# SYLLABUS

## FOR

# III and IV semester B.E.

# 2026 - 2027

**Sree Siddaganga Education Society®**

## Siddaganga Institute of Technology

**(An Autonomous Institution affiliated to V.T.U., Belagavi, Approved by AICTE, New Delhi, Accredited by NAAC with 'A++' Grade and ISO 9001:2015 Certified)**

**Dr Sree Sree Sivakumara Swamiji Road, Tumakuru – 572 103, Karnataka, India**

**Ph. :+91-816-2214001, 2282696, 2214000 Fax.:+91-816-2282994**

**E-Mail: principal@sit.ac.in web: www.sit.ac.in**

**Siddaganga Institute of Technology, Tumkur-572103**
**Department of Electronics & Instrumentation Engineering**

**Vision of the Institute**

To develop thoughtful and creative young minds in a learning environment of high academic ambience by synergizing spiritual values and technological competence.

**Mission of the Institute**

1. To continuously strive for the total development of students by educating them in state-of-the-art-technologies and managerial competencies providing best in class learning experience with emphasis on skills, values and learning outcomes and helping them imbibe professional ethics and societal commitment.
2. To create a research ambience that promotes interdisciplinary research catering to the needs of industry and society.
3. To collaborate with premier academic and research institutions and industries to strengthen multidisciplinary education, applied research, innovation, entrepreneurship and consulting ecosystems.

**Quality Policy**

Siddaganga Institute of Technology is committed to:

1. Impart Quality Education by establishing effective learning - teaching - learning processes to produce competent engineers and managers with high professional ethics and societal responsibility.
2. Create congenial environment and provide state-of the-art infrastructure.
3. Continually improve the effectiveness of the Quality Management System.
4. Satisfy applicable requirements.

**Vision of the Department**

To become a premier Electronics and Instrumentation Engineering Department by imparting quality education in the fields of electronics, instrumentation and cutting edge technologies developing competence to meet industrial norms and to pursue research and innovation contributing to socioeconomic development.

**Mission of the Department**

1. Develop competent professionals by offering industry aligned curriculum in Electronics, Instrumentation and VLSI and embedded systems along with an exposure to cutting edge technologies by providing best in class learning, promoting interdisciplinary research and innovation catering to industrial and societal needs.
2. Encourage and prepare students for higher studies to promote lifelong learning.

3. Imbibe professional ethics and skills in students to provide engineering service to the society.
4. Collaborate with industries to inculcate industry readiness, creativity, managerial competence, experiential learning and entrepreneurship skills.

**Program Educational Objectives (PEOs)**

Graduates of the Electronics and Instrumentation Programme

**PEO 1:** Contribute effectively in industry and excel in higher education by applying the knowledge of Science, Technology, Engineering and Math (STEM) principles.

**PEO 2:** Engage in lifelong learning by adapting emerging technologies, and excel in research pursuits and entrepreneur to meet the global challenges.

**PEO 3:** Exhibit professional skills, communication skills, teamwork and leadership qualities imbibing ethical values in their profession for the benefit of society.

**Programme Outcomes (PO):**

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

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

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

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

**PO5: Engineering Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modeling recognizing their limitations to solve complex engineering problems.

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

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

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

**PO9: Communication:** Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.

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

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

**Programme specific Outcomes (PSO):**

Student will be able to

**PSO1:** Apply the technical knowledge of measurement techniques, instrumentation, control, communications and the state - of - the art technologies in process, healthcare and related domains.

**PSO2:** Apply the knowledge of Signal Processing, Electronic Circuits and Programming Skills to design embedded systems for real time applications.

# SIDDAGANGA INSTITUTE OF TECHNOLOGY, TUMAKURU

**(An autonomous institution affiliated to VTU, Belagavi, Approved by AICTE, New Delhi, Accredited by NAAC with 'A++' grade & ISO 9001:2015 Certified)**

## B.E. in Electronics and Instrumentation Engineering

## SCHEME OF TEACHING AND EXAMINATION FOR THE AY: 2026-27

### III Semester

| Sl. No. | Course and Course Code | | Course Title | Teaching / Paper setting Dept. | Teaching and Learning scheme | | | | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Lecture | Tutorial | Practical / Drawing | TW&SL | Total Hours / Sem. | Duration in hrs. | CIE Marks | SEE Marks | Total Marks | |
| | | | | | L | T | P | SL | | | | | | |
| 1. | ASC /PCC | P3EI1 | Transform Techniques for Signals and Systems | EIE | 42 | 28 | 0 | 50 | 120 | 3 | 50 | 50 | 100 | 4 |
| 2. | IPCC | P3EII1 | Sensors and Actuators | EIE | 42 | 0 | 28 | 50 | 120 | 3 | 50 | 50 | 100 | 4 |
| 3. | PCC | P3EI2 | Digital Electronic Circuits with Verilog | EIE | 42 | 0 | 28 | 50 | 120 | 3 | 50 | 50 | 100 | 4 |
| 4. | PCC | P3EI3 | Analog Electronic Circuits | EIE | 42 | 0 | 0 | 48 | 90 | 3 | 50 | 50 | 100 | 3 |
| 5. | PCC | P3EI4 | Network Analysis | EIE | 42 | 0 | 0 | 48 | 90 | 3 | 50 | 50 | 100 | 3 |
| 6. | PCCL | P3EIL1 | Analog Electronics Circuits Lab | EIE | 0 | 0 | 28 | 2 | 30 | 3 | 50 | 50 | 100 | 1 |
| 7. | AEC | P3EIAX | Ability Enhancement Course Laboratory | EIE | 0 | 0 | 28 | 2 | 30 | 3 | 50 | 50 | 100 | 1 |
| 8. | SDC | SDCEI3 | Community Project (Project-Based Learning) | EIE. | 0 | 0 | 0 | 30 | 30 | 3 | 50 | 50 | 100 | 1 |
| 9. | NCMC | PMC1 | National Service Scheme (NSS) | NSS coordinator | 0 | 0 | 0 | 28 | 28 | -- | 100 | -- | 100 | PP |
| | | PMC2 | Physical Education (PE) (Sports and Athletics) | Ph.Edn. Director | | | | | | | | | | |
| | | PMC3 | Yoga (Yoga Teacher) | | | | | | | | | | | |
| | | PMC4 | Music (Music Teacher) | | | | | | | | | | | |
| | | | **Total** | | | | | | | | **600** | **400** | **1000** | **21** |
| | | AAP | **AICTE Activity Points:** (Regular students have to earn 100 activity points from I to VI semesters and Lateral Entry students have to earn 75 activity points from III to VI semesters) | Compulsory requirement for the award of a degree | | | | | | | | | | |
| 10. | NCMC | P3MATDIP | Foundations of Engineering Mathematics-I (Mathematics course for Lateral Entry Students) | Maths Dept. | 40 | 0 | 0 | 48 | 90 | 3 | 100 | --- | 100 | PP |

**Note: ASC**: Applied Science Course **PCC**: Professional Core Course, **IPCC**: Integrated Professional Core Course, **PCCL**: Professional Core Course laboratory, **AEC**: Ability Enhancement Course, **SDC**: Skill Development Course **NCMC**: Non Credit Mandatory Course **L**: Lecture, **T**: Tutorial, **P**: Practical **SL:** Self Learning **TW&SL:** Team works & Self Learning **CIE**: Continuous Internal Evaluation, **SEE**: Semester End Evaluation.

| **Ability Enhancement Course (Laboratory)** | | | |
|---|---|---|---|
| P3EIA1 | Circuit Simulation using SPICE | P3EIA2 | Virtual Instrumentation |
| P3EIA3 | Data Analytics with R Programming | P3EIA4 | Signal Processing Lab |

**Ability Enhancement Course Laboratory** can be offered either as a single compulsory course or as multiple elective options.

**Community Project:** A community is a social unit or group of people sharing socially-significant characteristics, such as place, set of norms, culture, religion, values, customs or identity. A community project involves addressing issues or needs within such a community or a network of entities working toward a common purpose. These projects may cover a wide range of areas, including welfare, sustainability, technology integration, and social development. Examples include establishing and maintaining an orphanage, implementing solar power generation and its maintenance, or developing environmental improvement solutions, etc. A community project is an experiential learning activity that encourages students to identify, analyse, and address real-life problems of the community using engineering knowledge. It aims to promote social responsibility and civic engagement, interdisciplinary thinking and collaboration and practical application of theoretical concepts, thereby enabling students to contribute meaningfully to community welfare and sustainable development. Students can take up project individually or in a group not exceeding 4 students.

The evaluation shall be done as per the following;

**CIE:** The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide. The CIE marks awarded for the project work shall be based on the rubrics.

**SEE:** SEE will be conducted by the two examiners appointed by the Institute. The SEE marks awarded for the project work shall be based on the rubrics.

**National Service Scheme / Physical Education / Yoga / Music (NSS / PE / YOG / Music):** All students are required to register for any one of the following courses; National Service Scheme (NSS), Physical Education (PE) (Sports and Athletics), Yoga (YOG) or Music (MUSIC) during the first week of the third semester through online.

- Students may opt for different activities/options across semesters. For instance, a student participating in PE during 3rd semester may choose NSS in the 4th semester or Yoga.
- Activities shall be conducted over two semesters (III & IV), and successful completion of the registered course / or courses along with the required CIE score is mandatory for the award of the degree.
- The events are appropriately scheduled and reflected in the semester-wise calendar for NSS, PE, Music, and Yoga activities.
- These courses shall not be considered for the calculation of SGPA or CGPA and for vertical progression. However, completion of course(s) is compulsory for degree eligibility.

# SIDDAGANGA INSTITUTE OF TECHNOLOGY, TUMAKURU

**(An autonomous institution affiliated to VTU, Belagavi, Approved by AICTE, New Delhi, Accredited by NAAC with 'A++' grade & ISO 001:2015 Certified)**

## B.E. in Electronics and Instrumentation Engineering

## SCHEME OF TEACHING AND EXAMINATION FOR THE AY: 2026-27

### IV Semester

| Sl. No. | Course and Course Code | | Course Title | Teaching / Paper setting Dept. | Teaching and Learning scheme | | | | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Lecture | Tutorial | Practical / Drawing | TW&SL | Total Hours / Sem. | Duration in hrs. | CIE Marks | SEE Marks | Total Marks | |
| | | | | | L | T | P | SL | | | | | | |
| 1. | ASC/ PCC | P4EI1 | Mathematics for Machine Learning | EIE | 42 | 0 | 0 | 48 | 90 | 3 | 50 | 50 | 100 | 3 |
| 2. | IPCC | P4EII1 | Embedded Architectures | EIE | 42 | 0 | 28 | 50 | 120 | 3 | 50 | 50 | 100 | 4 |
| 3. | PCC | P4EI2 | Control Systems and Robotics | EIE | 42 | 28 | 0 | 50 | 120 | 3 | 50 | 50 | 100 | 4 |
| 4. | PCC | P4EI3 | Linear ICs and Data Converters | EIE | 42 | 0 | 0 | 48 | 90 | 3 | 50 | 50 | 100 | 3 |
| 5. | PCCL | P4EIL1 | Signal Conditioning & Data Acquisition Circuits Lab | EIE | 0 | 0 | 28 | 2 | 30 | 3 | 50 | 50 | 100 | 1 |
| 6. | PCCL | P4EIL2 | Computational Sensing Laboratory | EIE | 0 | 0 | 28 | 2 | 30 | 3 | 50 | 50 | 100 | 1 |
| 7. | AEC | P4EIAX | Ability Enhancement Course Laboratory | EIE | 0 | 0 | 28 | 2 | 30 | 3 | 50 | 50 | 100 | 1 |
| 8. | BSC | P4EIB1 | Biology For Instrumentation | EIE | 14 | 0 | 0 | 16 | 30 | 1.5 | 50 | 50 | 100 | 1 |
| 9. | SDC | SDCEI4 | Environmental Science Project | EIE | 0 | 0 | 0 | 30 | 30 | 3 | 50 | 50 | 100 | 1 |
| 10. | NCMC | PMC1 | National Service Scheme (NSS) | NSS coordinator | 0 | 0 | 0 | 28 | 28 | -- | 100 | -- | 100 | PP |
| | | PMC2 | Physical Education (PE) (Sports and Athletics) | Ph.Edn. Director | | | | | | | | | | |
| | | PMC3 | Yoga (Yoga Teacher) | | | | | | | | | | | |
| | | PMC4 | Music (Music Teacher) | | | | | | | | | | | |
| | | | **Total** | | | | | | | | **500** | **400** | **900** | **19** |
| | | AAP | **AICTE Activity Points** (Regular students have to earn 100 activity points from I to VI semesters and Lateral Entry students have to earn 75 activity points from III to VI semesters) | Compulsory requirement for the award of a degree | | | | | | | | | | |
| 11. | NCMC | P4MATDIP | Foundations of Engineering Mathematics-II (Mathematics course for Lateral Entry Students) | Maths Dept. | 40 | 0 | 0 | 48 | 90 | 3 | 100 | --- | 100 | PP |

