SGGS INSTITUTE OF ENGINEERING & TECHNOLOGY,

VISHNUPURI, NANDED

DEPARTMENT OF INSTRUMENTATION ENGINEERING

Curriculum Structure of B. Tech.
(With effective from 2021-2022)

Semester I						
Course Code	**Name of the course**	**L**	**T**	**P**	**Credits Th**	**Pr**
PCC-IN401	Modern Control Theory	03	--	02	03	01
PCC-IN402	Chemical and Analytical Instrumentation	03	--	--	03	--
PCC-IN403	Biomedical Instrumentation	03	--	02	03	01
PEC-IN4**	Elective-III	03	--	--	03	--
PEC-IN4** / OEC-**4**	Elective-IV	03	--	--	03	--
SII-IN417	Seminar on Industrial Training	--	--	02	--	01
PRJ-IN418	Mini Project	--	--	10	--	05
	Total	**15**	**--**	**16**	**23**	
Semester II (Scheme-A)						
Course Code	**Name of the course**	**L**	**T**	**P**	**Credits Th**	**Pr**
PCC-IN421	Instrumentation Project Management	03	--	02	03	01
PEC-IN4**	Elective-V	03	--	--	03	--
PEC-IN4**	Elective-VI	03	--	--	03	--
PRJ-IN434	Project (In house)	--	--	14	--	07
	Total	**09**	**--**	**16**	**17**	
Semester II (Scheme-B)						
PRJ-IN435	Project (In Industry/Research Institute)	--	--	34	--	17
	Total	**--**	**--**	**34**	**17**	

L – No. of Lecture Hours/week, T – No. of Tutorial Hours/week, P – No. of Practical Hours/week

B.Tech.(INST)	Contact Hours	Credits
TOTAL (Scheme-A)	56	40
TOTAL (Scheme-B)	65	40

Stream	Elective-III		Elective-IV	
Control	PEC-IN404	Process modeling & Optimization	PEC-IN411	Digital Control Systems
	PEC-IN405	Optimal and Robust Control	PEC-IN412	Advanced Control Systems
Industrial	PEC-IN406	Building Automation System	PEC-IN413	Cyber Security
	PEC-IN407	Industrial Safety & Hazards	PEC-IN414	Industrial Automation and Robotics
Instrumentation	PEC-IN408	Virtual Instrumentation	PEC-IN415	Embedded System Design
	PEC-IN409	SMART and Wireless Instrumentation		
Signal Processing	PEC-IN410	Advanced Digital Signal Processing	PEC-IN416	Digital Image Processing
			OEC-**4**	*Any one from list of Open Elective offered by department/Institute*

Stream	Elective-V		Elective-VI	
Control	PEC-IN422	System Identification	PEC-IN429	AI Based Control System
	PEC-IN423	Non-linear Control Systems		
Industrial	PEC-IN424	Batch Process Control	PEC-IN430	Product Design and Development
	PEC-IN425	Industrial Internet of Things(IIoT)	PEC-IN431	Automobile Instrumentation
Instrumentation	PEC-IN426	Agricultural Instrumentation	PEC-IN432	Intelligent Sensors
	PEC-IN427	Energy Harvesting		
Signal Processing	PEC-IN428	Digital Signal Processors and Applications	PEC-IN433	Biomedical Signal Processing

- **Open Elective/s offered by department: 1) OEC-IN436 Introduction to MEMS**

CONTENTS

Semester-VII

PCC-IN401 Modern Control Theory			
Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination : 30 marks End Semester Examination : 50 marks
Tutorials	0	hrs/week	
Practical	2	hrs/week	
Credits	4		

Course objectives:	
1.	To develop problem solving skills and understanding of control system
2.	To develop understanding of optimal control system
3.	To develop ability to apply knowledge of control system for nonlinear system analysis
Course Outcomes: After successfully completing the course students will be able to,	
1.	Know the concept of state, state variable, state model and state space representation of physical systems.
2.	Illustrate stability, controllability and observability of a system.
3.	Apply knowledge of control theory for practical implementations in engineering and network analysis.
4.	Analyze dynamics of a linear system by solving system model/equation or applying domain transformation.
5.	Test non linearity of the system and evaluate various techniques for finding stability of nonlinear system.
6.	Formulate and solve deterministic optimal control problems in terms of performance indices.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PCC-IN401.1	3	2	3	2	-	-	-	-	-	-	-	2	3	2	2	3
PCC-IN401.2	3	2	2	2	3	-	-	-	-	-	-	1	3	2	2	2
PCC-IN401.3	3	3	2	3	2	-	-	-	-	-	-	2	3	2	2	2
PCC-IN401.4	3	3	-	2	2	-	-	-	-	-	-	2	3	2	3	2
PCC-IN401.5	3	3	2	3	1	-	-	-	-	-	-	2	3	2	2	2
PCC-IN401.6	3	3	2	2	2	-	-	-	-	-	-	2	3	2	2	1
PCC-IN401	**3**	**2**	**2**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**2**	**2**	**2**

Syllabus:	
Unit 1	**State variable method**
	Modeling and Analysis Concept of state, state variable, and state model, state space representation using physical, phase and canonical variables and their block diagram representation, state model and transfer function, diagonalization, solution of state equation, state transition matrix its properties and computation, concept of controllability and Observability and their test criterion.
Unit 2	**State feedback Controllers Design**
	Designpole placement design using state feedback, state observer, reduced order and full orderobserver design, Design of control systems with observers, Design of servo system, Study of some physical plant like inverted pendulum for analysis and

	Design.
Unit 3	**Introduction to Optimal Control systems, Linear Quadratic regulator (LQR)**
	Theory and Design: LQR solution using the minimum principle, Generalization of LQR; LQR properties with classical interpretations; Optimal observer design-Kalman-Bucy filter: Problem formulation and Solution, The Linear Quadratic Gaussian (LQG) problem: Introduction, LQG problem formulation and solution, Performance and Robustness of optimal state feedback.
Unit 4	**Non-linear system analysis**
	Behavior of nonlinear systems, common physical nonlinearities, describing function method, Concept and derivation of describing function method, phase plane method, singular points, stability of nonlinear system.
Unit 5	**Fundamentals of Lyapunov Theory**
	Equilibrium points, concept of stability, linearization and local stability, Lyapunov's Direct method: positive definite functions and Lyapunov functions, equilibrium point theorems, System Analysis based on Lyapunov's Direct Method: Lyapunov analysis of LTI systems, Krasovski's method, the variable gradient method, physically motivated Lyapunov functions, Performance analysis.
Text/Reference Books:	
1.	K. Ogata, "Modern Control Engineering", Fourth Edition, Prentice Hall of India, 2002.
2.	G. Franklin, J. D. Powell and A. E. Naeini, "Feedback Control of Dynamic Systems", Fourth Edition, Pearson Education, 2002.
3.	J. Nagrath and M. Gopal, "Control System Engineering",Second Edition, Wiley Eastern Limited, Sixteenth reprint 1990.
4.	M. Gopal, "Control Systems, Principles and Design", Second Edition, TMH, New Delhi, 2002.
5.	B. C. Kuo, "Automatic Control Systems", Seventh Edition, Prentice Hall of India,New Delhi, 2002.
6.	J. E. Slotine and W. Li, "Applied Nonlinear Control", Prentice Hall International,1991.
7.	A. Tewari, "Modern Control Design with MATLAB and SIMULINK", John Wiley and Sons, Ltd., 2002.
8.	B. Friedland, "Control System Design: An Introduction to State-space Methods",McGraw Hill International Edition, Singapore, 1987.
Term Work:	
It will consist of at least eight experiments/assignments/programs based on above syllabus.	

PCC-IN402 Chemical and Analytical Instrumentation

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory
Tutorials	0	hrs/week	In Semester Evaluation : 20 Marks
Practical	0	hrs/week	Mid Semester Examination : 30 marks
Credits	3		End Semester Examination : 50 marks

Course objectives:	
1.	Identify the interferences in chemical and instrumental analysis and assess the sources of error.
2.	Integrate a fundamental understanding of the underlining physics principles as they relate to specific instrumentation used for atomic, molecular, and mass spectrometry,

	magnetic resonance spectrometry and chromatography.
3.	Distinguish, compare and select methods for elemental and molecular analyses using qualitative and quantitative measurement techniques.
4.	Understand and be able to apply theory and operational principles of analytical instruments.
Course Outcomes: After successfully completing the course students will be able to,	
1.	Know the basics of Analytical Instruments like Chromatography,Gas Analyzers, and Spectrophotometers.
2.	Understand the use of appropriate methodology for different analytical techniques and recognize their advantages and limitations.
3.	Organize analytical techniques to accurately determine the elements present in the given sample.
4.	Analyze the theoretical principles of various separation techniques in chromatography and typical applications of chromatographic techniques.
5.	Evaluate the calculations related to quantitative aspects in Analytical Instruments.
6.	Create a modern library for scientific information about a topic like chemical and spectroscopic analysis.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PCC-IN402.1	3	-	1	2	-	2	2	-	-	2	2	2	3	3	3	1
PCC-IN402.2	3	2	2	2	2	2	3	-	-	2	2	2	3	2	1	1
PCC-IN402.3	2	2	2	3	2	1	2	2	-	2	2	2	2	3	3	1
PCC-IN402.4	3	3	-	3	3	2	1	-	1	1	2	2	3	2	2	1
PCC-IN402.5	2	1	3	3	2	1	-	-	2	2	3	2	2	3	3	1
PCC-IN402.6	1	-	2	-	2	3	2	2	2	2	2	2	3	2	2	1
PCC-IN402	**3**	**2**	**2**	**3**	**2**	**2**	**2**	**1**	**1**	**2**	**3**	**3**	**3**	**3**	**3**	**1**

