# M.Sc. ELECTRONICS

## LOCF SYLLABUS 2023


Department of Electronics
School of Physical Sciences
St. Joseph's College (Autonomous)
Tiruchirappalli - 620 002, Tamil Nadu, India

## Vision

Forming globally competent, committed, compassionate and holistic persons, to be men and women for others, promoting a just society.

## Mission

- Fostering learning environment to students of diverse background, developing their inherent skills and competencies through reflection, creation of knowledge and service.
- Nurturing comprehensive learning and best practices through innovative and value-driven pedagogy.
- Contributing significantly to Higher Education through Teaching, Learning, Research and Extension.

## Programme Educational Objectives (PEOs)

- Graduates will be able to accomplish professional standards in the global environment.
- Graduates will be able to uphold integrity and human values.
- Graduates will be able to appreciate and promote pluralism and multiculturalism in working environment.

## Programme Outcomes (POs)

1. Graduates will be able to apply assimilated knowledge to evolve tangible solution to emerging problems.
2. Graduates will be able to analyze and interpret data to create and design new knowledge.
3. Graduates will be able to engage in innovative and socially relevant research and effectively communicate the findings.
4. Graduates will become ethically committed professional and entrepreneurs upholding human values.
5. Graduates imbibed with ethical values and social concern will be able to understand and appreciate cultural diversity, social harmony and ensure sustainable environment.

## Programme Specific Objectives (PSOs)

1. Critical and Analytical Thinking Skills
2. Focus on latest technology in Electronics
3. Hardware designing skills
4. Trouble shooting and programming skill
5. Digital design synthesis and simulation
6. Entrepreneurial Skills
7. Employability Enhancement
8. Research and industrial consultancy.

**CONTINUOUS INTERNAL ASSESSMENT**
**Categorizing Outcome Assessment Levels Using Bloom's Taxonomy**

| Level | Cognitive Domain | Description |
|---|---|---|
| K1 | Remember | It is the ability to remember the previously learned concepts or ideas. |
| K2 | Understand | The learner explains concepts or ideas. |
| K3 | Apply | The learner uses existing knowledge in new contexts. |
| K4 | Analyse | The learner is expected to draw relations among ideas and to compare and contrast. |
| K5 | Evaluate | The learner makes judgements based on sound analysis. |
| K6 | Create | The learner creates something unique or original. |

**Question Paper Blueprint for Mid and End Semester Tests**

<table>
<tr><td colspan="3">Duration: 2 Hours</td><td colspan="6">Maximum Marks: 60</td></tr>
<tr><td colspan="2" rowspan="2">Section</td><td colspan="6">K level*</td><td rowspan="2">Marks</td></tr>
<tr><td>K1</td><td>K2</td><td>K3</td><td>K4</td><td>K5</td><td>K6</td></tr>
<tr><td colspan="2">A (no choice)</td><td>7</td><td></td><td></td><td></td><td></td><td></td><td>7 × 1 = 7</td></tr>
<tr><td colspan="2">B (no choice)</td><td></td><td>5</td><td></td><td></td><td></td><td></td><td>5 × 3 = 15</td></tr>
<tr><td colspan="2">C (either… or type)</td><td></td><td></td><td>3</td><td></td><td></td><td></td><td>3 × 6 = 18</td></tr>
<tr><td rowspan="4">D (2 out of 3)</td><td>Courses with K4 as the highest cognitive level</td><td></td><td></td><td></td><td>2</td><td></td><td></td><td rowspan="4">2 × 10 = 20</td></tr>
<tr><td>Courses with K5 as the highest cognitive level wherein one question each on K4 and K5 is compulsory.<br>(Note:K4 has two questions whereas, K5 has no choice.)</td><td></td><td></td><td></td><td>1</td><td>1</td><td></td></tr>
<tr><td rowspan="2">Courses with K6 as the highest cognitive level wherein one question each on K5 and K6 is compulsory.<br>(Note: Mid Sem: K4 has two questions whereas, K5 has no choice; End sem: K5 has two questions whereas, K6 has no choice)</td><td></td><td></td><td></td><td colspan="2">Mid Sem</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">End Sem</td></tr>
<tr><td colspan="6">Total</td><td>60</td></tr>
</table>

** K4 and K5 levels will be assessed in the Mid semester test whereas K5 and K6 levels will be assessed in the End semester test.*

**Question Paper Blueprint for Mid and End Semester Tests** *(For quantitative courses only)*

| **Duration: 2 Hours** | | | | | | | **Maximum Marks: 60** |
|---|---|---|---|---|---|---|---|
| **Section** | **K level** | | | | | | **Marks** |
| | **K1** | **K2** | **K3** | **K4** | **K5** | **K6** | |
| A *(no choice)* | 5 | 4 | | | | | 9 × 1 = 9 |
| B *(either… or type)* | | | 2 | 1 | | | 3 × 5 = 15 |
| C *(2 out of 3)* | | | | | 1 | 1* | 2 × 18 = 36 |
| | | | | | | **Total** | **60** |

**NOTE:** *K4 and K5 will be assessed in the Mid semester test whereas K5 and K6 will be assessed in the End semester test.*
** K6 compulsory*

**SEMESTER EXAMINATION**
**Question Paper Blueprint for Semester Examination**

| **Duration: 3 Hours** | | | | | | | | **Maximum Marks: 100** |
|---|---|---|---|---|---|---|---|---|
| **Section** | | **K level** | | | | | | **Marks** |
| | | **K1** | **K2** | **K3** | **K4** | **K5** | **K6** | |
| A *(no choice, two questions from each unit)* | | 10 | | | | | | 10 × 1 = 10 |
| B *(no choice, two questions from each unit)* | | | 10 | | | | | 10 × 3 = 30 |
| C *(either… or type, one question from each unit)* | | | | 5 | | | | 5 × 6 = 30 |
| D *(3 out of 5, one question from each unit)* | *Courses with K4 as the highest cognitive level* | | | | 3 | | | 3 × 10 = 30 |
| | *Courses with K5 as the highest cognitive level wherein two K4 questions and one K5 question are compulsory. (Note: Three questions on K4 and two questions on K5)* | | | | 2 | 1 | | |
| | *Courses with K6 as the highest cognitive level wherein one question each on K4, K5, and K6 is compulsory. (Note: Two questions each on K4 and K5 and one question on K6)* | | | | 1 | 1 | 1 | |
| | | | | | | | **Total** | **100** |

**Question Paper Blueprint for Semester Examination** *(For quantitative courses only)*

| Section | Marks | K level |
|---|---|---|
| A | 10 × 1 = 10 | K1 |
| B | 5 × 6 = 30 *(either…or)* | K2 *(Q. No. 11 & 12)*<br>K3 *(Q. No. 13, 14 & 15)* |
| C | 4 × 15 = 60 *(4 out of 5)* | K4 *(Q. No. 16 & 17)*<br>K5 *(Q. No. 18 & 19)*<br>K6 *(Q. No. 20 compulsory)* |
| **Total Marks: 100** | | |

**Evaluation Pattern for Part IV One/Two Credit Courses**

| Title of the Course | CIA | Semester Examination | Total Marks |
|---|---|---|---|
| Internship | 100 | | **100** |
| **UG**<br>Skill Enhancement Course (Non Major Elective)<br>Foundation Course<br>**PG**<br>Ability Enhancement Course | 20 + 10 + 20 = 50 | 50<br>*(External member from the Department)* | **100** |
| Value Education | 50 | 50 *(CoE)* | **100** |

| M.Sc. ELECTRONICS | | | | | | | |
|---|---|---|---|---|---|---|---|
| PROGRAMME PATTERN | | | | | Scheme of Exams | | |
| **Sem** | **Course Code** | **Title of the Course** | **Hours** | **Credits** | **CIA** | **SE** | **Final** |
| 1 | 23PEL1CC01 | **Core Course -1:** Embedded Systems Design with PIC | 6 | 5 | 100 | 100 | 100 |
| | 23PEL1CC02 | **Core Course - 2**: Digital Communication Systems | 5 | 5 | 100 | 100 | 100 |
| | 23PEL1CP01 | **Core Practical - 1:** Embedded systems -1 | 8 | 6 | 100 | 100 | 100 |
| | 23PEL1ES01 | **Elective - 1:** Digital Signal Processing | 5 | 3 | 100 | 100 | 100 |
| | 23PEL1ES02 | **Elective - 2:** Instrumentation Control Techniques | 4 | 3 | 100 | 100 | 100 |
| | 23PEL1AE01 | **Ability Enhancement Course:** Electronics Research and Entrepreneurship | 2 | 1 | 100 | - | 100 |
| | | **Total** | **30** | **23** | | | |
| 2 | 23PEL2CC03 | **Core Course - 3:** Mechatronics and Automotive Electronics | 4 | 4 | 100 | 100 | 100 |
| | 23PEL2CC04 | **Core Course - 4:** Embedded Systems | 5 | 5 | 100 | 100 | 100 |
| | 23PEL2CP02 | **Core Practical - 2**: Signal Processing and Electronic Communication | 8 | 6 | 100 | 100 | 100 |
| | 23PEL2SP01A | **Self-paced Learning:** Programmable Logic Controller* | - | 2 | 50 | 50 | 50 |
| | 23PEL2SP01B | **Self-paced Learning:** Nanoelectronics* | | | | | |
| | 23PEL2SP01C | **Self-paced Learning:** Medical Electronics* | | | | | |
| | 23PEL2ES03A | **Elective - 3:** Electromagnetics and Antenna Design | 5 | 4 | 100 | 100 | 100 |
| | 23PEL2ES03B | **Elective - 3:** Power Electronics and Solar PV Systems | | | | | |
| | 23PSS2SE01 | **Skill Enhancement Course:** Soft Skills | 4 | 3 | 100 | - | 100 |
| | 23PEL2EG01 | **Generic Elective - 1 (WS):** Electronics Media | 4 | 3 | 100 | 100 | 100 |
| | - | Extra Credit Courses (MOOC/Certificate Courses) - 1 | - | (3) | | | |
| | | **Total** | **30** | **27(3)** | | | |
| 3 | 23PEL3CC05 | **Core Course - 5:** VLSI Design and VERILOG Programming | 4 | 4 | 100 | 100 | 100 |
| | 23PEL3CC06 | **Core Course - 6:** Electronic Instrumentation and Virtual Instrumentation | 5 | 5 | 100 | 100 | 100 |
| | 23PEL3CC07 | **Core Course - 7:** Internet of Things with Single Board Computer | 4 | 4 | 100 | 100 | 100 |
| | 23PEL3CP03 | **Core Practical - 3**: Microcontroller Interfacing and FPGA | 8 | 6 | 100 | 100 | 100 |
| | 23SPS3CC01 | **Common Core:** Materials Science | 5 | 4 | 100 | 100 | 100 |
| | 23PEL3EG02 | **Generic Elective - 2 (BS):** Computer Hardware and Networks | 4 | 3 | 100 | 100 | 100 |
| | 23PEL3IS01 | Internship | - | 2 | 100 | - | 100 |
| | - | Extra Credit Courses (MOOC/Certificate Courses) - 2 | - | (3) | | | |
| | | **Total** | **30** | **28(3)** | | | |
| 4 | 23PEL4CC08 | **Core Course - 8:** Artificial Intelligence | 5 | 5 | 100 | 100 | 100 |
| | 23PEL4CP04 | **Core Practical - 4:** Internet of Things and Artificial Intelligence | 8 | 6 | 100 | 100 | 100 |
| | 23PEL4ES04A | **Elective - 4:** Control System and Industrial Automation | 5 | 4 | 100 | 100 | 100 |
| | 23PEL4ES04B | **Elective - 4:** Biomedical Signal and Image Processing | | | | | |
| | 23PEL4PW01 | Project Work and Viva Voce | 12 | 11 | 100 | 100 | 100 |
| | 23PEL4CE01 | Comprehensive Examination* | - | 2 | 50 | 50 | 50 |
| | - | Extra Credit Courses (MOOC/Certificate Courses) - 3 | - | (3) | | | |
| | | **Total** | **30** | **28(3)** | | | |
| **2 - 4** | 23PCW4OR01 | Outreach Programme (SHEPHERD) | - | 4 | | | |
| **1 - 4** | | **Total (2 years)** | **120** | **110** | | | |

*- for grade calculation 50 marks are converted into 100 in the mark statements

| Semester | Course Code | Title of the Course | Hours/ Week | Credits |
|---|---|---|---|---|
| 1 | 23PEL1CC01 | **Core Courses -1**: Embedded Systems Design with PIC | 6 | 4 |

| Course Objectives |
|---|
| To study the architecture of the PIC -CPU, Memory and Micro C Programming Techniques |
| To understand Programming Parallel I/O Ports and Interface output devices |
| To understand Programming internal ADC, DAC and PWM |
| To understand how to handle Timers and interrupts |
| To understand Serial communication Protocols, programming various protocols, interface and communicate with GPS, Bluetooth Modules using serial communication protocols. |

**UNIT I: PIC 18 Architecture and Embedded C Programming: (18 Hours)**

Architecture – WREG – File Register – Default Access Bank – Status Register – Program Counter - oscillator used in PIC - PIC Microcontroller Memory Types - Flash Program Memory, Data Memory (RAM) and EEPROM Data Memory - Program ROM Space - Embedded C Programming and data types in MikroC Pro for PIC – Variables – Conditional and Looping statements– arrays and user defined functions.