**Note: ASC**: Applied Science Course **PCC**: Professional Core Course, **IPCC**: Integrated Professional Core Course, **PCCL**: Professional Core Course laboratory, **AEC**: Ability Enhancement Course, **SDC**: Skill Development Course **NCMC**: Non Credit Mandatory Course
**L**: Lecture, **T**: Tutorial, **P**: Practical **SL:** Self Learning **TW&SL:** Team works & Self Learning, **CIE**: Continuous Internal Evaluation, **SEE**: Semester End Evaluation.

| **Ability Enhancement Course (Laboratory)** | | | |
|---|---|---|---|
| P4EIA1 | Advanced Technical Training Lab | P4EIA2 | COMSOL Multiphysics |
| P4EIA3 | Arduino UNO Programming | P4EIA4 | Python for measurement Lab |

**Environmental Science Project:** The Environmental Science Project is an applied learning component designed to develop students' awareness, understanding, and responsibility toward the environment. It provides an opportunity to study real-world environmental issues and apply scientific and engineering principles to design feasible and sustainable solutions.
The topics under environment include, but not limited to, climate change, biodiversity, air and water pollution, land use, excess use of natural resources, earthquakes, rise in the earth's temperature, power generation, soil erosion, environment issues related program, etc.
The project involves problem identification, field surveys, case studies, data collection, environmental audits, analysis, and proposal of remedial or preventive measures aimed at improving biodiversity, air quality, and thermal comfort, etc. Students can take up project individually or in a group not exceeding 4 students. Students can opt for Interdisciplinary Project based on their interest.
The evaluation shall be done as per the following;
**CIE:** The CIE marks shall be awarded by a committee consisting of the Head of the concerned Department and two senior faculty members of the Department, one of whom shall be the Guide. The CIE marks awarded for the project work, shall be based on the rubrics.
**SEE:** SEE will be conducted by the two examiners appointed by the Institute. The SEE marks awarded for the project work shall be based on the rubrics.

# 3rd Semester

# TRANSFORM TECHNIQUES FOR SIGNALS AND SYSTEMS

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 3+2+0 (L+T+P) | Credits: | 4 |
| Total Lecture Hours: | 42 | CIE Marks: | 50 |
| Total Tutorial Hours: | 28 | SEE Marks: | 50 |
| Total Practical Hours: | 0 | Course Code: | P3EI1 |
| Course Type: | PCC | Exam Hours: | 3 |

| **Course objectives:** This course will enable students to: | |
|---|---|
| 1. | Learn the characteristics, representation and properties of signals and systems in time and frequency domains. |
| 2. | Learn advanced time–frequency analysis techniques such as STFT and Wavelet Transform for non-stationary signal representation. |
| 3. | Understand Z-transform techniques and their role in system analysis. |

| **UNIT I** |
|---|
| **Mathematical representation of Signals and Systems:** Definition of signals and systems, Mathematical Representation, Classification of signals, Operation on signals, Elementary signals, Systems viewed as interconnection of operations, Properties of systems. |
| **8 Hours** |

| **UNIT II** |
|---|
| **Time Domain Representation of LTI Systems:** Introduction, Impulse response representation of Discrete LTI systems, Properties of impulse response representation, difference equation representation of LTI systems, Block diagram representation. |
| **8 Hours** |

| **UNIT III** |
|---|
| **Fourier Representations:** Orthogonality of complex sinusoids, Fourier Series (FS), Fourier Transform (FT), Discrete Time Fourier Series (DTFS), Discrete Time Fourier Transform (DTFT), Properties of FT and DTFT.<br>**Time-Frequency Representation:** Limitations of Fourier Transform, windowing concept, Short-Time Fourier Transform (STFT), resolution trade-off. |
| **9 Hours** |

| UNIT IV |
|---|
| **Applications of Fourier Representations:** Frequency response of LTI systems, solution of difference equations using Fourier Transform, Fourier Transform representation for periodic signals, sampling of continuous-time signals.<br>**Wavelet Transform and Advanced Analysis:** Limitations of STFT, introduction to Wavelet Transform, continuous and discrete wavelet transform (concepts), multi-resolution analysis, comparison of FT, STFT, and Wavelet Transform, applications in signal denoising and feature extraction. |
| **9 Hours** |

| UNIT V |
|---|
| **Z-Transform and System Analysis:** Introduction, Region of Convergence (ROC), properties of Z-transform, inversion of Z-transform, transform analysis of LTI systems, stability and causality analysis, unilateral Z-transform and its applications. |
| **8 Hours** |

| **TEXT BOOKS** | | |
|---|---|---|
| 1 | Simon Haykin and Barry Van Veen | Signals and Systems, Wiley India, 2nd Edition, 2021. |
| 2 | Alan V Oppenheim, Alan S WilIsky and S Hamid Nawab | Signals and Systems, Pearson Education, 2nd Edition, 2015. |
| 3 | Paul S. Addison | The Illustrated Wavelet Transform Handbook, CRC Press, 2nd Edition, 2017. |

| **REFERENCE BOOKS** | | |
|---|---|---|
| 1 | Udaykumar.S | Signals and Systems, Prism books Pvt. Ltd., 7th Edition, 2017. |
| 2 | Ganesh Rao and Satish Tunga | Signals and Systems, Cengage India Publisher. 1st Edition, 2017. |
| 3 | Stéphane Mallat | A Wavelet Tour of Signal Processing, Elsevier, 3rd Edition, 2009. |

| **Course Outcomes:** Upon completion of this course the student will be able to: | |
|---|---|
| CO1 | **Apply** the knowledge of Mathematics to represent, Classify and perform operations on signals and characterize systems. |
| CO2 | **Analyze** discrete LTI systems in time domain using convolution and solve linear constant coefficient difference equations. |
| CO3 | **Apply** Fourier Transform techniques for signal representation and analysis. |
| CO4 | **Analyze** signals and LTI systems using Fourier-based techniques, and non-stationary signals using STFT and Wavelet Transform methods |
| CO5 | **Apply** Z-transform techniques for analysis and characterization of LTI system and discrete time systems. |

**Course Articulation Matrix**

| | | **POs** | | | | | | | | | | | **PSOs** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **1** | **2** |
| **COs** | **CO1** | 3 | 1 | | | | | | | | | | | 2 |
| | **CO2** | 3 | 1 | | | | | | | | | | | 2 |
| | **CO3** | 3 | 1 | | | | | | | | | | | 2 |
| | **CO4** | 3 | 1 | | | | | | | | | | | 2 |
| | **CO5** | 3 | 1 | | | | | | | | | | | 2 |

# SENSORS AND ACTUATORS

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 3+0+2 (L+T+P) | Credits: | 4 |
| Total Lecture Hours: | 42 | CIE Marks: | 50 |
| Total Tutorial Hours: | 00 | SEE Marks: | 50 |
| Total Practical Hours: | 28 | Course Code: | P3EII1 |
| Course Type: | IPCC | Exam Hours: | 3 |

**Course objectives:**

This course will enable students to:

| | |
|---|---|
| 1. | Understand the operating principles, characteristics, selection criteria, and applications of various sensors and transducers. |
| 2. | Learn the working principles and performance of actuators and control elements. |
| 3. | Study MEMS technology, advanced sensing systems, sensor fusion concepts, and AI-enabled smart sensors for modern engineering applications. |

**UNIT I**

**Introduction to Sensors and Transducers:** Primary sensing elements and transduction principles, Classification of sensors.

**Static and Dynamic Characteristics of Sensors:** Accuracy, precision, sensitivity, and resolution, Linearity, hysteresis, drift and repeatability. Response time and dynamic behaviour, Criteria for sensor selection, Sources of measurement error and uncertain.

**Resistive and Thermoelectric Sensors:** Strain gauges and bridge circuits, Resistance Temperature Detector (RTD) and thermistors, Thermocouple principles and applications.

**Optical Sensors:** Photoresistors (LDRs), Photodiode operation and characteristics

**9 Hours**

**UNIT II**

**Inductive Sensors:** Principle, construction, characteristics and applications of LVDT and variable reluctance sensors.

**Capacitive Sensors:** Principle of operation, types, characteristics and applications of capacitive sensors.

**Piezoelectric Sensors:** Working principle, characteristics and industrial applications.

**AC bridges: Maxwell's and De sauty's** bridge circuits

**9 Hours**

| UNIT III |
|---|
| **Introduction to Actuators:** Classification of actuators – linear, rotary, electrical and mechanical actuators.<br>**Hydraulic and pneumatic Actuators:** Principle, construction and applications of hydraulic and pneumatic actuators.<br>**Electrical Actuators:** Working principle and applications of DC motors, AC motors, stepper motors and servo motors.<br>**Final Control Elements:** Solenoids, relays, Control valves: Types and characterises. **Smart Actuators:** Piezoelectric and electrothermal actuators – principles and applications. |
| **8 Hours** |
| **UNIT IV** |
| **Introduction to MEMS Technology:** Fundamentals of Micro-Electro-Mechanical Systems (MEMS) and their advantages.<br>**Micromachining Techniques:** Bulk micromachining and surface micromachining techniques used in MEMS fabrication.<br>**MEMS Sensors:** Principle and applications of MEMS-based pressure sensors, accelerometers and gyroscopes.<br>**Micro Actuators:** Electrostatic, thermal and magnetic micro actuators – working principles and applications. |
| **8 Hours** |

| UNIT V |
|---|
| **ADVANCED SENSING SYSTEMS**: Introduction to vision and image-based sensing systems. Basics of radar and sonar sensors. Inertial Measurement Units (IMUs): accelerometers and gyroscopes. Thermal and infrared sensors. Sensor fusion concepts and applications. Introduction to smart and AI-enabled sensors. Applications in autonomous systems and industrial monitoring. |
| **8 Hours** |

| **TEXT BOOKS** | | |
|---|---|---|
| 1 | D. Patranabis | Sensors and Transducers, 3rd Edition, PHI Learning Pvt. Ltd., 2017. |
| 2 | Jacob Fraden | Handbook of Modern Sensors: Physics, Designs and Applications, 5th Edition, Springer, 2016. |

| **REFERENCE BOOKS** | | |
|---|---|---|
| 1 | Robert H Bishop | The Mechatronics Handbook, 2nd Edition, CRC Press, 2018. |
| 2 | Thomas. G. Bekwith and Lewis Buck.N | Mechanical Measurements, 7th Edition, Pearson, 2020. |
| 3 | M.H Bao | Micro Mechanical Transducers: Pressure Sensors, Accelerometers and Gyroscopes, 2nd Edition, Elsevier, 2020. |
| 4 | Manfred Kohl | Microsensors, MEMS and Smart Devices, 2nd Edition, Wiley, 2014. |

| **TRANSDUCERS AND MEASUREMENTS LAB: (Only for CIE)**<br>(2 Hours per week per batch) 13 Lab sessions + 1 Lab assessment | |
|---|---|
| 1. | Characteristics of RTD and calculation of range, linearity, Sensitivity and hysteresis by using software tools. |
| 2. | Characteristics of AD590 and calculation of range, linearity, Sensitivity and hysteresis by using software tools. |
| 3. | Characteristics of LVDT and calculation of range, linearity, Sensitivity and hysteresis by using software tools. |
| 4. | Characteristics of Capacitive transducer and calculation of range, linearity, Sensitivity and hysteresis by using software tools. |
| 5. | Characteristics of cantilever beam strain gauge for quarter, half and full bridge and calculation of range, linearity, Sensitivity and hysteresis by using software tools. |
| 6. | Characteristics of Load cell and calculation of range, linearity, Sensitivity and hysteresis by using software tools. |
| 7. | Characteristics of hall effect proximity sensor and calculation of range, linearity, Sensitivity and hysteresis by using software tools. |
| 8. | Characteristics of flow meter and calculation of linearity and sensitivity using software tools. |
| 9. | Characteristics of thermistor and calculation of range, linearity, Sensitivity and hysteresis by using software tools. |
| 10. | Measurement of resistance using Wheatstone bridge. |
| 11. | Measurement of Inductance by Maxwell's Bridge. |
| 12. | Measurement of Capacitance by Desauty's Bridge. |

| **Course Outcomes:** Upon completion of the course the student will be able to: | |
|---|---|
| CO1 | **Analyze** the operating principles, characteristics, and performance of sensors and transducers used in measurement systems. |
| CO2 | **Apply** the principles of inductive, capacitive, and piezoelectric transducers in sensing and measurement applications. |
| CO3 | Select appropriate hydraulic, pneumatic, and electrical actuators for control system applications. |
| CO4 | **Analyze** MEMS fabrication techniques, MEMS sensors, and microactuators for industrial applications. |
| CO5 | **Analyze** modern sensing systems, sensor fusion techniques, and AI-enabled smart sensors for autonomous and industrial applications. |