Syllabus:	
Unit 1	**Introduction**
	Introduction to Chemical instrumental analysis, advantages over classical methods, selection of instruments for application in industries. Classification of Instrumental methods. Interaction of radiation with matter, concept of design of analytical instrument.
Unit 2	**Chromatography**
	Introduction, definitions, classification, Gas chromatography apparatus, details of different parts, applications, factors affecting separation. HPLC-Instrumentation, Sample introduction, Separation Column, Detectors.
Unit 3	**Absorption and emission spectroscopy**
	Laws of Photometry, atomic energy levels, vibrational energy level, Raman Effect nuclear spin behavior, electron spin behavior, Atomic Absorption Spectroscopy: Principle and working of absorption spectroscopy, hollow cathode lamp, atomizer, back-ground correction. Atomic Emission Spectroscopy: Principle, types, Flame photometer, DC arc and AC arc excitation, plasma excitation.
Unit 4	**Ultraviolet and Visible Spectrometry**
	Instrumentation radiation sources, detectors, Readout module filters,

	Monochromators, Monochromator performance, Grating Monochromator systems, Instruments for absorption Photometry.
Unit 5	**X-ray Spectroscopy**
	A. X-ray spectroscopy: production of X-rays spectra. Instrumental methods, detectors, direct absorption, fluorescence methods, X-ray diffraction. Bragg's law, Auger emission spectroscopy. B. Radiation detectors: Ionization chamber, Geiger-Muller counter, proportional counter, scintillation counters.
Unit 6	**Mass Spectrometry**
	Mass Spectrometry: Components of mass spectrometers, Resolution, Mass spectrometers, Interfacing Chromatography and Mass spectrometry, Quantitative analysis of mixtures, use of stable isotopes, leak detection correlation of mass spectra with molecular structure
Text/Reference Books:	
1.	Instrumental Methods of Analysis, Willard, Merritt, Dean, Settle, CBS Publishers & Distributors, New Delhi, Seventh edition.
2.	Instrumental Methods of Chemical Analysis, Galen W. Ewing, McGraw-Hill Book Company, Fifth edition
3.	Principles of Instrumental Analysis, Skoog, Holler, Nieman, Saunders College Publishing, 1998.
4.	Handbook of Analytical Instruments, Khandpur R. S., Tata McGraw-Hill Publication 1989.
5.	Instrumental Methods of Chemical Analysis By Chatwal G. R. and Anand S, Himalya Publishing House 1998.
6.	Undergraduate Instrumental Analysis by James W. Robinson et.al., CRC Press Seventh Edition 2014.

PCC-IN403 Biomedical Instrumentation

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory
Tutorials	0	hrs/week	In Semester Evaluation : 20 Marks
Practical	2	hrs/week	Mid Semester Examination : 30 marks
Credits	4		End Semester Examination : 50 marks

Course objectives:	
1.	With widespread use and requirements of medical instruments, this course gives knowledge of the principle of operation and design of biomedical instruments.
2.	It attempts to render a broad and modern account of biomedical instruments.
3.	It gives the introductory idea about human physiology system which is very important with respect to design consideration.

Course Outcomes: After successfully completing the course students will be able to,

1.	Understand biomedical instrumentation, with transducer, electrode used.
2.	Study Electrographs, Physiological pressure measurements, Respiratory system.
3.	Study Instrumentation for measuring Brain parameters.
4.	The Students will have a clear knowledge about human physiology system.
5.	They will have knowledge of the principle operation and design and the background.
6.	Knowledge of biomedical instruments and specific applications of biomedical engineering.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PCC-IN403.1	2	2	3	2	2	-	-	1	2	3	2	2	3	3	2	2
PCC-IN403.2	3	3	3	1	3	-	-	2	2	3	3	2	3	2	2	2
PCC-IN403.3	3	-	-	2	2	-	-	-	2	-	3	2	3	2	2	1
PCC-IN403.4	3	3	3	2	3	-	-	1	3	2	2	1	3	1	1	1
PCC-IN403.5	3	2	3	2	3	-	-	2	2	1	2	2	3	1	3	1
PCC-IN403.6	3	3	2	3	3	-	-	3	3	2	3	2	3	1	3	1
PCC-IN403	**3**	**3**	**3**	**2**	**3**	**-**	**-**	**2**	**3**	**2**	**3**	**2**	**3**	**2**	**3**	**2**

Syllabus:	
Unit 1	**Introduction, Electrodes and Transducers for Biomedical measurements**
	Biomedical instrumentation, Introduction to human body systems,Cell, Electrophysiology, Biomedical signals and their ratings and features, The body as a control system. Types of Electrodes for Biophysical sensing, Transducers used in Biomedical Instrumentation.
Unit 2	**Bioelectric Amplifiers**
	Operational amplifiers, High-impedance PH probe amplifier, Circuit for driving large capacitive loads, Low-droop positive peak detector, Multiple input amplifier, Differential amplifier, Instrumentation amplifier with NPN and FET inputs, PH probe electrometer instrumentation amplifier, Bridge amplifier with 1 Hz low pass filter, Hot wire anemometer thermistor circuit, 4 ma to 20 ma current loop bridge transmitter, load cell weighing scale instrumentation amplifier, Input protection circuit, signal processing circuits, Offset null methods, Auto-zero amplifier, Isolation amplifier.
Unit 3	**Bioelectrical Signals ECG, EEG, EMG**
	The heart as a potential source, the ECG waveform, standard lead system, ECG preamplifier, Defibrillator protection circuit, Electrosurgery unit interference filter, multichannel physiological monitoring system, five patient electrode (6-lead) ECG system, QRS and pacer pulse detector system, ECG mechanism, patient cables, ECG machine maintenance, ECG faults and trouble shooting. Organization of the nervoussystem, the neuron, cerebral angiography, computerized axial tomography (CAT), EEG, EEG electrodes and the 10-20 system, EEG amplitude and frequency bands, EEG diagnostic uses, EEG amplifiers, EEG telemetry systems.EMG.
Unit 4	**Physiological pressure measurements&Cardiovascular Measurements**
	Pressure measurements, blood pressure measurements, Oscillometric and ultrasonic Noninvasive pressure measurements, Direct methods (H2o manometers), pressure transducers, pressure amplifiers Calibration methods, systolic, diastolic and mean detector circuits, pressure differentiation (dp/dt) circuits. Automatic zero circuits, practical problems in pressure monitoring. Cardiac output measurement, Dilution methods, Input circuit for a thermos dilution cardiac output computer, Right side heart pressures, Plethysmography, Blood flow measurements, phonocardiography, Vectorcardiogaphy (VCG). Defibrillator, Defibrillator circuits, Cardioversion, Testing Defibrillators, Pacemakers, Heart lung machines, Audiometers, Hearing aids, Artificial kidney, endoscope, Different therapetic instruments (electronic pain killer, ultrasound therapy)

Unit 5	**Respiratory system**
	Human respiratory system, Gas laws, internal (cellular) respiration, External (Lung) respiration, Organs of respiration, Mechanics of breathing, parameters of respiration, regulation of respiration, Unbalanced and diseased stages, Major measurements of pulmonary functions, Respiratory Instrumentation: Respiratory transducers and instruments, spirometers,Respiratory therapy equipment, oxygen therapy, artificial mechanical ventilator.
Unit 6	**Radiology and nuclear Medicine equipment's**
	Physics of sound waves, Ultrasound energy, ultrasound transducer, Types and uses of X-Ray and Nuclear Medicine equipment's. Generation of X-Ray in an X-Ray tube, Block diagram and operation of X-Ray machine.
Unit 7	**Electrical safety in the Medical environment**
	Definition of electrical safety, Macro shock and micro shock, Design considerations for reducing electric hazards, Line isolation system, Equipotential grounding systems, Ground fault interrupters, Proper power wiring, Distribution and ground systems, specialized electric safety test equipment's.
Text/Reference Books:	
1.	Biomedical Instrumentation by Joseph J. Carr and John M. Brown.
2.	Handbook of Biomedical Instrumentation by R.S. Khandpur.
3.	Biomedical Instrumentation and Measurements by Leslie Cromwell, Weibell and Pfoeiffer.
4.	Medical physics and physiological measurements by B. H. Brown and R.A.Smallwood.
5.	Introduction to biomedical instrumentation by S.G. Kahalekar.
Term Work:	
It will consist of at least eight experiments/assignments/programs based on above syllabus.	

Elective-III

Control Stream

PEC-IN404 Process Modeling and Optimization

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory
Tutorials	0	hrs/week	In Semester Evaluation : 20 Marks
Practical	0	hrs/week	Mid Semester Examination : 30 marks
Credits	3		End Semester Examination : 50 marks

Course objectives:	
1.	To understand mathematical models of Physical and Chemical systems.
2.	To understand numerical methods for solving algebraic and differential equations and curve fitting.
3.	To understand basic concepts of optimization and unconstrained optimization.
Course Outcome: After successfully completing the course students will be able to,	
1.	Understand what mathematical modeling is and how it is related to physical problems.
2.	Recognize the need for modeling, estimate necessary model complexity.
3.	Understand how models are built from balances and constitutive equations.
4.	Understand the basis of rate laws and adjustable parameters in them.
5.	Understand Numerical methods and their applications.
6.	Develop ability to do Linear and nonlinear programming.

