M.E. -ELECTRONIC INSTRUMENTATION AND CONTROL

Course Scheme

and

Syllabi

w.e.f. July 2017

Department of Electrical and Instrumentation Engineering

First Semester

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PEI101	Microcontroller and Embedded Systems	3	1	2	4.5
2.	PEI102	Digital Signal Processing and Techniques	3	1	2	4.5
3.	PEI103	Industrial Instrumentation and Control	3	0	2	4.0
4.	PEI104	Intelligent Techniques and Applications	3	1	2	4.5
5.	PEIXXX	Measurement Techniques	3	1	0	3.5
6.	PEI105	Process Modelling and Control	3	1	0	3.5
		Total	18	5	8	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.	PEI205	Digital Image Processing and Analysis	2	1	2	3.5
3.	PEI309	Optimal and Robust Control	3	1	2	4.5
4.	PEI203	Virtual Instrumentation and Applications	2	0	4	4.0
5.		Elective–I	3	1	0	3.5
6.		Elective–II	3	0	0	3.0
		Total	16	3	10	22.5

Third Semester

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PEI491	Dissertation (Start)				
2.	PEI392	Minor Project				6.0
3.	PEIXXX	Seminar (Dissertation based)				4.0
		Total				10.0

Fourth Semester

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PEI491	Dissertation (Continued)				16

List of Electives

Elective–I

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PEI306	Embedded System fundamentals and Programming	2	1	2	3.5
2.	PEI307	Industrial Electronics	3	1	0	3.5
3.	PEI202	Micro-Sensors and Actuators	3	1	0	3.5
4.	PEI207	Remote Sensing and Telemetry	3	1	0	3.5
5.	PEI311	Robotic Technology	3	1	0	3.5
6.	PEI301	Advanced Soft Computing Techniques	2	1	2	3.5
7.	PEI303	Biometric Techniques	2	1	2	3.5
8.	PEI305	Computational Electromagnetic	3	1	0	3.5
9.	PEIXXX	Embedded Control System	2	1	2	3.5
10.	PEI308	Microcontroller based System Design	2	1	2	3.5

Elective–II

S. No.	Course No.	Course Name	L	T	P	Cr
1.	PEI302	Biomechanics and Rehabilitation	3	0	0	3.0
2.	PEI204	Cognitive Engineering	3	0	0	3.0
3.	PEI206	Environmental Monitoring Instrumentation	3	0	0	3.0
4.	PEI310	Power System Instrumentation	3	0	0	3.0
	PEIXXX	System Identification and Adaptive Control	3	0	0	3.0
5.	PEI312	Ultrasonic and Opto–Electronic Instrumentation	3	0	0	3.0

Total Number of Credits: 73

PEI101: MICROCONTROLLERS AND EMBEDDED SYSTEMS

L	T	P	Cr
3	1	2	4.5

Course objective: To understand the concepts of Hardware of various microcontrollers to enable Programming and Interfacing of microcontroller.

8051 Microcontroller: Architecture, TIMERS and Counters, Interrupts, Serial Communication, Addressing modes, instruction set and, Jumps, Loops, Interrupts and returns, Timers and Interrupts, I/O programming.

PIC Microcontrollers: Introduction to 16 and 18F families, Architecture and programming, TIMERS and Counters, Interrupts, SPI, I2C, I/O programming and interfacing.

Hardware Interfacing: Interfacing with LEDs, Seven Segment, Sensors, Basic concepts of LCD, ADC, DAC, Relays etc. and their interfacing to microcontroller.

Laboratory work (if any): Laboratory Work: PC Interfacing using RS232, Parallel port with LED, Seven Segments, LCD etc. 8051 assembler, Compilers and simulator, Programming concepts using Simulator, Microcontroller Interfacing with LEDs, Seven Segment, LCD, Sensors, ADC, DAC etc.

Course learning outcome (CLO):

1. Learn basic hardware of various microcontrollers.
2. Assembly and programming concepts, jump and call instructions.
3. Hardware interfacing of microcontroller with led's, seven segment, sensors.
4. Introduction to 16-bit microcontrollers.

