 4 | 75% | 65% |

**Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)**

| **CLOs** | **Program Learning Outcomes (PLO)** |
|---|---|

| | Engineering Knowledge | Problem Analysis | Design and Development | Analysis, Design and Research | Modern Tool and ICT Usage | Society and Multicultural Skills | Environment and Sustainability | Moral, and Ethical Awareness | Individual and Team work Skills | Communication Skills | Project Management and Finance | Self-Directed and Life Long Learning | PSO 1 | PSO 2 | PSO 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outcome 1 | 3 | 1 | 3 | 2 | | | 1 | | 1 | | | 1 | 1 | | |
| Outcome 2 | 3 | 1 | 2 | 2 | 1 | | 1 | | 1 | | | 1 | 2 | 1 | |
| Outcome 3 | 3 | 1 | 2 | 2 | 2 | | 1 | | 1 | | | 1 | 1 | | |
| Outcome 4 | 3 | 3 | 3 | 3 | 3 | | 3 | | 2 | | 1 | 3 | 2 | 2 | 1 |
| **Course Average** | **3** | **2** | **3** | **2** | **2** | | **2** | | **1** | | **1** | **2** | **2** | **2** | **1** |

**Course Unitization Plan**

| Unit No. | Syllabus Topics | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| | **Introduction to Drone Design and Assembly** | **9** | | |
| | Definition and history of drones, Types of drones, and their applications. | 2 | 1 | 1,4,5,6 |

| | | | | |
|---|---|---|---|---|
| **Unit No. 1** | Drone components and terminology | 1 | 1 | 1,4,5,6 |
| | Regulations, Guidelines, and Standards | 1 | 1 | 1,4,5,6 |
| | Design of drone airframe and propulsion system | 2 | 1 | 1,4,5,6 |
| | Drone components - motors, flight controllers, batteries, cameras, etc. | 2 | 1 | 1,4,5,6 |
| | Basic wiring and soldering techniques. | 1 | 1 | 1,4,5,6 |
| | **Motors and Speed Controllers** | **8** | | |
| **Unit No. 2** | Working, Types: Brush and Brushless Motors | 2 | 1 | 1,4,5,6 |
| | Motor sizing and identification, mounting patterns | 2 | 1 | 1,4,5,6 |
| | Motor thread size, thrust-to-weight ratio | 1 | 1 | 1,4,5,6 |
| | KV ratings, advanced motor selection. | 1 | 1 | 1,4,5,6 |
| | Electronic Speed Controller (ESC). | 2 | 1 | 1,4,5,6 |
| | **Mechanics and Dynamics** | **8** | | |
| **Unit No. 3** | Basic principles of flight mechanics | 2 | 2 | 1,4,5,6 |
| | Flight controller board | 2 | 2 | 1,4,5,6 |
| | Selection of drone controller with examples | 2 | 2 | 1,4,5,6 |
| | Factors affecting drone flight performance and efficiency | 2 | 2 | 1,4,5,6 |
| | **Communication Protocols and Connectivity** | **12** | | |
| **Unit No. 4** | Zigbee, Zwave, Dash7, Bluetooth Low Energy | 2 | 3 | 2,3 |
| | IEEE 802.11, TCP, UDP, CoAP | 2 | 3 | 2,3 |
| | 6LowPAN, RPL | 2 | 3 | 2,3 |
| | MQTT, HTTP, REST | 2 | 3 | 2,3 |
| | Network Layer-IPv4, IPv6 | 2 | 3 | 2,3 |
| | AMCP, web sockets | 2 | 3 | 2,3 |

| | | | | |
|---|---|---|---|---|
| | **Applications** | **8** | | |
| **Unit No. 5** | Overview of commercial and industrial drone applications | 1 | 4 | 1,4,7 |
| | Case studies and examples of successful drone deployments | 2 | 4 | 1,4,8 |
| | GPS-based navigation system | 1 | 4 | 1,4,8 |
| | Drone Camera Systems | 2 | 4 | 1,4,8 |
| | Agro application, Drone delivery, Future trends and developments in the drone industry. | 2 | 4 | 1,4,8 |
| **Contact Hours** | | **45** | | |

**Recommended Resources**


1. M. LaFay, Building Drones for Dummies, John Wiley & Sons, Inc.
2. Agus Kurniawan, “Learning AWS IoT Effectively Manage Connected Devices on the AWS Cloud Using Services Such as AWS Greengrass, AWS Button, Predictive Analytics and Machine Learning”, Packt Publisher, 2018
3. Ammar Rayes and Samer Salam, "Internet of Things from Hype to Reality - The Road to Digitization", Springer, Second Edition
4. E. Tooley, Practical Drones: Building, Programming, and Applications, Apress, 2021.
5. S. K. Kopparthy, Drone Technology: Theory and Practice, Springer, 2020.
6. P. Horowitz and W. Hill, The Art of Electronics, Cambridge University Press, 2015.
7. K. Sundar and R. V. Rajakumar, Multicopters: Principles and Applications, Springer, 2021.


