# M.E. -ELECTRONIC INSTRUMENTATION AND CONTROL

# Course Scheme

# and

# Syllabi

***w.e.f. July 2019***

## Department of Electrical and Instrumentation Engineering

**Thapar Institute of Engineering & Technology, Patiala**

*(Deemed to be University)*

**Post Bag No. 32, Bhadson Road, Patiala -147004 (India)**

First Semester

| S. No. | Course No. | Course Name | L | T | P | Cr |
|---|---|---|---|---|---|---|
| 1. | PEI111 | Microcontroller and Embedded Systems | 3 | 0 | 2 | 4.0 |
| 2. | PEI107 | Digital Signal Processing and Techniques | 3 | 1 | 2 | 4.5 |
| 3. | PE102 | Industrial Instrumentation and Control | 3 | 0 | 2 | 4.0 |
| 4. | PEI109 | Intelligent Techniques and Applications | 3 | 1 | 2 | 4.5 |
| 5. | PEI110 | Measurement Techniques | 3 | 1 | 0 | 3.5 |
| 6. | PEI112 | Process Modelling Simulation and Control | 3 | 0 | 2 | 4.0 |
| | | Total | 18 | 3 | 10 | 24.5 |

Second Semester

| S. No. | Course No. | Course Name | L | T | P | Cr |
|---|---|---|---|---|---|---|
| 1. | PEI201 | Biomedical Instrumentation and Techniques | 3 | 0 | 2 | 4.0 |
| 2. | PEI202 | Digital Image Processing and Analysis | 3 | 0 | 2 | 4.0 |
| 3. | PEU216 | Optimal and Robust Control | 3 | 1 | 2 | 4.5 |
| 4. | PEI204 | Virtual Instrumentation and Applications | 2 | 0 | 4 | 4.0 |
| 5. | | Elective–I | 3 | 0 | 2 | 4.0 |
| 6. | | Elective–II | 3 | 0 | 0 | 3.0 |
| | | Total | 17 | 1 | 10 | 23.5 |

Third Semester

| S. No. | Course No. | Course Name | L | T | P | Cr |
|---|---|---|---|---|---|---|
| 1. | PEIXXX | Minor Project | | | | 6.0 |
| 2. | PEI391 | Seminar | | | | 2.0 |
| 3. | PEI491 | Dissertation (Starts) | | | | |
| | | Total | | | | 8.0 |

Fourth Semester

| S. No. | Course No. | Course Name | L | T | P | Cr |
|---|---|---|---|---|---|---|
| 1. | PEI491 | Dissertation (completes) | | | | 16 |
| | | | | | Total | 16 |

Total Number of Credits: 72

## List of Electives

Professional Elective–I

| S. No. | Course No. | Course Name | L | T | P | Cr |
|---|---|---|---|---|---|---|
| 1. | PEI231 | Embedded System fundamentals and Programming | 3 | 0 | 2 | 4.0 |
| 2. | PEI232 | Soft Computing Techniques and Applications | 3 | 0 | 2 | 4.0 |
| 3. | PEI233 | Biometric Techniques | 3 | 0 | 2 | 4.0 |
| 4. | PEI234 | Embedded Control System | 3 | 0 | 2 | 4.0 |
| 5. | PEI235 | Microcontroller based System Design | 3 | 0 | 2 | 4.0 |
| 6. | PEI236 | Wireless Sensor Networks | 3 | 0 | 2 | 4.0 |
| 7. | PEI237 | Nonlinear control system | 3 | 0 | 2 | 4.0 |
| 8. | PEI238 | Robotic Technology | 3 | 0 | 2 | 4.0 |

Professional Elective–II

| S. No. | Course No. | Course Name | L | T | P | Cr |
|---|---|---|---|---|---|---|
| 1. | PEI302 | Biomechanics and Rehabilitation | 3 | 0 | 0 | 3.0 |
| 2. | PEI207 | Cognitive Engineering | 3 | 0 | 0 | 3.0 |
| 3. | PEI213 | Environmental Monitoring Instrumentation | 3 | 0 | 0 | 3.0 |
| 4. | PEI310 | Power System Instrumentation | 3 | 0 | 0 | 3.0 |
| 5. | PEI327 | System Identification and Adaptive Control | 3 | 0 | 0 | 3.0 |
| 6. | PEI341 | Opto–Electronic Instrumentation | 3 | 0 | 0 | 3.0 |
| 7. | PEI342 | Industrial Electronics | 3 | 0 | 0 | 3.0 |
| 8. | PEI343 | Micro-Sensors and Actuators | 3 | 0 | 0 | 3.0 |
| 9. | PEI344 | Remote Sensing and Telemetry | 3 | 0 | 0 | 3.0 |
| 10. | PEI345 | Computational Electromagnetic | 3 | 0 | 0 | 3.0 |

Total Number of Credits: 72

## PEI111: MICROCONTROLLERS AND EMBEDDED SYSTEMS

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 2 | 4.0 |

**Course objective:** To understand the architecture of microcontrollers and develop application specific programs and interfacing circuit using microcontroller.

**PIC Microcontrollers:** Introduction to 16 and 18F families, Architecture, programmingusing assembly and embedded C, introduction to TIMERS and Counters, special operations compare, capture, PWM using timers, analog to digital converters, Interrupts, introduction to communication protocols such as UART,SPI, I2C, CAN, USB I/O programming and interfacing.

**Introduction to special features:** configuration word, oscillator configuration, power on reset, watch dog timer, brown out reset, in circuit serial programming, in circuit debugger

**Hardware Interfacing:**Interfacing with LEDs, Seven Segment,LCD, Relays, D.C. and stepper motors etc., port expansion using SPI and I2C.

**Sensor interfacing:** Introduction to temperature, pressure and accelerometerIc packages, interfacing using SPI/I2C/CAN protocol.

**Embedded system:** Introduction to embedded system, classification, embedded hardware units and devices in a system, embedded softwares in a system, examples of embedded system, introduction to RTOS.

**Laboratory work:** Application programs for data transfer and timers operations using simulators and development boards/ kits, implementation of ADC based applications using hardware circuits, implementation of communication protocol based application programs, interfacing with key pads, display devices, sensors, D.C. and stepper motors.

**Minor Project:**

1. Case study of an instrumentation system based on the Microcontrollers.
2. Development of microcontroller based signal conditioning stages for measurement and control.

**Course learning outcome (CLO):**

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

1. Apply basicconcepts of microcontroller architecture for application design.
2. Develop application oriented assemblylanguageand embedded C programs.
3. Interface microcontroller with display devices, sensors and motors.

4. Elucidate the basic concepts of embedded systems and RTOS.

***Recommended Books:***


1. *Peatman J., Design with PIC microcontrollers, Pearson Education, 2006*
2. *Peatman J., Embedded system Design using PIC18Fxxx, Prentice Hall, 2003.*
3. *Mazidi M.A., PIC Microcontroller and Embedded Systems: Using assembly and C for PIC, 2008*
4. *Rajkamal,Embedded systems: architecture, programming and design, Tata McGraw-Hill Education, 2011*


**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 25 |
| EST | 40 |
| Minor Project | 10 |
| Sessionals (May include Assignments/ Tutorials/ Quizes/ Lab Evaluations) | 25 |

## PEI107: DIGITAL SIGNAL PROCESSING TECHNIQUES

| L | T | P | Cr |
|---|---|---|---|
| 3 | 1 | 2 | 4.5 |

**Course objective:**To understand the concepts, classifications and properties of discrete time signals and systems, to understand frequency domain analysis, awareness about filter designing and structure.

**Introduction**:signals and systems, Linear Time Invariant (LTI) Systems, Difference Equations: Finite Impulse Response (FIR) systems, Infinite Impulse Response (IIR) systems, Correlation: Cross-correlation and Auto-correlation and their properties, Analog to Digital (A/D) Conversion: Sampling, Frequency Relationships, Aliasing, Quantization, Encoding, Sampling theorem and Anti Aliasing Filter, review of Z transform.

**Transformation techniques:** Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT): Discrete Fourier Transform and its Properties, Efficient Computation of DFT using FFT algorithms: Direct computation of the DFT, Divide and Conquer Approach, Radix-2 and Radix-4 FFT algorithms, Linear Filtering Approach to Computation of DFT.Introduction to finite word length effects and quantization effect.

**Design of Digital Filters:** Characteristics of Practical Frequency Selective Filters, Design of FIR Filters using different windows, Design of IIR Filters from Analog Filters, Frequency Transformations.

**Digital Filter Structure:** Describing Equation of digital filter, Structures for FIR and IIR systems

**Hardware Architecture of DSP Processor:** Introduction, Desirable features of DSP processors, Types of architectures, Internal architecture of ADSP-21xx family, Features of ADSP-21xx family processors, DSP-21xx Development tools.

**Multirate Digital Signal Processing:** Introduction, Decimation by factor D, multistage implementation of sampling rate conversion, sampling rate conversion of bandpass filters.

**Optimum Filters**: Introduction, Forward and backward predictions, AR lattice and ARMA lattice ladder filters, Wiener filters for filtering and prediction.

**Laboratory work:**Calculation of Z transform, Calculation of Fourier transform, Design of FIR and IIR filters, Multirate signal processing, Design of optimum filters, realization of prediction.