Course Articulation Matrix: Mapping of Course Outcome and Program Outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN404.1	3	2	3	3	3	-	-	-	-	2	-	2	3	3	3	2
PEC-IN404.2	3	3	2	3	3	-	-	-	-	-	-	2	3	2	2	2
PEC-IN404.3	3	2	2	2	2	-	-	-	-	2	-	2	3	1	2	1
PEC-IN404.4	3	2	2	2	3	1	-	-	-	2	-	2	3	3	3	3
PEC-IN404.5	3	2	2	3	3	2	-	-	-	1	-	2	3	3	3	3
PEC-IN404.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PEC-IN404	**3**	**2**	**2**	**3**	**3**	**2**	**-**	**-**	**-**	**2**	**-**	**2**	**3**	**2**	**3**	**2**

Syllabus:	
Unit 1	**Mathematical models of Physical and Chemical systems**
	Principles of formulation and applications of mathematical models. Different types of models: White box model (using fundamental physical and chemical laws), Black box model (using input-output data), Gray box model. Fundamental laws: Continuity equations, Energy equation, Equations of motion, Equations of state, Equilibrium, Chemical kinetics. Examples of models: Modeling of CSTR's isothermal, non-isothermal, constant holdup, variable holdup), Batch reactor, Ideal binary distillation column, Stirred tank heater (mixing tank), Field controlled and Armature controlled D.C. Motors.
Unit 2	**Solution of algebraic equations**
	Interval halving method, Newton Raphson method. Solution of differential equations: Euler method, Modified Euler method, Runge-Kutta methods (2nd and 4th order), Adom Bashforth method. Curve fitting: Lagrange interpolation method, Least squares method.
Unit 3	**Computer simulation of chemical and physical systems**
	Gravity flow tank, three isothermal CSTR's in series, non-isothermal CSTR, Batch reactor, Ideal binary distillation column.
Unit 4	**Basic concepts of optimization and unconstrained optimization**
	Basic concept of optimization: Continuity of functions, Concave and convex functions, Unimodal and Multimodal functions, Necessary and sufficiency condition for an extremum of an unconstrained function. Unconstrained single-variable optimization: scanning and bracketing procedures. Numerical methods: Newton, Quasi Newton and Secant methods. Unconstrained Multivariable optimization, Direct methods.Conjugate search directions, Powell's method. Indirect methods: Gradient methods, Conjugate gradient method, Newton's method. Constrained optimization: Linear and nonlinear programming. Linear programming: Degeneracies, Graphical method, Simplex method, Karmarkar algorithm. Nonlinear programming: Lagrange multiplier method, Quadratic programming.
Text/Reference Books:	
1.	W. L. Luyben, "Process, Modeling, Simulation and Control for Chemical Engineers", McGraw Hill Publications.
2.	T. F. Edgar, D. M. Himmelblau, "Optimization of Chemical Processes", McGraw Hill Publications.
3.	B. S. Grewal, "Higher Engineering Mathematics", Khanna Publications.

Control Stream

PEC-IN405 Optimal and Robust Control

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination : 30 marks End Semester Examination : 50 marks
Tutorials	0	hrs/week	
Practical	0	hrs/week	
Credits	3		

Course objectives:	
1.	To provide a basic knowledge of the theoretical foundations of optimal control.
2.	To develop the skill needed to design controllers using available optimal control Theory and software.

Course Outcome: After successfully completing the course students will be able to,	
1.	Design and implement system identification experiments.
2.	Use input-output experimental data for identification of mathematical dynamical models.
3.	Use singular value techniques to analyze the robustness of control systems.
4.	Incorporate frequency-domain-based robustness specifications into multivariable control system designs.
5.	Use H-infinity methods to design robust controllers.
6.	Explain the advantages and disadvantages of robust control relative to other control approaches.

Course Articulation Matrix: Mapping of Course Outcome and Program Outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN405.1	3	2	3	2	-	-	-	-	2	1	2	2	3	2	2	3
PEC-IN405.2	3	2	2	2	3	1	-	-	1	1	2	1	3	2	2	2
PEC-IN405.3	3	3	2	3	2	2	-	-	-	-	-	2	3	2	2	2
PEC-IN405.4	3	3	-	2	2	2	-	-	2	-	1	2	3	2	3	2
PEC-IN405.5	3	3	2	3	1	-	-	-	-	2	-	2	3	2	2	2
PEC-IN405.6	3	3	2	2	2	-	-	-	3	2	1	2	3	2	2	1
PEC-IN405	**3**	**2**	**2**	**2**	**2**	**2**	**-**	**-**	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**2**

Syllabus:	
Unit 1	**Linear Quadratic Control**
	The Linear Quadratic Regulator (LQR) problem: LQR solution using the minimum principle, Generalization of LQR; LQR properties with classical interpretations; Optimal observer design- Kalman-Bucy filter: Problem formulation and Solution, The Linear Quadratic Gaussian (LQG) problem: Introduction, LQG problem formulation and solution, Performance and Robustness of optimal state feedback, Loop Transfer Recovery (LTR).
Unit 2	**Robust H-infinity Control**
	Introduction, Critique of LQG, Performance specification and robustness: Nominal performance of feedback system; Nominal performance:Multivariable case, Novel problem formulation of classical problem, Modeling uncertainty, Robust stability, Mathematical background: Singular Value Decomposition. (SVD); Singular values and matrix norms; The supremum of functions, Norms and spaces

Unit 3	**H2 Optimization and Loop Transfer Recovery (LTR) Control**
	A brief history, Notation and terminology, The two-port formulation of control problems;controlproblem formulation and assumptions; Problem solution, Weights in control problems, Design example.
Unit 4	**Robust Control**
	The Parametric Approach: Stability theory via the boundary crossingtheorem, The stability of a line segment, Interval polynomials: Kharitonov's theorem for real and complex polynomials, Interlacing and Image set interpretations, Extremal properties of the Kharitonov polynomial, Robust-state feedback stabilization, Schurstability of interval polynomials, The Edge theorem, The Generalized Kharitonov theorem, State space parameter perturbations, Robust stability of Interval matrices, Robustness using the Lyapunov approach, Robust parametric stabilization.
Text/Reference Books:	
1.	J. M. Maciejowski, Multivariable Feedback Design, Addison-Wesley Publishing Company, 1989.
2.	H. Kwakernaak and R. Sivan, Linear Optimal Control Systems, Wiley-Interscience,1972.
3.	B. D. O. Anderson and J. B. Moore, Linear Optimal Control, Prentice-Hall, 1990.
4.	S. P. Bhattacharya, H. Chapellat and L. H. Keel, Robust Control: The Parametric Approach, Prentice-Hall, PTR, NJ07458, 1995.
5.	K. Zhou, J. C. Doyle and K. Glover, Robust and Optimal Control, Prentice-Hall, NJ07458, 1996.
6.	J. Ackermann, Robust Control: Systems with Uncertain Physical Parameters, Springer-Verlag, London, 1993.
7.	F. L. Lewis and V. L. Syrmos, Optimal Control, Second Edition, John Wiley and Sons,Inc. 1995.

Industrial Stream

PEC-IN406 Building Automation System

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination : 30 marks End Semester Examination : 50 marks
Tutorials	0	hrs/week	
Practical	0	hrs/week	
Credits	3		

Course objectives:	
1.	To understand about the building automation and its management system, different communication protocols for BAS.
2.	Study about the security and safety system in smart building.
3.	Suggest suitable possibilities to integrate systems and its managements for intelligent building.
4.	Study of lighting control system, PA system and EPBX systems.
Course outcomes: After successfully completing the course students will be able to:	
1.	Get the knowledge of basic fundamentals of Building Automation and management system.
2.	Describe BAS Communication standards, Internet technologies used in building

	automation such as BACnet, LonWorks, Modbus, PROFIBUS and EIB.
3.	Employ different kinds of systems to develop optimized way of air- conditioning, ventilation, heating, cooling and central chilling.
4.	Devise Lighting- control system using standard lighting control protocols, common automation protocols for energy management and lighting control so as to achieve typical benefits of BAS.
5.	Support building management function by providing security and safety systems to people and equipment.
6.	Design a total building management system to provide a individual a highly efficient, comfortable, convenient and safe environment by satisfying four fundamental demands Structure, System, Service and management and optimizing their interrelationship.

Course Articulation Matrix: Mapping of Course Outcome and Program Outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN406.1	3	-	-	-	-	2	1	-	-	-	-	2	3	3	2	2
PEC-IN406.2	3	1	-	-	-	2	1	-	-	-	-	2	3	3	1	2
PEC-IN406.3	3	-	1	-	2	3	2	-	-	-	-	2	3	2	2	2
PEC-IN406.4	3	-	2	1	-	3	1	-	-	-	-	2	3	1	1	1
PEC-IN406.5	3	1	1	1	2	2	-	-	-	-	-	2	2	2	2	1
PEC-IN406.6	2	-	3	-	-	2	1	-	-	-	-	2	2	1	2	1
PEC-IN406	**3**	**1**	**2**	**1**	**2**	**2**	**1**	**-**	**-**	**-**	**-**	**2**	**3**	**2**	**2**	**2**

Syllabus:	
Unit 1	**Introduction to intelligent buildings**
	Introduction to intelligent buildings Definitions of intelligent building, Intelligent architecture and structure, Facilities management vs. intelligent buildings, Technology systems and evolution of intelligent buildings, What is BAS? The progress of BAS, Programming and monitoring platforms and environment, Building management functions.
Unit 2	**BAS communication standards**
	BAS communication standards, Internet technology and their applications in BAS Background and problems, BACnet and its features, LonWorks and its features, Modbus and its features, PROFIBUS and its features, EIB and its features, Compatibility of different open protocol standards, Integration at management level, An overview of applications of Internet technologies in BAS, Use of Internet technologies at automation level, Use of Internet technologies at management level, Convergence networks and total integration.
Unit 3	**Control and optimization of air- conditioning systems**
	Control and optimization of air- conditioning systems and central chilling systems Typical control loops of the air- conditioning process, Control of CAV systems, Control of VAV systems, Outdoor air ventilation control and optimization, An overview of optimal control methods used for HVAC systems, Optimal control of air- side systems, Basic knowledge of chillers, Chiller capacity control and safety interlocks, Chillers and central chilling system configurations, Chiller performance and optimal control, Optimal control of heat- rejection systems, Optimal set- point reset of chilled water supply temperature, Sequence control of multiple chiller plants, Pump speed and sequence control of chilled water systems.