**Course Articulation Matrix**

| | | **POs** | | | | | | | | | | | **PSOs** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **1** | **2** |
| **COs** | **CO1** | 3 | 2 | | | | | | 3 | 3 | | | 2 | |
| | **CO2** | 3 | 2 | | | | | | 3 | 3 | | | 2 | |
| | **CO3** | 3 | 2 | | | | | | 3 | 3 | | | 2 | |
| | **CO4** | 3 | 2 | | | | | | 3 | 3 | | | 2 | |
| | **CO5** | 3 | 2 | | | | | | 3 | 3 | | | 2 | |

# DIGITAL ELECTRONIC CIRCUITS WITH VERILOG

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 3+0+2 (L+T+P) | Credits: | 4 |
| Total Lecture Hours: | 42 | CIE Marks: | 50 |
| Total Tutorial Hours: | 0 | SEE Marks: | 50 |
| Total Practical Hours: | 28 | Course Code: | P3EI2 |
| Course Type: | PCC | Exam Hours: | 3 |

**Course objectives:**

This course will enable students to:

| | |
|---|---|
| 1. | Understand the properties of logic gates, simplification of Boolean expressions using Karnaugh maps, and basic concepts of Verilog HDL. |
| 2. | Learn the design of combinational and sequential logic circuits, finite state machines, and modeling using Verilog HDL. |
| 3. | Study the architecture and operation of programmable logic devices, FPGAs, and hazards in combinational logic circuits. |

**UNIT I**

**Properties of logic gates:** Noise Margin, Fan-out, Propagation Delay, Power Dissipation.

**Simplification of Boolean Expressions:** Canonical forms, Karnaugh maps (3 and 5 variable)

**Introduction to Verilog HDL:** HDL basic concepts, Syntax & semantics, Data types, Operators, HDL modeling types, Developing HDL code for logic circuits using Verilog HDL program.

**9 Hours**

**UNIT II**

**Combinational Logic Circuits:** Binary adders and subtractors, Carry look-ahead adder, Decimal adders, Comparators- one bit and two bit, Decoders, Encoder, Multiplexer, Demultiplexer, Logic design using decoders and multiplexers. Modeling combinational logic circuits using dataflow, gate level and behavioral Verilog HDL program.

**8 Hours**

| UNIT III |
|---|
| **Sequential Circuit design**: Basic bi-stable element, Latches- SR Latch using NAND gates, D Latch, Gated D Latch, Flip-flops – SR, D, JK and T, Characteristic equations, Flip flop conversions. Introduction to Setup, Hold, Clock skew and jitter.<br>**Registers:** shift register- SISO, SIPO, PISO, Universal shift register. **Counters:** asynchronous and MOD counter, ring Counter and Johnson counter, Modeling sequential circuits using behavioral Verilog HDL program. |
| **9 Hours** |

| UNIT IV |
|---|
| **Counters:** Synchronous counter design, Introduction to Mealy and Moore models.<br>**Finite state machine** (Mealy and Moore model): state graph and synchronous sequential circuit design, design of Sequence detector (overlapping & non-overlapping), synchronous sequential circuit analysis.<br>**State encoding techniques:** Binary, One-hot and Grey. |
| **8 Hours** |

| UNIT V |
|---|
| **Programmable logic Devices(PLDs):**<br>PROMs, Programmable logic arrays (PLAs), Programmable array logic (PALs): structure, logic diagram, representation in PLD notation, Logic design using PLDs, Introduction to FPGA architecture, LUTs, and routing.<br>**Static and Dynamic Hazards in combinational networks:** Static hazards, detecting static hazards, eliminating static hazards, Dynamic Hazards |
| **8 Hours** |

| **TEXT BOOKS** | | |
|---|---|---|
| 1 | Donald D. Givone | Digital Principles and Design, TATA Mc Graw-hill, 2017 |
| 2 | Samir Palnitkar | Verilog HDL A guide to Digital Design and Synthesis" 2nd Edition, Pearson Education, 2003 |

| **REFERENCE BOOKS** | | |
|---|---|---|
| 1 | Ronald J Tocci, Neal S Widmer and Regory L Moss. | Digital Systems Principles and Applications, 12th Edition, Pearson, 2017. |
| 2 | Charles H. Roth. Jr. | Digital Systems Design using Verilog, Thomson Learning, Inc, 1st Edition 2015. |
| 3 | Pong P. Chu | FPGA prototyping by, verilog examples, by John Wiley & Sons Publication, Inc, 2018. |
| 4 | Jan M. Rabaey, AnanthaChandrakasan, Borivoje Nikolić | Digital Integrated Circuits, 2nd Edition, Pearson Education India, 2016 |

| **DIGITAL ELECTRONIC CIRCUITS WITH VERILOG LAB (Only for CIE)** (2 Hours per week per batch) 13 Lab sessions + 1 Lab assessment | |
|---|---|
| Part-A Hardware Experiments: | |
| 1. | Basic Logic Gates |
| 2. | Binary Adder and Subtractor |
| 3. | Multiplexers and De multiplexers |
| 4. | 1-bit and 2-bit Comparator |
| 5. | Encoder and Decoder |
| 6. | Flip-Flops |
| 7. | SISO Shift Registers |
| 8. | SIPO Shift Registers |
| 9. | Synchronous Up Counter |
| 10 | Synchronous Down Counter |
| **Open ended experiments** | |
| 1 | Vending machine controller using Verilog HDL |
| 2 | Elevator controller using Verilog HDL |

| **Course Outcomes:** Upon completion of this course the student will be able to: | |
|---|---|
| CO1 | **Apply** K-Maps to simplify Boolean expressions and develop Verilog code for logic circuits. |
| CO2 | **Design** combinational circuits and develop Verilog code. |
| CO3 | **Implement** shift registers and counters using flip-flops and develop Verilog code. |
| CO4 | **Design** Finite state machine using Mealy and Moore model |
| CO5 | **Design** logic circuits using programmable logic devices and analyze hazards in combinational networks. |

**Course Articulation Matrix**

| | | **POs** | | | | | | | | | | | **PSOs** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **1** | **2** |
| **COs** | **CO1** | 3 | 2 | | | 3 | | | 3 | 3 | | | | 2 |
| | **CO2** | 3 | 2 | | | 3 | | | 3 | 3 | | | | 2 |
| | **CO3** | 3 | 2 | | | 3 | | | 3 | 3 | | | | 2 |
| | **CO4** | 3 | 2 | | | 3 | | | 3 | 3 | | | | 2 |
| | **CO5** | 3 | 2 | | | 3 | | | 3 | 3 | | | | 2 |

# ANALOG ELECTRONIC CIRCUITS

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 3+0+0 (L+T+P) | Credits: | 3 |
| Total Lecture Hours: | 42 | CIE Marks: | 50 |
| Total Tutorial Hours: | 00 | SEE Marks: | 50 |
| Total Practical Hours: | 00 | Course Code: | P3EI3 |
| Course Type: | PCC | Exam Hours: | 3 |

**Course objectives:**

This course will enable students to:

| | |
|---|---|
| 1. | Learn the operation and characteristics of MOSFET analog circuits and differential amplifiers. |
| 2. | Study high-frequency MOS amplifiers, power amplifier classes, feedback techniques, stability analysis, and oscillator design. |
| 3. | Understand of noise, signal integrity, reliability issues, and low-noise design techniques in MOS analog circuits. |

**UNIT I**

Device structure and Physical operation, Current- voltage characteristics, MOSFET Circuit at DC. MOSFET operation as a switch and Linear Amplifier (qualitative analysis). MOSFET biasing by fixing VGS, Biasing by fixing VG and connecting a resistance in the source, Biasing Using a Drain to Gate feedback Resistor, Constant-Current Source Biasing (using current mirror).

**9 Hours**

**UNIT II**

DC Bias Point, Signal Current in the Drain Terminal, Voltage Gain, Small- Signal equivalent-circuit models, Trans conductance gm, The T-equivalent Circuit model. Common Source Amplifier, Common Source Amplifier with Source Resistance, Common Gate Amplifier (qualitative analysis), Common Drain Amplifier (qualitative analysis), Comparison.

**9 Hours**

| UNIT III |
|---|
| High-Frequency Model, Frequency Response of CS Amplifier, Cascode amplifiers.<br>**Basic difference pair:** Qualitative and Quantitative analysis, Common mode response of differential amplifier and Problems, Differential pair with MOS loads.<br>**Power amplifiers:** Classification, Class A, B, AB and class C power amplifiers. |
| **8 Hours** |

| UNIT IV |
|---|
| **Feedback concepts:** General theory of Feedback, advantages and disadvantages. Concept of feedback connections in amplifiers.<br>**Stability :** Concept of stability in feedback amplifiers , Causes of instability, Loop gain and phase shift, Barkhausen criterion, Frequency response and stability considerations, Oscillator principles, high frequency Oscillators using MOSFETs |
| **8 Hours** |

| UNIT V |
|---|
| Noise and Applications of MOS Analog Circuits: Introduction to noise in electronic circuits, Thermal noise, Flicker noise, Noise modelling in MOSFETs , Noise figure and signal-to-noise ratio (SNR), Noise analysis in amplifiers and filters, Sources of analog circuit failures, Temperature and process variations, Fault analysis in analog circuits<br>Soft errors and transient faults, Signal integrity issues, Side-channel attacks in analog systems, Low-noise circuit design techniques, Shielding and grounding methods, EMI and EMC considerations. |
| **8 Hours** |

| **TEXT BOOKS** | | |
|---|---|---|
| 1 | Adel S. Sedra, Kenneth Carless Smith | Microelectronic Circuits Theory and Applications, Oxford University Press, 7th Edition. 2017. |
| 2 | Behzad Razavi | Fundamentals of Microelectronics, Wiley, 3rd Edition, 2021. |

| | | |
|---|---|---|
| 3 | Sergio Franco | Design with Operational amplifiers and Analog Integrated circuits, Mc Graw Hill, 4th Edition, 2014. |
| **REFERENCE BOOKS** | | |
| 1 | Robert L. Boylestad and Louis Nashelsky. | Electronic Devices and Circuit Theory.10th Ed, PHI, 2009. |
| 2 | Robert F. Coughlin and Frederick F, Driscoll. | Operational Amplifiers and Linear integrated Circuits, PHI, 6th Ed, 2000. |

| **Course Outcomes:** | |
|---|---|
| Upon completion of this course the student will be able to: | |
| CO1 | **Analyze** the structure, operation, characteristics, and biasing methods of MOSFETs. |
| CO2 | **Design** the MOSFET amplifier of different configurations using small-signal models. |
| CO3 | **Analyze** the frequency response of MOS amplifiers, differential amplifier and efficiency of power amplifiers. |
| CO4 | **Apply** feedback and stability concepts to analyze MOSFET-based oscillator circuits. |
| CO5 | **Analyze** the impact of noise, reliability, and EMI/EMC factors on MOS analog circuit performance. |

**Course Articulation Matrix**

| | | **POs** | | | | | | | | | | | **PSOs** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **1** | **2** |
| **COs** | **CO1** | 3 | 2 | | | | | | | | | | | 2 |
| | **CO2** | 3 | 2 | | | | | | | | | | | 2 |
| | **CO3** | 3 | 2 | | | | | | | | | | | 2 |
| | **CO4** | 3 | 2 | | | | | | | | | | | 2 |
| | **CO5** | 3 | 2 | | | | | | | | | | | 2 |

# NETWORK ANALYSIS

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 3+0+0 (L+T+P) | Credits: | 3 |
| Total Lecture Hours: | 42 | CIE Marks: | 50 |
| Total Tutorial Hours: | 00 | SEE Marks: | 50 |
| Total Practical Hours: | 00 | Course Code: | P3EI4 |
| Course Type: | PCC | Exam Hours: | 3 |

**Course objectives:**

This course will enable students to:

| | |
|---|---|
| 1. | Study the behaviour of electrical circuits using different theorems |
| 2. | Understand the transient response and characteristics of series and parallel resonance RLC circuits. |
| 3. | Study the application of Laplace transforms and two-port networks in circuit analysis. |

**UNIT I**

**Basic network concepts:** Circuit elements, sources, Kirchhoff's Laws, Source transformations, star–delta transformations

**Analysis of DC circuits:** Mesh, supermesh, node and supernode analysis with linearly dependent and independent sources.