**Minor Project:**Nil

**Course learning outcome (CLO):** After the completion of the course the students will be able to:

1. Apply transformation tools and analysesystem response.
2. Design various types of filters.
3. Implement filter structures.
4. Analyze multirate signal processing

***Recommended Books:***


1. *Proakis, J.G. and Manolakis, D.K., Digital Signal Processing, Prentice Hall of India (2006 4th ed).*
2. *Rabiner, Lawrence R. and Gold, B., Theory and Applications of Digital Signal Processing, Prentice Hall of India (2000).*


Evaluation Scheme:

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 25 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 30 |

## PEI102: INDUSTRIAL INSTRUMENTATION AND CONTROL

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 2 | 4.0 |

**Course objective:**To understand the concepts of industrial instrumentation and control, to enable select, design and program industrial instrumentation equipment

**Industrial Instrumentation**: Instrumentation for hazardous areas, safety standards, Instrumentation for environment monitoring, Instrumentation for energy monitoring and conservation, Multi sensor fusion, Control valves, Characteristics, Sizing and selection, P/I, I/P converter, Valve positioner, Instrumentation Symbols, P–I diagrams

**Programmable Logic Control:** :Evolution of PLC, Block diagram, Different components of PLC, PLC Scan cycle, Memory organization and addressing, Advancements in PLCs, PLC Instruction set including NO, NC, Set, Reset, Timer, Counter, Mathematical functions, LIFO, FIFO, Jump, Bit shift instructions etc., PLC selection Process, Estimating program memory and time requirements, Selecting hardware.

**Distributed control system (DCS):**Evolution and advantages of computer control, Configuration of supervisory control, Direct digital control (DDC), Distributed control systems (DCS), Remote terminal units (RTUs), System integration with PLCs, SCADA Systems

**Robotics:**History, Present status, Future trends, Robot anatomy, Robot sensors, Actuators and end effectors, Robot degrees of freedom, Robot joints, Robot Coordinates, Robot reference frames, Robot work space, Matrix representation, Representation of transformations like pure translation, Pure rotation and combined rotation, Forward and reverse kinematics

**Digital communication in Process Control:**Smart transmitters, Hardware and Software protocols, RS232, GPIB, CAN, HART, Foundation Field bus, TCP/IP, Zigbee and other wireless communication protocols.

**Laboratory work:** Valve Characteristics, P/I, I/P converter, Valve positioner, PLC: Programming, interfacing and application development, Programming robotic arm.

**Minor Project:**

1. To investigate recent advancement in sensors
2. To develop PLC programs for various applications on simulators.

**Course learning outcome (CLO):** After the completion of the course the students will be able to:

1. Perform ladder programme for PLC

2. Elucidate the concept of DCS for industrial applications
3. Programme and analyze robotic system
4. Use different communication protocol for process control system

***Recommended Books***


1. *Anand, M.M.S., Electronic Instruments and Instrumentation technology, Prentice–Hall of India (2006).*
2. *Deb S., Robotics technology and flexible automation, Tata McGraw Hill (2004).*
3. *Doeblin E.O., Measurement systems: applications and design, Tata McGraw Hill (2003) 5th ed.*
4. *Liptak B.G., Process control: Instrument engineers' Handbook, Butterworth Heinemann (2003) 4th ed.*


**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 25 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 30 |

## PEI109: INTELLIGENT TECHNIQUES AND APPLICATIONS

| L | T | P | Cr |
|---|---|---|---|
| 3 | 1 | 2 | 4.5 |

**Course objective**: To understand the concepts of Artificial Intelligence, to enable to design Intelligent Controls

**Artificial Neural Networks:**Artificial Neuron models, Types of activation functions, Neural network architectures, Neural Learning: Correlation, Competitive, Feedback based weight adaptation, Evaluation of networks, Generalizability, Computational resources, Supervised learning: Perceptrons, linear separability, Multilayer networks, Back propagation algorithm and its variants, Unsupervised learning, Winner–take all networks, Adaptive resonance theory, Self organizing maps, Hopfield networks, Typical application in identification, Optimization, Pattern recognition, Process control, Robotics and other industrial control methods.

**Fuzzy Logic:**Fuzziness vs probability, Crisp logic vs fuzzy logic, Fuzzy sets and systems, Operations on sets, Fuzzy relations, Membership functions, Fuzzy rule generation, Defuzzification, Mamdani and Takagi-Sugeno Model, Fuzzy controllers

**Evolutionary Computation:**Introduction to optimization problem, constraints, objective functions, unimodal/ multimodal problems, classical techniques/evolutionary computational techniques Genetic Algorithms and its Operators, variants of Genetic Algorithm and its use in Engineering Process Control.

**Introduction to Advanced AI techniques**:Support Vector Machine, Particle Swarm Optimization, Ant Colony Optimization, Differential Evolution and Hybrid techniques.

**Laboratory work:**Experiments around Input and output using Fuzzy logic, Graphical analysis of various control systems using Fuzzy logic, Neural networks learning for identification and control, GA based optimization for different application.

**Minor Project:**

1. Case studies related to application of artificial intelligence to process control.
2. Application of neural network/fuzzy logic to pattern recognition / classification / process control.
3. Application of ANN/ fuzzy logic techniques to system identification and control.
4. Application of evolutionary algorithms to controller design.

**Course learning outcome (CLO): After the completion of the course the students will be able to**

1. Explain the concept of different training algorithms used in ANN.

2. Apply fuzzy logic for different application.
3. Use of evolutionary computation algorithm to solve engineering problems.
4. Apply intelligent techniques in process control, robotics and industrial control systems.

***Recommended Books:***


1. *Narayana, Y., Artificial Neural Networks, Prentice–Hall of India (1999).*
2. *Rich, E., and Knight, K., Artificial intelligence, McGraw Hill (1991) 2nd ed.*
3. *Ross, J. T., Fuzzy Logic with Engineering Applications, John Wiley (2004) 2nd ed.*


**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 25 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 30 |

## PEI 110:MEASUREMENT TECHNIQUES

| L | T | P | Cr |
|---|---|---|---|
| 3 | 1 | 0 | 3.5 |

**Introduction:** Definition, Application and types of measurements.

**Error Analysis:** Types of errors, Methods of error analysis, Uncertainty analysis, Statistical analysis, Gaussian error distribution, Chi-Square test, Correlation coefficient, Students t-test, Wilcoxon test, Method of least squares, Curve fitting, Graphical analysis, Rejection of data, Regression techniques.

**Static and Dynamic characteristics:** Dynamic analysis of instrumentation system, relative merits of analytical and experimental modelling of dynamic behaviour, Response of zero, first and $2^{nd}$ order system to step, Pulse, Harmonic and random test signals, Frequency spectra, Auto correlation spectral density, Loading effects under static and dynamic conditions, Simulation of dynamic response.

**Generalized measurement system:** Different functional elements (Sensors, Signal condition (Regeneration, Conversion, Shaping) signal manipulation, Data transmission, Data presentation, Inverse transducers). Review of conventional devices, technologies and introduction to recent ones.

**Advanced measurement techniques:** Advanced techniques for the precise measurement of temperature, pressure, flow, vibration, current, voltage and energy.

**Smart Sensors for IOT applications:** Smart sensors, MEMS based sensors, PIR motion sensors, Ultrasound proximity sensors, Touch sensors, Accelerometer and Gyroscope, Gas sensors.

**Course learning outcome (CLO):** After the completion of the course the students will be able to

1. Apply different techniques for the analysis of errors
2. Exhibit knowledge about measurement system and their characteristics
3. Elucidate advanced techniques for the precise measurement of the physical parameters
4. Explain smart sensors for IOT applications

***Recommended Books:***


1. *Measurement system, Application & Design, E.O. Debelin, McGraw Hill*
2. *Handbook of Transducers. H.N. Norton, Prentice Hall*
3. *Electronics Instrumentation and instrumentation technology, M.M.S Anand, Prentice Hall*
4. *Experimental methods for engineers, J.P Homan, Tata McGraw Hill*

**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 30 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 25 |

## PEI112: PROCESS MODELLING SIMULATION AND CONTROL

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 2 | 4.0 |

**Course objective:**To understand the concepts of process model and control, to enable to develop model and simulation of process control

**Simulation and Modelling:**Importance of simulation, Terms used Simulation, Mathematical modelling, Process dynamics of fluid flow and heat transfer systems, Mass transfer dynamics and distillation column, Reaction kinetics of chemical processes. Modelling of chemical processes like CSTR, single tank / multi-tank system and Distillation column, Modelling of physical systems like inverted pendulum, study the behaviour of above mentioned systems for various test signals, analysis of PID controller response.

**Advanced Control Schemes:**Structure, analysis and application of Cascade control, Selective control, Ratio Control, Design of steady state and dynamic feed forward controller, Feed forward combined with feedback control, Structure, analysis and applications of inferential control, Dead time and inverse response compensators, Concepts and applications of Adaptive control.

**Design of Multi-loop Controllers:**Interactions and decoupling of control loops. Design of cross controllers and selection of loops using Relative Gain Array (RGA).

**Digital Control:**Sampling and reconstruction, introduction to z–transform, Mapping of j–plane to z–plane, Pulse transfer function, Stability analysis in z–plane using Jury stability criterion, Implementation of digital controller.

**Discrete Event System Modelling:**Introduction to various methods of modelling, Automata theory, Introduction to Petri Nets, Distributed computing and scheduling of real time systems.

**State Space Analysis:**State space representation of continuous and discrete time control systems, Converting a continuous and discrete time system into its state space equivalent using MATLAB, Control theory, State space concepts, State variables, Pole placement design and state observes, Controllability and Observability of linear time invariant systems and the relation between them.Stability analysis, Definition, First and second method of Liapunov, Stability analysis of linear systems.