Recommended Books:

1. *Ayala J.K., The 8051 Microcontroller: Architecture, programming and applications, Penram International (2005) 3rd ed.*
2. *Mazidi,E. and Mazidi,F., The 8051 Microcontroller and Embedded Systems, Prentice-Hall of India (2004) 2nd ed.*
3. *Peatman J., Embedded system Design using PIC18Fxxx, Prentice Hall, 2003.*

Evaluation Scheme:

Evaluation Elements	Weightage (%)
MST	25
EST	35
Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations)	40

PEI102: 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.

Discrete Time Signals and Systems: Introduction, Discrete time signals as array of values, Standard discrete time signals, Classification of discrete time signals, Discrete time systems and their classifications, Linear Time Invariant (LTI) Systems, Difference Equations: Finite Impulse Response (FIR) systems, Infinite Impulse Response (IIR) systems, Non-recursive Systems and Recursive Systems and representation of discrete time systems via difference equations, 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.

The z-Transforms: Introduction, z-transform, Properties of z-transform, Inverse z-transform, System function and Pole-zero plots from z-transform, Causality and Stability in terms of z-transform, Bilateral z-transform, Computation of z-transform

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.

Digital Filter Structure: Describing Equation of digital filter, Structures for FIR Systems: Direct Form Structure, Cascade Form Structure, Frequency Sampling Structure and Lattice Structure, Structure for IIR Systems: Direct Form Structures (Form-I and Form-II), Cascade Form Structure, Parallel Form Structure and Lattice Structure, Representation of Structures using Signal Flow Graph.

Design of Digital Filters: Characteristics of Practical Frequency Selective Filters, Design of FIR Filters using Windows: Rectangular, Bartlett, Hanning, Hamming and Blackman, Design of IIR Filters from Analog Filters, Frequency Transformations.

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.

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

1. Identify various type of discrete signal and systems.
2. Analyse frequency domain response of systems.
3. Design various type of filter.

4. Implement filter structures.

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	35
Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations)	40

PEI103: 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, 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 of Field bus and other IEEE Standards.

Laboratory work: Valve Characteristics, P/I, I/P converter, Valve positioner, PLC, Programming and interfacing, Level and Flow control on basic process rig, Programming robotic arm.

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

1. Acquire knowledge about industrial instrumentation and control
2. Handle PLC and DCS system
3. Programme and analyze robotic system
4. Interface the hardware and software through buses 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 automatio, 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, Butterwirth Heinemann (2003) 4th ed.*

Evaluation Scheme:

Evaluation Elements	Weightage (%)
MST	25
EST	40
Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations)	35

PEI104: INTELLIGENT TECHNIQUES AND APPLICATIONS

L	T	P	Cr
3	1	2	4.5

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

Overview of Intelligent techniques: Intelligent techniques, Concept of artificial intelligence.

Artificial Neural Networks: Artificial Neuron models, Types of activation functions, Neural network architectures, Neural Learning: Correlation, Competitive, Feedback based weight adaptation, Evaluation of networks, Quality of results, Generalizability, Computational resources, Supervised learning: Perceptrons, linear separability, Multilayer networks, Back propagation algorithm and its varianta, Unsupervised learning, Winner–take all networks, Adaptive resonance theory, Self organizing maps, Hopfield networks, Boltzmann machines, Support Vector Machine, Typical application in identification, Optimization, Pattern recognition. Applications of ANN in 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, De fuzzy controllers, Type–2 Fuzzy Logic Controllers, Multi–layer and other advanced Fuzzy Logic Models, Applications of Fuzzy Logic. Applications in Process control, Robotics and other industrial control methods.

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.

Expert Systems: General Concepts of Expert System, basic building block of expert systems, knowledge base concepts, rule based expert system, computerized expert systems, industrial applications of expert systems.

Laboratory work: Experiments around Input and output using Fuzzy logic, Graphical analysis of various control systems using Fuzzy logic, Dynamical and optimal training for neural networks, Algorithms around GA.