Unit 4	**Lighting- control systems& Lighting Protocols**
	Lighting- control systems Purpose of lighting- control systems, Basic components of lighting and lighting- control systems, Systems based on standard lighting- control protocols, Systems based on common automation protocols, Strategies for energy management and lighting control.
Unit 5	**Security and safety control systems**
	Security and safety control systems CCTV systems, Access- control systems, Burglar alarm systems, Fire alarm systems, System integration and convergence. Biometrics, issues with biometrics, cabling, video door phone, intrusion detection system-sensors, working principles, access control system programming.
Unit 6	**PA System**
	PA System and EPBX System Components of public address system like speakers, indicators, control panels, switches. Design aspect of PA System, design consideration of EPBX System and its component. Integration of all above systems to design a total building management system.
Text/Reference Books:	
1.	Shengwei Wang, 'Intelligent buildings and automation system'.
2.	Reinhold A. Carlson, Robert A. Di Giandomenico, 'Understanding Building Automation system: Direct Digital Control, Energy Management, Life Safety, Security Access control, Lighting Building', First Edition.
3.	Jim Sinopoli, 'Smart Buildings', Fairmount Press, March 8, 2007.
4.	Barney Capehart, 'Web Based Enterprise Energy and Building Automation systems' C.E.M.
5.	Anto Budiardjo, 'Building Automation Beyond the simple web server', Clasma Evens, Inc.
6.	Paul Ehrlich, 'What is an Intelligent Building?', Building Intelligent Group.

Industrial Stream

PEC-IN407 Industrial safety and Hazards

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory
Tutorials	0	hrs/week	In Semester Evaluation : 20 Marks
Practical	0	hrs/week	Mid Semester Examination : 30 marks
Credits	3		End Semester Examination : 50 marks

Course objectives:	
1.	To provide comprehensive knowledge of safety and hazards aspects in industries and the management of hazards.
2.	To analyze industrial hazards and its risk assessment.
Course Outcome: After successfully completing the course students will be able to,	
1.	Analyze the effect of release of toxic substances.
2.	Understand the industrial laws, regulations and source models.
3.	Apply the methods of prevention of fire and explosions.
4.	Understand the relief and its sizing methods.
5.	Understand the methods of hazard identification and preventive measures.
6.	Understand Preventive and protective management.

Course Articulation Matrix: Mapping of Course Outcome and Program Outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN407.1	3	2	2	1	2	3	2	-	-	2	2	2	3	2	3	1
PEC-IN407.2	3	1	2	2	2	3	1	2	-	2	2	2	3	1	3	1
PEC-IN407.3	3	2	2	2	2	3	3	-	-	2	2	2	3	2	3	1
PEC-IN407.4	3	1	2	-	1	3	-	1	1	1	2	2	3	1	2	1
PEC-IN407.5	3	2	2	2	2	3	2	-	2	2	3	2	3	3	2	1
PEC-IN407.6	3	1	2	2	2	3	-	-	2	2	2	2	3	2	2	1
PEC-IN407	**3**	**2**	**3**	**2**	**2**	**3**	**2**	**1**	**1**	**2**	**3**	**3**	**3**	**2**	**3**	**1**

Syllabus:	
Unit 1	**Fire and Explosion**
	Introduction, Industrial processes and hazards potential, mechanical electrical, thermal and process hazards. Safety and hazards regulations, Industrial hygiene. Factories Act, 1948 and Environment (Protection) Act, 1986 and rules thereof. Shock wave propagation, vapour cloud and boiling liquid expanding vapours explosion (VCE and BLEVE), mechanical and chemical explosion, multiphase reactions, transport effects and global rates.
Unit 2	**Relief Systems**
	Preventive and protective management from fires and explosion, inerting, static electricity, passivation, ventilation, and sprinkling, proofing, relief systems, relief valves, flares, scrubbers.
Unit 3	**Toxicology and Hazards identification**
	Hazards identification, toxicity, fire, static electricity, noise and dust concentration; Material safety data sheet, hazards indices, Dow and Mond indices, hazard operability (HAZOP) and hazard analysis (HAZAN).
Unit 4	**Leaks and Leakages**
	Spill and leakage of liquids, vapors, gases and their mixture from storage tanks and equipment; Estimation of leakage/spill rate through hole, pipes and vessel burst; Isothermal and adiabatic flows of gases, spillage and leakage of flashing liquids, pool evaporation and boiling; Release of toxics and dispersion. Naturally buoyant and dense gas dispersion models; Effects of momentum and buoyancy; Mitigation measures for leaks and releases.
Unit 5	**Case Studies**
	Flixborough, Bhopal, Texas, ONGC offshore, HPCL Vizag and Jaipur IOC oil storage depot incident; Oil, natural gas, chlorine and ammonia storage and transportation hazards.
Text/Reference Books:	
1.	Crowl D.A. and Louvar J.F., "Chemical Process Safety: Fundamentals with Applications", 2nd Ed., Prentice Hall.2001.
2.	Mannan S., "Lee's Loss Prevention In the Process Industries", Vol.I, 3rd Ed., Butterworth Heinemann 2004.
3.	Mannan S., "Lee's Loss Prevention in the Process Industries",Vol.II, 3rdEd., Butterworth Heinemann 2005.
4.	Mannan S., "Lee's Loss Prevention in the Process Industries",Vol.III,3rd Ed., Butterworth Heinemann 2005.

Instrumentation Stream

PEC-IN408 Virtual Instrumentation

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination : 30 marks End Semester Examination : 50 marks
Tutorials	0	hrs/week	
Practical	0	hrs/week	
Credits	3		

Course objectives:

1.	To understand the principles of operation and limitations of common measuring instruments.
2.	Tomodel transducers and their operating conditions.
3.	To design systems for the acquisition, analysis, and communication of data.
4.	To gain awareness of economic and social aspects of instrumentation systems.

Course Outcome: After successfully completing the course students will be able to,

1.	Apply the knowledge of LabVIEW programming for simulating and analyzing the data.
2.	Create applications that uses plug in DAQ boards and built in analysis functions to process the data.
3.	Build applications that use general purpose interface bus and Serial communication Interface.
4.	Design and analyze various applications using signal Processing tool kit.
5.	Engage in designing, implementing, analyzing and demonstrating an application using tools in available in LabVIEW through an open ended experiment.

Course Articulation Matrix: Mapping of Course Outcome and Program Outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN408.1	3	-	-	-	1	-	-	-	-	-	-	1	3	3	2	-
PEC-IN408.2	3	-	-	-	1	-	-	-	-	-	-	1	3	3	2	-
PEC-IN408.3	1	3	2	2	3	-	-	-	-	-	-	2	3	3	3	2
PEC-IN408.4	1	2	3	1	3	-	-	-	-	-	-	2	3	3	3	2
PEC-IN408.5	3	2	3	2	3	-	-	-	-	-	-	2	3	3	3	1
PEC-IN408.6	1	2	1	-	2	-	-	-	-	-	-	1	2	2	2	-
PEC-IN408	**2**	**2**	**2**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**3**	**3**	**2**

Syllabus:

Unit 1	**Virtual Instrumentation**
	Historical perspective, advantages, Need of VI, Advantages of VI, Define VI, blocks diagram and architecture of a virtual instrument, data-flow techniques, graphical programming in data flow, and comparison with conventional programming. Development of Virtual Instrument using GUI, Real-time systems, Embedded Controller, OPC, HMI / SCADA software, Active X programming.
Unit 2	**VI programming techniques**
	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, Instrument Drivers, Publishing measurement data in the web.
Unit 3	**Data acquisition basics**

	Introduction to data acquisition on PC, Sampling fundamentals, Input/output techniques and buses. ADC, DAC, Digital I/Ocounters and timers, DMA, Software and hardware installation, Calibration, Resolution, Data acquisition interface requirements.
Unit 4	**VI Interface requirements**
	Common Instrument Interfaces: Current loop, RS 232C/RS485, GPIB. Bus Interfaces: USB, PCMCIA, VXI, SCSI, PCI, PXI, Fire wire. PXI system controllers, Ethernet control of PXI. Networking basics for office and Industrial applications, VISA and IVI.
Unit 5	**VI toolsets**
	Distributed I/O modules. Application of Virtual Instrumentation: Instrument Control, Development of process database management system, Simulation of systems using VI, Development of Control system, Industrial Communication, Image acquisition and processing, Motion control.
Text/Reference Books:	
1.	Gary Johnson, "LabVIEW Graphical Programming", 2nd Edition, McGraw Hill, New York, 1997.
2.	Lisa K. wells & Jeffrey Travis, "LabVIEW for everyone", Prentice Hall, New Jersey, 1997.
3.	Jane W. S. Liu, "Real-time Systems", Pearson Education India, 2001.
4.	Jean J. Labrosse, "Embedded Systems Building Blocks:Complete and Readyto- use Modules in C", 2nd Edition, CMP Books, 1999.
5.	Kevin James, "PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control", Newnes, 2000.
6.	Jean J. Labrosse, "MicroC/OS-II. The Real-time Kernal", CMP Books, 2002.
7.	Robert H. Bishop, "Learning with LabVIEW 7 Express", Pearson Education, 2005 (Indian Edition).
8.	Sanjay Gupta and Joseph John, "Virtual Instrumentation using LabVIEW", Tata McGraw-Hill, New Delhi, 2005.