**Laboratory work:** Introduction of MATLAB Software and basic mathematical operations in MATLAB, Simulation studies of PID Controller for different processes like inverted pendulum, Controllability and Observability of Control system, Stability of Continuous and Discrete Systems

**Minor Project:**Nil

**Course learning outcome (CLO):**After the completion of the course the students will be able to

1. Model, simulate and implement advanced control schemes for different processes.
2. Design de-coupler for multi-loop controllers and digital controllers.
3. Develop model for discrete event systems.
4. Analyse the system using state space analysis.

***Recommended Books:***


1. *Bequette, B.W., Process Control: Modeling, Design And Simulation Prentice Hall of India (2003).*
2. *Harriott, P., Process Control, Tata McGraw Hill (2002).*
3. *Luyben, E., Essentials of Process Control, Tata McGraw Hill (1989).*


**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 25 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 30 |

## PEI201: BIOMEDICAL INSTRUMENTATION AND TECHNIQUES

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 2 | 4.0 |

**Course Objectives:** To understand the concepts of Biological Measurement, to enable selection, design and configuration of Biomedical Instruments

**Characteristics of Transducers and Electrodes for Biological Measurement:** Introduction to human physiology, classification and characteristics ofvarious physiological events, Bioelectric potentials, Transducers and electrodes for biological measurements.

**Cardiac System:** Cardiac musculature, Electro cardiography, ECG recording, Phonocardiography, Holter recording ECG lead system, Heart rate meter, Vector cardiography, BCG, Blood pressure measurement, Blood flow measurement, Pacemakers, Defibrillators.

**Respiratory System:** Mechanics of breathing, Parameters of respiration, Respiratory system measurements, Respiratory therapy instruments and Pulse-oximeter.

**Neurological signal processing:** Brain and its potential, EEG signal and its characteristics, EEG analysis, Linear prediction theory, Auto regressive methods, Recursive parameter estimation.

**Biomedical imaging:**Infrared imaging, principles of ultrasonic measurements, ultrasonic diagnosis, ultrasonic imaging systems, Doppler, Computed tomography, Principles of sectional imaging, scanner configuration, image formation principles, 2D image reconstruction techniques. Magnetic Resonance Imaging - Principles of MRI, pulse sequence, image acquisition and reconstruction techniques, MRI instrumentation, comparison of imaging modes.

**Telemedicine:** Definition and scope, Types, Applications and Advantages, Challenges, Legal and Ethical issues, Case study of telemedicine in India.

**Laboratory work:**Experiments around Polyrite, ECG, EEG, Spirometer, Pulse-oximeter, Sphygmomanometer and Bio-signal digital analysis.

**Minor Project:**Nil

**Course learning outcome (CLO):**After the completion of the course the students will be able to:

1. Explaincharacteristics of transducers and electrodes for several physiological measurements.
2. Demonstrate the knowledge of measurements on cardiac and respiratory system.

3. Analyzeand process neurological signals.
4. Differentiate and explain different biomedical imaging techniques and its applications in telemedicine.

***Recommended Books:***


1. *Carr. John M Brown., Biomedical Instrumentation, Prentice Hall of India (2000) 4th ed.*
2. *Cromwell,l.,Weibell, Fred j.,Pfeiffer, Eric A. Biomedical instrumentation and measurements, Prentice Hall of India (2000) 2th ed.*
3. *Khandpur R.S., Handbook of Biomedical Instrumentation, Tata McGraw-Hill Education, 2003*


**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 25 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 30 |

## PEI202: DIGITAL IMAGE PROCESSING AND ANALYSIS

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 2 | 4.0 |

**Course Objectives:**To understand the concepts of digital image processing, to enable to design applications of digital image processing.

**Fundamentals of image processing:**Introduction, Steps in Image Processing Systems, Image Acquisition, Sampling and Quantization Pixel Relationships, Colour Fundamentals and Models, File Formats, Image operations- Arithmetic, Geometric and Morphological.

**Image enhancement:**Spatial Domain Gray level Transformations Histogram Processing Spatial Filtering – Smoothing and Sharpening. Filtering in Frequency Domain, DFT, FFT, DCT, Smoothing and Sharpening filters, Homomorphic Filtering.

**Image segmentation and feature analysis:**Detection of Discontinuities, Edge Operators, Edge Linking and Boundary Detection, Thresholding, Region Based Segmentation, Morphological WaterSheds, Feature Analysis and Extraction.

**Multi-resolution analysis and compressions**: Multi Resolution Analysis: Image Pyramids, Multi resolution expansion, Wavelet Transforms. Image Compression: Fundamentals, Models, Elements of Information Theory, Error Free Compression, Lossy Compression, Compression Standards.

**Applications:**Image Classification, Image Recognition, Video Motion Analysis, Image Fusion, Digital Compositing, Colour Image Processing etc. in Biomedical, Machine vision/Robotics.

**Laboratory work:**Experiments related to image acquisition, enhancement/ filtering segmentation, morphological operations, multi resolution analysis and compression

**Minor Project:**

1. Projects related to image enhancement/ filtering.

**Course learning outcome (CLO):** After the completion of the course the students will be able to:

1. Exhibit the fundamental conceptsof digital image processing.
2. Apply image filtering in spatial and frequency domain.
3. Apply image segmentation, restoration and compression techniques
4. Apply multi resolution techniques in image processing

***Recommended Books:***

1. *Rafael C.Gonzalez and Richard E.Woods, "Digital Image Processing" Second Edition, Pearson Education, 2003.*
2. *Milan Sonka, Vaclav Hlavac and Roger Boyle, "Image Processing, Analysis and Machine Vision", Second Edition, Thomson Learning, 2001*
3. *Anil K.Jain, "Fundamentals of Digital Image Processing", PHI, 2006.*
4. *Sanjit K. Mitra, and Giovanni L. Sicuranza, "Non Linear Image Processing", Elsevier, 2007.*

**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 25 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 30 |

## PEI216: OPTIMAL AND ROBUST CONTROL

| L | T | P | Cr |
|---|---|---|---|
| 3 | 1 | 2 | 4.5 |

**Course Objectives:**To understand the concepts of optimal and robust control, to enable to analyze and design a robust Control System

Review of State space analysis, controllability, observability and stability

**Introduction and Parametric Optimization:**Introduction to optimal control problems, Classification of optimal control problems, performance indices for optimal control and their Selection.

**Iterative Method of Optimization:**Optimization using gradient methods and interactive techniques (steepest descent), Newton Raphson and Fletcher Powell. Introduction to multivariable system and decoupling, advance numerical techniques for optimal control, Introduction to Optimal Filters (Kalman Filter)

**Calculus of variations:**Lagrange multiplier, Euler Lagrange's equation for different conditions, Transversality conditions, Dynamic optimization with equality and inequality constraints, Optimization using Pontryegans maximum principle

**Dynamic Programming in Continuous and Discrete Time:**Developments of Hamilton Jacobi equation, Matrix Riccati equation, Optimal control based on quadratic performance indices, Linear regulator and servomechanism problem, Dynamic programming multi stage decision processes in continuous time. Principle of causality, invariant imbedding and optimality

**Robust Control System:**Introduction, Robust Control System and System sensitivity, Analysis of Robustness, system with uncertain parameters, the design of robust control system, PID controllers, design of robust PID controlled systems, design examples

**Laboratory work :** Mathematical modeling, stability analysis and optimal controller design for inverted cart pendulum system and magnetic ball suspension system using Simulink in Matlab environment.

**Minor Project :** Nil

**Course learning outcome (CLO):** After the completion of the course the students will be able to:

1. Apply Parametric Optimization/ iterative method/ Calculus of variations for optimization.
2. Apply Pontryegans Max/min Principle for optimization.
3. Apply Dynamic Programming in Continuous and Discrete Time systems

4. Analyze and design a robust Control System

***Recommended Books:***


1.*M. Gopal, Modern Control System Theory, New Age International, 1993*
2.*Richard C. Dorf and Robert H. Bishop, Modern Control Systems, Pearson Education, 2016*
3.*J. Arora, Introduction to Optimum Design, Elsevier Science, 2016*
4.*Donald E. Kirk, Optimal control theory: An introduction, Dover Publication, 2004*
5.*B. D. O. Anderson and J. B. Moore, Optimal Control: Linear Quadratic Methods, Dover Publications, 2007*
6.*D. S. Naidu, Optimal Control System, Taylor & Francis, 2002*


**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 25 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 30 |

## PEI204: VIRTUAL INSTRUMENTATION AND APPLICATIONS

| L | T | P | Cr |
|---|---|---|---|
| 2 | 0 | 4 | 4.0 |

**Course Objectives:**To understand the concepts of Virtual Instrumentation, to enable design and programming of Virtual Instruments

**Review:**Graphical programming in data flow VIs and sub–VIs, loops and charts, Arrays, Clusters and graphs, Case and sequence structures, Formula nodes, Local and global variables, String and file I/O.

**Elements of Data acquisition:** ADC, DAC, DIO, Counters and timers, PC Hardware structure, Timing, Interrupts; DMA Software and hardware installation Current loop RS232C/ RS485, GPIB, USB

**Signal Processing:** Sampling Signals, Sampling Considerations, Need of Anti-aliasing Filters, The Discrete Fourier Transform (DFT) and the Fast Fourier Transform (FFT), The Power Spectrum, Auto-correlation, Cross-correlation, Convolution, Deconvolution, Characteristics of Different Types of Window Functions , Realization of IIR and FIR filters.

**Machine Vision:**Digital images, definition, types, files, borders ad masks, Image display, Pallets, Region of Interest, Non–Destructive overlays, Convolution kernels, Spatial filters, Gray scale morphology, Thresholding, Particle measurement, Edge detection, Pattern matching.

**Laboratory Work:** Experiments around various elements of Labview like charts, Graphs, Loops, Arrays, Clusters etc., and data–acquisition and signal processing tools.