**UNIT II: Programming Parallel I/O Ports: (18 Hours)**

Port A, B, C, D, E and F – Reading and WritingRegisters in PIC microcontroller - I/O Bit Manipulation Programming - LED Blinking Program - 16×2 LCD Interfacing with PIC - 7 Segment Display interfacing with PIC - Stepper Motor Interfacing with PIC

**UNIT III: ADC, DAC and PWM: (18 Hours)**

PIC18F ADC Module - PIC18F ADC Block Diagram - PIC18F ADC Registers - IC18F4550 Microcontroller ADC Programming - PIC Microcontroller Built-in DAC Modules - DAC Module Control Registers - DAC Module Programming - PWM using PIC Microcontroller - PWM Duty cycle - PWM Programming - PWM for DC Motor Speed Control

**UNIT IV: Timers and Interrupts in PIC microcontroller: (18 Hours)**

Types of timers in PIC microcontroller - Clock source of PIC microcontroller timers - Delay Calculation of timers - Timers Registers Configuration - Working of PIC microcontroller timers - Code to generate delay with timers - Counter Programming - PIC 18 Interrupts – Programming Timer Interrupts – Programming External Hardware Interrupts

**UNIT V: PIC Communication Modules: (18 Hours)**

UART Communication with PIC- Use UART Interrupt of PIC - PIC SPI Module - I2C Communication using PIC - USB interfacing with PIC - Serial Communication Using PIC - GPS module interfacing with PIC - GSM Module interfacing with PIC - PIC Bluetooth module interfacing with PIC

| | |
|---|---|
| **Teaching Methodology** | Demo Videos, PPT, Handouts, circuit simulations and analysis |

**Books for Study**


1. Mazidi, M. A., McKinlay, R., & Causey, D. (2013). *PIC microcontroller and embedded systems using assembly and C for pic 18.* Pearson.


**Books for Reference**


1. Peatman, J.B. (2009). *Design with PIC microcontroller.* Prentice Hall of India.
2. Predko, Myke. (2008). *PIC microcontroller.* Tata McGraw Hill Edition.


**Web Sources**

1. https://electronicsdesk.com/pic-microcontroller.html
2. https://ww1.microchip.com/downloads/en/devicedoc/39632e.pdf
3. https://www.microchip.com/wwwproducts/pic18f4550
4. https://www.dauniv.ac.in/public/frontassets/coursematerial/embeddedsystems/Chap_5 L01Emsys3EIOPortsSerial_Parallel.pdf
5. https://circuitdigest.com/microcontroller-projects/pic-to-pic-communication-using-rf-module

| **Course Outcomes** | | |
|---|---|---|
| **CO No.** | **CO-Statements**<br>On successful completion of this course, students will be able to | **Cognitive Levels (K - Level)** |
| **CO1** | describe the architecture, characteristics embedded systems | **K1** |
| **CO2** | outline and restate the embedded system design | **K2** |
| **CO3** | solve hardware and software issues and apply in embedded system | **K3** |
| **CO4** | analyze the embedded system in various applications | **K4** |
| **CO5** | assess and develop programming skill | **K5** |
| **CO6** | design their own Embedded System using PIC microcontroller | **K6** |

| **Relationship Matrix** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semester** | **Course code** | **Title of the Course** | | | | | | | | **Hours** | **Credits** |
| **1** | **23PEL1CC01** | **Core Courses -1**: Embedded Systems Design with PIC | | | | | | | | **6** | **4** |
| **Course Outcomes** | **Programme Outcomes (POs)** | | | | | **Programme Specific Outcomes (PSOs)** | | | | | **Mean Score of COs** |
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | |
| **CO1** | **2** | **2** | **2** | **2** | **3** | **2** | **3** | **3** | **3** | **3** | **2.5** |
| **CO2** | **2** | **3** | **2** | **3** | **3** | **2** | **2** | **2** | **2** | **3** | **2.4** |
| **CO3** | **2** | **2** | **3** | **3** | **2** | **2** | **3** | **2** | **2** | **3** | **2.4** |
| **CO4** | **2** | **2** | **2** | **2** | **3** | **2** | **3** | **2** | **3** | **2** | **2.3** |
| **CO5** | **2** | **2** | **2** | **3** | **2** | **2** | **2** | **3** | **3** | **3** | **2.4** |
| **CO6** | **2** | **2** | **2** | **3** | **2** | **2** | **3** | **2** | **3** | **2** | **2.3** |
| **Mean overall Score** | | | | | | | | | | | **2.38 (High)** |

| Semester | Course Code | Title of the Course | Hours /Week | Credits |
|---|---|---|---|---|
| 1 | 23PEL1CC02 | **Core Courses - 2**: Digital Communication Systems | 5 | 4 |

| Course Objectives |
|---|
| To know the principles of Digital Communication System and Information theory |
| To study various waveform coding schemes |
| To learn various baseband transmission schemes |
| To understand various Digital Modulation Schemes |
| To learn various error control coding |

**UNIT I: Information Theory: (15 Hours)**

Digital Communication System - Discrete Memory less source, Information, Entropy, Mutual Information – Discrete Memory less channels – Binary Symmetric Channel, Channel Capacity – Hartley – Shannon law – Source coding theorem – Shannon – Fano & Huffman codes.

**UNIT II: Waveform Coding & Representation: (15 Hours)**

Prediction filtering and DPCM – Delta Modulation – ADPCM & ADM principles-Linear Predictive Coding- Properties of Line codes- Power Spectral Density of Unipolar / Polar RZ & NRZ – Bipolar NRZ – Manchester

**UNIT III: Baseband Transmission & Reception: (15 Hours)**

ISI – Nyquist criterion for distortion less transmission – Pulse shaping – Correlative coding – Eye pattern – Receiving Filters – Matched Filter, Correlation receiver, Adaptive Equalization.

**UNIT IV: Digital Modulation Scheme: (15 Hours)**

Geometric Representation of signals – Generation, detection, PSD & BER of Coherent BPSK, BFSK & QPSK – QAM – Carrier Synchronization – Structure of Non-coherent Receivers – Principle of DPSK.

**UNIT V: Error Control Coding: (15 Hours)**

Channel coding theorem – Linear Block codes – Hamming codes – Cyclic codes – Convolutional codes – Viterbi Decoder.

| **Teaching Methodology** | Demo Videos, PPT, Handouts, circuit simulations and analysis |
|---|---|

Books for Study


1. Proakis, J. G., & Salehi, M. (2014). *Digital communication.* McGraw Hill Education Edition.
2. Bhattacharya, A. (2006). *Digital communication*. McGraw Hill Education (India) Pvt. Ltd.
3. Sklar, B., & Ray, P. K. (2014). *Digital communications fundamentals and applications.*

Pearson Education.

4. Haykin, S. (2005). *Digital communications.* John Wiley India.

Books for Reference

1. Shanmugam, K. S. (2012). *Digital and communication systems.* Wiley, India.
2. Nishanth, N. (2017). *Digital communication.* Cengage Learning India.
3. Rao, R. (2011). *Digital communication.* Tata McGraw Hill Education Pvt.
4. Haykin, S . ( 2012). *Communication systems* ($4^{Th}$ ed.). Wiley, India.
5. Kundu, S. (2010). *Analog and digital communications*. Pearson.

Web Sources

1. https://www.sciencedirect.com/topics/engineering/digital-communication-system
2. https://www.tutorialspoint.com/digital_communication/digital_communication_quick_guide.htm
3. https://www.egr.msu.edu/~tongli/teaching/ece865/Introduction
4. https://www.electronicdesign.com/technologies/communications/article/21798737/electronic-design-understanding-modern-digital-modulation-techniques
5. https://www.site.uottawa.ca/~yongacog/courses/elg3175/Lecture18-19-AY-Coding.pdf

| **Course Outcomes** | | |
|---|---|---|
| **CO No.** | **CO-Statements**<br>On successful completion of this course, students will be able to | **Cognitive Levels (K - Level)** |
| **CO1** | Understand the basic of Digital communication systems | **K1** |
| **CO2** | illustrate various waveform coding | **K2** |
| **CO3** | sketch the signaling and transmission schemes | **K3** |
| **CO4** | analyze spectral characteristics of band pass signaling scheme and digital modulation | **K4** |
| **CO5** | Assess and develop PCM systems | **K5** |
| **CO6** | design a digital communication scheme and error control coding schemes | **K6** |

| **Relationship Matrix** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semester** | **Course code** | **Title of the Course** | | | | | | | | **Hours** | **Credits** |
| **1** | **23PEL1CC02** | **Core Courses - 2**: Digital Communication Systems | | | | | | | | **5** | **4** |
| **Course Outcomes** | **Programme Outcomes (POs)** | | | | | **Programme Specific Outcomes (PSOs)** | | | | | **Mean Score of COs** |
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | |
| **CO1** | **2** | **2** | **2** | **2** | **3** | **2** | **3** | **2** | **3** | **3** | **2.4** |
| **CO2** | **2** | **3** | **2** | **2** | **3** | **2** | **2** | **2** | **2** | **3** | **2.3** |
| **CO3** | **2** | **2** | **3** | **3** | **2** | **2** | **3** | **2** | **2** | **3** | **2.4** |
| **CO4** | **2** | **2** | **2** | **2** | **1** | **2** | **3** | **2** | **3** | **2** | **2.2** |
| **CO5** | **2** | **2** | **2** | **3** | **2** | **2** | **2** | **3** | **1** | **1** | **2.2** |
| **CO6** | **2** | **2** | **2** | **3** | **2** | **2** | **3** | **2** | **3** | **2** | **2.3** |
| **Mean overall Score** | | | | | | | | | | | **2.3 (High)** |

| Semester | Course Code | Title of the Course | Hours/ Week | Credits |
|---|---|---|---|---|
| **1** | 23PEL1CP01 | **Core Practical -1**: Embedded Systems - 1 | 8 | 4 |

| **Course Objectives** |
|---|
| To understand interfacing, I/O devices with PIC Parallel I/O and develop the embedded C programming in microC pro IDE / MPLAB IDE |
| To understand and develop timer, interrupt and Serial communication Programming |
| To study Digital communication Modulators and Demodulators |
| To develop MATLAB Programs to generate signals, Analyze the signal in Time and frequency domain |
| To develop MATLAB Programs to design FIR and IIR Filters |