Instrumentation Stream

PEC-IN409 SMART and Wireless Instrumentation

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination : 30 marks End Semester Examination : 50 marks
Tutorials	0	hrs/week	
Practical	0	hrs/week	
Credits	3		

Course objectives:	
1.	To introduce the technologies and applications for the emerging domain of wireless sensor networks.
2.	To impart knowledge on the design and development of the various layers in the WSN protocol stack.
3.	To elaborate the various issuesrelated to WSN implementations.
4.	To familiarize the students with the hardware and software platforms used in the design WSN.

Course Outcome: After successfully completing the course students will be able to,

1.	Ability to analyze WSN with respect to various performance parameters in the protocol stack.
2.	Ability to understand MAC algorithms and Network protocols used for specific WSN applications.
3.	Design and develop a WSN for a given application.
4.	Design self-diagnosing instrumentation system.
5.	Understand the issues in power efficient systems.
6.	Design wireless instrumentation systems for the given requirement.

Course Articulation Matrix: Mapping of Course Outcome and Program Outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN409.1	3	-	-	-	-	-	-	-	-	-	-	2	3	3	2	1
PEC-IN409.2	3	2	2	-	1	-	-	-	-	-	-	2	3	3	2	1
PEC-IN409.3	3	3	-	2	1	-	2	-	-	-	-	2	3	2	2	1
PEC-IN409.4	3	2	2	2	2	1	2	-	1	-	-	2	3	3	2	2
PEC-IN409.5	3	2	3	2	3	1	2	-	1	-	-	2	3	3	2	2
PEC-IN409.6	3	-	-	-	-	-	-	-	-	-	-	2	3	3	2	1
PEC-IN409	3	3	3	3	3	3	3		3			3	3	3	3	3

Syllabus:	
Unit 1	**Sensor Classification-Thermal sensors**
	Humidity sensors-Capacitive Sensors-Planar Inter digital Sensors-Planar Electromagnetic Sensors-Light Sensing Technology-Moisture Sensing Technology-Carbon Dioxide (CO_2) sensing technology-Sensors Parameters.
Unit 2	**Frequency of Wireless communication**
	Development of Wireless Sensor Network based Project-Wireless sensor based on Microcontroller and communication device-Zigbee Communication device.
Unit 3	**Power sources**
	Energy Harvesting –Solar and Lead acid batteries-RF Energy /Harvesting-Energy Harvesting from vibration-Thermal Energy Harvesting-Energy Management Techniques-Calculation for Battery Selection.
Unit 4	**Tedes IEEE 1412**
	Brief description of API mode data transmission-Testing the communication between coordinator and remote XBee-Design and development of graphical user interface for receiving sensor data using C++; A brief review of signal processing techniques for structural health monitoring.
Unit 5	**WSN based physiological parameters monitoring system**
	Intelligent sensing system for emotion recognition-WSN based smart power monitoring system.
Text/Reference Books:	
1.	Subhas Chandra Mukhopadhyay, "Smart Sensors, Measurement and Instrumentation", Springer Heidelberg, New York, Dordrecht London, 2013.
2.	Halit Eren, "Wireless Sensors and Instruments: Networks, Design and Applications", CRC Press, Taylor and Francis Group, 2006.
3.	Uvais Qidwai, Smart Instrumentation: A data flow approach to Interfacing", Chapman & Hall; 1st Ed., December 2013.

Signal Processing Stream

PEC-IN410 Advanced Digital Signal Processing

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination : 30 marks End Semester Examination : 50 marks
Tutorials	0	hrs/week	
Practical	0	hrs/week	
Credits	3		

Course objectives:

1.	To provide complete view of Digital Signal Processing subject with conceptualclarity in first few lectures.
2.	To study fundamentals of multirate signal processing and filter banks.
3.	To study the fundamentals of wavelet transform, multiresolution formulation of wavelet transform and implementation of wavelet transform using filter banks.
4.	To develop the foundation for modeling of signal, linear prediction and estimation theory.

Course Outcome: After successfully completing the course students will be able to,

1.	An ability to apply knowledge of mathematics, science, and engineering to the analysis and design of digital system.
2.	An ability to identify, formulate and solve engineering problems in the area signal processing.
3.	An ability to use the techniques, skills, and modern engineering tools such as Matlab.
4.	An ability to function on multi-disciplinary teams.
5.	An ability to design a system, components or process to meet desired needs within realistic constraints such as economic, environmental, social political, ethical, health and safety, manufacturability and sustainability.
6.	An ability to use the modern engineering tools such as digital processors with simulators.

Course Articulation Matrix: Mapping of Course Outcome and Program Outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN410.1	3	3	3	3	3	-	-	3	3	3	3	3	3	2	3	-
PEC-IN410.2	3	2	3	1	3	-	-	2	3	3	3	3	3	1	3	-
PEC-IN410.3	3	3	3	2	3	-	-	2	3	3	3	3	3	-	2	1
PEC-IN410.4	3	2	3	3	1	-	-	2	2	3	3	3	3	2	3	-
PEC-IN410.5	3	3	3	2	3	3	-	3	3	3	3	3	3	1	2	1
PEC-IN410.6	3	2	3	1	1	-	-	2	2	2	2	3	3	1	2	1
PEC-IN410	**3**	**3**	**3**	**3**	**3**	**1**	**-**	**3**	**3**	**3**	**3**	**3**	**3**	**1**	**3**	**1**

Syllabus:

Unit 1	**Fundamentals of DSP**
	Background and review discrete time random signals.Quantization effects: - Effect of round of noise in digital filter, zero input limit cycles infixed point realization of IIR digital filters. Effects of finite register length in DFT computations.
Unit 2	**Multirate Digital Signal Processing**
	Fundamentals of Multirate systems, Basic multirate operations, Decimation, interpolation, filter design and implementation of sampling rate conversion,

	polyphase filter structures, time variant filter, structures, multistage implementation of sampling rate conversion of BP signals, sampling rate conversion by an arbitrary factor, interconnection of building blocks, polyphase representation, multistage implementations.
Unit 3	**Wavelet Transform**
	Introduction to wavelets, wavelets and wavelet expansion systems, discrete wavelet transform, multiresolution formulation of wavelet systems, Haar Wavelet and other wavelet representations, scaling function, wavelet functions, Parseval's theorem.
Unit 4	**Multirate Filter Banks**
	Maximally decimated filter banks, errors created in QMF banks, simple alias free QMF system, power symmetric filter banks, M channel filter banks, polyphase representation, PR systems, alias free filter banks, Linear phase PR QMF banks, cosine modulated filter banks, Wavelet transform and its relation to multirate filter banks, paraunitary PR filter banks, Applications of multirate signals processing narrow band LPF, suband coding of speech.
Unit 5	**Linear Prediction**
	Innovations representation of a stationary random process, forward and backward linear prediction, solutions of the normal equations (Levinson-Durbin algorithm and Schur algorithm) Power Spectrum Estimation: Parametric and non-parametric methods for power spectrum estimation.
Unit 6	**Response of linear systems**
	Response of linear systems to random process inputs. Be aware of common applications of such models to communication systems, sources of noise such as thermal noise, behavior of queues and particle emission systems.
Text/Reference Books:	
1.	Multirate filters and Filter banks: P. P. Vaidyanathan, PH International, Englewood Cliffs.
2.	Multirate signal Processing: Rabiner and Schafer, PH International, Englewood Cliffs.
3.	Introduction to Wavelets and Wavelet Transform: C. S. Burrus, Ramesh and A. Gopinath, Prentice Hall Inc.
4.	Digital Signal Processing: Principles, Algorithms, and Applications: J. G. Proakis and D.G. Manolakis; Prentice Hall of India Ltd, 1995.
5.	Discrete-Time Signal Processing; A. V. Oppenheim and R. W. Schafer; ; Prentice Hall of India Ltd, 1997.

Elective-IV

Control Stream

PEC-IN411 Digital Control System

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination : 30 marks End Semester Examination : 50 marks
Tutorials	0	hrs/week	
Practical	0	hrs/week	
Credits	3		
Course objectives:			

1.	To equip the students with the basic knowledge of A/D and D/A conversion.
2.	To understand the basics of Z- Transform.
3.	To study the stability analysis of digital control system.
4.	To equip the basic knowledge of digital process control design.
Course Outcome: After successfully completing the course students will be able to,	
1.	Understand the basic sampling theory and converter.
2.	Understand Z-transform and its properties.
3.	Analyze signals in both time domain and Z domain.
4.	Understand d transfer function, block diagram, and signal flow graphs.
5.	Understand the state variable technique.
6.	Understand the basic knowledge necessary for system stability.