**9 Hours**

**UNIT II**

**Analysis of AC circuits:** Introduction, R, L and C circuits with sinusoidal excitation, Loop and node analysis of AC Networks.

**Network Theorems for DC and AC circuits:** Super position theorem, Thevenin's theorem, Norton's theorem, Maximum power transfer theorem.

**9 Hours**

**UNIT III**

**Network Topology:** Graph of a network, Concept of tree and co-tree, incidence matrix, tie-set and cut-set schedules, Principle of duality**.**

**Resonance:** Series resonance, Quality factor – Q and Bandwidth, Parallel resonance (qualitative analysis only)

**8 Hours**

| UNIT IV |
|---|
| **Transient Response and Initial Conditions**: Behaviour of circuit elements under switching conditions and their representations. Evaluation of initial and final conditions in RL, RC and RLC circuits for DC excitation. |
| **8 Hours** |
| **UNIT V** |
| **Laplace Transform and its applications:** Introduction, Definition, properties, initial & final value theorem, step, ramp and impulse functions, waveform synthesis, Laplace transforms of periodic functions, solution of a network using Laplace transform.<br>**Two port network:** Two port networks (z, y only) parameters, interrelationship between z and y parameters, conditions for symmetry and reciprocity (no derivation). |
| **8 Hours** |

| **TEXT BOOKS** | | |
|---|---|---|
| 1 | W.H. Hayt ,<br>J E Kemmerly and<br>S M. Durbin. | Engineering Circuit Analysis 9th Edition. TMH. 2019. |

| **REFERENCE BOOKS** | | |
|---|---|---|
| 1 | M E Van Valkenburg | Network Analysis. 3rd Edition. PHI. 2015. |
| 2 | Allan H. Robbins and Wilhelm C. Miller | Circuit Analysis Theory and Practice, 5th Edition, CENGAGE Learning 2026 |

| **Course Outcomes:**<br>Upon completion of this course the student will be able to: | |
|---|---|
| CO1 | **Apply** network transformation, loop, and node analysis techniques to DC electrical circuits with dependent and independent sources. |
| CO2 | **Analyze** AC circuits and electrical networks using network theorems under DC and AC excitation. |
| CO3 | **Analyze** network topology parameters, resonance characteristics. |
| CO4 | **Interpre**t the transient response and operating conditions of RL, RC, and RLC circuits under switching conditions. |
| CO5 | **Apply** Laplace transform technique for the analysis of electrical networks, and analyze two-port network parameters. |

## Course Articulation Matrix

| | | POs | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **1** | **2** |
| **COs** | **CO1** | 3 | 2 | | | | | | | | | | | 2 |
| | **CO2** | 3 | 2 | | | | | | | | | | | 2 |
| | **CO3** | 3 | 2 | | | | | | | | | | | 2 |
| | **CO4** | 3 | 2 | | | | | | | | | | | 2 |
| | **CO5** | 3 | 2 | | | | | | | | | | | 2 |

# ANALOG ELECTRONIC CIRCUITS LAB

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 0+0+2 (L+T+P) | Credits: | 1 |
| Total Lecture Hours: | 0 | CIE Marks: | 50 |
| Total Tutorial Hours: | 0 | SEE Marks: | 50 |
| Total Practical Hours: | 28 | Course Code: | P3EIL1 |
| Course Type: | PCCL | Exam Hours: | 3 |

| **Course objectives:** | |
|---|---|
| This course will enable students to: | |
| 1. | Gain hands-on experience in the design, implementation, and analysis of analog electronic circuits. |

| **List of Experiments:** | |
|---|---|
| (2 Hours per week per batch) 13 Lab sessions + 1 Lab assessment | |
| **For CIE and SEE** | |
| 1. | Zener Regulator |
| 2. | RC coupled single stage FET amplifier |
| 3. | Frequency Response of single stage CE amplifier |
| 4. | Current series feedback amplifier. |
| 5. | RC Phase Shift Oscillator |
| 6. | Hartley Oscillator. |
| 7. | Colpitt's Oscillator. |
| 8. | Class B Push-Pull Amplifier |
| 9 | Darlington Emitter Follower |
| 10 | Voltage Regulator using LM723 |
| **Open ended experiments (only for CIE):** | |
| 1. | RC coupled single stage MOSFET amplifier. |
| 2. | Voltage series feedback amplifier |

| **Course Outcomes:** | |
|---|---|
| Upon completion of this course the student will be able to: | |
| CO1 | **Design** voltage regulator circuits using Zener diode and LM723 regulator IC. |
| CO2 | **Design** RC coupled BJT (with and without Feedaback), FET and MOSFET amplifiers and obtain frequency response. |
| CO3 | **Design** RC phase-shift, Hartley, and Colpitts oscillators. |
| CO4 | **Analyze** the performance of Class-B Push-Pull amplifiers through efficiency and distortion characteristics. |
| CO5 | **Analyze** the performance of Darlington emitter follower with and without bootstrap. |

## Course Articulation Matrix

| | | POs | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **1** | **2** |
| **COs** | **CO1** | 3 | 2 | | | | | | 3 | 3 | | | | 2 |
| | **CO2** | 3 | 2 | | | | | | 3 | 3 | | | | 2 |
| | **CO3** | 3 | 2 | | | | | | 3 | 3 | | | | 2 |
| | **CO4** | 3 | 2 | | | | | | 3 | 3 | | | | 2 |
| | **CO5** | 3 | 2 | | | | | | 3 | 3 | | | | 2 |

# ABILITY ENHANCEMENT COURSE LABORATORY
# CIRCUIT SIMULATION USING SPICE

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 0+0+2 (L+T+P) | Credits: | 1 |
| Total Lecture Hours: | 0 | CIE Marks: | 50 |
| Total Tutorial Hours: | 0 | SEE Marks: | 50 |
| Total Practical Hours: | 28 | Course Code: | P3EIA1 |
| Course Type: | AEC | Exam Hours: | 3 |

| **Course objective:** | |
|---|---|
| This course will enable students to: | |
| 1. | Learn the SPICE tool to simulate analog and digital circuits. |

| **List of Experiments:** | |
|---|---|
| (2 Hours per week per batch) 13 Lab sessions + 1 Lab assessment | |
| **Only for CIE** | |
| 1. | SPICE installation and basic Linux commands and familiarity with Linux environment. |
| 2. | Familiarity with SPICE model files. |
| **For CIE and SEE**<br>**Circuit simulation using NG-SPICE or LT-SPICE or P-SPICE.** | |
| 1. | RC and RL - circuits: Transient analysis. |
| 2. | MOSFET I-V characteristics: DC - analysis |
| 3. | Static CMOS inverter: DC, transient and power analysis. |
| 4. | Common source amplifier. DC, operating point and AC analysis |
| **Circuit simulation using Altium** | |
| 5. | Schematic design, simulation (transient analysis) and PCB-layout design of Inverting and the non-inverting amplifier using OP-AMP. |
| 6. | Schematic design, simulation (transient analysis) and PCB-layout design of difference amplifier using OP-AMP. |
| 7. | Schematic design, simulation (transient analysis) and PCB-layout design of integrator. |
| 8. | Schematic design, simulation (transient analysis) and PCB-layout design of Inverting Adder. |
| 9 | Schematic design, simulation (transient analysis) and PCB-layout design of differentiator. |
| 10 | Schematic design, simulation (transient analysis) and PCB-layout design of noninverting Adder. |

| **Only for CIE**<br>**Open Ended Experiments.** | |
|---|---|
| 1. | Design of instrumentation amplifier using ALTIUM (Circuit Design + PCB Layout + Gerber File + Hardware Design). |
| 2. | Design of stepper motor driver circuit using ALTIUM (Circuit Design + PCB Layout + Gerber File + Hardware Design). |

| **Course Outcomes:**<br>Upon completion of this course the student will be able to: | |
|---|---|
| CO1 | **Simulate** the Characteristics of MOSFET, RLC circuit and inverter in SPICE and interpret the results. |
| CO2 | **Design** schematic and simulate electronic circuits in ALTIUM and interpret the results. |
| CO3 | **Design** PCB Layout for electronic circuits using ALTIUM. |

**Course Articulation Matrix**

| | | **POs** | | | | | | | | | | | **PSOs** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **1** | **2** |
| **COs** | **CO1** | 3 | 1 | | | 3 | | | 3 | 3 | | | | 2 |
| | **CO2** | 3 | 1 | | | 3 | | | 3 | 3 | | | | 2 |
| | **CO3** | 3 | 1 | | | 3 | | | 3 | 3 | | | | 2 |

# VIRTUAL INSTRUMENTATION

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 0+0+2 (L+T+P) | Credits: | 1 |
| Total Lecture Hours: | 0 | CIE Marks: | 50 |
| Total Tutorial Hours: | 0 | SEE Marks: | 50 |
| Total Practical Hours: | 28 | Course Code: | P3EIA2 |
| Course Type: | AEC | Exam Hours: | 3 |

| **Course objectives:** This course will enable students to: | |
|---|---|
| 1. | Learn LabVIEW environment and gain proficiency in virtual instrumentation programming. |
| 2. | Implement intelligent data acquisition and control systems involving real-time DAQ hardware and signal analysis |

| **List of Experiments:** (2 Hours per week per batch) 13 Lab sessions + 1 Lab assessment | |
|---|---|
| 1. | Build a Virtual Waveform Generator. |
| 2. | Build a Virtual Instrument that simulates a Water Level Detector. |
| 3. | Build a cluster control which consists of a seven-segment LED display, a switch, a string control and a numeric control. |
| 4. | Build a Virtual Instrument to automate room temperature using LabVIEW |
| 5. | Build a Virtual Instrument for Arithmetic and Boolean operations using LabVIEW. |
| 6. | Build a Virtual Instrument for 4-bit binary to gray code converter using LabVIEW. |
| 7. | Build a Virtual Instrument for Sequential blinking of LEDs in LabVIEW. |
| 8. | Real-Time Data Acquisition (DAQ): Implement continuous buffered acquisition modes using DAQ cards. Configure and verify Analog Input and Analog Output for load sensor/strain gauge interfacing. |
| 9 | Real-Time Data Acquisition (DAQ): Implement finite and continuous buffered acquisition modes using DAQ cards. Configure and verify Analog Input and Analog Output for temperature sensor interfacing. |

| **Open Ended Experiments:** | |
|---|---|
| 1 | Real-Time Temperature measurement system by interfacing LM35 (Interface LM35 sensor with LabVIEW Using NI 6008 DAQ Card and Data Logging). |
| 2 | Build a Virtual Instrument for measurements of vibration using Accelerometers in LabVIEW |
| 3 | Noise Analysis Using LabVIEW and NI-DAQ |

| **TEXT BOOKS** | | |
|---|---|---|
| 1 | Dr. Sumathi. S and Prof. Surekha. P | LabVIEW Based Advanced Instrumentation Systems", 2nd edition, 2007. |
| 2 | Jovitha Jerome | Virtual Instrumentation using LabVIEW", PHI Learning Pvt. Ltd, New Delhi, 2010. |
| 3 | Gary Johnson | LabVIEW Graphical Programming, McGraw Hill, 2006. |

**Course Outcome:**

Upon completion of this course the student will be able to:

| | |
|---|---|
| CO1 | **Develop** virtual instruments for simulation of real-world systems. |
| CO2 | **Develop** real-time data acquisition systems using DAQ hardware for analog signal interfacing and sensor-based applications. |

**Course Articulation Matrix**

| | | **POs** | | | | | | | | | | | **PSOs** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **1** | **2** |
| **COs** | **CO1** | 3 | 1 | | | 3 | | | 3 | 3 | | | 2 | 2 |
| | **CO2** | 3 | 1 | | | 3 | | | 3 | 3 | | | 2 | 2 |