1. The DSP programs shall be implemented in software using MATLAB/C
2. BCD and ASCII Conversion
3. Testing PIC I/O Ports using LED and DIP switches
4. Interfacing Traffic Light Controller
5. Interfacing Seven Segment Display
6. Interfacing Relay and Buzzer
7. Interfacing LCD to PIC
8. ADC Programming in PIC
9. Interfacing Temperature Sensor to PIC
10. Interfacing Stepper Motor to PIC
11. Interfacing N x M Key Board to PIC
12. DAC Interfacing in PIC
13. Interfacing a DC Motor to PIC.
14. Timer Program
15. Event Counter Programmer
16. Interrupt Programming
17. PIC UART serial Interfacing
18. Study of ASK modulation and Demodulation
19. Study of FSK modulation and Demodulation
20. Study of BPSK modulation and Demodulation
21. Generation Of Basic Signals (unit impulse Signal, Step, Ramp, Exponential) Using Matlab
22. Generate Continuous Time and Discrete time sin/ cosine signal.
23. Compute Convolution of a given Sequence
24. Compute Correlation of a given Sequence
25. Compute Auto Correlation of a given Sequence
26. Compute Cross Correlation of a given sequence
27. Compute Correlation Coefficient of a given data
28. Find frequency response of a given system given in (Transfer Function/ Differential equation form).
29. Evaluate the impulse response of the system
30. Find the DFT / IDFT of given signal

31. Determination of Power Spectrum of a given signal(s).
32. Implementation of windows
33. Implementation of LP FIR filters for a given sequence.
34. Implementation of HP FIR filters for a given sequence.
35. Implementation of LP IIR filters for a given sequence.
36. Implementation of HP IIR filters for a given sequence.

| Semester | Course Code | Title of the Course | Hours /Week | Credits |
|---|---|---|---|---|
| 1 | 23PEL1ES01 | **Elective - 1**: Digital Signal Processing | 5 | 4 |

| Course Objectives |
|---|
| To Study the basics of Discrete Time signals and systems |
| To understand Discrete Fourier Transformation techniques to analyze the signals |
| To Learn Z Transformation along with Transfer functions |
| To Explain Digital filters and design of FIR and IIR filters |
| Explain Adaptive filters and design Adaptive filters using steepest decent, LMS algorithms |

**UNIT I: Discrete Time Signals and Systems: (15 Hours)**

Sampling Theorem- Sampling of Analog Signals – Anti Aliasing Filter - Various Types of Signals -Standard Discrete Time Signals – Classification of Discrete Time Signals – Basic Operations on DTS – Discrete Time Systems – LTI invariant System (Discrete Convolution) - Classification of DT LTI systems – DT Deconvolution and Correlation.

**UNIT II: Discrete Fourier Transformation: (15 Hours)**

Discrete Fourier Transform – Matrix Relation for Computing DFT and IDFT – Important Properties of DFT – Circular Convolution and its implementation – Linear Convolution from circular convolution –Decimation in Frequency FFT – Decimation in Time FFT – Radix -2 Inverse FFT – Frequency analysis of Known DT Signals – Power and Energy Spectral Density.

**UNIT III: Z Transformation: (15 Hours)**

The Z Transform – Properties of Z-Transform – The Inverse Z-Transform – Elements of a Digital Filters – Transfer Functions of a Difference Equation – The z-Plane Pole-Zero Plot.

**UNIT IV: Basics of Digital Filtering: (15 Hours)**

FIR Filter Structure – Properties of Linear Phase FIR Filters –Window Design Techniques – Design of Linear Phase FIR Filter Using Window- Generic Equation for IIR Filter - Design of Low Pass IIR Butterworth Filter – Design of Low Pass Chebyshev Filter

**UNIT V: Adaptive Filters: (15 Hours)**

Basic Adaptive Filter - System Identification - Noise Cancellation – Equalization - Adaptive Prediction - Computing the coefficients of an adaptive filter - The Steepest Decent Algorithm – LMS Adaptive Algorithm – Adaptive Noise Canceller - Adaptive System identification.

| | |
|---|---|
| **Teaching Methodology** | Demo Videos, PPT, Handouts, circuit simulations and analysis |

**Books for Study**

1. Oppenheim A. V. & Schafer R. W. (1975). *Digital signal processing*.

2. Reddy, D.C. (2009). *Biomedical signal processing principles and techniques.* The Tata-McGraw Hill Publishing Company Ltd, New Delhi.

3. Apte, S.D. (2010). *Digital signal processing*. WILEY INDIA.

4. Proakis, J. G. & Monolakis, D. G. (2011). *Digital signal processing principals, algorithms and applications*. PEARSON.

5. Rao, K. D. & Swamy, M. N. S. (2012). *Digital signal processing.* JAICO Publishing House.

**Books for Reference**

1. Cristi, R. (2012). *Modern digital signal processing.* Cengage Learning.

2. Salivhanan, S. (2019). *Digital signal processing* (4th ed.). McGraw-Hill.

3. Ingle, V. K., &. Proakis, J. G. (2012). *Essentials of digital signal processing using MATLAB* (3rd ed.). Cengage Learning.

4. Tompkins, W. J. (2000). *Biomedical digital signal processing.* Prentice - Hall of India Pvt. Ltd.

5. Yong, W. Y., et al. (2001). *Signals and systems with MATLAB.* Springer International Edition.

**Web Sources**

1. https://www.analog.com/en/design-center/landing-pages/001/beginners-guide-to-dsp.html
2. https://www.tutorialspoint.com/digital_signal_processing/index.htm
3. https://www.geeksforgeeks.org/what-is-z-transform/
4. https://web.ece.ucsb.edu/~yoga/courses/DSP/P9_Intro_Digital_Filters.pdf
5. https://www.mathworks.com/help/dsp/ug/overview-of-adaptive-filters-and-applications.html

| **Course Outcomes** | | |
|---|---|---|
| **CO No.** | **CO-Statements**<br>On successful completion of this course, students will be able to | **Cognitive Levels (K - Level)** |
| **CO1** | describe the discrete time signal and systems in time domain | **K1** |
| **CO2** | outline Digital Signal Processing | **K2** |
| **CO3** | solve the problem of discrete time signal and systems in time domain using convolution and correlation | **K3** |
| **CO4** | analyze the discrete time signal and systems in time domain using convolution and correlation | **K4** |
| **CO5** | Assess and develop an algorithm to design adaptive filters for system identification, noise cancellation and Equalization | **K5** |
| **CO6** | design an algorithm to design and analyze the FIR and IIR filters using Z – transform | **K6** |

| Relationship Matrix | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semester** | **Course code** | | **Title of the Course** | | | | | | | **Hours** | **Credits** |
| **1** | **23PEL1ES01** | | **Elective - 1**: Digital Signal Processing | | | | | | | **5** | **4** |
| **Course Outcomes** | **Programme Outcomes (POs)** | | | | | **Programme Specific Outcomes (PSOs)** | | | | | **Mean Score of COs** |
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | |
| **CO1** | **2** | **2** | **2** | **2** | **3** | **2** | **2** | **2** | **3** | **3** | **2.3** |
| **CO2** | **2** | **3** | **2** | **2** | **3** | **2** | **2** | **2** | **2** | **3** | **2.3** |
| **CO3** | **2** | **2** | **2** | **2** | **2** | **2** | **3** | **2** | **3** | **3** | **2.3** |
| **CO4** | **2** | **2** | **2** | **2** | **3** | **2** | **3** | **2** | **3** | **2** | **2.3** |
| **CO5** | **2** | **2** | **2** | **3** | **2** | **2** | **2** | **2** | **3** | **3** | **2.3** |
| **CO6** | **2** | **2** | **2** | **3** | **2** | **2** | **3** | **2** | **3** | **3** | **2.4** |
| **Mean overall Score** | | | | | | | | | | | **2.32 (High)** |

| Semester | Course Code | Title of the Course | Hours /Week | Credits |
|---|---|---|---|---|
| 1 | 23PEL1ES02 | **Elective - 2**: Instrumentation Control Techniques | 4 | 4 |

| Course Objectives |
|---|
| To learn the concept of measurement and error estimation |
| To learn various industrial detection sensor and its interfacing |
| To learn to design data acquisition systems |
| To learn DC motor construction, operations and its drive |
| To know industrial control techniques |

**UNIT I: Measurement: (12 Hours)**

Performance characteristics of instruments- Static characteristics- Accuracy- Resolution- Precision- Expected value- Error- Sensitivity- Errors in Measurement, Dynamic Characteristics- speed of response- Fidelity- Lag and Dynamic error.

**UNIT II: Industrial Detection Sensors and Interfacing: (12 Hours)**

Proximity Detectors – Inductive Proximity Switches – Capacitive Proximity Switches – Hall Effect Sensor –IC Temperature Sensor – Optical Shaft Encoder Displacement Sensor - Photoelectric Sensor – Methods of Detection –Ultrasonic Sensors – Sensor Interfacing.

**UNIT III: Data acquisition and Handling: (12 Hours)**

Systems: Introduction-signal conditioners-Instrumentation amplifiers-filters- Data conversion – multiplexers - A/D-D/A conversion - PC based telemetry System.

**UNIT IV: DC Motor and Variable Speed Drive: (12 Hours)**

DC Motor: Principles of Operation - Practical DC Motor - Basic Motor Construction – Motor Classification – Coil terminal Identification – DC Servo Motor – Stepper Motor – Permanent Magnet Stepper Motor – Variable Reluctance Stepper Motor DC drive Fundamental – Variable Voltage DC drive – Motor

Breaking.

**UNIT V: Process Control- Techniques and Control Methods: (12 Hours)**

Pressure Control system - Temperature Control System– Flow Control System – Level Control System – Analytical Instrumentation – Non-Destructive Testing – Open Loop Control – Closed Loop Control – Single Variable Control – Selecting a Controller – On-Off Control – Case Study – Continuous Control – Tuning the Controller.

| | |
|---|---|
| **Teaching Methodology** | Demo Videos, PPT, Handouts, circuit simulations and analysis |