**Minor Project :**

1. Case studies of virtual instrumentation related to data acquisition, processing and control.
2. Application of virtual instrumentation to image processing, sound processing etc.
3. Applications of virtual instrumentation to process modelling.
4. Applications of virtual instrumentation to process control.

**Course learning outcome (CLO):** After the completion of the course the students will be able to

1. Applythe concepts of graphical programming
2. Identify elements of data acquisition for software and hardware installation
3. Apply signal processing, sampling signals and filtering
4. Implement and design machine vision and motion control.

***Recommended Books:***

1. *Johnson, G., LabVIEW Graphical Programming, McGraw Hill (2006) 4th ed.*
2. *Sokoloft, Basic Concepts of LabVIEW 4, Prentice Hall of India (1998).*
3. *Wells, L.K., and Travis, J., LabVIEW for Everyone, Prentice Hall Inc. (2001) 2nd ed.*

**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 25 |
| EST | 35 |
| Minor Project | 15 |
| Sessionals (May include Assignments/ Tutorials/ Quizes/ Lab Evaluations) | 25 |

## PEI231: EMBEDDED SYSTEM FUNDAMENTALS AND PROGRAMMING

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 2 | 4.0 |

**Course Objectives:**To understand the concepts of embedded systems, to enable design and programming of embedded systems.

**Introduction:**Review of Microcontrollers, Introduction to Embedded Systems, Introduction to the ARM Processor architecture, Embedded Hardware Building Blocks.

**ARM Microprocessor Architecture**: Core Architecture, Reset, Power architecture, Low power modes, Clock Functions, Memory organization and system, addressing modes, instruction set, Input & Output port, Timer programming, Exception Processing–Watch dog, Soft Resets and Interrupts, SPI, RS232, I2C, CAN and Ethernet, Analog-to-Digital Conversion System.

**EMBEDDED PROGRAMMING:**Embeddedd C programming, Declarations and Expressions, Arrays, Decision and Control Statements.Dedicated Tools like Code-warior tools: Project IDE, Compiler, Assembler and Debugger

**Interfacing:**Interfacing to LED, Keypad, Motors, Graphic LCDs, ADC, RS−232, SPI and I2C.

**Real Time operating systems:**Basic concepts of RTOS and its types, Concurrency, Reentrancy, Intertask communication, Implementation of RTOS with some case studies.

**Laboratory Work:**Various programming examples on ARM based FRDM board, Interfacing of LED, PWM, Sensors, LCD, Keypad, RS232, SPI, I2C.

**Minor Project:**

Case study of an Embedded system around ARM Microcontroller

**Course learning outcome (CLO):** After the completion of the course the students will be able to:

1. Implement basic hardware of ARM series Microcontrollers.
2. Implement system programming and peripheral interfacing to Keypad, Motors, LCD etc.
3. Implement the Networking and Connectivity
4. Handle Development and Programming Tools, and RTOS concepts

***Recommended Books:***


1. *Barrett, S.F. and Pack, J.D., Embedded Systems, Dorling Kingsley (2008).*
2. *Alexander G Dean, Embedded Systems Fundamentals with ARM Cortex-M based Microcontrollers: A Practical Approach, Arm Education Media (2017).*
3. ***Di Paolo Emilio,*** *Maurizio, Embedded Systems Design for High-Speed Data Acquisition and Control, Springer, (2014)*


Evaluation Scheme:

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 25 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 30 |

## PEI232: SOFT COMPUTING TECHNIQUES AND APPLICATIONS

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 2 | 4.0 |

**Course Objectives:**To understand the concepts of advanced soft computing, to enable to develop applications of advanced soft computing in instrumentation

**Introduction to Soft Computing:**Review of AI techniques and soft computing techniques and their applications in instrumentation engineering.

**Multi-objective optimization:**Comparison with single objective optimization, Dominance,Non Dominated sorting, Multi-objective optimization using GA.

**Advanced AI Techniques**: , Boltzmann machines, Support Vector Machine,Swarm Intelligence (SI), Particle swarm optimization (PSO), Ant-Colony Optimization, Petri-nets, Coloured-Petrinets, Entropy, Multi-agent and Hierarchical applications of advanced AI techniques in Control/ Signal processing/ Robotics.

**Rough Set Theory:** Introduction, Information system, Indiscernibility, Rough sets, Rough set theory, Set approximation, Rough membership, Attributes, Dependency of attributes, Rough equivalence, Reducts, Rough Reducts based on SVM, Hybrid set systems –Fuzzy rough sets, Topological structures of rough sets over fuzzy lattices, Fuzzy reasoning based on universal logic, , Type–2 Fuzzy Logic, Adaptive Neuro-Fuzzy Inference System, Multi–layer and other advanced Fuzzy Logic Models, Applications of Fuzzy Logic. Applications in Process control, Robotics and other industrial control methods.

**Granular Computing:** Soft sets to information systems, Uses and applications of granular computing in instrumentation engineering.

**Hybrid AI Techniques:**Introduction to Hybrid AI systems: Neuro- Fuzzy, Fuzzy-rough set systems, Neuro-Fuzzy-GA systems and case studies around Hybrid systems.

**Laboratory work:** Experiments around multi input and multi output using AI techniques, application of soft computing techniques for solving single objective problems, simple multi objective problem identification and its solution procedure

**Minor Project:**

1. Application of hybrid techniques for system identification and control.
2. Application of advance soft computing techniques for pattern classification and recognition.
3. Application of multi-objective optimization algorithms for process control.

**Course learning outcome (CLO):** After the completion of the course the students will be able to

1. Applysoft computing techniques to solve engineering problems.
2. Handle multi-objective optimization problems.
3. Apply advanced AI techniques of swarm intelligence, particle swarm optimization, ant-colony optimization and petrinets.
4. Applyrough set theory and granular computing to solve process control applications

***Recommended Books:***


1. *Duntsch,I and Gediga, G., Rough set data analysis: A Road to Non-invasive Knowledge Discovery, Methodos Publishers (2006).*
2. *Klir, G. J., Yuan, Bo, Fuzzy Sets and Fuzzy Logic, Theory and Applications, Prentice–Hall of India Private Limited (2007).*
3. *Ross, T.J., Fuzzy Logic with Engineering Applications, Wiley (2004) 2nd ed.*
4. *Deb.K, Multi-Objective Optimization using Evolutionary Algorithms, Wiley (2010)*


**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 25 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 30 |

## PEI233: BIOMETRICS TECHNIQUES

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 2 | 4.0 |

**Course Objectives:** To understand the concepts of Biometrics, to enable design of biometric system

**Introduction:** Benefits of biometrics, Verification and identification: Basic working of biometric matching, Accuracy, False match rate, False non-match rate, Failure to enroll rate, Active and passive biometric, Parameters of a good biometrics

**Finger Biometric Technology:** General description of fingerprints, Micro and Macro Feature, Types of algorithms used for interpretation, Components and Operations: Strength and weakness.

**Facial Biometric Technology:** General description, Features, Types of algorithms used for interpretation, Components and Operations, Strength and weakness.

**Iris Biometric Technology:**General description, Feature, Types of algorithms used for interpretation, Components and Operations, Strength and weakness.

**Voice Biometric Technology:**General description, Feature, Types of algorithms used for interpretation, Components and Operations, Strength and weakness.

**Other Physiological Biometrics:**Hand scan, Retina scan, Behavioural Biometrics: Signature scan, keystroke scan etc. Applications of biometrics.

**Laboratory work:**Experiments around data acquisition, linearization, segmentation, thinningand development of a biometric system.

**Minor Project:**

1. Developments of Finger print authentication system.
2. Application of statistical and / or soft computing techniques for face recognition.
3. Development of Speech/speaker recognition system.
4. Development of Iris recognitionsystem

**Course learning outcome (CLO): After the completion of the course the students will be able to**

1. Apply biometric matching for identification
2. Identify algorithms for finger biometric technology

3. Apply facial biometrics for identification.
4. Apply iris biometric, voice biometric, physiological biometrics etc. for identification.

***Recommended Books:***


1. *Reid, P., Biometrics for Network Security, Dorling Kingsley (2007).*
2. *Woodward, J.D. and Orlans, Nicholos M., Biometrics, McGraw Hill (2002).*


**Evaluation Scheme**:

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 25 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 30 |

## PEI234: EMBEDDED CONTROL SYSTEMS

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 2 | 4.0 |

**Introduction:** Introduction to Embedded Systems, Its Architecture and system Model, Microprocessors &Microcontrollers, Introduction to the ARM Processor architecture, Embedded Hardware Building Block.

**Microprocessor Architecture**: Core Architecture, Reset, Power architecture, Low power modes, Clock Functions, Memory organization and system, addressing modes, instruction set, Input & Output port, Data Conversion, RAM & ROM Allocation, Timer programming, Exception Processing–Watch dog, Soft Resets and Interrupts, Communications – SPI, RS232, I2C, CAN and Ethernet, Analog-to-Digital Conversion System.

**Embedded programming:** C and Assembly language programming, Programming Style, Declarations and Expressions, Arrays, Qualifiers and Reading Numbers, Decision and Control Statements.Real-time Operating Systems (RTOS), Basic concepts of RTOS and its types, Task, process & threads, interrupt routines in RTOS, Multiprocessing and Multitasking, Preemptive and non-pre-emptive scheduling, Task communication shared memory, message passing, Concurrency, Re-entrancy, Intertask communication, Inter process Communication – synchronization between processes-semaphores, Mailbox, pipes, priority inversion, priority inheritance, Implementation of RTOS with some case studies.