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

1. Apply artificial intelligence and expert system concepts to control process.
2. Use of evolutionary computation algorithm to solve engineering problems.
3. Acquire knowledge about hybrid search techniques.
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	40
Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations)	35

PEI XXX: 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, Method of least squares, Curve fitting, Graphical analysis, rejection of data.

Static and Dynamic characteristics: Dynamic analysis of instrumentation system, relative merits of analytical and experimental modelling of dynamic behaviour, Response of zero, first and 2nd 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, and Shaping) signal manipulation, Data transmission, Data presentation, Inverse transducers). Review of conventional devices, technologies and introduction to recent ones.

Measurement of electrical and electronic quantities: charge, current, voltage, power, power factor, energy, reactive power, megger, low resistance measurement, high resistance measurement, non contact type current measurement, magnetic flux, electric field, electrical phase noise, electrical amplitude noise, electrical spectral density, transconductance, electrical power gain, voltage gain, current gain, frequency gain.

Applications: conventional and recent measurement techniques for measurements of Temperature, Pressure, Flow, Level, Shaft power Torque, speed, vibration, Viscosity, pH, Humidity.

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. Analyse the response of systems for various test signals
3. Explain different sensors and signal conditioning circuits.
4. Elucidate techniques for the measurement of the Shaft Power Torque, speed, vibration, Viscosity, pH, and Humidity
5. Examine various techniques for the measurement of Temperature, Pressure, and Flow.

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*

5. *Course in Mechanical Measurements and Instrumentation and Control, A.K. Sawhney, P. Sawhney, Dhanpat Rai & Company, 2001*

Evaluation Scheme:

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

PEI 105: PROCESS MODELING AND CONTROL

L	T	P	Cr
3	1	0	3.5

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

Static and Dynamic characteristics: Dynamic analysis of instrumentation system, Relative merits of analytical and experimental modelling of dynamic behaviour, Response system to step, Pulse, Harmonic and random test signals, Frequency spectra, Auto correlation spectral density, Loading effects under static and dynamic conditions.

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, 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, Model reference adaptive control, Self tuning regulator.

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, Transform analysis of sampled–data systems: z–transform and its evaluation, Inverse z–transform, Theorems of z–transform, Modified z–transform, Mapping of j–plane to z–plane, Pulse transfer function, Stability analysis in z–plane, Mapping approximation of z–transform, Numerical solution of differential equations, Implementation of digital controller, case studies.

Discrete Event System Modelling: Introduction to various methods of modelling, Automata theory, Introduction to Petri Nets.

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.

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

1. Perform static and dynamic analysis of existing instrumentation system
2. Implement advanced control schemes for different process.

3. Design multi-loop controllers and digital controller and model discrete event system.
4. Analyse the system using state space analysis.
5. Apply fundamentals to real time control problems.

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

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 body, block diagram, classification, characteristics, Various physiological events, Bioelectric potentials.

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

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

Instrumentation for Measuring Nervous Function: EEG signal, Frequency band classification, Lead systems, EEG recording, Clinical applications of EEG signal.

Neurological signal processing: Brain and its potential, EEG signal and its characteristics, EEG analysis, Linear prediction theory, Auto regressive methods, Recursive parameter estimation, Spectral error measure, Adaptive segmentation, Transient detection and elimination.

Biomedical imaging: Infrared imaging, principles of ultrasonic measurements, ultrasonic diagnosis, ultrasonic imaging systems, Doppler, X ray machine, Fluoroscopy, Computed tomography, Principles of sectional imaging, scanner configuration, data acquisition system, image formation principles, 2D image reconstruction techniques. Magnetic Resonance Imaging - Principles of MRI, pulse sequence, image acquisition and reconstruction techniques, MRI instrumentation, Functional MRI, Application of MRI, comparison of imaging modes, Introduction to Fusion imaging.

Telemedicine: Definition and scope, Types, Applications and Advantages, Challenges, Legal and Ethical issues. Compression and Analysis of Bio-signals for Telemedicine.