**Books for Study**

1. Nakra & Chaudhry, K. K. (2004). *Instrumentation- measurement and analysis*. Tata McGraw Hill Second Edition.

2. Bartelt,T. L. (2006). *Industrial electronics: Circuits instruments and control techniques.* Cengage Learning.

**Books for Reference**

1. Bose, B. K. (2004). *Modern power electronics and AC drives*. Pearson Education.

2. Biswanath, P. (2005). *Industrial electronics and control.* Prentice Hall of India.

3. Nagrath, I.J. &.Gopal, M. (1995), *Control systems engineering*. New Age International Pvt. Ltd.

4. Mathivanan, N. (2009). *PC based instrumentation concept and practice.* Prentice Hall of India.

5. Biswas, S.N. (2000). *Industrial electronics*. Dhanpat Rai & Co.

**Web Sources**

1. https://instrumentationtools.com/what-is-instrumentation-and-control-engineering/
2. https://www.britannica.com/technology/measurement#:~:text=measurement%2C%20the%20process%20of%20associating,to%20almost%20all%20everyday%20activities.
3. https://www.g2datasystems.co.uk/continuous-emissions-monitoring-software/data-acquisition-and-handling-system-dahs/134/#:~:text=What%20is%20a%20Data%20Acquisition,can%20then%20be%20stored%20digitally
4. https://www.haroldbeck.com/process-control/#:~:text=Process%20control%20is%20the%20ability,a%20heater%20and%20a%20thermostat.
5. https://www.sciencedirect.com/topics/engineering/process-control

| Course Outcomes | | |
|---|---|---|
| **CO No.** | **CO-Statements**<br>On successful completion of this course, students will be able to | **Cognitive Levels (K - Level)** |
| **CO1** | remember the characteristics of instruments | **K1** |
| **CO2** | understand the basic techniques of instruments used in instrumentation control system | **K2** |
| **CO3** | explain the control techniques after measuring the signals | **K3** |
| **CO4** | select suitable instrument and control methods for different applications | **K4** |
| **CO5** | assess and develop the instruments for various applications | **K5** |
| **CO6** | design an instrument for a specific need | **K6** |

| Relationship Matrix | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semester** | **Course code** | **Title of the Course** | | | | | | | | **Hours** | **Credits** |
| **1** | **23PEL1ES02** | **Elective - 2**:<br>Instrumentation Control Techniques | | | | | | | | **4** | **4** |
| **Course Outcomes** | **Programme Outcomes (POs)** | | | | | **Programme Specific Outcomes (PSOs)** | | | | | **Mean Score of COs** |
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | |
| **CO1** | **2** | **2** | **2** | **2** | **3** | **2** | **3** | **2** | **3** | **2** | **2.3** |
| **CO2** | **2** | **3** | **2** | **3** | **3** | **2** | **2** | **2** | **2** | **2** | **2.3** |
| **CO3** | **2** | **2** | **2** | **3** | **2** | **2** | **3** | **2** | **2** | **3** | **2.3** |
| **CO4** | **2** | **2** | **2** | **2** | **3** | **2** | **3** | **2** | **3** | **2** | **2.3** |
| **CO5** | **2** | **2** | **2** | **3** | **2** | **2** | **2** | **2** | **3** | **3** | **2.3** |
| **CO6** | **2** | **2** | **2** | **3** | **2** | **2** | **3** | **2** | **3** | **3** | **2.3** |
| **Mean overall Score** | | | | | | | | | | | **2.3 (High)** |

| Semester | Course Code | Title of the Course | Hours/ Week | Credits |
|---|---|---|---|---|
| 1 | 23PEL1AE01 | **Ability Enhancement Course**: Electronics Research and Entrepreneurship | 2 | 1 |

| Course Objectives |
|---|
| To learn the basic concept of Matrices and Vectors |
| To learn various industrial detection sensor and its interfacing |
| To learn to design data acquisition systems |
| To learn DC motor construction, operations and its drive |
| To know industrial control techniques |

**UNIT I: Mathematics I** **(6 Hours)**

Matrices and Vectors-Eigenvalues and eigenvectors-Gradient-divergence and curl-Line and surface integrals- Stroke's Theorem

**UNIT II: Mathematics II** **(6 Hours)**

Second order Ordinary Differential Equations with variable coefficients - Cauchy-Euler equation - Bessel functions and their properties- Introduction to Partial Differential Equations + Definition of Laplace transform and its electronics applications

**UNIT III: Logical Reasoning and Data Interpretation** **(5 Hours)**

Understanding the structure of arguments: Venn diagram: Analogies - Data Interpretation - Graphical representation

**UNIT IV: Research Skills** **(7 Hours)**

Meaning – types - characteristics – methods - research problem identification and formulation – Deductive and inductive theory – Hypothesis and quality of measure for the hypothesis - Thesis and article writing - Research ethics Introduction to reference management software (Mendeley) - Software for detection of plagiarism.

**UNIT V: Troubleshooting skills** **(6 Hours)**

Identification of problems – understanding the symptoms – causes for the problems – analysing the solutions – implementing the solutions – testing and validation – Troubleshooting by observing the signals (voltage measurement, current measurement, resistance measurement, waveform, …) – case study (troubleshooting an electronic device)

| | |
|---|---|
| **Teaching Methodology** | Demo Videos, PPT, Handouts, Circuit Troubleshooting |

**Books for Study**


1. Kreyszig, E. (2011). *Advanced engineering mathematics (*10th ed). Wiley Plus.
2. Sinha, N. K. (2019). *Logical reasoning and data interpretation for CAT* (6th ed).

Pearson Education.
3. Warburton, C & Bookman, S. (2007). *Basic college research skills*, University Press of America.
4. Text prepared by the Department

**Books for Reference**

1. Bird, J. (2010). *Higher engineering mathematics* (6th ed). Elsevier.
2. Tomal, D. R. & Agajanian, A. S. (2014). *Electronic troubleshooting* (4th ed). Mc Graw Hill Education.
3. Kothari, C. R. & Garg, G. (2019). *Research methodology* (4th ed). New Age International Publishers.

**Web Sources**

1. https://www.niti.gov.in/innovation-and-entrepreneurship-sustainable-growth
2. http://www.untag-smd.ac.id/files/Perpustakaan_Digital_1/ENTREPRENEURSHIP%20Innovation%20and%20entrepreneurship.PDF
3. https://www.globalknowledge.com/us-en/resources/resource-library/articles/4-tips-to-strengthen-your-troubleshooting-skills/
4. https://cleverism.com/skills-and-tools/troubleshooting/
5. https://www.universityofgalway.ie/academic-skills/readingandresearch/#:~:text=Research%20skills%20refer%20to%20the,relevant%20to%20a%20particular%20topic.

| **Course Outcomes** | | |
|---|---|---|
| **CO No.** | **CO-Statements**<br>On successful completion of this course, students will be able to | **Cognitive Levels (K - Level)** |
| **CO1** | analyze the electronic circuits | **K4** |
| **CO2** | evaluate the symptoms | **K5** |
| **CO3** | trouble shoot the electronic circuits | **K6** |

| **Relationship Matrix** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semester** | **Course code** | **Title of the Course** | | | | | | | | **Hours** | **Credits** |
| **1** | **23PEL1AE01** | **Ability Enhancement Course**: Electronics Research and Entrepreneurship | | | | | | | | **2** | **1** |
| **Course Outcomes** | **Programme Outcomes (POs)** | | | | | **Programme Specific Outcomes (PSOs)** | | | | | **Mean Score of COs** |
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | |
| **CO1** | **2** | **2** | **2** | **3** | **3** | **2** | **3** | **2** | **3** | **2** | **2.4** |
| **CO2** | **2** | **2** | **2** | **3** | **2** | **2** | **2** | **3** | **3** | **3** | **2.4** |
| **CO3** | **2** | **2** | **3** | **3** | **3** | **2** | **3** | **2** | **3** | **2** | **2.5** |
| | | | | | | | | | | **Mean overall Score** | **2.4 (High)** |

| Semester | Course Code | Title of the Course | Hours/Week | Credits |
|---|---|---|---|---|
| 2 | 23PEL2CC03 | **Core Course - 3:** Mechatronics and Automotive Electronics | 4 | 4 |

| Course Objectives |
|---|
| To describe the components of automotive electronics |
| To understand the basics of automotive sensors, control systems and network protocols |
| To discover electronic circuits for automobile applications |
| To select suitable sensors and protocols for automobile applications |
| To decide and create new circuits for vehicles |

**UNIT I: Basics of Automotive Electronics** **(12 Hours)**

Introduction to Electronic systems in Automotives - The Basics of Electronic Engine Control Concept of an Electronic Engine Control System - Definition of Engine Performance Terms (Torque, Power, Fuel Consumption, Engine Overall Efficiency, Calibration, Engine Mapping)- Electronic Fuel Control System- Analysis of Intake Manifold Pressure- Idle Speed Control - Electronic Ignition.

**UNIT II: Sensors and Actuators** **(12 Hours)**

Automotive Control System Applications of Sensors and Actuators- Airflow Rate Sensor - Pressure Measurement -Throttle Angle Sensor- Temperature Sensors- Typical Coolant Sensor Sensors for Feedback Control- Knock Sensors- Angular Rate Sensor- LIDAR- Digital Video Camera- Flex-Fuel Sensor- Automotive Engine Control Actuators- Variable Valve Timing Electric Motor Actuators- Stepper Motors- Ignition System.

**UNIT III: Digital Powertrain Control Systems** **(12 Hours)**

Control Modes for Fuel Control- Discrete Time Idle Speed Control- EGR Control Turbocharging- Integrated Engine Control System- Automatic System Adjustment- System Diagnosis- Summary of Control Modes.

**UNIT IV: Vehicle Motion Controls and Automotive Instrumentation** **(12 Hours)**

Cruise Control Electronics - Stepper Motor-based Actuator Electronics- Antilock Braking System - Electronic Suspension Control System- Electronic Steering Control- Modern Automotive Instrumentation- Input and Output Signal Conversion- Advantages of Computer Based Instrumentation- Measurement Examples- Fuel Quantity- Coolant Temperature- Oil Pressure- Vehicle Speed- Trip Information Function of the System

**UNIT V: Motor vehicle Communications** **(12 Hours)**

IVN- CAN- Local Interconnect Network (LIN)- FlexRay IVN- MOST IVN- Vehicle to Infrastructure Communication- Vehicle-to-Cellular Infrastructure- Quadrature Phase Shifter and Phase Modulation (QPSR)- Short-Range Wireless Communications- Satellite Vehicle Communication- GPS Navigation- Safety Aspects of Vehicle-to-Infrastructure Communication- Electronic Safety-Related Systems- Airbag Safety Device- Blind Spot Detection- Automatic Collision Avoidance System- Lane Departure Monitor - Advanced driver-assistance systems (ADAS).

| | |
|---|---|
| **Teaching Methodology** | Demo Videos, PPT, Handouts, Study materials |

**Books for Study**

1. William, B.R. (2017). *Understanding Automotive Electronics*. (8th Ed.). Butterworth Heinemann Woburn.

| Unit | Book | Chapter | Sections |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **I** | 1 | 4 | all |
| **II** | 1 | 5 | all |
| **III** | 1 | 6 | all |
| **IV** | 1 | 7, 8 | all |
| **V** | 1 | 9, 10 | all |

**Books for Reference**


1. James, L., & John, L. (2003). *Electric Vehicle Technology Explained.* John Wiley and Sons.
2. Robert, B. (2000). *Automotive Hand Book*, (5th Ed.). SAE.
3. Al Santini. (2013). *Automotive Electricity and Electronics*. Cengage Learning.