# DATA ANALYTICS WITH R PROGRAMMING

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 0+0+2 (L+T+P) | Credits: | 1 |
| Total Lecture Hours: | 0 | CIE Marks: | 50 |
| Total Tutorial Hours: | 0 | SEE Marks: | 50 |
| Total Practical Hours: | 28 | Course Code: | P3EIA3 |
| Course Type: | AEC | Exam Hours: | 3 |

| **Course objectives:** This course will enable students to: | |
|---|---|
| 1. | Learn R programming and data handling for working with sensor datasets. |
| 2. | Study characteristics of time-series sensor data. |
| 3. | Understand the fundamental analytical and predictive techniques. |

| **List of Experiments:** (2 Hours per week per batch) 13 Lab sessions + 1 Lab assessment | |
|---|---|
| 1. | Introduction to R & RStudio (Foundation Lab). Install and explore RStudio environment; |
| 2. | Create vectors, matrices, data frames; Simulate a simple sensor dataset and arithmetic operations; |
| 3. | Data manipulation with dplyr package |
| 4. | Data handling and preprocessing with tidyverse ecosystem. |
| 5. | Importing & Exploring Sensor<br>Data Load CSV dataset; Use head(), str(), summary(). Work with built-in dataset (air quality) |
| 6. | Data Cleaning & Preprocessing<br>Identify missing values; Replace using mean/median; Apply moving average smoothing. |
| 7. | Time-Series Visualization<br>Plot sensor data using base R; Use ggplot2 for line plots<br>Customize axes, labels. |
| 8. | Multi-Sensor Visualization & Correlation<br>Plot multiple sensor variables; Compute correlation matrix<br>Interpret relationships; |

| | |
|---|---|
| 9 | Exploratory Data Analysis (EDA)<br>Summary statistics (mean, SD); Distribution plots (histogram, boxplot); Identify trends and patterns |
| 10 | Anomaly Detection in Sensor Data<br>Dataset: NASA Turbofan Engine Degradation Dataset |
| 11 | Prediction using Sensor Data<br>Build regression model to and predict Environmental condition using air quality datset |
| 12 | Open Ended: multivariate regression with Appliance Energy Prediction Dataset (UCI)<br>https://archive.ics.uci.edu/ml/datasets/Appliances+energy+prediction |

| **TEXT BOOK** | | |
|---|---|---|
| 1. | W. N. Venables, D.M. Smith and the R Development Core Team. | An Introduction to R: Notes on R: A Programming Environment for Data Analysis and Graphics, Version 4.3.1 (2023-06-16) (eBook). |

| **REFERENCE BOOKS** | | |
|---|---|---|
| 1. | Jared P Lander | R for Everyone: Advanced analytics and graphics, Pearson Education, 2nd Edition, 2017 |
| 2. | Ajit C, Tamhane, Dorothy D, Dunlop | Statistics and data analysis: From Elementary to Intermediate, Prentice Hall, 2nd Edition, 2000. |
| 3. | G Casella and R.L. Berger | Statistical Inference, Thomson Learning, 2nd Edition, 2007. |
| **E-Resources** | | https://www.kaggle.com/datasets/behrad3d/nasa-cmaps; |

| **Course Outcomes:**<br>Upon completion of this course the student will be able to: | |
|---|---|
| CO1 | **Apply** R programming to preprocess, visualize, and analyze real-world sensor datasets |
| CO2 | **Interpret** sensor data patterns and perform basic prediction for domain-specific applications |

## Course Articulation Matrix

| | | POs | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 1 | 2 |
| COs | CO1 | 3 | 1 | | | 3 | | | 3 | 3 | | | | 2 |
| | CO2 | 3 | 1 | | | 3 | | | 3 | 3 | | | | 2 |

# SIGNAL PROCESSING LAB

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 0+0+2 (L+T+P) | Credits: | 1 |
| Total Lecture Hours: | 0 | CIE Marks: | 50 |
| Total Tutorial Hours: | 0 | SEE Marks: | 50 |
| Total Practical Hours: | 28 | Course Code: | P3EIA4 |
| Course Type: | AEC | Exam Hours: | 3 |

| **Course objective:** This course will enable students to: | |
|---|---|
| 1. | Generate signals and perform operations on signals. |

| **List of Experiments:** (2 Hours per week per batch) 13 Lab sessions + 1 Lab assessment | |
|---|---|
| **Only for Practice** | |
| 1. | Basic MATLAB programs |
| **For CIE and SEE** | |
| 1. | Generation of Basic Signals |
| 2. | Time domain Operations on Signals |
| 3. | Arithmetic operations on signals |
| 4. | Computing Energy of Signals |
| 5. | Even and Odd Decomposition of Signals |
| 6. | Response calculation of LTI System (Linear Convolution) |
| 7. | Step response of a given system |
| 8. | Spectral analysis using FS |
| 9 | Stability and causality analysis: pole –zero plot |
| 10 | Frequency domain representations of single tone sinusoidal signals. |
| **Open Ended Experiments: Only for CIE** | |
| 1. | Acquire the speech signal with different sampling signal and analyze the effect of sampling rate on the signal |
| 2. | Frequency domain representations of multi tone sinusoidal signals |

| **Course Outcomes:** Upon completion of this course the student will be able to: | |
|---|---|
| CO1 | **Apply** signal processing concepts to generate and perform arithmetic operations on basic signals. |
| CO2 | **Apply** spectral analysis and sampling theorem for signal analysis in time and frequency domains. |
| CO3 | **Apply** Z-transform technique to study the stability criteria of linear systems |

**Course Articulation Matrix**

| | | **POs** | | | | | | | | | | | **PSOs** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **1** | **2** |
| **COs** | **CO1** | 3 | 1 | | | 3 | | | 3 | 3 | | | | 2 |
| | **CO2** | 3 | 1 | | | 3 | | | 3 | 3 | | | | 2 |
| | **CO3** | 3 | 1 | | | 3 | | | 3 | 3 | | | | 2 |

# FOUNDATIONS OF ENGINEERING MATHEMATICS-I

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 3+0+0 (L+T+P) | Credits: | 00 |
| Total Lecture Hours: | 40 | CIE Marks: | 100 |
| Total Tutorial Hours: | 0 | SEE Marks: | 00 |
| Total Practical Hours: | 0 | Course Code: | P3MATDIP |
| Course Type: | NCMC | Exam Hours: | 3 |

**Course objectives:**
This course will enable students to:

| | |
|---|---|
| 1. | **Familiarize** the importance of differential calculus. |
| 2. | **Familiarize** the importance of calculus associated with one variable and multivariable arising in engineering. |
| 3. | **Analyze and solve** engineering problems by applying Ordinary Differential Equations. |

**UNIT I**

**Differential Calculus-I** Polar curves: angle between the radius vector and tangent, angle of intersection of polar curves. Pedal equation for polar curves. Curvature and radius of curvature in pedal form. (Without proof)

**8 Hours**

**UNIT II**

**Partial differentiation** Partial derivatives, Total derivatives, differentiation of composite functions. Jacobians.

**8 Hours**

**UNIT III**

**Series Expansion and Application** Taylor's and Maclaurin's series expansions for one variable **(statement only).** Indeterminate forms L' Hospital Rule (without proof)
***00, ∞∞, 0×∞ □□□ ∞−∞ □□□□)***

**8 Hours**

**UNIT IV**

**Differential Equations of I Order** Solution of first order and first degree differential equations: Variable Separable, Linear differential equations and Exact differential equations

**8 Hours**

| UNIT V |
|---|
| **Differential Equations of higher order** Solution of second and higher order equations with constant coefficients by inverse differential operator method, method of variation of parameters. |
| **8 Hours** |

| **TEXT BOOKS** | | |
|---|---|---|
| 1 | Erwin Kreyzig | Advanced Engineering Mathematics", 10th edition, Wiley Publications, 2016. ISBN: 9788126508273. |
| 2 | B. S. Grewal | "Higher Engineering Mathematics", 43rd edition, Khanna Publications, 2015. ISBN;9788174091955. |

| **REFERENCE BOOKS** | | |
|---|---|---|
| 1 | Maurice D. Weir, Joel R. Hass and George B. Thomas | "Thomas' calculus**:** Early Transcendental", 12th edition, Pearson Education, 2016. ISBN: 978078024269. |
| 2 | Ramana .B.V | Higher Engineering Mathematics, McGraw-Hill Education, 11th Ed., 2017, ISBN: 9780070634190. |
| 3 | C.Ray Wylie, Louis. C. Barrett | Advanced Engineering Mathematics, McGraw – Hill Book Co., New York, 6th Ed., 2017, 9780070722064. |
| 4 | Louis A. Pipes and Lawrence R. Harvill | "Applied Mathematics for Engineers and Physicists", 3rd edition, McGraw Hill, 2014. ISBN: 9780486779515. |
| 5 | Peter V.O 'Neil | "Advanced Engineering Mathematics", 7th edition, CENGAGE Learning India Pvt. Ltd. Publishers, 2012. ISBN; 9788131503102. |

# 4th Semester

# MATHEMATICS FOR MACHINE LEARNING

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 3+0+0 (L+T+P) | Credits: | 3 |
| Total Lecture Hours: | 42 | CIE Marks: | 50 |
| Total Tutorial Hours: | 0 | SEE Marks: | 50 |
| Total Practical Hours: | 0 | Course Code: | P4EI1 |
| Course Type: | PCC | Exam Hours: | 3 |

| **Course objectives:** | |
|---|---|
| This course will enable students to: | |
| 1. | Gain knowledge of mathematical foundations underlying basic machine learning models. |
| 2. | Understand the principles of probability and statistics for data analysis and uncertainty modeling. |
| 3. | Understand optimization techniques used in training machine learning models |

**UNIT I**

**Linear Algebra for Machine Learning:**

**Review of Basic Concepts (Recap):** Scalars, vectors and matrices, vector operations, matrix operations, transpose, inverse.

Rank, system of linear equations, eigenvalues and eigenvectors (basic idea), vector spaces and norms. Data representation, feature vectors, similarity measures, role of eigenvalues in dimensionality reduction (intro idea). Principal Component Analysis (PCA) –and applications in dimensionality reduction (basic concepts).

**8 Hours**

**UNIT II**

**Calculus for Machine Learning:**

Functions, limits and continuity, partial derivatives, gradients, chain rule, higher order derivatives (basic idea), Taylor series (concept), , Jacobian and Hessian matrices (basic idea), optimization using derivatives,

Applications in Learning Algorithms: Role of derivatives and gradients in optimization problems.

**8 Hours**

| UNIT III |
|---|
| **Probability Theory:**<br>Introduction to probability, events and conditional probability, Bayes theorem, random variables (discrete and continuous), probability distributions (Gaussian, Bernoulli), expectation, variance, covariance, introduction to random vectors. Applications in Machine Learning -Naïve Bayes classification and introduction to Maximum Likelihood Estimation (MLE). |
| **9 Hours** |

| UNIT IV |
|---|
| **Statistics and Data Analysis:**<br>Descriptive statistics, sampling and sampling distributions, estimation (mean, variance), hypothesis testing (basic idea), correlation and regression, introduction to data analysis and interpretation. Applications in Data Analysis: Linear Regression using least squares method for modeling relationships between variables and prediction. Regression visualization using Python demonstrations |
| **9 Hours** |

| UNIT V |
|---|
| **Optimization Techniques for Machine Learning:**<br>Introduction to optimization, cost functions, gradient descent, stochastic gradient descent, Adam optimizer (concept only) ,learning rate, convex and non-convex functions (basic idea), overfitting and regularization (concept), Applications in Machine Learning: Optimization in linear regression and classification models. |
| **8 Hours** |

**TEXT BOOKS**


| | | |
|---|---|---|
| 1 | Sheldon M. Ross | Introduction to Probability and Statistics for Engineers and Scientists, Elsevier, 6th Edition, 2020. |
| 2 | Gilbert Strang | Linear Algebra and Its Applications, Cengage Learning, 4th Edition, 2006 (Reprint). |

| REFERENCE BOOKS | | |
|---|---|---|
| 1 | Christopher M. Bishop | Pattern Recognition and Machine Learning, Springer, 1st Edition, 2006. |
| 2 | Aurélien Géron | Hands-On Machine Learning with Scikit-Learn, Keras and TensorFlow, O'Reilly, 2nd Edition, 2019. |
| 3 | D. P. Bertsekas and John N. Tsitsiklis | Introduction to Probability, Athena Scientific, 2nd Edition, 2008. |

| **Course Outcomes:** Upon completion of this course the student will be able to: | |
|---|---|
| CO1 | **Apply** linear algebra concepts such as vectors and matrices for data representation and analysis. |
| CO2 | **Apply** calculus concepts for analyzing and optimizing machine learning models. |
| CO3 | **Apply** probability concepts to model uncertainty in engineering and data-driven problems. |
| CO4 | **Analyze** data using statistical methods and interpret results for decision making. |
| CO5 | **Apply** optimization techniques in developing and improving machine learning models. |

**Course Articulation Matrix**

| | | POs | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **1** | **2** |
| **COs** | **CO1** | 3 | 1 | | | | | | | | | | | 2 |
| | **CO2** | 3 | 1 | | | | | | | | | | | 2 |
| | **CO3** | 3 | 1 | | | | | | | | | | | 2 |
| | **CO4** | 3 | 1 | | | | | | | | | | | 2 |
| | **CO5** | 3 | 1 | | | | | | | | | | | 2 |

# EMBEDDED ARCHITECTURES

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 3+0+2 (L+T+P) | Credits: | 4 |
| Total Lecture Hours: | 42 | CIE Marks: | 50 |
| Total Tutorial Hours: | 0 | SEE Marks: | 50 |
| Total Practical Hours: | 28 | Course Code: | P4EII1 |
| Course Type: | IPCC | Exam Hours: | 3 |

**Course objectives:**

This course will enable students to:

| | |
|---|---|
| 1. | Understand the architectural features, programming models, and system organization of ARM7 and RISC-V based embedded processors. |
| 2. | Learn implementation of embedded applications using ARM7 and introductory RISC-V. |

**UNIT I**

**ARM Embedded Systems**: Harvard and VonNeumann Architecture, CISC vs RISC, RISC design philosophy, ARM design philosophy, embedded system hardware- AMBA AHB/APB **/** AXI, master/slave bus, embedded system software, ARM7TDMI processor core diagram,

**9 Hours**

**UNIT II**

**ARM Processor Fundamentals**: ARM Processor Families, ARM Cortex-M Series Overview, ARM Data flow Model, Processor Operating States, Memory formats: Big endian and Little endian formats, Data types, Operating Modes, Registers – ARM state register set and Thumb state register set, the relationship between ARM state and Thumb state registers, Program Status Registers, Exceptions, Interrupt latencies, Reset, Pipeline- **3 stage and 5 stage**.