**Development tools and Programming**: Hardware and Software development tools, Code warrior tools- Project IDE, Compiler, Assembler and Debugger, JTAG and Hardware Debuggers, Interfacing Real Time Clock and Temperature Sensors with I2C and SPI bus.

**Case Study: Embedded System Application using Microcontrollers:** Product specification, Hardware design, Software design, System configuration, Integration of HW & SW, Product testing, Performance tools, Bench marking, Reports, User manual. – RTOS Micro Controller -issues in selection of processors.

**Laboratory Work**:

Programming of microcontroller with Integrated development environment (IDE), Use of JTAG and Hardware Debuggers, Input Devices and Output Devices with their Programming, programming for Interrupts, Clock Functions, LCD interfacing, Interfacing Keypad and Switch Debouncing, ADC, DAC, Real Time Clock, Temperature Sensors with I2C and SPI bus. Interfacing to Motor, LCDs, Transducer, RS-232 Interface and their Examples.

**Course learning outcome (CLO):**After the completion of the course the students will be able to

1. Express the building block of microcontrollers and specifically S12X architecture.
2. Elucidate the C-programming using IDE like code warrior for S12X microcontroller and can develop the programs for timers, PWM etc.
3. Demonstrate the interfacing modules (ADC, LCD etc.) in control applications.
4. Express understanding of real time operating system.

***Recommended Books:***


1. *Barrett, S.F. and Pack, J.D., Embedded Systems, Pearson Education (2008).*
2. *Haung, H.W., The HCS12 / 9S12: An Introduction to Software and Hardware Interfacing, Delmar Learning (2007).*
3. *Fredrick, M.C., Assembly and C programming for HCS12 Microcontrollers, Oxford University Press (2005).*
4. *Ray, A.K., Advance Microprocessors and Peripherals – Architecture, Programming and Interfacing, Tata McGraw□Hill (2007)*


**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 25 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 30 |

## PEI235: MICROCONTROLLER BASED SYSTEM DESIGN

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 2 | 4.0 |

**Course Objectives:**To understand the concepts of microcontroller based system, to enable design and programming of microcontroller based system

**Review of 8-bit microcontrollers:**Introduction to 16-bit microcontrollers, Introduction to 32-bit ARM microcontrollers Architecture, Functional blocks, Programmer's model, Timer, Counter, Interrupts, ISR, GPIO. A/D configuration and interfacing.

**Assembly and C-programming:** ARM microcontrollers, Programming for Timer, Delays, Port interfacing, LED, A/D, LCD and Keypad programming. Introduction to Rs232, Rs485, CAN, Ethernet, Wireless 802.11 standards/protocols. MODBUS

**Data communication and interfacing:** communication using I2C, SPI, RS232, RS485, CAN, and CAN, USB , Bluetooth, protocols. Interfacing with Optocoupler/Relay, RTC, EEPROM, GPS, GPRS, Ethernet interface design principles.

**Introduction to RTOS:**A case study based on 32-bit ARM Cortex microcontrollers for Web monitoring of a system using transducers and display running free RTOS.

**Laboratory Work:**Basic programming of ARM microcontroller, Programming of Timer/counters, Port interfacing, LED, A/D, LCD and Keypad. Interfacing with I2C, SPI, RS232, RS485, CAN, RTC, EEPROM, GPS, Ethernet and CANBUS.

**Minor Project:**

Designing of signal and data acquisition circuits related to sensors and control

**Course learning outcome (CLO):**

1. Review 8-bit microcontrollers
2. Implement assembly and c-program of ARM microcontrollers.
3. Design of basic circuits for ARM microcontroller.
4. Design interfacing circuits for ARM microcontroller.

***Recommended Books:***


1. *Elahi, A., Arjeski, T., ARM Assembly Language with Hardware Experiments, Springer, (2014)*
2. *Hintenaus, P. ,Engineering Embedded Systems, Springer, (2015)*


**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|

| | |
|---|---|
| MST | 25 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 30 |

## PEI237 : NONLINEAR CONTROL SYSTEM

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 2 | 4.0 |

**Course Objective:** To understand different types of nonlinearities present in system, their stability analysis and controller design for some specific nonlinear system

**Introduction:** Linear versus nonlinear systems, common nonlinearities (saturation, dead-zone, on-off non-linearity, backlash, and hysteresis)

**Describing function analysis**: Analysis of common nonlinearities (saturation, dead-zone, on-off non-linearity, backlash, and hysteresis) using describing function method; Reliability of describing function analysis; Compensation and design of nonlinear system using describing function.

**Phase plane analysis**: Phase portraits; Singular points characterization; Analysis of nonlinear systems using phase plane technique; Existence of limit cycles.

**Linearization:**Exact linearization; input-state linearization; input-output linearization.

**Concept of stability:** Stability in the sense of Lyapunov and absolute stability; Zero-input and BIBO stability; Second (or direct) method of Lyapunov stability theory for continuous and discrete time systems; Aizermans and Kalmans conjecture.

**Construction of Lyapunov function:** Methods of Aizerman, Zubov; variable gradient method.

**Stability analysis of nonlinear system:** Lure problem; Popovs stability criterion; generalized circle criterion; Kalman-Yakubovich-Popov Lemma; Popovs hyperstability theorem; Disturbance issues in nonlinear control.

**Concept of variable-structure system and sliding mode control**: Reaching condition and reaching mode; implementation of switching control laws; Reduction of chattering in sliding and steady state mode.

**Laboratory Work:**Analysis of nonlinearity using describing function method and phase plane method; Linearization of nonlinear system; Stability analysis of nonlinear system using Lyapunov function with major focus on Linear Matrix Inequality; Simulation of Variable Structure System.

**Minor Projects:** Some design examples of nonlinear systems such as the ball and beam, flight control, magnetic levitation and robotic manipulator etc; Approximate solution of nonlinear system using the perturbation method and averaging method.

**Course learning outcome (CLO):**

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

1. *Analyze nonlinear systems using describing function and phase plane methods*
2. *Linearize non linear systems using different methods*

3. *Analyse stability of nonlinear systems*
4. *Synthesize controller for feedback systems*

***Recommended Books:***


1. *H. K. Khalil, Nonlinear Systems, Prentice Hall, 2002*
2. *M. Vidyasagar, Nonlinear Systems Analysis, Society for Industrial and Applied Mathematics, 2002*


**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 25 |
| EST | 45 |
| Sessionals (May include Assignments/ Tutorials/ Quizzes// Lab Evaluations) | 30 |

## PEI236: WIRELESS SENSOR NETWORK

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 2 | 4.0 |

**Course Objectives:**To understand the concepts of wireless sensor network and IoT for application development

**Introduction to wireless sensor networks:**

Introduction to computer and wireless sensor networks, Motivation for a network of Wireless Sensor nodes- Sensing and sensors-challenges and constraints, architecture of WSN, sensing subsystem, processor subsystem-communication interfaces-prototypes, Application of Wireless sensors- Introduction of Tiny OS Programming and TOSSIM Simulator.

Internet of Things, definition, Scope, Structure of IoT, An Architectural Overview, M2M and IoT Technology Fundamentals- Devices and gateways, Local and wide area networking, Data management

**Standards and protocols:** WSN Time synchronization protocols, IEEE802.11, IEEE802.15, Bluetooth, ZigBee, 6LowPAN, NFC (IEC18000-3).

**Sensors:** Sensors for IoT Applications, Industrial sensors, Temperature Sensor/ Optical Sensor/ MEMS and Smart Sensors, Integrated IoT Sensors, Sensors' Swarm, Interacting with the hardware.

**Cloud Architecture Basics :** The Cloud-Hype cycle, metaphorical interpretation, cloud architecture standards and interoperability, Cloud types; IaaS, PaaS, SaaS, Benefits and challenges of cloud computing, public, private clouds community cloud, cloud service provider for application development: Google, Amazon, IBM, NI cloud portal.

**Applications and Scope**: Smart City-Smart grid, Smart Water Networks, Intelligent Transportation, Smart Homes. Agriculture- Smart Cultivation, Harvesting and Irrigation, Healthcare, Artificial Intelligence and Machine Learning.

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

1. *Elucidate basic concepts of wireless sensor network and IoT*
2. *Select communication protocol for application development*
3. *Interface wireless sensor network with application sensors*

***Recommended Books:***

1. *W. Dargie, C. Poellabauer , Fundamentals of Wireless Sensor Networks, Theory and Practice, Wiley Series on wireless Communication and Mobile Computing, 2011*

2. *J. Holler, V. Tsiatsis, C. Mulligan, S. Avesand, S. Karnouskos, D. Boyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", 1st Edition, Academic Press, 2014.*
3. *N. Ida, Sensors, Actuators and Their Interfaces, Scitech Publishers, 2014.*
4. *G. Reese, Cloud Application Architectures: Building Applications and Infrastructure in the Cloud. Sebastopol, CA: O'Reilly Media, Inc. (2009).*

**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 25 |
| EST | 45 |
| Sessionals (May include Assignments/ Tutorials/ Quizzes/ / Lab Evaluations) | 30 |

## PEI238 ROBOTIC TECHNOLOGY

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 2 | 4.0 |

**Course Objectives**: To understand the concepts of Robotic technology, to enable selection, programming and design of robotic systems

**Fundamentals:**Historical information, robot components, Robot characteristics, Robot anatomy, Basic structure of robots, Resolution, Accuracy and repeatability

**Robot Kinematics:**Position Analysis forward and inverse kinematics of robots, Including frame representations, Transformations, position and orientation analysis and the Denavit–Hartenberg representation of robot kinematics, The manipulators, The wrist motion and grippers.