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

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

1. Study characteristics of transducers and electrodes for biological measurement.
2. Understand cardiac system and respiratory system.
3. Apply instrumentation system for measuring nerve function parameter.
4. Apply ECG and neurological signal processing for analysis.
5. Apply telemedicine concepts for handling distant patients.

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	40
Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations)	35

PEI205: DIGITAL IMAGE PROCESSING AND ANALYSIS

L	T	P	Cr
2	1	2	3.5

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, Motion Segmentation, 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,/ Image Understanding, Video Motion Analysis, Image Fusion, Steganography, Digital Compositing, Mosaics, Colour Image Processing, etc. in Biomedical, Machine vision/Robotics.

Laboratory work (if any): Experiments around image segmentation, morphological operations, multi resolution analysis and compression, image enhancement and filtering

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

1. *Understand the concept of digital image processing.*
2. Apply image smoothing and spatial filtering for images.
3. Study and analyze the performance through frequency domain analysis.
4. Apply image restoration, compression, segmentation and morphological 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	20
EST	40
Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations)	40

PEI309: 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.

Calculus of variations: Lagrange multiplier, Euler Lagrange's equation for different conditions, Transversality conditions, Dynamic optimization with equality and inequality constraints, Fractional order controllers.

Pontryegans Max/min Principle: Optimization using Pontryegans maximum (minimum) principles with special emphasis on Bang-Bang type system

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

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

1. Apply Parametric Optimization
2. Apply Calculus of variations for optimization problems.
3. Apply of Pontryegans Max/min Principle for optimization.
4. Apply Dynamic Programming in Continuous and Discrete Time systems
5. Apply iterative method of optimization
6. Analyze and design a robust Control System

Recommended Books:

1. *M Gopal, Modern Control System Theory, Wiley Eastern*
2. *C Drof and R H Bishop, Modern Control Systems, Richard Addision Wesley*
3. *Kirk, Optimal control theory: An introduction, PHI*
4. *Andrew P Sage and C C White, Optimum Systems Control, PHI*
5. *B D O Anderson and B Moree, Optimum System Control, PHI*

Evaluation Scheme:

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

PEI203: 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

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.

Interface buses: USB, PCMCIA, VXI, SCXI, PXI, etc., Networking basics for office and industrial applications, VISA and IVI, Motion Control.

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.

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

1. Apply graphical programming
2. Identify elements of data acquisition for software and hardware installation
3. Apply signal processing, sampling signals and filtering
4. Handle network interface layer protocol, system buses, interface buses.
5. 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
Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations)	40

PEI306: EMBEDDED SYSTEM FUNDAMENTALS AND PROGRAMMING

L	T	P	Cr
2	1	2	3.5

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

Introduction: Review of some 8-bit Microcontrollers, Introduction to Embedded Systems, Its Architecture and system Model, Introduction to the HCS12/S12X series Microcontrollers, Embedded Hardware Building Blocks.

HCS12 System Description and Programming: The HCS12 Hardware System, Modes of Operation, The B32 Memory System, The HCS12 DP256 Memory System, Exception Processing–Resets and Interrupts, Clock Functions, TIM, RTI, Serial Communications, SPI–Serial Peripheral Interface, I2C, HCS12 Analog-to-Digital Conversion System.

Basic Interfacing Concepts: Interfacing to Keypad, Motors, Graphic LCDs, The RS–232 Interface and their Examples.

Networking and Connectivity: Introduction to various networking techniques like I2C, Controller Area Network (CAN), IrDA, Bluetooth, Zigbee, Description of their protocols and applications in Sensor–Netwroking and Peripheral networking.

Development and Programming Tools: Hardware and Software development tools, C language programming, Dedicated Tools like Code-warior tools: Project IDE, Compiler, Assembler and Debugger, JTAG and Hardware Debuggers, Interfacing Real Time Clock and its applications.

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 HCS12 core, Interfacing of LCD, Motor, Keypad, ADC, RS232, USB, SPI, I2C.