**9 Hours**

**UNIT III**

**LPC214X ARM-based microcontroller**: Features of LPC214x Microcontroller, LPC 214x block diagram, Memory Maps, Cache Fundamentals: Cache Memory Basics, Instruction Cache and Data Cache, and ARM Memory Protection Unit (MPU). Register description and C-programming of GPIO, Interfacing LED, Switch, Push button keys to LPC214x microcontroller, ADC, DAC and DC motor.

**8 Hours**

| UNIT IV |
|---|
| **Introduction:** Evolution of RISC Architectures, Introduction to RISC-V ISA Open-Source Hardware Philosophy RISC-V Base ISA and Extensions RV32I Programmer's Model Register Organization Comparison of RISC-V, ARM, MIPS, and x86 RISC-V Memory Organization, RISC-V Privilege Modes: Machine Mode, Supervisor Mode. RISC-V Pipelining: Pipeline Architecture, Pipeline Hazards |
| **8 Hours** |

| UNIT V |
|---|
| **RISC-V Instructions and programming:** Data Transfer Instructions, *Control and Status Register Instructions*, Pseudo Instructions, Assembler directives, RISC-V Machine level instruction formats: Base Instruction formats for R, I, S/B, U/J type instructions, immediate encodings. RISC-V memory map, Compiling, Assembling, Linking and Loading RISC-V programs, Exception handlers. Assembly level programming examples. |
| **8 Hours** |

| **TEXT BOOKS** | | |
|---|---|---|
| 1 | Andrew N. Sloss, Dominic Symes and Chris Wright | ARM System Developer's Guide – Designing and Optimizing System Software, Elsevier 2004. |
| 2 | David Money Harris and Sarah L. Harris | Digital Design and Computer Architecture (RISC-V Edition) |

| **REFERENCE BOOKS** | | |
|---|---|---|
| 1 | Shibhu K.V | Introduction to Embedded Systems, TMH, 2nd Edition, 2017. |
| 2 | David Patterson and Andrew Waterman | The RISC-V Reader: An Open Architecture Atlas, First Edition, Version 1.0.0, Strawberry Canyon LLC, 2017. |
| 3 | David Patterson and John L. Hennessy | Computer Organization and Design: RISC-V Edition – The Hardware/Software Interface, 2nd Edition, Morgan Kaufmann, 2021. |

**Integrated Lab (CIE only)**

**List of Experiments:**

(2 Hours per week per batch) 13 Lab sessions + 1 Lab assessment

1. Introduction to ARM7 Development Environment using Keil µVision4 and Basic Programming.
2. Develop a program for Flashing / rolling LED
3. Develop a program to turn on LED whenever a push button is pressed and sound the alarm
4. Develop a program to generate a square wave on a GPIO pin when a key is pressed and stop whenever key is released
5. Develop a program to interface a DC motor and rotate it in clockwise and anticlockwise direction.
6. Develop a program to generate square wave / sine wave/ triangular/Staircase wave using DAC of LPC2148.
7. Develop a program to interface ADC and convert given analog voltage to digital value.
8. Introduction to PYNQ Board and Vivado Design Environment.
9. Implementation of Arithmetic Processing using RISC-V Soft-Core Processor on PYNQ FPGA. (ALU Operations)
10. Develop an embedded application for LED Control using RISC-V Processor on PYNQ FPGA.

**Open Ended Experiments:**

1. Develop a program to convert given analog voltage to digital value and display it on 16X2 LCD using LPC2148
2. Develop a program to display the key pressed from keypad over a 16X2 LCD using LPC2148.

**E-resources:**

| | |
|---|---|
| 1 | https://archive.nptel.ac.in/courses/117/106/117106111/ |
| 2 | https://archive.nptel.ac.in/courses/106/105/106105193/ |
| 3 | https://onlinecourses.nptel.ac.in/noc22_cs93/preview |
| 4 | https://developer.arm.com/documentation/ddi0403/ee |

| **Course Outcomes:** Upon completion of this course the student will be able to: | |
|---|---|
| CO1 | **Analyze** ARM architecture, processor organization, and RISC design philosophy. |
| CO2 | **Analyze** the programmer's model of the ARM processor. |
| CO3 | **Develop** software solutions and interfacing circuits for I/O devices. |
| CO4 | **Analyze** the RISC-V Architecture, its programmer's model, memory organization, privilege modes, and pipelining concepts. |
| CO5 | **Develop** RISC-V assembly programs using instruction formats, assembler directives, memory mapping, and exception handling concepts. |

**Course Articulation Matrix**

| | | **POs** | | | | | | | | | | | **PSOs** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **1** | **2** |
| **COs** | **CO1** | 3 | 1 | | | 3 | | | 3 | 3 | | | | 2 |
| | **CO2** | 3 | 1 | | | 3 | | | 3 | 3 | | | | 2 |
| | **CO3** | 3 | 1 | | | 3 | | | 3 | 3 | | | | 2 |
| | **CO4** | 3 | 1 | | | 3 | | | 3 | 3 | | | | 2 |
| | **CO5** | 3 | 1 | | | 3 | | | 3 | 3 | | | | 2 |

# CONTROL SYSTEMS AND ROBOTICS

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 3+2+0 (L+T+P) | Credits: | 4 |
| Total Lecture Hours: | 42 | CIE Marks: | 50 |
| Total Tutorial Hours: | 28 | SEE Marks: | 50 |
| Total Practical Hours: | 00 | Course Code: | P4EI2 |
| Course Type: | PCC | Exam Hours: | 3 |

| **Course objectives:** This course will enable students to: | |
|---|---|
| 1 | **Understand** the fundamentals of control systems and stability analysis. |
| 2 | **Study** state-space analysis and controller design using conventional and AI/ML-based PID tuning methods. |
| 3 | **Learn** the principles of non-linear control and robotic systems. |

| **UNIT I** |
|---|
| **Basics of Control:** Control Systems: Types of Controllers, Introduction to closed loop control, Differential Equation, Transfer function, Signal Flow Graph<br>**Time Response**: Routh-Hurwitz test, relative stability, Root locus design, construction of root loci |
| **9+6 Hours** |

| **UNIT II** |
|---|
| **Frequency Response**: Frequency domain specifications, Correlation between time and frequency response, Polar plots, Bode plots, Closed-loop frequency response(Transfer function) from Bode Plot, Nyquist stability, Relative stability using Nyquist Stability criterion-Gain and phase margin. |
| **9+6 Hours** |

| **UNIT III** |
|---|
| **Linear Control System:** Concept of states, state space model, different form, controllability, observability; pole placement by state feedback, observer design, P, PI & PID Controller, control law partitioning, modelling and control of a single joint, case studies on AI/ML Techniques Used for PID Tuning |
| **8+6 Hours** |

| UNIT IV |
|---|
| **Non-Linear Control System**: Common physical non-linear system, phase plane method, system analysis by phase plane method, stability of non-linear system, stability analysis by describing function method, Liapunov's stability criterion, control problems for manipulators. |
| **8+5 Hours** |

| UNIT V |
|---|
| **Basics of Robotics:** Introduction to Robots and Robotics, Robot Kinematics and Trajectory Planning, Sensors in Robotics, LiDAR sensors, case studies on AI/ML Integration in Trajectory Planning<br>**Motion Control:** Point to Point Control, trajectory generation, Continuous Path Control, Joint based control, Cartesian Control, Force Control, hybrid position/force control system. |
| **8+5 Hours** |

| **TEXT BOOKS** | | |
|---|---|---|
| 1 | M. Gopal | Control Systems, McGraw-Hill (2023) |
| 2 | K. Ogata | Modern Control Engineering, 5th Edition, Prentice Hall India (2021) |
| 3 | M. Spong, M. Vidyasagar, S. Hutchinson | Robot Modeling and Control, 2nd Edition Wiley & Sons, (2020) |
| 4 | J. J. Craig | Introduction to Robotics: Mechanics and Control, 4th Edition, Addison-Wesley (2022). |

| **REFERENCE BOOKS** | | |
|---|---|---|
| 1 | S. K. Saha | Introduction to Robotics , 3rd Edition, TATA McGraw Hills Education (2024) |
| 2 | Thomas Kailath | Linear Systems, Prentice Hall (2019) |
| 3 | Alok Sinha, | Linear Systems: Optimal and Robust Control, 2nd Edition, Taylor & Francis (2021) |

| **Course Outcomes:** Upon completion of this course the student will be able to: | |
|---|---|
| CO1 | **Analyze** the stability of linear time-invariant systems using transfer functions, Routh–Hurwitz criterion, and root locus techniques. |
| CO2 | **Interpret** the frequency domain performance and stability of linear time-invariant systems. |
| CO3 | **Design** controllers using state-space methods, P/PI/PID controllers, state feedback, observers, and AI/ML-based PID tuning approaches. |
| CO4 | **Analyze** non-linear control systems using phase plane methods, stability criteria, and describing function techniques for practical applications. |
| CO5 | **Apply** robot kinematics, trajectory planning, and motion control strategies for robotic system operation and control. |

**Course Articulation Matrix**

| | | **POs** | | | | | | | | | | | **PSOs** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **1** | **2** |
| **COs** | **CO1** | 3 | 2 | | | | | | | | | | 2 | |
| | **CO2** | 3 | 2 | | | | | | | | | | 2 | |
| | **CO3** | 3 | 2 | | | | | | | | | | 2 | |
| | **CO4** | 3 | 2 | | | | | | | | | | 2 | |
| | **CO5** | 3 | 2 | | | | | | | | | | 2 | |

# LINEAR ICs AND DATA CONVERTERS

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 3+0+0 (L+T+P) | Credits: | 3 |
| Total Lecture Hours: | 42 | CIE Marks: | 50 |
| Total Tutorial Hours: | 0 | SEE Marks: | 50 |
| Total Practical Hours: | 0 | Course Code: | P4EI3 |
| Course Type: | PCC | Exam Hours: | 3 |

**Course objectives:**
This course will enable students to:

| | |
|---|---|
| 1 | Understand the operation of Op-amp circuits. |
| 2 | Study the operation of circuits used in data acquisition systems. |

**UNIT I**

**Op-amps:** Op-amp parameters: CMRR, Slew Rate, Input Offset Voltage, Input Bias Current, Input Offset Current.
Design and Analysis of op-amp circuits using ideal and practical parameters- inverting, non-inverting, combination of inverting and non-inverting amplifiers, inverting and non-inverting –adder and average circuits, difference and Instrumentation amplifier Analysis of Practical Integrator & Differentiator.

**9 Hours**

**UNIT II**

**Frequency response of op-amp:** high frequency op-amp equivalent circuit, open loop voltage gain as a function of frequency. Analysis and design of -Comparators, ZCD and Schmitt trigger.
Voltage to current converter with floating and grounded load, non-inverting integrator, High input impedance circuit.