**Inverse Manipulator Kinematics:**Differential motions and velocity analysis of robots and frames.

**Robot Dynamic Analysis and Forces:**Analysis of robot dynamics and forces, Lagrangian mechanics is used as the primary method of analysis and development.

**Trajectory Planning:** Methods of path and trajectory planning, Both in joint–space and in Cartesian–space.

**Actuators and Sensors:**Actuators, including hydraulic devices, Electric motors such as DC servomotors and stepper motors, Pneumatic devices, as well as many other novel actuators, It also covers microprocessor control of these actuators, Mechatronics, Tactile sensors, Proximity and range sensors, Force and torque sensors, Uses of sensors in robotics.

**Robot Programming:**Robot languages, Method of robots programming, Lead through programming methods, A robot programs as a path in space, Motion interpolation, WAIT, SIGNAL and DELAY commands, Branching capabilities and limitation of lead through methods and robotic applications.

**Fuzzy Logic Control:**Basic principles of fuzzy logic and its applications in microprocessor control and robotics.

**Course learning outcome (CLO): After the completion of the course the students will be able to**

1. Handle robot components and study its characteristics
2. Learn about robot kinematics.
3. Analyze the differential motions, inverse manipulator kinematics.
4. Perform robot dynamic analysis and trajectory planning.

5. Use actuators and sensors in robot.
6. Program systems for different applications.

***Recommended Books:***


1. *Gonzalez, R. C., Fu, K. S. and Lee, C.S.G., Robotics Control Sensing, Vision and Intelligence, McGraw Hill (1987).*
2. *Koren,Y., Robotics for Engineers, McGraw Hill (1985).*
3. *Niku, S.B., Introduction to Robotics, Analysis, Systems, Applications, Dorling Kingsley (2006).*
4. *Predko, M., Programming robot controllers, McGraw Hill (2002).*


**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 25 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 30 |

## PEI302: BIOMECHANICS AND REHABILITATION

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 0 | 3.0 |

**Course Objectives:**To understand the concepts of Biomechanics, to enable to apply biomechanics for rehabilitation

**Introduction:** Introduction to Biomechanics, Movements of the body, Skeletal System, Naming characteristics that describe muscle features, Muscular system, Regional anatomical kinesiology.

Scope of Mechanics in Medicine: Orthopedics, Cardiology, Exercise Physiology, Surgery, Biomechanics in Orthopedics: Principles, Introduction to the structure and mechanics of the musculoskeletal system, Application of mechanics to bone, Tendon, Ligaments and other biological materials, Definition of biological tissue and orthopaedic device mechanics.

**Engineering Concepts in Rehabilitation Engineering Anthropometry**: Methods for Static and Dynamic Measurements: Area Measurements, Measurement of Characteristics and Movement, Measurement of Muscular Strength and Capabilities, Measurement Tools and Processes in Rehabilitation Engineering: Fundamental Principles, Structure, Function, Performance and Behaviour.

Engineering Concepts in Sensory Rehabilitation Engineering: Sensory Augmentation and Substitution, Visual System, Visual Augmentation, Tactual Vision Substitution and Auditory Vision Substitution, Auditory System: Auditory Augmentation, Audiometer, Hearing Aids, Cochlear Implantation, Visual Auditory Substitution, Tactual Auditory Substitution, Tactual System.

**Orthopedic**Prosthetics and Orthotics in Rehabilitation: Engineering Concepts in Motor Rehabilitation, Applications. Intelligent Prosthetic Knee, A Hierarchically Controlled Prosthetic Hand, A Self-aligning Orthotic Knee Joint, Externally Powered and Controlled Orthotics and Prosthetics, FES Systems–Restoration of Hand Function, Restoration of Standing and Walking, Hybrid Assistive Systems (HAS).

**Active Prostheses:** Active above knee prostheses, Myoelectric hand and arm prostheses: Different types, Block diagram, Signal flow diagram and functions.

**Course learning outcome (CLO):** After the completion of the course the students will be able to

1. Apply Orthopedics, Cardiology, Exercise Physiology, Surgery, Biomechanics in Orthopaedics

2. Engineer rehabilitation engineering anthropometry
3. Use sensory rehabilitation engineering concepts.
4. Rehabilitation using orthopedic prosthetics and orthotics in
5. Handle applications of active prostheses.

***Recommended Books:***


1. *Bronzino and Joseph, Handbook of Biomedical Engineering. CRC Press (2004).*
2. *Ghista, D.N., Orthopedic Mechanics, Academic Press (2008).*
3. *Horia-Nocholai, T. and Jain, L.C., Intelligent Systems and Technologies in Rehabilitation Engineering, CRC Press (2001).*
4. *Park, J.B., Bio-materials: Science and Engineering, Springer (1984).*
5. *Robinson C.J, Rehabilitation engineering, CRC Press (2006).*


**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 30 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 25 |

## PEI207: COGNITIVE ENGINEERING

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 0 | 3.0 |

**Course Objectives:** To understand the concepts of Cognitive Neuroscience, to enable design experiments related to Cognitive Engineering

**Overview of Nervous System:**Cellular components of Nervous system; Organizational Principles of Neural System: Organelles and Their Functions; Membrane Potential and Action Potential; Synaptic transmission and Cellular signalling (Basic Neurochemistry)

**Introduction to Cognitive Neuroscience:**General Introduction and philosophy of Mind; Cellular/Molecular Basis of Cognition; Visual perception and Object recognition; Spatial Processing and Attention; Concept Formation, Logic and Decision Making; Problem Solving, Creativity and Intelligence; Learning Memory (I)- Memory Models and Short Term Memory; Learning Memory (II)- Long term potentiation and Long Term Memory

**Psychophysiology:**Tools of physiology - experimental approach; Electroencephalography for cognitive perspectives; Event related potentials (ERP) for cognitive events; Electrodermal Activity(EDA)and Cardiovascular psychophysiology; Polysomnography for Sleep research

**Functional neuro-imaging of cognition and Image processing**: PET(Positron Emission Tomography); Concepts of NMR (Nuclear Magnetic Resonance) and fMRI (Functional MRI); DTI(Diffusion Tensor Imaging); Image processing for brain functioning

**Signal Processing and Neural engineering:**Physiological signals– Generation and Sensing; Bio-signal acquisition; Data pre-processing; Feature Extraction; Applications:-Brain Computer Interface and Neuro-feedback

**Research methodology:**Designing an experiment; Issues in Human research and Ethics; Statistical data analysis

**Minor Project :**

Development of cognitive assessment techniques around PEBL

**Course learning outcome (CLO):** After the completion of the course the students will be able to

1. Acquire basic knowledge of cognitive neuroscience.
2. Acquire basic knowledge of psychophysiology
3. Acquire basic knowledge of functional neuro-imaging of cognition and image processing
4. Apply signal processing and neural engineering in relation to cognitive engineering.
5. Design experiments related to cognitive engineering

***Recommended Books:***


1. *Dale Purves, Neuroscience, Sinauer Associates, Inc (2001)*
2. *Handbook of Psychophysiology, Cambridge University Press (Third Edition)(2007)*
3. *Michael S. Gazzaniga, The Cognitive Neurosciences, (Fourth Edition) MIT, (2009)*
4. *Robert L. Solso,Otto H. MacLin, M. Kimberly MacLin, Cognitive Psychology (Eighth Edition), Pearson (2007)*
5. *PetterLaake, Haakon BreienBenestad,Research Methodology in the Medical and Biological Sciences, Academic Press (2007)*


**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 30 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 25 |

## PEI213: ENVIRONMENT MONITORING INSTRUMENTATION

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 0 | 3.0 |

**Course Objectives:**To understand the concepts of pollution monitoring, to enable select, design and configure pollution monitoring instruments

**Review:**Elemental analysis of C, H, N, S and O, Spectrometry, Optical Techniques, Chromatography, Potentiometer, X-ray Analytical Methods

**Air Pollution:** Impact of man of the environment: An overview, Air pollution sources and effects, Metrological aspect of air pollutant dispersion, Air pollution sampling and measurement, Air pollution control methods and equipment, Air sampling techniques, soil pollution and its effects, Gas analyzer, Gas chromatography, Control of specific gaseous pollutants, Measurement of automobile pollution, Smoke level meter, CO/HC analyzer.

**Water pollution:** Sources And classification of water pollution, Waste water sampling and analysis, marine pollution, Waste water sampling techniques and analyzers, Gravimetric, Volumetric, Calometric, Potentiometer, Flame photometry, Atomic absorption spectroscopy, Ion chromatography, Instruments used in waste water treatment and control, Solid waste management techniques.

**Pollution Management:**Management of radioactive pollutants, Noise level measurement techniques, Instrumentation for environmental pollution, Monitoring and audit, Instrumentation setup for pollution abatement. Noise pollution and its effects, social and political involvement in the pollution management system

**Minor Project :**

1. Investigate the status of various pollutants.
2. Investigate recent advancements in handling pollutants/ pollutant's effects.
3. Explore latest research related to ill effects of pollutants.

**Course learning outcome (CLO):** After the completion of the course the students will be able to:

1. Study air pollution sources and its effects
2. Analyse air pollution sources and its effects
3. Investigate sources and classification of water pollution
4. Perform air pollution sampling and measurement, air pollution control methods and equipment, air sampling techniques

5. Monitor and audit management, noise level measurement techniques, instrumentation for environmental pollution.

***Recommended Books:***


1. *Bhatia, H.S., A Text Book in Environmental Pollution and control, Galgotia Publication (1998).*
2. *Dhameja, S.K., Environmental Engineering and Management, S.K Kataria (2000).*
3. *Rao, M.N. and Rao, H.V., Air Pollution, Tata McGraw Hill (2004).*
4. *Rao. C.S., Environmental Pollution Control, New Age International (P) Limited, Publishers (2006) 2nd ed.*


**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 30 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 25 |

## PEI310: POWER SYSTEM INSTRUMENTATION

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 0 | 3.0 |

**Course Objectives:**To understand the concepts of Power System Instrumentation, to enable design an selection of Power System Instrumentation sub-systems

**Power System Introduction:**Structures of power systems. Conventional and unconventional sources of electric energy, Representation of power system components, Per unit (PU) system. Representation of power system components, Per unit (PU) system.