Course Articulation Matrix: Mapping of Course Outcome and Program Outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN411.1	3	2	3	2	-	-	-	-	-	-	-	2	3	2	2	3
PEC-IN411.2	3	2	2	2	3	-	-	-	-	-	-	1	3	2	2	2
PEC-IN411.3	3	3	2	3	2	-	-	-	-	-	-	2	3	2	2	2
PEC-IN411.4	3	3	-	2	2	-	-	-	-	-	-	2	3	2	3	2
PEC-IN411.5	3	3	2	3	1	-	-	-	-	-	-	2	3	2	2	2
PEC-IN411.6	3	3	2	2	2	-	-	-	-	-	-	2	3	2	2	1
PEC-IN411	**3**	**2**	**2**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**2**	**2**	**2**

Syllabus:	
Unit 1	**Digital control Systems**
	Introduction, description of some physical systems, continuous versus digital control, Discrete-time signals, discrete time systems, sampling and reconstruction, digitizing analog controllers.
Unit 2	**The Z Transforms**
	Definition and evaluation of Z-Transform, mapping between the s-plane and the z-plane, the inverse z-transform, theorems of z-transform, imitation of z-transform method. The pulse transfer function, pulse, transfer function of zero order hold, responses between the sampling instants, signal flow graph method applied to digital systems, stability of digital control systems, jurystability criterion.
Unit 3	**State variable analysis of digital control systems**
	Introduction, state description of digital processors, state description of sampled continuous- time plant, state description of systems with dead time and sample and hold discrete state models using phase physical and canonical variables. Relation between state equation and transfer function and solution of state difference equations, controllability and observability.
Unit 4	**Pole-placement design and digital state observer**
	Stability improvement by state feedback, digital control systems, with state feedback, dead beat control by state feedback, design of the full order and reduced-order state observers, linear digital regulator design (Finite time and infinite time problems).
Unit 5	**Design of Sampled Data Control systems**
	Discretizing the differential equation of continuous PID controllers, Parameter optimized discrete control algorithms of low order, PID control algorithm through

	Z transformations, Deadbeat algorithm, Dahlin's algorithm, Digital Equivalent of convention controller, Smith Predictor algorithm, Internal Model control, Analytical Predictor Algorithm, Kalman algorithm, Algorithm of Gautam and Mutharasan, Treatment of noisy process signals.
Text/Reference Books:	
1.	Ogata K -. Discrete time control system Englewood cliffs prentice-Hall 1987.
2.	Kuo B. C. – Digital control system 2nd edition Orlando florida saunders college publishing 1992.
3.	M.Gopal- Digital control and state variable methods, Second Edition, Tata McGraw Hill 2002.
4.	M. Gopal - Digital Control Engineering Wikey eastern 1988.
5.	Houpls C. H. and G. B.Lamont – Digital control systems, McGraw Hill 1984.
6.	P. B. Deshpande and R. H. Ash – Computer Process control with advanced
7.	Control applications, Second Edition, Instrument Society of America (ISA) Publications, 1988.
8.	R. Iserman – Digital Control Systems, Vol.I; Fundamentals, Deterministic Control, Second Edition, springer- Verlag, Berlin, Heidelberg 1989.

Control Stream

PEC-IN412 Advanced Control Systems

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination : 30 marks End Semester Examination : 50 marks
Tutorials	0	hrs/week	
Practical	0	hrs/week	
Credits	3		

Course objectives:	
1.	To understand the basics of mathematical modeling.
2.	To study the stability analysis oflinear and nonlinear systems.
3.	To understand optimal control.
Course Outcome: After successfully completing the course students will be able to,	
1.	At the end of the course students willbe able to apply the modeling concepts.
2.	Demonstrate advanced knowledge and understanding of theory and application in Control system engineering.
3.	Students will be equipped with stabilityanalysis of linear andnonlinear systems.
4.	Demonstrate advanced knowledge and understanding of optimal system control, Nonlinear optimization and stochastic optimal control.
5.	Design, analyze and perform simulation of digital control system design and ensure desired performance and stability criteria are met.
6.	Apply mathematical and theoretical knowledge to design and model an effective control system for a practical mechatronic engineering process

Course Articulation Matrix: Mapping of Course Outcome and Program Outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN412.1	3	2	3	2	-	-	-	-	-	-	-	2	3	2	2	3

PEC-IN412.2	3	2	2	2	3	-	-	-	-	-	-	1	3	2	2	2
PEC-IN412.3	3	3	2	3	2	-	-	-	-	-	-	2	3	2	2	2
PEC-IN412.4	3	3	-	2	2	-	-	-	-	-	-	2	3	2	3	2
PEC-IN412.5	3	3	2	3	1	-	-	-	-	-	-	2	3	2	2	2
PEC-IN412.6	3	3	2	2	2	-	-	-	-	-	-	2	3	2	2	1
PEC-IN412	**3**	**2**	**2**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**2**	**2**	**2**

Syllabus:	
Unit 1	**Introduction**
	Non-linear systems types of non-linearity, typical examples, singular points, phase plane analysis, limit cycles, linearization, describing functions. Need for model reduction, dominant pole concept. Model reduction via partial realization. Time moment matching and Pade approximation, Hankel norm model reduction.
Unit 2	**Stability of Nonlinear system**
	Stability concepts - equilibrium points - BIBO and asymptotic stability, Lyapunovtheory, definitions (stability and functions). Direct method of Lyapunov, application to non-linear problems. Stability analysis by describing function method –jump resonance. Frequency domain stability criteria, Popov's method and is extensions.
Unit 3	**Model reference adaptive control**
	Different configurations and classifications of MRAC - mathematical description - direct and indirect model reference adaptive control - MIT rule for continues time MRAC systems Lypunov approach and hyper stability approach for continuous time and discrete time MRAC systems - multivariable systems - stability and convergence studies.
Unit 4	**Self-tuning regulators**
	Different approaches to self-tuning - recursive parameter estimation implicit and explicit STR-LQG self-tuning - convergence analysis minimum variance and pole assignment approaches to multivariable self-tuning regulators.
Unit 5	**Adaptive control**
	Recent trends and applications of adaptive controlRecent trends in self-tuning robustness studies multivariable system. Model updating general-purpose adaptive regulator. Application to process control components and systems. Industrial applications.
Unit 6	**Optimal control**
	Optimal control problem formulation, necessary conditions of optimality, state regulator problem. Matrixriccati equation, infinite time regulator problem, output regulator and tracking problems. pontryagin’s minimum principles, time, and optimal control problem. Dynamic programming. Linear quadratic regulator, model matching based on linear quadratic optimal regulator. Observer design, linear optimal filter.
Text/Reference Books:	
1.	Chalam, V.V., "Adaptive Control Systems", Techniques & Applications, Marcel Dekker, Inc. NY and Basel. 1987.
2.	Eveleigh, V.W., "Adaptive Control and Optimisation Techniques". McGraw-Hill, 1967.
3.	Narendra and Annasamy, "Stable Adaptive Control Systems", Prentice Hall, 1989.
4.	Astry, S. and Bodson, M., "Adaptive Control", Prentice Hall,1989.

5.	M. Vidyasagar, "Nonlinear Systems Analysis", 2nd Ed., Prentice Hall, 1993.
6.	Hassan K. Khalil, "Nonlinear Systems", Third Edition, Prentice Hall, 2002.
7.	William S. Levine (Editor), "The Control Handbook(Electrical Engineering Handbook Series)", CRC Press, March 1996.
8.	Nagrath I.J., and Gopal, M., "Control system Engineering" Wiley Eastern Reprint 1995.
9.	Kirk D.E., "Optimal control theory-an introduction", Prentice Hall, N.J. 1970.
10.	Gopal. M., "Modern control system Theory", Wiley Eastern Ltd., 2nd Edition Reprint 1995.
11.	Graham C., Goodwill, S. F. Graebe and M. E. Salgado,"Control System Design" Pearson; US edition (26 September 2000).
12.	System Design" Prentice Hall India, New Delhi, 2002.

Industrial Stream

PEC-IN413 Cyber security

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination : 30 marks End Semester Examination : 50 marks
Tutorials	0	hrs/week	
Practical	0	hrs/week	
Credits	3		

Course objectives:

1.	To identify the key components of cybersecurity network architecture.
2.	To apply cybersecurity architecture principles.
3.	To describe risk management processes and practices.
4.	To identify security tools and hardening techniques.

Course Outcome: After successfully completing the course students will be able to,

1.	Understand cyber-attack, types of cybercrimes, cyber laws and also how to protect them self and ultimately society from such attacks.
2.	Highlight the need for security architecture and its relevance to systems, service continuity and reliability
3.	Discuss the application of techniques such as defenses in depth to demonstrate how controls can be selected, deployed and tested to minimize risk and impact
4.	Differentiate between controls to protect systems availability and reliability; controls to protect information; and controls to manage human behavior
5.	Understand the trade-offs for functionality, usability and security
6.	Understand the role of operations in monitoring, maintaining and evolving controls

Course Articulation Matrix: Mapping of Course Outcome and Program Outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN413.1	3	3	2	-	2	2	-	-	-	2	2	2	3	3	3	1
PEC-IN413.2	3	3	2	2	2	2	-	-	-	2	2	2	3	3	3	1
PEC-IN413.3	3	2	2	2	2	2	-	-	-	2	2	2	3	3	3	1
PEC-IN413.4	3	1	2	1	1	-	-	1	1	1	2	2	3	1	2	1
PEC-IN413.5	3	3	2	2	2	-	-	-	2	2	3	2	3	3	2	1

PEC-IN413.6	3	3	2	2	2	-	-	-	2	2	2	2	3	2	2	1
PEC-IN413	**3**	**3**	**3**	**2**	**2**	**1**	**-**	**1**	**1**	**2**	**3**	**3**	**3**	**3**	**3**	**1**