**9 Hours**

**UNIT III**

**Data Acquisition Systems:** Introductory Concepts, Block Diagram, Analog Switches and Multiplexers, Multiplexer and Demultiplexer, Fundamentals of Sampling and Quantization, Sample and Hold. **Digital to Analog Converters (DACs):** Classification, weighted resistor DAC, R-2R DAC, Inverted ladder DACs, Bipolar DAC, Multiplying DAC, Introduction to Cyclic DAC, and Pipeline DAC, Conversion errors. Monolithic DACs: Discussion on DAC 0800, AD557 DAC. General applications of DACs.

**8 Hours**

| UNIT IV |
|---|
| **Analog to Digital converters (ADCs):** Classification, Counter type ADC, Successive approximation ADC, Voltage to frequency converter, Single and Dual Slope, cyclic converters, Flash ADC, Pipelined type, Bipolar A/D Conversion, Conversion errors. Monolithic ADCs: Discussion on 0816 and ICL 7109 ADCs. General applications of ADCs. |
| **8 Hours** |

| UNIT V |
|---|
| **Analysis of Active Filters using op-amp**: Classification of filters, first and second order low-pass and high-pass filters, second order LP and HP Butterworth filter, first order Band-pass filters, Band reject filters<br>**Specialized IC's:** Design and analysis of Monostable and Astable Multivibrator circuits using 555 Timer. Phase Locked Loop (IC565): Block diagram, operation, and its applications as Frequency Multiplier. Voltage regulators: three terminal Voltage regulators, Fixed and Adjustable Voltage Regulators (78XX, 79XX, LM317). |
| **8 Hours** |

| **TEXT BOOKS** | | |
|---|---|---|
| 1 | Ramakanth A. Gayakwad,PHI. | Op-amps and Linear Integrated circuits, 3rd and 4thEdition, 2015. |
| 2 | Adel S. Sedra, Kenneth C. Smith, | Microelectronic circuits, Oxford University press, 2015. |

| **REFERENCE BOOKS** | | |
|---|---|---|
| 1 | Tobey-Graeme-Huelsman, | Operational amplifier, McGraw Hill, 1971. |
| 2 | Clayton G.B. | Operational amplifier, 2nd Edition. ECBS, 2013. |
| 3 | Robert F. Coughlin and Frederick F, | Operational Amplifiers and Linear integrated Circuits, Driscoll PHI, 1997. |

| **Course Outcomes:** Upon completion of this course the student will be able to: | |
|---|---|
| CO1 | **Design** operational amplifier circuits and determine their performance. |
| CO2 | **Design** operational amplifier circuits incorporating frequency response characteristics and application-oriented analog signal processing functions. |
| CO3 | **Design** data acquisition systems and digital-to-analog converters |
| CO4 | **Design** different types of analog to digital converters. |
| CO5 | **Design** active filters, timing and waveform generation circuits, PLL-based frequency control systems, and voltage regulator circuits for electronic applications. |

**Course Articulation Matrix**

| | | **POs** | | | | | | | | | | | **PSOs** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **1** | **2** |
| **COs** | **CO1** | 3 | 2 | | | | | | | | | | | 2 |
| | **CO2** | 3 | 2 | | | | | | | | | | | 2 |
| | **CO3** | 3 | 2 | | | | | | | | | | | 2 |
| | **CO4** | 3 | 2 | | | | | | | | | | | 2 |
| | **CO5** | 3 | 2 | | | | | | | | | | | 2 |

# SIGNAL CONDITIONING & DATA ACQUISITION CIRCUITS LAB

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 0+0+2 (L+T+P) | Credits: | 1 |
| Total Lecture Hours: | 0 | CIE Marks: | 50 |
| Total Tutorial Hours: | 0 | SEE Marks: | 50 |
| Total Practical Hours: | 28 | Course Code: | P4EIL1 |
| Course Type: | PCCL | Exam Hours: | 3 |

| **Course objective:** | |
|---|---|
| This course will enable students to: | |
| 1. | Learn the design of signal conditioning circuits |
| 2. | Learn the design and operation of data converters |

| **List of Experiments:** | |
|---|---|
| (2 Hours per week per batch) 13 Lab sessions + 1 Lab assessment | |
| 1 | Instrumentation amplifier |
| 2 | Current to Voltage and Voltage to Current Converter |
| 3 | Schmitt Trigger circuit |
| 4 | First Order Low Pass and High Pass filters |
| 5 | Second Order Low Pass and High Pass filters |
| 6 | Astable and monostable multivibrator using 555 Timer |
| 7 | Sample and Hold circuits |
| 8 | Digital to Analog converter (IC version) |
| 9 | 4 bit R-2R ladder and binary weighted DAC |
| 10 | Analog to digital converter (IC Version) |
| **Open ended Experiments** | |
| 1 | Design of PLL using IC 565 |
| 2 | 3 bit Flash ADC |

| Course Outcomes: | |
|---|---|
| Upon completion of this course the student will be able to: | |
| CO1 | **Design** and implement analog signal conditioning circuits such as instrumentation amplifier, Schmitt trigger, and voltage/current conversion circuits along with active filters. |
| CO2 | **Design** and test waveform generation and sampling circuits using astable and monostable multivibrators and sample-and-hold systems. |
| CO3 | **Design** and evaluate data conversion systems including digital-to-analog and analog-to-digital converters for signal processing applications. |

## Course Articulation Matrix

| | | POs | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 1 | 2 |
| COs | CO1 | 3 | 2 | | | | | | 3 | 3 | | | | 2 |
| | CO2 | 3 | 2 | | | | | | 3 | 3 | | | | 2 |
| | CO3 | 3 | 2 | | | | | | 3 | 3 | | | | 2 |

# COMPUTATIONAL SENSING LABORATORY

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 0+0+3 (L+T+P) | Credits: | 1 |
| Total Lecture Hours: | 0 | CIE Marks: | 50 |
| Total Tutorial Hours: | 0 | SEE Marks: | 50 |
| Total Practical Hours: | 28 | Course Code: | P4EIL2 |
| Course Type: | PCCL | Exam Hours: | 3 |

**Course objectives:**

This course will enable students to:

| | |
|---|---|
| 1. | Represent and manipulate sensor data as vectors and matrices using Python and NumPy. |
| 2 | Apply dimensionality reduction and descriptive statistics to characterise multi-sensor data. |
| 3 | Model sensor behaviour — calibration, noise and sensitivity — using numerical and probabilistic methods. |
| 4 | Build and evaluate a simple regression model, including gradient-descent optimisation, to predict sensor output. |

**List of Experiments:**

(2 Hours per week per batch) 13 Lab sessions + 1 Lab assessment

| | |
|---|---|
| 1 | Acquire data from a temperature or humidity sensor and represent the data as vectors and matrices using Python. |
| 2 | Perform matrix operations (addition, multiplication, transpose, inverse) on sensor datasets using NumPy. |
| 3 | Apply Principal Component Analysis (PCA) to a multi-sensor dataset and visualize the reduced-dimensional data. |
| 4 | Plot the calibration curve of a temperature sensor (LM35/DHT11) and estimate its numerical gradient (sensor sensitivity) using Python. |
| 5 | Study Gaussian distribution of noisy sensor measurements and estimate probability parameters. |
| 6 | Analyze sensor data using descriptive statistics (mean, median, variance, and standard deviation). |
| 7 | Develop a simple Linear Regression model to predict sensor output and visualize the fitted curve. |
| 8 | Implement Gradient Descent to estimate the parameters of a linear regression model using sensor data. |
| 9 | Compare the effect of different learning rates on the convergence of Gradient Descent. |
| 10 | Mini Exercise: Analyze a real-time sensing dataset and perform prediction using linear regression. |

| **Open Ended Experiments** | |
|---|---|
| 1 | Develop a computational sensing system for monitoring indoor air quality using temperature, humidity, and gas sensors. |
| 2 | Develop a computational sensing system for detecting abnormal vibration events in a rotating machine. |

| **TEXT BOOKS** | | |
|---|---|---|
| 1 | Steven L Brunton and J Nathan Kutz | Data driven Science and Engineering, 2nd Edition, Cambridge University press, 2022 |
| 2 | Jake VanderPlas | Python Data Science Handbook, O'Reilly, 2016 |
| 3 | Chiac ASI | Computational Methods for sensor Data Analysis and Regression, Chiac ASI, 1st Edition |

| **Course Outcomes:** Upon completion of this course the student will be able to: | |
|---|---|
| CO1 | Represent, manipulate and visualise sensor data using Python-based numerical tools. |
| CO2 | Apply PCA and descriptive statistics to interpret multi-sensor measurement data. |
| CO3 | Characterise sensor calibration, sensitivity and measurement noise using numerical and probabilistic methods. |
| CO4 | Develop, optimise and evaluate a regression model to predict sensor output from real sensing data. |

**Course Articulation Matrix**

| | | **POs** | | | | | | | | | | | **PSOs** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **1** | **2** |
| **COs** | **CO1** | 3 | 2 | | | 3 | | | 2 | 2 | | | | 2 |
| | **CO2** | 3 | 2 | | | 3 | | | 2 | 2 | | | | 2 |
| | **CO3** | 3 | 2 | | | 3 | | | 2 | 2 | | | | 2 |
| | **CO4** | 3 | 2 | | | 3 | | | 2 | 2 | | | | 2 |

# ABILITY ENHANCEMENT COURSE LABORATORY
# COMSOL MULTIPHYSICS

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 0+0+2 (L+T+P) | Credits: | 1 |
| Total Lecture Hours: | 0 | CIE Marks: | 50 |
| Total Tutorial Hours: | 0 | SEE Marks: | 50 |
| Total Practical Hours: | 28 | Course Code: | P4EIA2 |
| Course Type: | AEC | Exam Hours: | 3 |

| **Course objectives:** | |
|---|---|
| This course will enable students to: | |
| 1 | Learn process flow for various electronic circuits using simulation software. |

| **List of Experiments:** | |
|---|---|
| (2 Hours per week per batch) 13 Lab sessions + 1 Lab assessment | |
| 1. | Introduction to COMSOL Tree, Model Components, Component Couplings Geometry, Material, Physics, Mesh and Study, Solvers |
| 2. | Introduction to AC/DC Module: Electrostatic, Electric currents and Magnetic Fields(2D/3D) |
| 3. | Experiments to realize diode clipping and Clamping circuits. |
| 4. | Experiment to Realize Half wave Rectifier |
| 5. | Design and conduct Modelling of electric current interface using COMSOL |
| 6. | Experiment to realize the electrical circuit using COMSOL Multiphysics |
| 7. | Design and conduct Modelling of an AC electromagnet using COMSOL |
| 8. | Design and static analysis of Cantilever beam using solid mechanics module |
| 9. | Set-up and study effect of magnetic field due to solenoid |
| 10. | Design and Multiphysics modeling of Piezoelectric transducer |
| 11. | Design and analysis of Micropatterned Resistive Force Sensor |
| 12. | Design an electrical stimulation for ARM Electrodes in Biomedical Application. |

| **Course Outcomes:** Upon completion of this course the student will be able to: | |
|---|---|
| CO1 | **Design** and simulate electronic circuits as per the specifications using discrete electronic components. |
| CO2 | **Perform** predictions and optimize the modeled systems depending on the specifications. |

**Course Articulation Matrix**

| | | **POs** | | | | | | | | | | | **PSOs** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **1** | **2** |
| **COs** | **CO1** | 3 | 2 | | | 3 | | | 3 | 3 | | | | 2 |
| | **CO2** | 3 | 2 | | | 3 | | | 3 | 3 | | | | 2 |

# ARDUINO UNO PROGRAMMING

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 0+0+2 (L+T+P) | Credits: | 1 |
| Total Lecture Hours: | 0 | CIE Marks: | 50 |
| Total Tutorial Hours: | 0 | SEE Marks: | 50 |
| Total Practical Hours: | 28 | Course Code: | P4EIA3 |
| Course Type: | AEC | Exam Hours: | 3 |

| **Course objective:** This course will enable students to: | |
|---|---|
| 1. | Learn Arduino Uno Microcontroller programming |
| 2. | Learn Interfacing of various I/O devices & communication modules |

| **List of Experiments:** (2 Hours per week per batch) 13 Lab sessions + 1 Lab assessment | |
|---|---|
| 1. | Interfacing digital I/O devices. |
| 2. | Timer function with digital I/O. |
| 3. | Interfacing temperature sensor. |
| 4. | PWM waveform generation. |
| 5. | Interfacing serial communication devices. |
| 6. | Interfacing stepper motor |
| 7. | Interrupt in Arduino. |
| 8. | I2C Communication. |
| 9. | Transmission and reception of data through Bluetooth to a Mobile phone |
| 10. | Automatic temperature control system – to switch on FAN if the temperature exceeds certain value. |
| **Open ended Experiments (Only for CIE).** | |
| 1. | Temperature data acquisition and transmission to cloud server |
| 2. | Case study in real time applications of Arduino |

| **Course Outcomes:** Upon completion of this course the student will be able to: | |
|---|---|
| CO1 | **Develop** an algorithm to Interface digital and analog I/O devices to microcontroller |
| CO2 | **Develop** an algorithm to Interface sensors & communication modules |
| CO3 | **Develop** an algorithm for remotely monitor data and control devices. |