**Websites and eLearning Sources***

1. https://www.tutorialspoint.com/difference-between-sensors-and-actuators
2. https://www.udemy.com/course/automotive-engineering-digital-powertrain-controlsystems/
3. https://www.speedgoat.com/products-services/i-o-connectivity/protocols/can-fd
4. https://www.elprocus.com/automotive-electronics-and-its-innovations/
5. https://www.techtarget.com/iotagenda/definition/vehicle-to-vehicle-communicationV2V-communication

(* subject to availability - not to be used for exam purpose)

| **Course Outcomes** | | |
|---|---|---|
| **CO No.** | **CO - Statements** | **Cognitive Levels (K- level)** |
| | On successful completion of this course, students will be able to | |
| **CO1** | acquire the basics of automotive sensors, controls and network protocols | **K1** |
| **CO2** | understand the concepts of Automotive Electronics | **K2** |
| **CO3** | apply various protocols for automotive control and communication networks | **K3** |
| **CO4** | analyze the Sensors and Actuators of Automotive Electronics Instrumentation | **K4** |
| **CO5** | evaluate Digital Powertrain Control Systems | **K5** |
| **CO6** | create next generation Electric Vehicle Technology System | **K6** |

| **Relationship Matrix** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semester** | **Course Code** | | **Title of the Course** | | | | | | **Hours** | | **Credits** |
| **2** | **23PEL2CC03** | | **Core Course - 3:** Mechatronics and Automotive Electronics | | | | | | **4** | | **4** |
| **Course Outcomes** | **Programme Outcomes (POs)** | | | | | **Programme Specific Outcomes (PSOs)** | | | | | **Mean Score of COs** |
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | |
| **CO1** | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | **2.3** |
| **CO2** | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 3 | **2.4** |
| **CO3** | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 2 | **2.6** |
| **CO4** | 2 | 2 | 3 | 2 | 1 | 3 | 3 | 3 | 3 | 3 | **2.5** |
| **CO5** | 2 | 2 | 3 | 2 | 1 | 3 | 3 | 3 | 3 | 3 | **2.5** |
| **CO6** | 2 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | **2.5** |
| | | | | | | | | | | **Mean Overall Score** | **2.46 (High)** |

| Semester | Course Code | Title of the Course | Hours/Week | Credits |
|---|---|---|---|---|
| 2 | 23PEL2CC04 | **Core Course - 4:** Embedded Systems Programming | 5 | 5 |

| Course Objectives |
|---|
| To describe the features of microcontrollers |
| To understand the architecture of microcontrollers and embedded Linux |
| To solve domestic and industrial problems with embedded systems |
| To analyse the functions of embedded systems |
| To recommend the microcontroller, embedded systems and create an embedded systems for social needs |

**UNIT I: Arduino Embedded System** **(15 Hours)**

AVR architecture - Atmega328p features - architecture - Arduino features - Arduino I/O - Arduino peripheral blocks - Arduino IDE - Arduino language - simple programs

**UNIT II: CORTEX-M CORTEX-R Microcontrollers** **(15 Hours)**

LPC2148 features - Architecture - Pinout and description - Development board - ARM Keil IDE - Simple applications - ARM Cortex M85 Architecture and features - ARM Cortex R82 Architecture and features

**UNIT III: STM32F103C8 Embedded System** **(15 Hours)**

Features - Architecture - Pinout and Pin description - memory mapping - Development board - STM32Cube - Architecture - Firmware package - Simple applications

**UNIT IV: Embedded Linux** **(15 Hours)**

Embedded Linux Fundamentals -Embedded Linux Commands - VI Editors -Kernel - Kernel Module Vs Application - Device Driver - The Role of Device Driver - Types of Device Driver - Character Driver - Block Driver and Network Driver

**UNIT V: Embedded System Design** **(15 Hours)**

Train controller - FIR filter - Data compressor - Audio player - Digital Still camera - Engine Control Unit - Air quality monitoring system

| | |
|---|---|
| **Teaching Methodology** | Demo Videos, PPT, Handouts, Study materials |

**Books for Study**

1. Study Material prepared by the department
2. Marilyn, W. (2012). *Computers as Components Principles of Embedded Computing System Design* (3rd Ed.). Elsevier.

| Unit | Book | Chapter | Sections |
|---|---|---|---|
| **I** | 1 | 1 | All |
| **II** | 1 | 2 | All |
| **III** | 1 | 3 | All |
| **IV** | 1 | 4 | All |
| **V** | 2 | 1-6 | E.g., 1.4, 2.1, 3.8, 4.9, 5.12, 6.11 |

**Books for Reference**

1. Data sheet - Atmega328p, LPC2148, Cortex M85, Cortex R82, STM32F103C8, stm32cubef1
2. www.arduino.cc

3. Karim Yaghmour, Jon Masters, Gilad Ben-Yossef and Philippe Gerum (2008), *Building Embedded*
4. *Linux Systems* (2nd Edition), O'Reilly Media.

**Websites and eLearning Sources***

1. https://www.arduino.cc/reference/en/
2. https://www.arm.com/products/silicon-ip-cpu/cortex-m/cortex-m85
3. https://www.st.com/
4. https://ubuntu.com/blog/what-is-embedded-linux
5. https://www.techopedia.com/definition/29946/embedded-linux

(* subject to availability - not to be used for exam purpose)

| **Course Outcomes** | | |
|---|---|---|
| **CO No.** | **CO - Statements** | **Cognitive Levels (K- level)** |
| | On successful completion of this course, students will be able to | |
| **CO1** | describe the architecture and different modes of operations of a microcontroller and Cortex-M processor | **K1** |
| **CO2** | outline and restate the microcontroller programs | **K2** |
| **CO3** | analyze the implementation of Microcontrollers in various applications | **K3** |
| **CO4** | identify requirements of RTOS and IoT in applications | **K4** |
| **CO5** | asses and develop programming skill for an embedded system | **K5** |
| **CO6** | design and construct embedded system with Arduino, Cortex-M Processor and IoT | **K6** |

| **Relationship Matrix** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semester** | **Course Code** | | | **Title of the Course** | | | | | **Hours** | | **Credits** |
| **2** | **23PEL2CC04** | | | **Core Course - 4:** Embedded Systems Programming | | | | | **5** | | **5** |
| **Course Outcomes** | **Programme Outcomes (POs)** | | | | | **Programme Specific Outcomes (PSOs)** | | | | | **Mean Score of COs** |
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | |
| **CO1** | 2 | 2 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | **2.5** |
| **CO2** | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | **2.6** |
| **CO3** | 2 | 2 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | **2.5** |
| **CO4** | 2 | 2 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 2 | **2.4** |
| **CO5** | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | **2.5** |
| **CO6** | 2 | 3 | 3 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | **2.5** |
| | | | | | | | | | | **Mean Overall Score** | **2.5 (High)** |

| Semester | Course Code | Title of the Course | Hours/Week | Credits |
|---|---|---|---|---|
| 2 | 23PEL2CP02 | **Core Practical - 2:** Signal Processing and Electronic Communication | 8 | 6 |

**Any 16 Experiments**

1. LM35, RTD, Thermistor, DS18S20 / DS18B20
2. Phototransistor and Opto TRIAC, TSOP 17 photo modules for PCM remote control system 3. MOC3041 zero cross opt isolators and TL173L linear hall effect sensor and KMZ51 magnetic field sensor
4. Pressure, Vibration and A1425 analog speed sensors
5. Sinewave generation using TMS320C54
6. Acoustic echo cancellation using TMS320C54
7. Study of DSP Toolbox in MATLAB.
8. Basic image processing using MATLAB
9. Design of buck boost regulator.
10. Study of PWM charge controller for solar.
11. PV system assembling for 12 V load.
12. Design of ASK and FSK generator
13. Design of CAN
14. I2C communication - Application
15. Multitasking algorithm - Application
16. Analysis and code optimization for an embedded system
17. CPU performance analysis
18. Characteristics of Antennas
19. DTFT signal - SCILAB
20. Automotive Sensors characteristics
21. Design of simple cruise control
22. GPS system
23. Design of IIR filter
24. Design of FIR filters
25. Delta modulation - MATLAB
26. Audio analysis - MATLAB
27. Design of transducer - light, sound and temperature
28. MEMS sensors performances - BP, Heartbeat, $SpO_2$
29. ASK, FSK and PSK - analysis
30. Process control - SCADA
31. Analysis of Pulse Code Modulation
32. Edge Detection using MATLAB
33. Basic CCS programming
34. PAM, PWM, PCM

| Semester | Course Code | Title of the Course | Hours/Week | Credits |
|---|---|---|---|---|
| 2 | 23PEL2SP01A | **Self-paced Learning:** Programmable Logic Controller | - | 2 |

| Course Objectives |
|---|
| To define different types of PLC and basic I/O modules |
| To understand PLC programming of basic logics |
| To apply programming of basic logics in PLC |
| To analyse basic relay switching circuits in PLC |
| To implement timer and counter based programs in various applications and design a network control system with PLC and SCADA |

**UNIT I: PLC Overview**

Programmable logic controllers- parts of PLC-principles of operation-modifying the operation the I/O Section-Discrete I/O modules- Analog I/O modules-I/O specifications-Memory design and types-programming terminal devices-Recording and retrieving data-human machine interfaces

**UNIT II: PLC Programming**

Number system and codes- Fundamentals of logic- AND, OR, NOT, XOR function-hardwired logic versus programmed logic-Producing the Boolean equation for a given logic circuit programming word level logic instructions.

PLC programming languages- Bit level logic instructions-instruction and branch instruction Internal relay instructions- programming examine if closed and examine if open instruction entering the ladder program-modes of operation-connecting with analog devices.

**UNIT III: Developing Fundamental PLC Wiring Diagrams**

Electromagnetic control relays-contactors-motor starters-manually operated switches mechanically operated switch-sensors-output control devices-Seal in circuits-electrical interlocking circuits-latching relays-converting relay schematics into ladder program-writing a ladder program from a narrative description-instrumentation

**UNIT IV: Programming Timers, Counters and Other Instructions**

Mechanical timing relays-timer instructions-on delay timer-off delay timer-retentive timer cascading timer-counter instructions-up counter-down counter-cascading counter-incremental encoder-counter application-combining counter and timer-high speed counters. Program control instruction-Master control reset instruction-jump and subroutine instruction-immediate input and output instructions-forcing external I/O addresses-selectable timed interrupt Temporary End and suspend instruction. Math instructions.

**UNIT V: Process Control, Network Systems and SCADA**

Structure of control systems-on/off control-PID control-motion control-Data Communications Data Highway - Serial communication - Device Net-ControlNet- Ether Net / IP-MODBUS Fieldbus - PROFIBUS - DP - Supervisory control and data acquisition (SCADA)

| | |
|---|---|
| **Teaching Methodology** | Demo Videos, PPT, Handouts, Study materials |

**Books for Study**

1. Frank, D. P. (2017). *Programmable logic controllers,* (5th Ed.). McGraw Hill Education.

| Unit | Book | Chapter | Sections |
|---|---|---|---|
| **I** | 1 | 1,2 | 1.1-1.4,2.1-2.11 |

| | | | |
|---|---|---|---|
| **II** | 1 | 3,4,5 | Overview of chapter 3,4.2-4.7,5.3-5.11 |
| **III** | 1 | 6 | 6.1-6.13, |
| **IV** | 1 | 7 | 7.1-7.6,8.5-8.7,9.1 |
| **V** | 1 | 14 | 14.2-14.7 |

**Books for Reference**


1. William, B. (2015). *Programmable logic controllers*, (6th Ed.). newness publications.
2. Pradeeka, S. (2017). *Building Arduino PLCs: The essential techniques you need to develop Arduino-based PLCs*, Apress publishers.
3. Daniel, K. (2010). *Programmable automation technologies: an introduction to CNC robotics and PLCs*. Industrial press.