**Additional Resources**


8. D. Saxby, Drone Aerial Photography and Video: Techniques and Stories from the Field, Cengage Learning, 2018.
9. D. McLeod, Getting Started with Drone: How to Build, Fly, and Program Your Own Drone, Apress, 2019.
10. M. A. Banks, Building and Flying Electric Model Aircraft, O'Reilly Media, Inc., 2014.
11. G. C. Camara Leal, Flying Robots: An Introduction to Autonomous Aerospace Systems, Springer, 2017.

**Learning Assessment**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (60 %) | | | | | | | | End Semester Exam (40 %) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CLA-1 (15 %) | | CLA-2 (15 %) | | CLA-3 (15 %) | | Mid Term (15 %) | | | |
| | | Th | Prac | Th | Prac | Th | Prac | Th | Prac | Th | Prac |
| Level 1 | Remember | 40% | | 50% | | 50% | | 60% | | 40% | |
| | Understand | | | | | | | | | | |
| Level 2 | Apply | 60% | | 40% | | 50% | | 30% | | 30% | |
| | Analyse | | | | | | | | | | |
| Level 3 | Evaluate | | | 10 % | | | | 20 % | | 30% | |
| | Create | | | | | | | | | | |
| **Total** | | **100 %** | | **100 %** | | **100 %** | | **100 %** | | **100%** | |

**Course Designers**

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## Embedded System Design for Drones

| Course Code | ECE 245 | Course Category | Minor | L-T-P-C | 2 | 0 | 1 | 3 |
|---|---|---|---|---|---|---|---|---|
| Pre-Requisite Course(s) | | Co-Requisite Course(s) | | Progressive Course(s) | | | | |
| Course Offering Department | ECE | Professional / Licensing Standards | | | | | | |

### Course Objectives / Course Learning Rationales (CLRs)

**Objective 1:** Develop application for drone motion control.
**Objective 2:** Develop application for IMU interfacing for stable flight.
**Objective 3:** Develop WiFi based TCP/UDP applications for drone communication.
**Objective 4:** Develop GSM/GPRS communication.
**Objective 5:** Develop GPS interfacing.

### Course Outcomes / Course Learning Outcomes (CLOs)

| | At the end of the course, the learner will be able to | Bloom's Level | Expected Proficiency Percentage | Expected Attainment Percentage |
|---|---|---|---|---|
| **Outcome 1** | Understand the mechanical basics of drone. | 2 | 80% | 70% |
| **Outcome 2** | Understand the drone motion control. | 2 | 80% | 70% |
| **Outcome 3** | Understand various drone communication and localization means. | 4 | 80% | 70% |
| **Outcome 4** | Understand the battery, charging circuitry and other sensors used in drones. | 4 | 80% | 70% |
| **Outcome 5** | Understand the autonomous navigation of drones | 4 | 80% | 70% |

### Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

| CLOs | Program Learning Outcomes (PLO) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Engineering Knowledge | Conduct Investigations of Complex Problems | Design and Development | Moder n Tools Usage | The Engineer and Society | Environment and Sustainability | Ethics | Individual and Teamwork Skills | Communication Skills | Life Long Learning | PSO 1 | PSO 2 | PSO 3 |
| Outcome 1 | 3 | 2 | 2 | 1 | | | | 1 | 1 | 1 | 1 | 1 | 1 |
| Outcome 2 | 3 | 2 | 3 | 3 | | | | 1 | 1 | 2 | 3 | 2 | 2 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outcome 3 | 3 | 3 | 3 | 3 | | | | 1 | 1 | 1 | 3 | 2 | 2 |
| Outcome 4 | 3 | 3 | 3 | 3 | | | | 1 | 1 | 2 | 3 | 2 | 2 |
| Outcome 5 | 3 | 3 | 3 | 3 | | | | 1 | 1 | 2 | 3 | 2 | 2 |
| **Course Average** | **3** | **2** | **3** | **3** | | | | **1** | **1** | **2** | **3** | **2** | **2** |