**Course Articulation Matrix**

| | | POs | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **1** | **2** |
| **COs** | **CO1** | 3 | 2 | | | 3 | | | 3 | 3 | | | | 2 |
| | **CO2** | 3 | 2 | | | 3 | | | 3 | 3 | | | | 2 |
| | **CO3** | 3 | 2 | | | 3 | | | 3 | 3 | | | | 2 |

# PYTHON FOR MEASUREMENT LAB

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 0+0+2 (L+T+P) | Credits: | 1 |
| Total Lecture Hours: | 0 | CIE Marks: | 50 |
| Total Tutorial Hours: | 0 | SEE Marks: | 50 |
| Total Practical Hours: | 28 | Course Code: | P4EIA4 |
| Course Type: | AEC | Exam Hours: | 3 |

| **Course objective:** | |
|---|---|
| This course will enable students to: | |
| 1. | Develop Python programming skills and apply them for measurement systems, sensor data analysis, and basic data-driven instrumentation applications. |

| **List of Experiments:** | |
|---|---|
| (2 Hours per week per batch) 13 Lab sessions + 1 Lab assessment | |
| **For CIE and SEE** | |
| 1. | Develop a Python program using control structures, Pandas, and functions to read measurement data from a CSV file, perform basic preprocessing (handling missing values), process the data, and store the results in a new file. |
| 2. | Develop a Python program using NumPy and Matplotlib to perform array/matrix operations on engineering data and visualize the results using appropriate plots. |
| 3. | Sensor data acquisition (offline or simulated dataset), statistical analysis (mean, variance, standard deviation), outlier detection using Z-score/IQR, and moving average trend analysis. |
| 4. | Calibration of measurement systems using regression techniques and estimation of measurement uncertainty. |
| 5. | Use scipy.optimize.curve_fit and NumPy polynomial fitting to calibrate a sensor linear fit voltage-vs-temperature data to linear/polynomial models, compute $R^2$ and residual error, and plot the calibration curve. |
| 6. | Acquire or simulate a periodic measurement signal (sine, square, mixed), perform sampling and FFT analysis using NumPy/SciPy, apply basic digital filtering (low-pass/high-pass Butterworth filters), plot the frequency spectrum, and identify dominant frequency components. |

| | |
|---|---|
| 7. | Visualization and analysis of multi-sensor data (temperature, pressure, flow) using real-time data simulation or serial communication-based acquisition. |
| 8. | Analysis of biomedical datasets (ECG/PPG) – feature extraction and interpretation. |
| 9. | Develop a Python-based sensor fault detection system using statistical and machine-learning techniques. Generate or acquire sensor data under normal and faulty conditions, extract relevant features, detect anomalies using methods such as Z-score, IQR, Isolation Forest, or Local Outlier Factor, and visualize the detected faults. Evaluate the performance using appropriate classification metrics. |
| 10. | Develop a Python-based sensor fault detection system using statistical and machine-learning techniques. Generate or acquire sensor data under normal and faulty conditions, extract relevant features, detect anomalies using methods such as Z-score, IQR, Isolation Forest, or Local Outlier Factor, and visualize the detected faults. Evaluate the performance using appropriate classification metrics. |
| **Open ended experiments (only for CIE):** | |
| 1. | Develop a Python-based measurement dashboard for sensor data visualization. |
| 2. | Design a data-driven model for calibration or anomaly detection in instrumentation systems. |

| **Course Outcomes:** | |
|---|---|
| Upon completion of this course the student will be able to: | |
| CO1 | **Apply** Python programming concepts for handling engineering and measurement data. |
| CO2 | **Analyze** and visualize sensor data using data analysis tools. |
| CO3 | **Apply** statistical methods for calibration and interpretation of measurement systems. |
| CO4 | **Analyz**e biomedical and industrial datasets for meaningful insights and fault identification. |

## Course Articulation Matrix

| | | POs | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 1 | 2 |
| COs | CO1 | 3 | 2 | | | 3 | | | 3 | 3 | | | 2 | |
| | CO2 | 3 | 2 | | | 3 | | | 3 | 3 | | | 2 | |
| | CO3 | 3 | 2 | | | 3 | | | 3 | 3 | | | 2 | |
| | CO4 | 3 | 2 | | | 3 | | | 3 | 3 | | | 2 | |

# BIOLOGY FOR INSTRUMENTATION

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 1+0+0 (L+T+P) | Credits: | 1 |
| Total Lecture Hours: | 15 | CIE Marks: | 50 |
| Total Tutorial Hours: | 0 | SEE Marks: | 50 |
| Total Practical Hours: | 0 | Course Code: | P4EIB1 |
| Course Type: | BSC | Exam Hours: | 1.5 |

**Course objectives:**

This course will enable students to:

| | |
|---|---|
| 1. | Learn the fundamentals of human physiology, physiological measurements, biomedical sensors, and smart healthcare technologies relevant to Instrumentation Engineering. |

**UNIT I**

**Fundamentals of Biology and Human Physiological Systems:** Introduction to Biology for Instrumentation Engineers, Levels of biological organization, Cell structure and function (overview), Homeostasis and physiological regulation.

**Physiological Measurements and Biomedical Sensors:** Physiological variables and their significance, Classification of physiological measurements. Basics of biomedical measurement systems.

**5 Hours**

**UNIT II**

Overview of major physiological systems: Nervous System, Cardiovascular System, Respiratory System, Musculoskeletal System, Physiological variables relevant to instrumentation. Principles and waveform characteristic of ECG, EEG, EMG, and PPG.

Measurement of Vital Parameters: Heart Rate, Blood pressure, Body temperature, Respiration rate, Oxygen saturation ($SpO_2$).

Temperature sensors (Thermistors, RTDs, Infrared sensors), Pressure sensors for blood pressure measurement, Optical sensors for pulse oximetry and PPG, Airflow sensors for respiration

**5 Hours**

**UNIT III**

**Smart Healthcare Technologies and Emerging Trends:** Introduction to Medical Device Regulatory Framework and Medical Devices Rules, 2017. Wearable Health Monitoring Technologies, Introduction to wearable medical devices, Continuous monitoring of vital signs, Smartwatches, fitness bands, and medical wearables, Applications in

| |
|---|
| preventive healthcare. Remote Patient Monitoring (RPM) Point-of-Care (PoC) diagnostic devices<br>Basics of Telemedicine. Internet of Medical Things (IoMT), Artificial Intelligence in Healthcare, Digital Health Ecosystem, Smart hospitals (overview). |
| **5 Hours** |

| **TEXT BOOKS** | | |
|---|---|---|
| 1 | Gerard J. Tortora and Bryan H. Derrickson | Principles of Anatomy and Physiology, 16th Edition, John Wiley & Sons, 2021. |
| 2 | John G. Webster and Amit J. Nimunkar. | Medical Instrumentation: Application and Design, 5th Edition, John Wiley & Sons, 2020. |
| | | |

| **REFERENCE BOOKS** | | |
|---|---|---|
| 1 | Shakti Chatterjee and Aubert Miller. | Biomedical Instrumentation Systems, Cengage Learning India, 2010. |
| 2. | Joseph D. Bronzino and Donald R. Peterson. | Introduction to Biomedical Engineering, 4th Edition, Academic Press, 2021. |

| **Course Outcomes:**<br>Upon completion of this course the student will be able to: | |
|---|---|
| CO1 | Apply fundamental concepts of human physiology and physiological variables to identify appropriate biomedical measurement approaches and instrumentation systems. |
| CO2 | Analyze physiological waveforms and vital-parameter measurements to relate signal characteristics with appropriate biomedical sensors and measurement techniques. |
| CO3 | Analyze emerging wearable, remote, IoMT, and AI-enabled healthcare technologies and their applications in modern healthcare systems |

## Course Articulation Matrix

| | | POs | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 1 | 2 |
| COs | CO1 | 3 | 1 | | | | | | | | | | 2 | |
| | CO2 | 3 | 1 | | | | | | | | | | 2 | |
| | CO3 | 3 | 1 | | | | | | | | | | 2 | |
| | CO4 | 3 | 1 | | | | | | | | | | 2 | |
| | CO5 | 3 | 1 | | | | | | | | | | 2 | |

# Foundations of Engineering Mathematics-II

| | | | |
|---|---|---|---|
| Contact Hours/ Week: | 3+0+0 (L+T+P) | Credits: | 00 |
| Total Lecture Hours: | 40 | CIE Marks: | 100 |
| Total Tutorial Hours: | 0 | SEE Marks: | 00 |
| Total Practical Hours: | 0 | Course Code: | P4MATDIP |
| Course Type: | NCMC | Exam Hours: | 3 |

**Course objectives:**

This course will enable students to:

| | |
|---|---|
| 1. | **Develop** the numerical schemes to solve algebraic, transcendental and differential Equations. |
| 2. | **Familiarize** the importance of Integral calculus and Vector calculus. |
| 3. | **Analyze** the engineering problems applying Partial Differential Equations |

**UNIT I**

**Elementary Numerical Methods - I** Solution of polynomial and transcendental equations - Newton-Raphson method (only formula) – Illustrative examples. Finite differences. Interpolation/extrapolation using Newton's forward and backward difference formulae, Newton's divided difference and Lagrange's formulae (All formulae without proof).

**8 Hours**

**UNIT II**

**Numerical Integration & Numerical Solution of Differential Equations** Numerical integration: Trapezoidal, Simpson's 1/3$^{rd}$, Simpson's 3/8$^{th}$ rule and Weddle's rule. Numerical solution of ordinary differential equations of first order and first degree - Taylor's series method, Modified Euler's method, Runge-Kutta method of fourth order and Milne's predictor-corrector method.

**8 Hours**

**UNIT III**

**Vector Calculus** Vector Differentiation: scalar and vector fields, Gradient, directional derivative, divergence, curl-physical interpretation; solenoidal and irrotational vector fields-illustrative problems.

**8 Hours**

| UNIT IV |
|---|
| **Partial Differential Equations** Formation of PDEs by elimination of arbitrary constants and functions. Solution of non-homogeneous PDE by direct integration. Homogeneous PDEs involving derivatives with respect to one independent variable only. |
| **8 Hours** |

| UNIT V |
|---|
| **Integral Calculus: Multiple integrals** –Evaluation of double and triple Integrals, **Beta and Gamma functions**: Definition, relation between Beta and Gamma functions and simple problems. |
| **8 Hours** |

| **TEXT BOOKS** | | |
|---|---|---|
| 1 | Erwin Kreyzig | Advanced Engineering Mathematics", 10th edition, Wiley Publications, 2016. ISBN: 9788126508273. |
| 2 | B. S. Grewal | "Higher Engineering Mathematics", 43rd edition, Khanna Publications, 2015. ISBN:9788174091955. |
| 3 | M.K. Jain, S.R.K. Iyengar and R.K. Jain | Numerical Methods for Scientific and Engineering Computation, New Age International Publishers, 8thEd., 2022. ISBN: 9788183893732 |

| **REFERENCE BOOKS** | | |
|---|---|---|
| 1 | Maurice D. Weir, Joel R. Hass and George B. Thomas | "Thomas' calculus**:** Early Transcendental", 12th edition, Pearson Education, 2016. ISBN: 978078024269. |
| 2 | Ramana B.V | Higher Engineering Mathematics, McGraw-Hill Education, 11th Ed., 2017, ISBN: 9780070634190. |
| 3 | C.Ray Wylie, Louis. C. Barrett | Advanced Engineering Mathematics, McGraw – Hill Book Co., New York, 6th Ed., 2017, ISBN: 9780070722064. |
| 4 | Louis A. Pipes and Lawrence R. Harvill | "Applied Mathematics for Engineers and Physicists", 3rd Edition, McGraw Hill, 2014. ISBN: 9780486779515. |
| 5 | Peter V.O 'Neil | "Advanced Engineering Mathematics", 7th edition, CENGAGE Learning India Pvt. Ltd. Publishers, 2012. ISBN: 9788131503102. |