Syllabus:	
Unit 1	**Introduction**
	Pre-requisites in Information and Network Security Overview of Networking Concepts, Basics of Communication Systems, Transmission Media, Topology and Types of Networks, TCP/IP Protocol Stacks, Wireless Networks, The Internet Information Security Concepts, Information Security Overview: Background and Current Scenario, Types of Attacks,. Goals for Security, E-commerce Security, Computer Forensics, Steganography.
Unit 2	**Security Threats and Vulnerabilities**
	Overview of Security threats, Weak / Strong Passwords and Password Cracking Insecure Network connections, Malicious Code, Programming Bugs, Cybercrime and Cyber terrorism, Information Warfare and Surveillance Cryptography / Encryption, Introduction to Cryptography / Encryption, Digital Signature, Public Key infrastructure, Applications of Cryptography, Tools and techniques of Cryptography.
Unit 3	**Security Management Practices**
	Overview of Security Management, Information Classification Process, Security Policy, Risk Management, Security Procedures and Guidelines, Business Continuity and Disaster Recovery, Ethics and Best Practice, Security Laws and Standards, Security Assurance, Security Laws, IPR, International Standards, Security Audit SSE-CMM / COBIT etc.
Unit 4	**Information and Network SecurityAccess Control and Intrusion Detection**
	Overview of Identification and Authorization, Overview of IDS, Intrusion Detection Systems and Intrusion Prevention Systems, Server Management and Firewalls, User Management, Overview of Firewalls, Types of Firewalls, DMZ and firewall features.
Unit 5	**Security for VPN and Next Generation Technologies**
	VPN Security, Security in Multimedia Networks, Various Computing Platforms: HPC, Cluster and Computing Grids, Virtualization and Cloud Technology and Security.
Unit 6	**System and Application Security**
	Architectures and Models, Designing Secure Operating Systems, Controls to enforce security services, Information Security Models,System Security, Desktop Security, email security: PGP and SMIME, Web Security: web authentication, SSL and SET, Database Security. OS Security, Vulnerabilities, updates and patches, OS integrity checks, Anti-virus software, updates and patches, Wireless Networks and Security, Components of wireless networks, Security issues in wireless.
Text/Reference Books:	
1.	Cyber Security Understanding Cyber Crimes, Computer Forensics and Legal Perspectives by Nina Godbole and Sunit Belpure, Publication Wiley.
2.	Anti-Hacker Tool Kit (Indian Edition) by Mike Shema, Publication Mc Graw Hill.

Industrial Stream

PEC-IN414 Industrial Automation and Robotics

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination : 30 marks End Semester Examination : 50 marks
Tutorials	0	hrs/week	
Practical	0	hrs/week	
Credits	3		

Course objectives:

1.	To understand basic skills useful in identifying the concepts of automated machines and equipment.
2.	To understand the terms and phrases associated with industrial automation.
3.	To explain the General function of Industrial Automation Identify Safety in Industrial Automation.
4.	To identify Practical Programmable Logic Controller Applications Categorize Input/output Modules and Wiring.

Course Outcome: After successfully completing the course students will be able to,

1.	Design and conduct experiments to analyze the data and interpret the results.
2.	Provide an appropriate solution for a given application related to automation.
3.	Apply modelling and analysis to provide solutions for automation.
4.	Design components and systems related to industrial automation with realistic constraints.
5.	Understand various Instrumentation Standard Protocols, PLC Configuration, Applications and Machine automation.
6.	Demonstrate knowledge and understanding of engineering principles to manage projects and in multidisciplinary environments.

Course Articulation Matrix: Mapping of Course Outcome and Program Outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN414.1	3	-	-	-	1	-	-	-	-	-	-	1	3	3	2	-
PEC-IN414.2	3	-	-	-	1	-	-	-	-	-	-	1	3	3	2	-
PEC-IN414.3	1	3	2	2	3	-	-	-	-	-	-	2	3	3	3	2
PEC-IN414.4	1	2	3	1	3	-	-	-	-	-	-	2	3	3	3	2
PEC-IN414.5	3	2	3	2	3	-	-	-	-	-	-	2	3	3	3	1
PEC-IN414.6	1	2	1	-	2	-	-	-	-	-	-	1	2	2	2	-
PEC-IN414	**2**	**2**	**2**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**3**	**3**	**2**

Syllabus:

Unit 1	**Introduction to Industrial Automation**
	Plant wide control systems andAutomation Strategy. Introduction to Industrial Automation, Role of automation in industries, Introduction to the types of manufacturing industries, Introduction to type of automation system, Benefits of automation. Introduction to Automation pyramid, Introduction to automation tools like PAC, PLC, SCADA, DCS, Hybrid DCS with reference to automation pyramid, Comparison of PLC, PAC, and SCADA on the basis of Performance criteria Control system audit, Performance criteria, Development of User Requirement Specifications (URS) for automation. Functional Design Specifications (FDS) for

	automation tools.
Unit 2	**Instrumentation Standard Protocols**
	Definition of protocol, Introduction to Open System Interconnection (OSI) model, Communication standard (RS232, RS485), Modbus (ASCII/RTU), Introduction to thirdparty interface, concept of OPC (Object linking and embedding for Process Control),HART Protocol: Introduction, frame structure, programming, implementation examples, benefits, advantages and limitation.Foundation Fieldbus H1: Introduction, frame structure, programming, implementation examples, benefits, advantages and limitation.Comparison of HART, Foundation Fieldbus, Devicenet, Profibus, Controlnet, Industrial Ethernet.
Unit 3	**PLC Configuration**
	Applications and Machine automation, PLC programming methods as per IEC 61131, Developing programs using Sequential Function Chart, Functional Block Diagram, Analog control using PLC (PID controller configuration), Interfacing PLC to SCADA/DCS using communication link (RS232, RS485) , Protocols (Modbus ASCII/RTU) and OPC, Development stages involved for PLC based automation systems. Introduction Computer Numerically Controlled (CNC) Machines, Basic CNC Principle, servo control, types of servo control for motion axes, Control system of CNC,Introduction to G-code.
Unit 4	**Distributed Control System**
	Basics,DCS introduction, Various function Blocks, DCS components/block diagram, DCSArchitecture of different makes, comparison of these architectures with automationPyramid, DCS specification, latest trend and developments, DCS support to Enterprise Resources Planning (ERP), performance criteria for DCS and other automation tools.
Unit 5	**DCS Design**
	Distributed Control Systems Engineering and Design ,DCS detail Engineering, configuration and programming, functions including databasemanagement, reporting, alarm management, diagnosis, Historical database management, security and user access management, communication, third party interfaces ,control, display etc. Enhanced functions like Advance process control, fuzzy logic, ANN.
Unit 6	**Robotics**
	Distributed Control System s Engineering and Design ,DCS detail Engineering, configuration and programming, functions including databasemanagement, reporting, alarm management, diagnosis, Historical database management, security and user access management, communication, third party interfaces ,control, display etc. Enhanced functions like Advance process control, fuzzy logic, ANN.
Text/Reference Books:	
1.	Mikell P. Weiss G.M., Nagel R.N., Odraj N.G., ―Industrial Robotics‖, McGraw-Hill, Singapore, 1996.
2.	The management of control system: Justification and Technical Auditing, N. E. Bhttiha, ISA.
3.	Computer aided process control, S.K.Singh, PHI.
4.	Understanding Distributed Process Systems For Control, Samuel Herb, ISA.
5.	Programmable Logic Controllers: Principles and Applications, Webb &Reis, PHI.
6.	Introduction to Programmable Logic Controllers, Garry Dunning, ThomsonLearning.
7.	Distributed computer control for industrial automation, Popovik Bhatkar, Dekkar Pub.

8.	Computer Based Process control, Krishna Kant, PHI
9.	Mechatronics ,HMT, TMH publication
10.	Deb. S. R., Robotics technology and flexible Automation, John Wiley, USA 1992.
11.	Asfahl C.R., Robots and manufacturing Automation, John Wiley, USA 1992.
12.	Klafter R.D., Chimielewski T.A., Negin M., Robotic Engineering – An Integrated approach, Prentice Hall of India, New Delhi, 1994.

Instrumentation Stream

PEC-IN415 Embedded System Design

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination : 30 marks End Semester Examination : 50 marks
Tutorials	0	hrs/week	
Practical	0	hrs/week	
Credits	3		

Course objectives:

1.	To Understand the architectural detail of 32 bit microcontroller.
2.	To Develop ability to program the microcontroller.
3.	To Develop ability to do the combination of software, Hardware and Interfacing the peripherals for various applications.

Course Outcome: After successfully completing the course students will be able to,

1.	Describe characteristics of embedded systems.
2.	Compare the RISC based architecture of ARM processor with other VLIW and DSP processors and its programming aspects.
3.	Interfacing the peripherals for various applications (like blinking of LEDs, digital I/O devices, precision analog and serial communications) based on ARM processor.
4.	Examine various protocols like I^2C, CAN, Bluetooth and its use for embedded applications.
5.	Judge the performance of embedded systems for measurement and control applications.
6.	Design real time embedded systems using the concept of RTOS.

Course Articulation Matrix: Mapping of Course Outcome and Program Outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN415.1	3	-	-	-	-	-	-	-	-	-	-	2	3	3	2	2
PEC-IN415.2	3	1	1	2	2	-	-	-	-	-	-	1	3	2	1	1
PEC-IN415.3	3	-	3	3	3	-	-	-	-	-	-	2	3	2	3	1
PEC-IN415.4	3	1	-	-	-	-	-	-	-	-	-	2	3	2	3	1
PEC-IN415.5	3	2	2	1	2	-	-	-	-	-	-	2	3	2	2	2
PEC-IN415.6	3	1	3	-	3	-	-	-	-	-	-	1	3	2	2	2
PEC-IN415	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**3**	**3**	**3**