**Energy Storage:**Energy storage methods, Secondary batteries, Fuel cells, Hydrogen energy system, Energy management systems, Electronics instrumentation schemes adopted for energy conservation and energy audit.

**Transmission lines:**Inductance and resistance of transmission lines, Capacitance of transmission lines, Characteristics and performance of power transmission lines, Instrumentation scheme used for HVDC and HVAC transmission systems.

**Automatic Generation and Voltage Control:**Load frequency control, Automatic voltage control, Digital LF controllers, Decentralized control, Load–flow studies, Automatic load dispatch using computers, Software used for optimum generator allocation, Instrumentation scheme for operation and maintenance of generation units.

**Instrumentation schemes for monitoring and control:**Instrumentation schemes for monitoring and control of various parameters of power plants through control panels, Computer based data acquisition system for power plant operation, Maintenance and protection, Use of SCADA in power systems.

**Signal Transmission Techniques:** Analog pulse and digital modulation, AM, FM, AM and FM Transmitter and receiver, Digital Transmission Technique, Error detection.

**Power Plant Instrumentation:** Hydroelectric Power Plant Instrumentation, Thermal Power Plant Instrumentation.

**Minor Project :** Nil

**Course learning outcome (CLO):** After the completion of the course the students will be able to

1. Handle automatic generation and voltage control in power generation station.
2. Identify instrumentation schemes for monitoring and control
3. Apply signal transmission techniques for sharing process information
4. Analyse cases of power plant instrumentation

***Recommended Books:***


1. *Chakrabarti, A., Soni, M.L., Gupta, P.V. and Bhatnagar, U.S., A Text Book on Power System Engineering, Dhanpat Rai and Co. (P) Ltd. (2008).*
2. *Nath, R., and Chandra,M., Power System Protection and Switchgear, New Age International (P) Limited, Publishers (2003).*
3. *Liptak, B.G., Instrument Engineers Handbook, Butterworth, Heinemann (2002) 3rd ed.*


**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 30 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 25 |

## PEI327: SYSTEM IDENTIFICATION AND ADAPTIVE CONTROL

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 0 | 3.0 |

**Process Identification**: Analysis of process models, the Laplace transform, input output process model, state space process models, discrete time process models. Models of linear dynamical systems, identification from step responses, first order system, under-damped second order system, system of a higher order. Least squares methods, recursive least square method, modification of recursive least squares, identification of a continuous time transfer function.

**Control:** Closed loop system, steady state behaviour, control problem indices, PID controller, PID controller structures, set point weighting, rules for controller selection. Optimal process control, problem of optimal control and principle of minimum, feedback Optimal control, optimal tracking servo problem and disturbance, Rejection, dynamical programming, observers and state observers, Analysis of state feedback with observes and polynomial pole Placement. Adaptive control, deterministic self tuning regulators, stochastic and predictive self tuning regulators, model reference adaptive systems, gain scheduling controllers

**Course learning outcome (CLO):**After the completion of the course the students will be able to

1. Develop input output process model, state space process models, discrete time process models.
2. Use the concept of least square methods and recursive least square method.
3. Solve optimal control problem and design of optimal controller.
4. Design adaptive control system.

***Recommended Books:***

1.*Process Modelling, Identification and control, J. Mikles and M. Fikar, Springer.*

*2. Adaptive Control, K.J. Astrom, PHI.*

**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 30 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 25 |

## PEI341: OPTO–ELECTRONIC INSTRUMENTATION

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 0 | 3.0 |

**Course Objectives:**To understand the concepts of Ultrasonic and Opto-Electronics based instrumentation, to enable selection and design of Ultrasonic and Opto-Electronics based instrumentation

**Ultrasonic based Instrumentation System:**Physics of sound, Ultrasonic waves, Generation and detection, Ultrasonic transducers, Pulse-echo method, Doppler method, Focusing system, industrial and medical application of Ultrasound.

**Introduction to Opto Electronics:**Principle, Advantages and disadvantages of Fiber optics, Fiber optic transducers, Extrinsic and Intrinsic Fiber optic transducers, Multimode polarization sensors, Multimode grating sensors, Industrial applications of fiber optic transducers in measurement of current, Voltage, Pressure, Temperature, Vibration, flow, Fluid level.

**Optical Instrumentation:**Principle, Advantages and disadvantages of fiber optics, Wavelength isolation devices, Optical filters, Arc, Spark and Flame sources, Mono-chromators, Radiation sources and their uses in Spectrometers, Fiber Optics: Analog and digital signal transmission, Modulation, Electro-optic modulators, Magneto Optic Devices.

**Optical Techniques and Spectrometeric Applications**: working, Principle and Construction of Turbidimetry, Nephelometry, Polarimetry and Refractory, Atomic absorption spectrometry, Absorption spectrometry, Emission spectrometry, spectro-photometry, Mass spectrometry.

**Lasers Based Instrumentation System:**Principles of operation, properties, optical resonators, emission and absorption of radiation in a two level systems, Axial and transverse Laser modes, Device fabrication, Measurement of laser characteristics, Application of laser in biomedical science, Defense systems, Instrumentation systems and Robotics

**Course learning outcome (CLO):**

1. Use ultrasonic based instrumentation.
2. Use opto-electronics for signal conditioning.
3. Use optical techniques and spectrometric methods of analysis
4. Use laser techniques in biomedical science, defence systems instrumentation systems, robotics

***Recommended Books:***

1. *Gerd, K., Optical fiber communication, McGraw-Hill (2007) 4th ed.*
2. *Luxon, T. and Parker, D.E., Industrial Lasers and Their Applications, Prentice-Hall of India Private Limited (2005) 2nd ed.*
3. *Pataranabis, D., Principles of Analytical Instrumentation, Tata McGraw-HillPublishing Company (2003) 2nd ed.*

Evaluation Scheme:

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 30 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 25 |

## PEI342: INDUSTRIAL ELECTRONICS

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 0 | 3.0 |

**Course Objectives:**To understand the concepts of industrial electronics, to enable selection an design of industrial electronic appliances

**Introduction:**Review of solid state devices, Switch characteristics and their comparison, Semi–conductor materials.

**Industrial Electronic converters:** Phase controllers, Dual converters, Choppers, Cyclo–converters, Inverters, Power Supplies, Multi-vibrators, Switching Transistors and Timers.

Design of Industrial Electronic Devices: Design and analysis of electromagnetic control of electric drives, Their characteristics, Operating modes, Motor Control, Heating and Welding Control, Opto-electronics and Optical Fibres, Servomotors and their applications.

**Industrial application of Industrial Electronic Devices:**Control of electric drives used in manufacturing and process industries, Protection of electric drives using solid state devices and controllers, Analysis of drive systems.

**Testing for drive controllers**: Design and testing of microprocessor based drive controllers, Analysis of solid state control of industrial drives, Design and testing of thyristor based controllers for electric drives.

**A C Power Conditioner**: Introduction and applications

**Minor Project :**Nil

**Course learning outcome (CLO):** After the completion of the course the students will be able to

1. Handle knowledge about solid state devices
2. Design industrial electronic converters and devices
3. Handle industrial application of industrial electronic devices and their control
4. Test drive controllers, microprocessor based drive controllers and their analysis
5. Implement power conditioner and applications

***Recommended Books:***


1. *Biswanath, P., Industrial Electronics and Control, Prentice Hall of India (2003).*
2. *Biswas, S.N., Industrial Electronics, Dhanpat Rai and Co. (P) Ltd. (2004).*

**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 30 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 25 |

## PEI343: MICRO-SENSORS AND ACTUATORS

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 0 | 3.0 |

**Course Objectives:**To understand the concepts of working of Micro-sensors and actuators, to enable selection, design and configuration of Micro-sensors and actuators

**Over View of Mems and Microsystems:**Definition – historical development, fundamental properties, micro fluidics, design and fabrication micro-system, microelectronics, working principle and applications of micro system.

**Materials, Fabrication Processes and Micro System Packaging:** Substrates and wafers, silicon as substrate material, mechanical properties of Si, Silicon Compounds silicon piezo resistors, Gallium arsenide, quartz, polymers for MEMS, conductive polymers. Photolithography, photo resist applications, light sources in implantation, diffusion process oxidation – thermal oxidation, silicon diode, chemical vapour deposition, sputtering - deposition by epitoxy–etching – bulk and surface machining – LIGA process Micro system packaging – considerations packaging – levels of micro system packaging die level, device level and system level.

**Micro-Sensors and Micro-Actuators:**Electrostatic sensors, Parallel plate capacitors,, Applications, Inter-digitated Finger capacitor, Comb drive devices, Thermal Sensing and Actuation, Thermal expansion, Thermal resistors Applications, Magnetic Actuators, Micromagnetic components.

**Case studies of MEMS in magnetic actuators:**Piezoresistive sensors – Piezoresistive sensor materials, Stress analysis of mechanical elements, Applications to Inertia, Pressure, Tactile and Flow sensors. Piezoelectric sensors and actuators piezoelectric materials, Applications to Inertia, Acoustic, Tactile and Flow sensors.