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

1. Implement basic hardware of HCS12/S12X series Microcontrollers.
2. Handle HCS12 System Programming and Serial Peripheral Interface Interfacing to Keypad, Motors, Graphic lcds.
3. Implement the Networking and Connectivity
4. Handle Development and Programming Tools, Hardware and Software development tools, C language
5. Implement Real-time Operating Systems

Recommended Books:

1. *Barrett, S.F. and Pack, J.D., Embedded Systems, Dorling Kingsley (2008).*
2. *Fredrick, M.C., Assembly and C programming for HCS12 Microcontrollers, Oxford University Press (2007) 2nd ed.*
3. *Haung, H.W., The HCS12 / 9S12: An Introduction to Software and Hardware Interfacing, Cengage Learning (2008).*

4. *Ray, A.K., Advance Microprocessors and Peripherals – Architecture, Programming and Interfacing, Tata McGraw–Hill Publishing Company (2009) 2nd ed.*
5. *Di Paolo Emilio*, *Maurizio, Embedded Systems Design for High-Speed Data Acquisition and Control, Springer, (2014)*

Evaluation Scheme:

Evaluation Elements	Weightage (%)
MST	20
EST	40
Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations)	40

PEI307: INDUSTRIAL ELECTRONICS

L	T	P	Cr
3	1	0	3.5

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

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

PEI202: MICRO-SENSORS AND ACTUATORS

L	T	P	Cr
3	1	0	3.5

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 examples, microvalves, micropumps, micromotors Microactuator systems: Ink-Jet printer heads, Micro-mirror TV Projector.

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 WG

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

1. Design MEMS system.
2. Handle Magnetic MEMS for process applications.
3. Use Bio-MEMS for process measurements.

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.*

Evaluation Scheme:

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

PEI207: REMOTE SENSING AND TELEMETRY

L	T	P	Cr
3	1	0	3.5

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.

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

PEI311 ROBOTIC TECHNOLOGY

L	T	P	Cr
3	1	0	3.5

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.

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

PEI301: ADVANCED SOFT COMPUTING TECHNIQUES

L	T	P	Cr
2	1	2	3.5

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 shorting, Multi-objective optimization using GA.

Advanced AI Techniques: 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

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 (if any): 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

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

1. Apply soft 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. Apply rough 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.*

Evaluation Scheme:

Evaluation Elements	Weightage (%)
MST	20

EST	40
Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations)	40

PEI303: BIOMETRICS TECHNIQUES

L	T	P	Cr
2	1	2	3.5

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 Features , 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 (if any): Experiments around data acquisition, binarization, segmentation, thinning and development of a biometric system.

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	20
EST	40
Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations)	40

PEI305: COMPUTATIONAL ELECTROMAGNETIC

L	T	P	Cr
3	1	0	3.5

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

PEIXXX: EMBEDDED CONTROL SYSTEMS

L	T	P	Cr
2	1	2	3.5

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 (if any):

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	20
EST	40
Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations)	40

PEI308: MICROCONTROLLER BASED SYSTEM DESIGN

L	T	P	Cr
2	1	2	3.5

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.

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	20
EST	40
Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations)	40

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	50
Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations)	20

PEI204: 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

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	50
Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations)	20

PEI206: ENVIRONMENT MONITORING INSTRUMENTATION

L	T	P	Cr
3	0	0	3.5

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, Potentiometry, 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

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	50
Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations)	20

PEI310: POWER SYSTEM INSTRUMENTATION

L	T	P	Cr
3	0	0	3.5

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.

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

1. Identify energy storage methods
2. Work on transmission lines and instrumentation scheme used for HVDC
3. Handle automatic generation and voltage control in power generation station.
4. Identify instrumentation schemes for monitoring and control
5. Apply signal transmission techniques for sharing process information

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	50
Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations)	20

PEIXXX: SYSTEM IDENTIFICATION AND 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	50
Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations)	20

PEI312: ULTRASONIC AND OPTO–ELECTRONIC INSTRUMENTATION

L	T	P	Cr
3	0	0	3.5

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

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	50
Sessionals (May include Assignments/ Projects/ Tutorials/ Quizes/ Lab Evaluations)	20