**Websites and eLearning Sources***

1. https://instrumentationtools.com/ladder-diagram-programming/
2. https://control.com/technical-articles/ladder-logic-in-programmable-logic-controllersplcs/
3. https://www.automation.com/en-us/articles/2018/a-beginners-plc-overview-part-3-of- 4-plc-inputs-an
4. https://dipslab.com/plc-input-output-modules-2/
5. https://control.com/textbook/programmable-logic-controllers/inputoutput-iocapabilities/

(* subject to availability - not to be used for exam purpose)

| **Course Outcomes** | | |
|---|---|---|
| **CO No.** | **CO - Statements**<br>On successful completion of this course, students will be able to | **Cognitive Levels (K- level)** |
| **CO1** | acquire knowledge on different types of PLC and basic I/O modules | **K1** |
| **CO2** | understand the programming of basic logics | **K2** |
| **CO3** | apply programming of basic logics in PLC | **K3** |
| **CO4** | analyse basic relay switching circuits in PLC | **K4** |
| **CO5** | implement timer and counter based programs in various applications | **K5** |
| **CO6** | design a network control system with PLC and SCADA | **K6** |

| **Relationship Matrix** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semester** | **Course Code** | | **Title of the Course** | | | | | | **Hours** | | **Credits** |
| **2** | **23PEL2SP01A** | | **Self-paced Learning:** Programmable Logic Controller | | | | | | **-** | | **2** |
| **Course Outcomes** | **Programme Outcomes (POs)** | | | | | **Programme Specific Outcomes (PSOs)** | | | | | **Mean Score of COs** |
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | |
| **CO1** | 2 | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 2 | 2 | **2.4** |
| **CO2** | 3 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | **2.4** |
| **CO3** | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | **2.3** |
| **CO4** | 2 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | **2.4** |
| **CO5** | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 3 | **2.4** |
| **CO6** | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | **2.3** |
| | | | | | | | | | **Mean Overall Score** | | **2.36 (High)** |

| Semester | Course Code | Title of the Course | Hours/Week | Credits |
|---|---|---|---|---|
| 2 | 23PEL2SP01B | **Self-paced Learning:** Nanoelectronics | - | 2 |

| Course Objectives |
|---|
| To describe the basics of nanoelectronics and devices |
| To understand the Quantum mechanics fundamentals, nanomaterials and fabrication techniques required to acquire knowledge on nanoelectronics |
| To apply the electron transition in nano electronic devices, operations and its characteristics |
| To analyse the inner behavior of electrons in nanomaterials |
| To evaluate nano structure and develop a new nanomaterial for electronic applications |

**UNIT I: Quantum Mechanics of Electronics**

Introduction to Nano Electronics - Top -Down Approach - Bottom - Up approach General postulates of Quantum Mechanics - Operators for Quantum Mechanics - Eigen values and Eigen functions - Hermitian Operators -Time Independent Schrodinger's Equation - Electrons in a Potential Well

**UNIT II: Materials for Nanoelectronics**

Semiconductors - Crystal Lattices - Bonding in Crystals - Electron Energy Bands - Direct Band Gap and Indirect Band Gap Semiconductors - Band Structure of Semiconductor Alloys - Semiconductor Heterostructure - Organic Semiconductors -Carbon Nanomaterials.

**UNIT III: Growth- and Fabrication for Nanostructures**

Bulk Crystal and Heterostructure Growth - Single Crystal Growth - Epitaxial Growth - Molecular Beam Epitaxy - Clusters and Nanocrystals - Methods of Nanotube Growth - Arc-Discharge and Laser Ablation - Chemical Vapor Deposition - Directed Growth of Single Walled Nanotube - Self Assembly of Nanostructures

**UNIT IV: Electron transport in Semiconductors**

Time and Length Scales of the electrons in solids - Statistics of the electron in solids and Nanostructures - The Density of States of Electrons in Nanostructure - Electron transport in Nanostructures - Electrons in Quantum Well - Electrons in Quantum Wires - Electrons in Quantum Dots.

**UNIT V: Nanoelectronics Devices**

Resonant-tunneling Diodes - Field-effect Transistor - Single Electron Transistor - Potential-effect Transistor - LEDs and Lasers - Quantum-dot Cellular Automata - Nanoelectromechanical System Devices.

| | |
|---|---|
| **Teaching Methodology** | Demo Videos, PPT, Handouts, Study materials |

**Books for Study**


1. Daniel, B. (2012). *Quantum Mechanics: A Modern and Concise Introductory Course (Graduate Texts in Physics)* (3rd Ed.). Springer.
2. Anupama, B. K. (2013). *Microelectronics to Nanoelectronics Materials, Devices & Manufacturability* (1st Ed.). CRC Press, Taylor & Francis Group.
3. Georage, W. H. (2008). *Fundamentals of Nanoelectronics*. Pearson Education.

| Unit | Book | Chapter | Sections |
|---|---|---|---|
| **I** | 1 | | Relevant sections |
| **II** | 2 | | Relevant sections |
| **III** | 2 | | Relevant sections |
| **IV** | 3 | | Relevant sections |
| **V** | 3 | | Relevant sections |

**Books for Reference**


1. Raza. (2019). *Nanoelectronics Fundamentals Materials Devices and Systems.* Springer.
2. Singh, K. & Singh, S. P. (2016). *Elements of Quantum Mechanics.* S. Chand & Company Pvt. Ltd.
3. Kar, A. (2017). *Nanoelectronics and Materials Development* (INTECH Ed.).
4. Loutfy, H. & Madkour. (2019). *Nano electronic Materials: Fundamentals and* Applications (1st Ed.). Springer (Advanced Structured Materials Book 116).
5. Robert, P., Livio B., Van de Voorde, M., Sebastiaan, E. & van Nooten. (2017). *Nanoelectronics: Materials, Devices, Applications,* 2 Volumes (Applications of Nanotechnology).
6. Valdimir, V., Mitin-Viatcheslav, A., Kochelap, & Michal, A. S. (2008). *Introduction to Nanoelectronics.* Cambridge University Press.


**Websites and eLearning Sources**

1. https://www.sciencedirect.com/topics/materials-science/nanoelectronics
2. https://www.nanowerk.com/nanoelectronics.php
3. https://www.azonano.com/article.aspx?ArticleID=6234
4. https://www.azom.com/article.aspx?ArticleID=18333
5. https://www.sigmaaldrich.com/IN/en/applications/materials-science-and-engineering/microelectronics-and-nanoelectronics
6. https://nano.stanford.edu/research/nanoelectronic-devices

(* subject to availability - not to be used for exam purpose)

| **Course Outcomes** | | |
|---|---|---|
| **CO No.** | **CO - Statements**<br>On successful completion of this course, students will be able to | **Cognitive Levels (K- level)** |
| **CO1** | identify nanoelectronics and devices | **K1** |
| **CO2** | explain the Quantum mechanics fundamentals, nanomaterials and fabrication techniques required to acquire knowledge on nanoelectronics | **K2** |
| **CO3** | apply the electron transition in nanoelectronics devices, operations and its characteristics | **K3** |
| **CO4** | analyze the inner behavior of electrons in nanomaterials | **K4** |
| **CO5** | evaluate the nano structure of a material | **K5** |
| **CO6** | develop a new nanomaterial for electronic applications | **K6** |

| Relationship Matrix | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semester** | **Course Code** | | | **Title of the Course** | | | | | | **Hours** | **Credits** |
| **2** | **23PEL2SP01B** | | | **Self-paced Learning:** Nanoelectronics | | | | | | **-** | **2** |
| **Course Outcomes** | **Programme Outcomes (POs)** | | | | | **Programme Specific Outcomes (PSOs)** | | | | | **Mean Score of COs** |
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | |
| **CO1** | 2 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | **2.3** |
| **CO2** | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | **2.3** |
| **CO3** | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | **2.3** |
| **CO4** | 2 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 2 | 1 | **2.3** |
| **CO5** | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 3 | **2.3** |
| **CO6** | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | **2.3** |
| | | | | | | | | | | **Mean Overall Score** | **2.3 (High)** |

| Semester | Course Code | Title of the Course | Hours/Week | Credits |
|---|---|---|---|---|
| 2 | 23PEL2SP01C | **Self-paced Learning:** Medical Electronics | - | 2 |

| Course Objectives |
|---|
| To recognize bio medical measurement and instruments |
| To understand bio medical signal measurements and the operations of bio medical instruments |
| To illustrate the bio medical instrumentation techniques |
| To categorize bio medical instruments |
| To compare different bio medical instrumentation techniques and choose the suitable instruments for bio medical needs |

**UNIT I: Introduction to Bio-Medical Instrumentation**

Physiological Systems of Human body- Resting and Action Potential-Basic Medical Instrumentation System-Half Cell Potential- Silver-Silver Chloride Electrodes- Electrodes for ECG- Electrodes for EEG- Electrodes for EMG- Micro Electrodes-Classification of Transducers-Pressure Transducers- Transducers for body temperature measurement Biosensors-Smart sensors

**UNIT II: Signal Conditioners and Bio-Medical Recording Systems**

Signal Conditioners- Preamplifier- Bridge Amplifiers-Signal recovery and data acquisition-Bio signal Analysis- Electro Cardio Graph- Phono Cardio Graph- Electro Encephalo Graph- Electro Myo Graph- other Bio Medical Recorders

**UNIT III: Blood Related Bio-Medical Measurement**

Blood Pressure Measurement- Measurement of Heart Rate-Pulse Oximeters- Electromagnetic Blood Flowmeters- Ultrasonic Blood Flowmeters-Spirometry- Blood pH Measurement - Measurement of Blood $pCO_2$ and Blood $pO_2$ - Photometers and Colorimeters

**UNIT IV: Human Assistive Bio-Medical Devices**

Pace Makers- Defibrillators-Cardiac Monitor- Methods of Monitoring Foetal Heart Rate Heart-Lung Machine-Angiography-Pulmonary Function Analyzers- Ventilators-Lithotriptors Haemo -Dialysis Machine- Surgical Diathermy

**UNIT V: Advanced Bio-Medical Applications**

Bedside Patient Monitoring Systems- Elements of Bio-Telemetry-Design of Bio-Telemetry System-Computers in Medicine- laser in Medicine- Magnetic Resonance Imaging- Computer Tomography-Microwave Diathermy for Electrotherapy-Nerve Stimulators

| | |
|---|---|
| **Teaching Methodology** | Demo Videos, PPT, Handouts, Study materials |

**Books for Study**


1. Khandpur, R. S. (2011). *Handbook of Biomedical Instrumentation* (2nd Ed.). Tata McGraw-Hill. (18th reprint)
2. Arumugam, M. (2011). *Biomedical Instrumentation* (2nd Ed.), Anuradha Publications.


| Unit | Book | Chapter | Sections |
|---|---|---|---|
| I | 1 2 | 1,2,31 | 1.2, 2.3-2.6,2.8,3.2,3.5,3.6,3.9,3.10 1.5,1.6 |
| II | 1 2 | 4,53 | 4.2,4.3,5.1,5.3-5.6 3.5,3.9,3.10 |
| III | 1 2 | 6,7,10,14,15 | 6.5,6.7,10.3,14.4,15.2 6.10,6.14,7.5 |
| IV | 1 2 | 6,8,13,315,6,7 | 6.2,8.2,13.5,31.2,31.3 5.2,5.5,5.7,5.8,6.2,6.8,7.12 |
| V | 1 2 | 2,6,8,9,10,20, 22 | 6.3,20.1-20.3,22.1-22.4,29.3,29.5,29.6 8.2,8.3,10.2,10.3 |

**Books for Reference**


1. Leslie, C. (2007). *Biomedical Instrumentation and Measurement* (2nd Ed.). Prentice Hall of India.
2. Myer, K. (2003). *Standard Handbook of Biomedical Engineering and Design* (1st Ed.).
3. McGraw-Hill.
4. Joseph, J., Carr, & John, M. B. (2004). *Introduction to Biomedical Equipment Technology* (4th Ed.). Pearson Education.