**Microactuator systems:** Ink-Jet printer heads, Micro-mirror projector (Digital Light Processor), Microactuator examples, microvalves, micropumps, micromotors, inching motors.

**Bio-MEMS:** Introduction to Bio MEMS, Cell Electrophysiology, Silicon Micro-fabrication, Micro-fluidics and Bio-MEMS applications, MEMS for Drug delivery.

**Communication standard:** IEEE P1451 standard for smart transducer interface for sensors and actuators

**Minor Project:** Nil

**Course learning outcome (CLO):** After the completion of the course the students will be able to

1. Exhibit knowledge of fundamental properties of MEMS system.
2. Explain the fabrication processes of MEMS.
3. Describe various types of micro sensors and micro actuators along with their applications
4. Elucidate the use of Bio-MEMS for various applications.

***Recommended Books:***


1. *Gardner, J. W., Microsensors, Principles and Applications, John Wiley (2008).*
2. *Gregory T. Korvacs, Micromachined Transducer sourcebook, McGraw Hill (1998).*
3. *Turner, A.P.F., and Wilson, G.S., Biosensors Fundamentals and applications, Oxford University Press (2005).*
4. *William T., Micromechanics and MEMS, IEEE Press (1997).*
5. *Tai – Ran Hsu, MEMS and Microsystems Design and Manufacture, Tata-McGraw Hill, New Delhi, 2002.*
6. *Elwenspoek, M.,Weigerink, R., Mechanical Microsensors, Springer, 2001.*


**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 30 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 25 |

## PEI344: REMOTE SENSING AND TELEMETRY

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 0 | 3.0 |

**Course Objectives:**To understand the concepts of remote sensing, to enable selection and design of remote sensing and telemetry systems

**Remote Sensing:**Electromagnetic radiation, Energy interactions, Energy recording technology, Across track and along track scanning, Resolution, Multispectral remote sensing, Thermal remote sensing, Hyper Spectral Remote sensing, Microwave Remote sensing, LIDAR, Earth resource satellites, Application of remote sensing.

**Introduction to Telemetry:**Classification of Telemetry Systems: Voltage, current, Position, Frequency, and time. Components of Telemetering and Remote Control Systems. Quantization theory: Sampling theorem, Sample and hold, Data conversion: Coding.

Multiplexing: Frequency Division Multiplexing with constant bandwidth and proportional bandwidth, Demultiplexing; Time division multiplexers, Demultiplexers: Theory and circuits, Scanning procedure, Pulse Code Modulation (PCM) Technique.

**Data acquisition and distribution system**: Fundamentals of audio and radio telemetry systems, Digital Modulation and demodulation Techniques in Telemetry Systems. Standard for telemetry e.g. IRIG etc. Microwave links, Practical Telemetry Systems: Pipe line telemetry, Power system telemetry, Supervisory telecontrol systems, Introduction to ISDN.

**Minor Project :** Nil

**Course learning outcome (CLO):** After the completion of the course the students will be able to

1. Study remote sensing applications.
2. Use components of telemetring and remote control systems
3. Use data acquisition and distribution system, digital modulation and demodulation techniques in telemetry system

***Recommended Books:***


1. *Lillesand, M.T. and Ralph, W., Remote Sensing and Image Interpreation, John Wiley (2004) 6th ed.*
2. *Patranabis, P., Telemetry Principles, Tata McGraw–Hill Publishing Company (2004) 2nd ed.*
3. *Swobada, G., Telecontrol Method and Application of Telemetering and Remote Control, Von Nostrand, (1971).*

**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 30 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 25 |

## PEI345: COMPUTATIONAL ELECTROMAGNETIC

| L | T | P | Cr |
|---|---|---|---|
| 3 | 0 | 0 | 3.0 |

**Course Objectives:**To understand the concepts of computational electromagnetic, to enable analysis of numerical stability and dispersion

**Overview: Background:**The Heritage of the 1980's , The Rise of Partial Differential Equation Methods , Interdisciplinary Impact of Emerging Time-Domain PDE Solvers, History of Space-Grid Time-Domain Techniques for Maxwell's Equations , General Characteristics of Space-Grid Time-Domain Approaches : Classes of FD-TD and FV-TD Algorithms , Predictive Dynamic Range, Scaling to Very Large Problem Sizes: Algorithm Scaling Factors , Computer Architecture Scaling Factors , Defense Applications, Dual-Use Electromagnetic Technology.

**One–Dimensional Scalar Wave Equation:** Propagating-Wave Solutions, Finite Differences, Finite-Difference Approximation of the Scalar Wave Equation, Dispersion Relations for the One-Dimensional Wave Equation, Numerical Phase Velocity, Numerical Group Velocity, Numerical Stability: The Time Eigen value Problem, The Space Eigen value Problem, Enforcement of Stability.

Introduction to Maxwell's' Equations and the Yee Algorithm: Maxwell's Equations in Three Dimensions , Reduction to Two Dimensions : TM Mode, TE Mode , Reduction to One Dimension : TM Mode , TE Mode, Equivalence to the Wave Equation in One Dimension , Yee Algorithm.

**Numerical Stability:**Basic-Stability Analysis Procedure, TM Mode, Time Eigen value Problem, Space Eigen value Problem, Enforcement of Stability, Extension to the Full Three-Dimensional Yee Algorithm, Generalized Stability Problem: Boundary Conditions, Variable and Unstructured Meshing, Lossy, Dispersive, Nonlinear, and Gain Materials

**Numerical Dispersion:**Basic Procedure, Substitution of Traveling-Wave Trial Solution, Extension to the Full Three-Dimensional Yee Algorithm, Comparison with the Ideal Dispersion Case, Reduction to the Ideal Dispersion Case for Special Grid Conditions, Dispersion-Optimized Basic Yee Algorithm, Dispersion-Optimized Yee Algorithm with Fourth-Order Accurate Spatial Central Differences: Formulation, Example, Pros and Cons

**Course learning outcome (CLO): After the completion of the course the students will be able to**

1. Apply partial differential equation and time-domain methods for analysis.
2. Apply one–dimensional scalar wave equation
3. Handle the concept of maxwell's' equations and yee algorithm
4. Apply the numerical stability schemes
5. Apply the numerical dispersion techniques.

***Recommended Books:***


1. *Taflove, A. and Hagness, S.C., Computational Electrodynamics, Artech House (2006).*
2. *Sullivan, D.M., Electromagnetic Simulation Using the FDTD Method, IEEE Computer Society Press (2000).*


**Evaluation Scheme:**

| Evaluation Elements | Weightage (%) |
|---|---|
| MST | 30 |
| EST | 45 |
| Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations) | 25 |

**PEI XXX: Minor Project**

| L | T | P | Cr |
|---|---|---|---|
| 0 | 0 | 0 | 6.0 |

**Course Description**: The minor project is a post-graduate level course generally consisting of a semester long project and emphasizes on both technical and managerial skills. The Electronic Instrumentation and control is very fundamental core discipline having balanced execution of theoretical and practical concepts and hence there is an emphasis on hands-on development, process, and usage of various fundamental tools in addition to theory and basic concepts. Students will be involved in examining; analysing and reporting different target oriented projects

**Course Learning Objectives:**

1. Learn the Application of advanced concepts of various domains of Instrumentation and Control Engineering.
2. Analyze the design and optimize it with respect to requirements.
3. To be skilful in the requirements of project documentation.
4. Demonstrate, professional report writing skills, communication skills and team skills.

**Evaluation Scheme:**

| S. No | Evalauation Elements | Weightage (%) |
|---|---|---|
| 1 | Assesment by Faulty mentor | 30 |
| 3 | Panel of Examiner's (As prescribed by DoAA ) | 70 |

## PEI 391: SEMINAR

| L | T | P | Cr |
|---|---|---|---|
| 0 | 0 | 0 | 2.0 |

**Course Objectives**: To impart technical and research reading and writing skills to the students.

**Course Description**: The seminar is to work on a topic assigned by instructor/mentor. Topics can include reaction/personal position on current event topics related to electronic instrumentation and control. All assigned reading material will need to be completed before each meeting with mentor. It involves analytical thinking – commonly known as *critical thinking that* involves analyzing and evaluating information, often in order to work through a problem or decision This seminar assignment will challenge students to apply critical thinking skills to the selected individual's topic. The faculty supervisor of the seminar will continuously assess the progress of the works of the assigned student. Each student will have to submit a detailed report of the seminar along with a power point presentation..

**Course Learning Outcomes:**

After the completion of the course, the students will be able:

- To identify gaps for research work design goals and analyze possible approaches to meet given specifications with realistic engineering constraints.
- To understand modern engineering methods and tools.
- To prepare technical report
- To deliver presentation on the research topic

**Evaluation Scheme:**

| S. No. | Evaluation Elements | Weightage (%) |
|---|---|---|
| 1. | Panel of Examiner's (within department) | 70 |
| 2. | Assessment by Supervisor | 30 |

## PEI491: DISSERTATION

| L | T | P | Cr |
|---|---|---|---|
| **0** | **0** | **0** | **16.0** |

**Course Objectives**: To impart the knowledge to understand the research methodology, carry out research in thrust areas and write a comprehensive report.

**Course Learning Outcomes (CLO):**

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

- Design and implementation of identified research problem or industrial projects.
- Develop acumen for higher education and research.
- Write technical reports and publish the research work in referred journals, national and international conferences of repute.
- Foresee how their current and future work will influence/impact the economy, society and the environment.

**Evaluation Scheme:**

| S. No. | Evaluation Elements | Weightage (%) |
|---|---|---|
| 1. | Panel of Examiner's (As prescribed by DoAA ) | 50 |
| 2. | Assessment by Supervisor | 50 |