**Course Unitization Plan - Theory**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **Unit 1** | **Drone Basics** | **6** | | |
| 1 | Fixed Wing - Multi Rotor | 2 | 1 | 1,3 |
| 2 | Principal forces – Thrust, Drag, Lift, Weight | 1 | 1 | 1,3 |
| 3 | Quadcopter - Components | 1 | 1 | 1,3 |
| 4 | Flight control - Pitch - Roll - Yaw | 1 | 1 | 1,3 |
| 5 | Payload calculation | 1 | 1 | 1,3 |
| **Unit 2** | **Drone Motion Control** | **9** | | |
| 7 | Flight Controller | 1 | **2** | **1,2** |
| 8 | Speed Control of Brushed Motor - PWM generation | 1 | 2 | 1,2 |
| 9 | Brushless DC Motor control | 2 | 2 | 1,2 |
| 10 | Inertial Measurement Unit (IMU) | 1 | 2,3 | 1,2 |
| 11 | Accelerometers – Gyros – Magnetometer Barometer. | 2 | 2,3 | 1,2 |
| 11 | PID Control. | 2 | 2 | 1,2 |
| **Unit 3** | **Drone communication & Control** | **8** | | |
| 12 | Short/Long range RF | 2 | 3 | 1,2,3 |
| 13 | Bluetooth | 2 | 3 | 1,2,3 |
| 14 | Wi-Fi - TCP/UDP - GSM/GPRS | 2 | 3 | 1,2,3 |
| 15 | Drone-external communication protocols | 1 | 3 | 1,2,3 |
| 16 | Drone localization - GPS | 2 | 3,5 | 1,2,3 |
| **Unit 4** | **Drone Battery & sensors** | **7** | | |
| 17 | Charging circuits | 1 | 4 | 1,2,3 |
| 18 | Battery lifetime calculation | 2 | 4 | 1,2,3 |
| 19 | Camera | 1 | 4 | 1,2,3 |
| 20 | SD Card storage/Streaming | 2 | 4 | 1,2,3 |
| 21 | Lidar based autonomous navigation. | 2 | 5 | 1,2,4 |
| | **Total Contact Hours** | **30** | | |

**Course Unitization Plan - Lab**

| Unit No. | Unit Name | Required Contact Hours | CLOs Addressed | References Used |
|---|---|---|---|---|
| **UNIT I** | **OVERVIEW** | | | |
| 1. | Brushed DC Motor speed control | 1 | 2 | 1,2 |
| 2. | Brushless Motor speed control | 2 | 2 | 1,2,3 |
| 3. | IMU sensor interfacing | 2 | 2,3 | 1,2 |
| 4. | PID Control programming | 2 | 2 | 1,2 |
| 5. | Drone Motion Control -Autonomous<br>1. Take-off Hover – Land<br>2. Follow set trajectory. | 3 | 2 | 1,2,3,5 |
| 6. | Drone telemetry through GSM/GPRS | 1 | 3 | 1,2,4 |
| 7. | GPS interfacing | 1 | 3,5 | 1,2,3 |
| 8. | Camera interfacing for surveillance | 1 | 4 | 1,2,3 |
| 9. | Ultrasonic/Lidar interfacing for navigation | 1 | 4,5 | 1,2,3 |
| 10. | Project/Case Study | 1 | | |
| **Total Contact Hours** | | **15** | | |

## Recommended Resources


1. Sumit Sharma, Drone Development from Concept to Flight: Design, assemble, and discover the applications of unmanned aerial vehicles, Packt Publishing, 2024.
2. David McGriffy, 'Make Drones. Teach an Arduino to Fly', Maker Media 2017
3. Cinnamon, Ian & Kadri, Romi & Tepper, Fitz, "DIY Drones for the Evil Genius_ Design, Build, and Customize Your Own Drones", Mcgraw-Hill Education, 2017.
4. Rogelio Lozano, "Unmanned Aerial Vehicles, Embedded Control", Wiley, 2007


**Learning Assessment – Theory**

| Bloom's Level of Cognitive Task | | Continuous Learning Assessments (50%) | | | | | End Semester Exam (50%) | |
|---|---|---|---|---|---|---|---|---|
| | | Theory (35%) | | | | Practical (15%) | | |
| | | CLA-1 (10%) | CLA-2 (5%) | CLA-3 (5%) | Mid-1(15%) | | Th (35%) | Prac (15%) |
| Level 1 | Remember | 60% | 40% | 60% | 60% | 20% | 40% | 30% |
| | Understand | | | | | | | |
| Level 2 | Apply | 40% | 60% | 40% | 40% | 80% | 60% | 70% |
| | Analyse | | | | | | | |
| Level 3 | Evaluate | | | | | | | |
| | Create | | | | | | | |
| **Total** | | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

**Course Designers**

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