**Websites and eLearning Sources***

1. https://www.udemy.com/course/electronics-with-applications-on-biomedicalengineering/
2. https://www.edx.org/course/fundamentals-of-biomedical-imaging-ultrasounds-x-ray
3. https://doi.org/10.1016/B978-0-323-85413-9.00005-0
4. https://link.springer.com/chapter/10.1007/978-3-540-36841-0_154
5. https://youtu.be/iK-6q4nnmtA

(* subject to availability - not to be used for exam purpose)

| **Course Outcomes** | | |
|---|---|---|
| **CO No.** | **CO - Statements**<br>On successful completion of this course, students will be able to | **Cognitive Levels (K- level)** |
| **CO1** | remember the Physiological systems and classify the types of electrodes and transducers | **K1** |
| **CO2** | interpret various Bio Medical Recorders | **K2** |
| **CO3** | categorize Blood related Measurements and Techniques | **K3** |
| **CO4** | appraise the performance of Bio Medical Instruments for major organs | **K4** |
| **CO5** | assess the need of modern society with professional ethics in Modern Bio Instruments and recommend solutions for the same | **K5** |
| **CO6** | plan a Bio Instruments for the need of modern society with professional ethics | **K6** |

| **Relationship Matrix** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semester** | **Course Code** | | | **Title of the Course** | | | | | **Hours** | | **Credits** |
| **2** | **23PEL2SP01C** | | | **Self-paced Learning:** Electronics | | | | | **-** | | **2** |
| **Course Outcomes** | **Programme Outcomes (POs)** | | | | | **Programme Specific Outcomes (PSOs)** | | | | | **Mean Score of COs** |
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | |
| **CO1** | 1 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 3 | 3 | **1.8** |
| **CO2** | 2 | 2 | 2 | 3 | 3 | 1 | 2 | 2 | 3 | 3 | **2.3** |
| **CO3** | 2 | 3 | 3 | 2 | 3 | 1 | 1 | 2 | 3 | 3 | **2.3** |
| **CO4** | 2 | 3 | 2 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | **2.5** |
| **CO5** | 3 | 3 | 2 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | **2.6** |
| **CO6** | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | **1.8** |
| | | | | | | | | | | **Mean Overall Score** | **2.2 (High)** |

| Semester | Course Code | Title of the Course | Hours/Week | Credits |
|---|---|---|---|---|
| 2 | 23PEL2ES03A | **Elective - 3:** Electromagnetics and Antenna Design | 5 | 4 |

| Course Objectives |
|---|
| To acquire Knowledge on fundamental concepts of Electro-Magnetic waves |
| To understand EM waves propagation and antennas |
| To Illustrate EM wave propagating devices and evaluate the modes of operation |
| To compare different type of Antennas |
| To assess and synthesis antennas for various requirements |

**UNIT I: Introduction to Electromagnetic Wave Theory (15 Hours)**

Static Electric Field-Electro Magnetic waves- Divergence Theorem- Stroke's Theorem Coulomb's Law-Electric field due to charge distribution- Gauss Law-Equation of continuity Inconsistency of Ampere Law- Boundary conditions for Electric field- Static magnetic field Biot-Savart's Law-Magnetic field intensity due to finite and infinite conductor- Boundary conditions for Magnetic field

**UNIT II: EM Wave Equations and Transmission Lines (15 Hours)**

Maxwell's Equations- Electromagnetic wave equation for free space- EM wave equation for conducting medium-Uniform Plane waves-Poynting Theorem- Transmission Lines-Types of Transmission lines-Transmission line parameters-Properties of Symmetrical Networks Current and Voltage along an infinite line - SWR- Applications of the Smith chart.

**UNIT III: Waveguides and Antennas (15 Hours)**

Introduction to Waveguides- Transverse Electric waves- Transverse Magnetic waves characteristics of TE and TM waves-Transverse Electro-Magnetic waves- velocities of propagation-Introduction to Antenna-Types of Antennas- Radiation Mechanism- Antenna parameters

**UNIT IV: Design of Antenna (15 Hours)**

Design and performance study of finite length Dipole- Halfwave Dipole Antenna- Loop Antenna-Design and study of small Circular Loop Antenna- Folded Dipole Antenna Broadband Antennas- Design of Frequency dependent Log Periodic Antennas-Antenna Array Two Element Array- Design Procedure

**UNIT V: Advanced Antenna Design (15 Hours)**

Aperture Antennas- Design considerations- Horn Antennas- Types of Horn Antennas Microstrip and Mobile Communication Antennas- Reflector Antennas- Smart Antennas-Smart Antenna system design and simulation.

| | |
|---|---|
| **Teaching Methodology** | Demo Videos, PPT, Handouts, Study materials |

**Books for Study**


1. Edward, C. J., Keith. G. B. (2002). *Electromagnetic Waves and Radiating Systems* (2nd Ed.). Prentice Hall Of India,15th reprint.
2. Bakshi, U. A, & Bakshi, A. V. (2009). *Electromagnetic waves and Transmission lines* (2nd Ed.). Technical Publications.
3. Constantine, A. B. (2016). *Antenna Theory Analysis and Design* (4th Ed.). Wiley.

| Unit | Book | Chapter | Sections |
|---|---|---|---|
| **I** | 1 | 1,2,3,4 | 1.01,1.05,2.03,2.05,2.11,3.02,3.03 4.01,4.02, 4.04 |
| **II** | 1 2 | 4,5,611,12 | 4.03,5.01-5.05,6.01 11.1,11.2,11.3,11.4,11.7, 12.5,12.11 |
| **III** | 2 3 | 131,2,9,10,11 | 13.1-13.71.1-1.3, 2,9.6,10.3,11.4 |
| **IV** | 3 | 4,5,6 | 4.5, 4.6, 5.1,5.2,6.1,6.2,6.5 |
| **V** | 3 | 12,13,14,15,16 | 12.1,12.7,13.1,13.2,13.3, 14.1-14.4,15.1-15.4,16.1,16.2,16.10,16.11 |

**Books for Reference**


1. Dhananjayan, P. (2013). *Electromagnetic Fields.* Laksmi publications.
2. Prasad, K. D. (2009). *Antenna and Wave Propagation* (2nd Ed.) Sathya Prahashan.
3. Ishimaru, A. (2017). *Electromagnetic Wave Propagation, Radiation and Scattering from Fundamentals to Applications,* IEEE press.


**Websites and eLearning Sources***

1. https://www.allaboutcircuits.com/textbook/alternating-current/chpt-14/waveguides/
2. https://ocw.mit.edu/courses/8-311-electromagnetic-theory-spring-2004/
3. https://edurev.in/courses/23240_Electromagnetic-Fields-Theory
4. https://examsdaily.in/antenna-pdf-download
5. https://www.sathyabama.ac.in/course-materials/antenna-and-wave-propagation

(* subject to availability - not to be used for exam purpose)

| **Course Outcomes** | | |
|---|---|---|
| **CO No.** | **CO - Statements**<br>On successful completion of this course, students will be able to | **Cognitive Levels (K- level)** |
| **CO1** | acquire knowledge on fundamental concepts of Electro-Magnetic waves | **K1** |
| **CO2** | explain EM waves propagation | **K2** |
| **CO3** | illustrate EM wave propagating devices and evaluate the modes of operation | **K3** |
| **CO4** | compare different type of Antennas | **K4** |
| **CO5** | recommend antennas for various requirements | **K5** |
| **CO6** | design antennas for various requirements | **K6** |

**Relationship Matrix**

| **Semester** | **Course Code** | **Title of the Course** | | | | | **Hours** | | | | **Credits** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **2** | **23PEL2ES03A** | **Elective - 3:** Electromagnetics and Antenna Design | | | | | **5** | | | | **4** |
| **Course Outcomes** | **Programme Outcomes (POs)** | | | | | **Programme Specific Outcomes (PSOs)** | | | | | **Mean Score of COs** |
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | |
| **CO1** | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 1 | **1.6** |
| **CO2** | 1 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | **2.3** |
| **CO3** | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 2 | 3 | 3 | **2.4** |
| **CO4** | 2 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | 3 | **2.6** |
| **CO5** | 1 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | 3 | **2.5** |
| **CO6** | 1 | 2 | 2 | 3 | 1 | 3 | 3 | 3 | 2 | 3 | **2.3** |
| | | | | | | | | | | **Mean Overall Score** | **2.3 (High)** |

| Semester | Course Code | Title of the Course | Hours/Week | Credits |
|---|---|---|---|---|
| 2 | 23PEL2ES03B | **Elective - 3:** Power Electronics and Solar PV Systems | 5 | 4 |

| Course Objectives |
|---|
| To identify suitable semiconductor devices for power control applications |
| To understand the working of high-power rectifiers and solar power systems |
| To calculate the energy requirement for the system requirements |
| To evaluate different power handling devices |
| To decide and develop a solar power system for the needs and become an entrepreneur |

**UNIT I: Power Semiconductor Devices (15 Hours)**

Introduction - Difference between linear and power devices - Power diodes - types - series connected and parallel connected diodes - BJT - steady state characteristics - switching characteristics - Power MOSFET-characteristics - COOLMOS - SIT - IGBTs, -switching characteristics - Thyristors - control characteristics - Advanced Silicon devices - Silicon HV thyristors, MCT, BRT & EST- SiC devices - diodes, thyristors, JFETs & IGBTs- Gallium nitrate devices - Diodes, MOSFETs.

**UNIT II: Rectifiers and DC-DC Converters (15 Hours)**

Single phase half - wave rectifiers - single phase full - wave rectifiers with RL load- -three phase bridge rectifiers- DC-DC converters- step-down operation- Generation of duty cycle - with RL load - Principle of step-up operation -with resistive load - performance parameters - converter classification - switching mode regulators buck regulators - boost regulators - Buck boost regulators - comparison of regulators - chopper circuit design

**UNIT III: Inverters and Charge Controllers (15 Hours)**

Full bridge converter - square wave inverter - Fourier series analysis -harmonic distortion - amplitude and harmonic control - half bridge inverter -multilevel inverters - PWM inverters - PWM harmonics - three phase inverters- induction motor speed control - PWM charge controller.

**UNIT IV: Solar PV Systems and PSIM Programming (15 Hours)**

Photovoltaic systems overview - electricity generation with PV cells - Basic of Solar PV systems -blocks of solar PV system - PV modules - solar array (roof top panel connection) - function of inverter - energy storage - charge controllers - calculation of solar panel - battery - types of battery - MPPT -MPPT algorithm - MPPT charge controller. grids. PSIM- Introduction -programming - power computation - instantaneous power - energy and average power - inductors and capacitors - RMS values of sinusoids - apparent power and power factor - Fourier analysis.

**UNIT V: Smart Grids (15 Hours)**

Definitions and Need for Smart Grid - Smart grid drivers - Functions -opportunities - Challenges and benefits - Difference between conventional& smart Grid - Concept of Resilient &Self-Healing Grid - off grid and on-grid - Introduction to Smart Meters - Advanced Metering infrastructure (AMI) drivers and benefits- Phasor Measurement Unit-(PMU) - Intelligent Electronic Devices (IED) &their application for monitoring & protection.

| | |
|---|---|
| **Teaching Methodology** | Demo Videos, PPT, Handouts, Study materials |

**Books for Study**

1. Muhammad, H. R (2009). *Power electronics,* (3rd Ed.). Pearson.

2. Smets, A.H., Jäger, K., Isabella, O., Swaaij, R.A. & Zeman, M. (2015). *Solar Energy: The physics and engineering of photovoltaic conversion, technologies and systems*, UIT Cambridge. (2017), *PSIM User Manual*.
3. Stuart, B. (2012), *Smart Grid: Infrastructure Technology and Solutions*, CRC Press.

| Unit | Book | Chapter | Sections |
|---|---|---|---|
| **I** | 1 | 1 | 1.1, 2.1-2.4,2.6, 3.1-3.5, 4.4, 5.2-5.4, 6.1-6.4,6.6,8.1,8.2, 9.8, lecture notes |
| **II** | 1 | 11,12,13 | 11.2, 12.2.4, 13.1-13.5 |
| **III** | 1 | 15,17 | 15.2,15.3,15.7, 17.2,17.3 |
| **IV** | 2<br>3 | 1, 3, 12,13,15, 17,19, 20,2,4,8 | 1.3,3, 3, 12.2,13.3, 15.1-15.4, 17.1-17.3, 19.1-19.4, 20.1,20.22.1, 4.1.1-4.1.3, 8.1.3, 8.1.4 |
| **V** | 4 | 2,3 | 2.1,2.2, 2.4.4,2.4.5, 3.1,3.3.1, 3.10.1-3.10.3, lecture notes |

**Books for Reference**

1. Ned, M. (2003). *First Course on Power Electronics and Drives* (1st Ed.). MNPERE.
2. Robert, W. E., & Dragan, M. (2004). *Fundamentals of Power Electronics,* (2nd Ed.). Kluwer Academic Publisher.
3. Parimita, M. Tariq, M., & Mohan, K. (2016). *Solar Photovoltaic System Applications*. Springer International Publishing, Switzerland.

**Websites and eLearning Sources***

1. https://www.tutorialspoint.com/power_electronics/index.htm
2. https://www.electrical4u.com/concept-of-power-electronics/
3. https://electronicscoach.com/power-electronics.html
4. https://www.energy.gov/eere/solar/solar-photovoltaic-technology-basics
5. http://www.ews-solarpower.co.uk/24-how-does-the-system-work

(* subject to availability - not to be used for exam purpose)

| **Course Outcomes** | | |
|---|---|---|
| **CO No.** | **CO - Statements**<br>On successful completion of this course, students will be able to | **Cognitive Levels (K- level)** |
| **CO1** | identify suitable semiconductor devices for power control applications | **K1** |
| **CO2** | illustrate the working of high-power rectifiers and solar power systems | **K2** |
| **CO3** | calculate the energy requirement for the system requirements | **K3** |
| **CO4** | evaluate different power handling devices | **K4** |
| **CO5** | recommend a solar power system for a requirement and become an entrepreneur | **K5** |
| **CO6** | plan a solar power system for a specific need | **K6** |

| Relationship Matrix | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semester** | **Course Code** | | **Title of the Course** | | | | | | | **Hours** | **Credits** |
| **2** | **23PEL2ES03B** | | **Elective - 3:** Power Electronics and Solar PV Systems | | | | | | | **5** | **4** |
| **Course Outcomes** | **Programme Outcomes (POs)** | | | | | **Programme Specific Outcomes (PSOs)** | | | | | **Mean Score of COs** |
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | |
| **CO1** | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | **2.5** |
| **CO2** | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 1 | **2.3** |
| **CO3** | 1 | 2 | 3 | 2 | 3 | 1 | 3 | 3 | 3 | 2 | **2.3** |
| **CO4** | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | **2.5** |
| **CO5** | 3 | 3 | 3 | 2 | 1 | 3 | 2 | 3 | 2 | 3 | **2.5** |
| **CO6** | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 1 | **2.3** |
| **Mean Overall Score** | | | | | | | | | | | **2.4 (High)** |

| Semester | Course Code | Title of the Course | Hours/Week | Credits |
|---|---|---|---|---|
| 2 | 23PSS2SE01 | **Skill Enhancement Course:** Soft Skills | 4 | 3 |

| Course Objectives |
|---|
| To provide a focused training on soft skills for students in colleges for better job prospects |
| To communicate effectively and professionally |
| To help the students take active part in group dynamics |
| To familiarize students with numeracy skills for quick problem solving |
| To make the students appraise themselves and assess others |

**Unit I: Effective Communication & Professional Communication (12 Hours)**

Definition of communication, Barriers of Communication, Non-verbal Communication; Effective Communication - Conversation Techniques, Good manners and Etiquettes; Speech Preparations & Presentations; Professional Communication.

**Unit II: Resume Writing & Interview Skills (12 Hours)**

Resume Writing: What is a résumé? Types of résumés, - Chronological, Functional and Mixed Resume, Purpose and Structure of a Resume, Model Resume.

Interview Skills: Types of Interviews, Preparation for an interview, Attire, Body Language, Common interview questions, Mock interviews & Practicum

**Unit III: Group Discussion & Personal effectiveness (12 Hours)**

Basics of Group Discussion, Parameters of GD, Topics for Practice, Mock GD & Practicum & Team Building.

Personal Effectiveness: Self Discovery; Goal Setting with questionnaires & Exercises

**Unit IV: Numerical Ability (12 Hours)**

Introducing concepts Average, Percentage; Profit and Loss, Simple Interest, Compound Interest; Time and Work, Pipes and Cisterns.

**Unit V: Test of Reasoning (12 Hours)**

Introducing Verbal Reasoning: Series Completion, Analogy; Data Sufficiency, Assertion and Reasoning; and Logical Deduction. Non-Verbal Reasoning: Series; and Classification

| | |
|---|---|
| **Teaching Methodology** | Chalk and talk, Lectures, Demonstrations, PPT. |

**Book for study**


1. Melchias G., Balaiah, J. & Joy, J. L. (Eds). (2018). *Winner in the Making: A Primer on soft Skills.* Trichy, India: St. Joseph's College.


**Books for References**


1. Aggarwal, R. S. (2010). *A Modern Approach to Verbal and Non-Verbal Reasoning.* S. Chand.
2. Covey, S. (2004). *7 Habits of Highly effective people.* Free Press.
3. Gerard, E. (1994). *The Skilled Helper* (5th Ed.). Brooks/Cole.
4. Khera, S. (2003). *You Can Win.* Macmillan Books.
5. Murphy, R. (1998). *Essential English Grammar*, (2nd Ed.). Cambridge University Press.
6. Sankaran, K., & Kumar, M. (2010). *Group Discussion and Public Speaking* (5th Ed.). M.I. Publications.
7. Trishna, K. S. (2012). *How to do well in GDs & Interview*s? (3rd Ed.). Pearson Education.
8. Yate, M. (2005). *Hiring the Best: A Manager's Guide to Effective Interviewing and Recruiting*

| Course Outcomes | | |
|---|---|---|
| CO No. | CO-Statements<br>On successful completion of this course, students will be able to | Cognitive Levels (K - Level) |
| CO1 | recall various soft skill sets | K1 |
| CO2 | understand personal effectiveness in any managerial positions | K2 |
| CO3 | apply verbal and non-verbal reasoning skills to solve problems | K3 |
| CO4 | differentiate problems at work and home; and design solutions to maintain work-life balance | K4 |
| CO5 | assess growth and sustainability and infuse creativity in employment that increases professional productivity | K5 |
| CO6 | construct plans and strategies to work for better human society | K6 |

| Relationship Matrix | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Semester | Course Code | | | Title of the Course | | | | Hours | | | Credits |
| 2 | 23PSS2SE01 | | | Skill Enhancement Course: Soft Skills | | | | 4 | | | 3 |
| Course Outcomes | Programme Outcomes (POs) | | | | | Programme Specific Outcomes (PSOs) | | | | | Mean Scores of COs |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | |
| CO1 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 2.7 |
| CO2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2.9 |
| CO3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2.8 |
| CO4 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2.8 |
| CO5 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 2.8 |
| CO6 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 2.8 |
| Mean Overall Score | | | | | | | | | | | 2.8 (High) |

| Semester | Course Code | Title of the Course | Hours/Week | Credits |
|---|---|---|---|---|
| 2 | 23PEL2EG01 | **Generic Elective - 1 (WS):** Electronics Media | 4 | 3 |

| Course Objectives |
|---|
| To familiarize the students with the theories of electronics media management |
| To understand the functionality of different electronic media technologies |
| To apply the mobile application and emergent technologies |
| To analyse the technologies of electronic media |
| To evaluate the basics of broadcasting, transmission standards and transmitter systems and substitute an alternative system |

**UNIT I: Introduction to Electronic in Media** **(12 Hours)**

An overview of electronic media: management - Skills, roles, and functions-electronic media industries - Evolution of Applied Electronics in Media. Development of broadcasting - Rise of the internet and deployment of broadband services - Leading to dramatic changes in telecommunication industry - Developments and changes in new media - Telephony to radio Mobile radio to visual radio - Geo-stationary satellites - Direct broadcasting satellites, narrowcasting, cable television, DTH - Public addressing system.

**UNIT II: Broadcasting Basics** **(12 Hours)**

Analog radio, Digital radio, satellite radio, Audio blogging - RSS - Pod safe music - Analog television - Digital television - Cable television - Working principle of video camera - Consoles, Video hosting / Download services - Internet radio and television - Digital media production - Sound and vision - Image capture techniques - Web-based social interaction.

**UNIT III: Transmission Standards and Systems** **(12 Hours)**

NTSC, PAL, SECAM, IPTV, HDTV, ATSC Digital television - Transmission / Reception lines and other equipment - Various modes of receiving systems - FM and TV antenna towers - Translators and repeaters - Transmitter remote controls - Mobile phone media production: SMS, MMS, Mobile phone media delivery - Streaming and video on demand.

**UNIT IV: Mobile and Emergent Technologies** **(12 Hours)**

Information technology: Computer storage, Computer networks, Internet streaming, Web Streaming, Audio and video streaming, Flash streaming, MP3 streaming (radio), Peer to Peer distribution - Digital video broadcasting via satellite services to handhelds (DVB-SH) Technology, Geo-spatial technology, Wi-fi and Wi-Max, podcasting, i-Pod, Information superhighways, Interactive portals.

**UNIT V: Media Input /Output Systems** **(12 Hours)**

Microphones- types - Mixing console - special effects units - equalizers - compressors - output devices - The Sound Recording Room-Display: LCD, LED, Plasma screens, IPOD, PDAs, Multimedia projectors, - Speakers, Active and passive speakers - Home theater network - connection diagram - types of cables, DolBy, DTS, CUBE. - Mobile devices for e-portfolios - Mobile devices in the classroom

| | |
|---|---|
| **Teaching Methodology** | Demo Videos, PPT, Handouts, Study materials |

**Books for Study**


1. Graham, J. (2005). *A Broadcast Engineering Tutorial for Non-Engineers*, Focal Press.
2. Study Material prepared by the department.

| Unit | Book | Chapter | Sections |
|---|---|---|---|
| **I** | 2 | 1 | all |
| **II** | 1 | 2, 3 | all |
| **III** | 1 | 5, 12, 14, 15 | all |
| **IV** | 2 | 2 | all |
| **V** | 2 | 3 | all |

**Books for Reference**


1. Tozer, E.P.J. (2004). Broadcasting Engineering Reference Book, Focal Press.
2. Borko, F., & Syed, A. A. (2008). Handbook of Mobile Broadcasting, Taylor & Francis.
3. Brian, W. (2000). Media Technology and Society: A History from the Telegraph to the Internet. Rutledge.


**Websites and eLearning Sources***

1. https://www.docsity.com/en/introduction-to-electronic-media-lecture-notes-jmc-
2. 1011/6267953/
3. https://www.tvwithoutborders.com/tutorials/dtv_intro/broadcast-engineering-basics/
4. https://www.eeeguide.com/television-systems-and-standards/
5. https://www.tutorialspoint.com/emerging-technologies-of-2017

(* subject to availability - not to be used for exam purpose)

| **Course Outcomes** | | |
|---|---|---|
| **CO No.** | **CO - Statements** | **Cognitive Levels (K- level)** |
| | On successful completion of this course, students will be able to | |
| **CO1** | familiarize the students with the theories of electronics media management | **K1** |
| **CO2** | know the functionality of different electronic media technologies | **K2** |
| **CO3** | apply the mobile application and emergent technologies | **K3** |
| **CO4** | analyse the technologies of electronic media | **K4** |
| **CO5** | evaluate the basics of broadcasting, transmission standards and transmitter systems. | **K5** |
| **CO6** | organize electronics media for a specific application | **K6** |

| **Relationship Matrix** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semester** | **Course Code** | | | **Title of the Course** | | | | | | **Hours** | **Credits** |
| **2** | **23PEL2EG01** | | | **Generic Elective - 1 (WS):** Electronics Media | | | | | | **4** | **3** |
| **Course Outcomes** | **Programme Outcomes (POs)** | | | | | **Programme Specific Outcomes (PSOs)** | | | | | **Mean Score of COs** |
| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | |
| **CO1** | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | **2.4** |
| **CO2** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | **2** |
| **CO3** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | **2** |
| **CO4** | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | **2.5** |
| **CO5** | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | **2.6** |
| **CO6** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | **2.1** |
| | | | | | | | | | | **Mean Overall Score** | **2.27 (High)** |