Syllabus:	
Unit 1	**Introduction to Embedded system**
	Embedded system definition, different scales of embedded systems, design with small scale embedded systems, CISC and RISC architecture, 32 bit Microcontrollers: Internal Block Diagram, CPU, ALU, address bus, data bus, control signals, Working Registers, SFRs, Clock and Reset circuits, Stack and use of Stack Pointer, Program Counter. I/O Ports, Memory structure, Data Memory, Program Memory , Architecture, Instruction set, different addressing modes, I/O ports, TIMER2 and interrupts, UART, External Interrupts and Timers.
Unit 2	**ARM processor**
	Architecture, Processor modes, Register organization, Exceptions and its handling, Memory and memory management, ARM and THUMB instruction sets, addressing modes, ARM floating point architecture. Real-Time system (RTOS) concepts, Kernel structure, Task management, Inter task communication & synchronization, Understanding Device Drivers.
Unit 3	**Assembly language programming and hardware interfacing techniques**
	Introduction to development tools like cross assembler, simulator, HLL cross compilers and in circuit emulators for system development. On-chip interfaces: Digital I/O pins, ADC, DAC, timers, counters, PWM, watchdog timers, LCD, LEDs, seven segment displays, I2C E2PROM and their applications. ExternalInterfaces: Stepper motor interfacing, DC Motor interfacing, sensor interfacing, SPI, CAN Protocols, USB protocol, Blue-tooth protocol. Writing application level programs for these interfaces using High level languages.
Unit 4	**Introduction to Real-Time /Embedded Operating Systems**
	Real Time Scheduling, Inter process communication, Programming paradigms: FSM and concurrent process models, Performance Metrics of RTOS, Linux & RTLinux Internals, Programming in Linux & RTLinux, Configuring & Compiling RTLinux, Overview of other RTOS.
Text/Reference Books:	
1.	Frank Vahid and Tony Givargis, Embedded system design: A unifiedhardware/software introduction, John Wiley and sons, 2002.
2.	Raj Kamal, “Embedded Systems” TATA McGraw Hill Edition.
3.	Sloss Andrew N, Symes Dominic, Wright Chris; ARM System Developer'sGuide: Designing and Optimizing; Morgan Kaufman Publication.
4.	An Implementation guide to Real Time Programming - David L. Ripps, Yourdon Press, 1990.
5.	D. E. Simon, An embedded software primer, Pearson Education, 2002.
6.	D. W. Lewis, Fundamentals of embedded software, Pearson Education.
7.	J. W. S. Liu, Real time systems, Pearson Education.
8.	Silberchatz, Galvin, Gagne, Operating system concepts, John Wiley.
9.	Dr. K. V. K. K. Prasad, “Embedded / Real – Time Systems: Concept, Design & Programming”, Dreamtech Press.
10.	Technical references on www.arm.com.

Signal Processing Stream

PEC-IN416 Digital Image Processing

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination : 30 marks End Semester Examination : 50 marks
Tutorials	0	hrs/week	
Practical	0	hrs/week	
Credits	3		

Course objectives:

1.	To understand the fundamentals of digital image processing.
2.	To understand Image transform used in digital image processing.
3.	To understand Image enhancement techniques used in digital image processing.
4.	To understand Image restoration techniques and methods used in digital image processing.
5.	To understand Image compression and Segmentation used in digital image processing.

Course Outcome: After successfully completing the course students will be able to,

1.	Understand image formation and the role human visual system plays in perception of gray and color image data.
2.	Get broad exposure to and understanding of various applications of image processing in industry, medicine, and defense.
3.	Learn the signal processing algorithms and techniques in image enhancement and image restoration.
4.	Acquire an appreciation for the image processing issues and techniques and be able to apply these techniques to real world problems.
5.	Student will also have sufficient expertise in both the theory of two-dimensional signal processing and its wide range of applications, for example, image restoration, image compression, and image analysis.
6.	Familiar with basic image processing techniques for solving real problems.

Course Articulation Matrix: Mapping of Course Outcome and Program Outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN416.1	3	3	3	2	-	-	-	1	2	2	3	2	3	3	3	1
PEC-IN416.2	3	1	-	1	-	-	-	3	2	3	3	2	3	3	3	1
PEC-IN416.3	3	3	-	-	-	-	-	2	2	3	3	2	3	3	3	1
PEC-IN416.4	3	3	-	-	-	-	-	2	2	3	3	2	3	1	2	1
PEC-IN416.5	2	2	-	2	-	-	-	3	2	3	3	2	3	3	2	1
PEC-IN416.6	3	3	3	2	2	-	-	3	2	3	3	2	3	2	2	1
PEC-IN416	**3**	**3**	**1**	**1**	**1**	**-**	**-**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**1**

Syllabus:

Unit 1	**Introduction**
	Digital Image processing, the origins of Digital Image Processing, Examples of Fields that use Digital Image Processing, Fundamentals Steps in Digital image processing, components of an image processing system.
Unit 2	**Digital Image Fundamentals**
	Elements of visual perception, Light and the electromagnetic spectrum, Image sensing and Acquisition, Image sampling and quantization, some basic

	Relationships between Pixels, Linear and nonlinear Operations.
Unit 3	**Image Enhancement in the spatial Domain**
	Background, Some basic Gray level Transformation, Histogram processing, Enhancement using arithmetic/logic operations, Basics of spatial Filtering, Smoothing spatial Filters, sharpening spatial Filters, Combining Spatial Enhancement Methods.
Unit 4	**Image Enhancement in the Frequency Domain**
	Background, Introduction to the Fourier transform and the Frequency domain, Smoothing Frequency –Domain Filters, Sharpening frequency Domain filters, Homomorphic filtering, Implementation.
Unit 5	**Image Restoration**
	A model of the Image Degradation/Restoration process, Noise Models, Restoration in the Presence of Noise only-spatial filtering, Periodic Nose Reduction by Frequency Domain Filtering, Linear Position-Invariant Degradations, Estimation of the Degradation function, Inverse filtering, Minimum Mean square Error (Wiener) filtering, Constrained Lease Squares Filtering, Geometric Mean Filter, Geometric Transformations.
Unit 6	**Image Compression**
	Fundamentals, Image Compression Methods, Elements of information Theory, Error-Free Compression, Lossy compression, Image compression standards. Image Segmentation: Detection of Discontinuities, Edge Linking and Boundary Detection, Thresholding, Region-based segmentation, the use of motion in segmentation. Representation and Description: Representation, Boundary Description, Regional Description.
Text/Reference Books:	
1.	Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing, Pearson Education (Singapore), 2nd edition, 2002.
2.	K. Jain, Fundamentals of Digital Image Processing, Prentice Englewood Cliffs, N. J., 1989.
3.	S. Burrus, R. A. Gopinath and H. Guo, Introduction to Wavelets and Wavelet Transforms, Prentice Hall, N. J., 1998.
4.	G. Haskell and A. N. Netravali, Digital Pictures: Representation, Compression and Standards, Perseus Publishing, N. Y., 1997.

SII-IN417 Seminar on Industrial Training

Teaching scheme:			**Examination scheme:**
Lectures	0	hrs/week	Practical Continuous Evaluation : 50 marks, End Term Evaluation : 50 marks
Tutorials	0	hrs/week	
Practical	2	hrs/week	
Credits	1		

Course objectives:

1.	To provide comprehensive learning platform to students where they can enhance their employ ability skills and become job ready along with real corporate exposure.
2.	To cultivate student's leadership ability and responsibility to perform or execute the given task.
3.	Awareness of the social, cultural, global and environmental responsibility as an engineer.

Course outcomes: After successfully completing the course students will be able to,	
1.	To enhance students' knowledge in one particular technology.
2.	Capability to acquire and apply fundamental principles of engineering.
3.	Ability to communicate efficiently.
4.	Knack to be a multi-skilled engineer with good technical knowledge, management, leadership and entrepreneurship skills.
5.	Capability and enthusiasm for self-improvement through continuous professional development and life-long learning
6.	Develop ability to identify, formulate and model problems and find engineering solution based on a systems approach.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
SII-IN417.1	3	1	1	-	-	-	-	3	3	2	1	2	3	1	1	1
SII-IN417.2	3	2	1	-	-	1	-	2	2	2	1	2	3	2	1	2
SII-IN417.3	3	-	1	-	-	1	-	3	1	2	1	2	3	3	1	1
SII-IN417.4	3	-	2	-	-	2	-	1	3	2	2	2	3	2	-	1
SII-IN417.5	3	-	3	-	-	1	-	3	3	3	2	2	3	1	-	2
SII-IN417.6	3	-	2	-	-	1	-	2	3	3	2	2	3	1	-	2
SII-IN417	3	**1**	**2**	**-**	**-**	**1**	**-**	**3**	**3**	**3**	**2**	**3**	**3**	**2**	**1**	**2**

Term Work:	
	A Talk will be delivered by the student based on Industrial Training work undertaken by the student during summer vacation after 3rd year. Industrial work of each student will be evaluated by two teachers appointed by Head of the Institution for giving term work marks. In case a student fails to obtain permission for program training from any industry, the department concerned can plan an equivalent program in the different laboratories under the guidance of faculties. The organizations where practical training will be preferred are: Process Industries, Instrumentation System Design, Instrument Manufacturing organizations, Research and Development establishments, Consultancy firms, Standards and Calibration laboratories.

PRJ-IN418 Mini Project

Teaching scheme:			**Examination scheme:**
Lectures	0	hrs/week	Practical Continuous Evaluation : 50 marks, End Term Evaluation : 50 marks
Tutorials	0	hrs/week	
Practical	10	hrs/week	
Credits	5		

Course objectives:	
1.	Understand &Apply the theoretical concepts to solve industrial problems with teamwork and multidisciplinary approach.
2.	Get capable of self-education and clearly understand the value of achieving perfection in

	project implementation & completion.
Course Outcome: After successfully completing the course students will be able to,	
1.	Identify, formulate and solve a problem of Instrumentation Engineering and allied areas.
2.	Understand social impact of automation, safety aspects and hazards associated with various processes in core instrumentation industry.
3.	Apply new and emerging technologies to analyze, design, maintain reliable, safe and cost effective solution for research and industry problems.
4.	Analyze parametric optimization of manufacturing process.
5.	Reframe work to accomplish projects in multidisciplinary areas.
6.	Design need based project for industry.

Course Articulation Matrix: Mapping of Course Outcome and Program Outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PRJ-IN418.1	3	2	1	2	3	-	-	-	1	1	1	-	3	3	3	1
PRJ-IN418.2	1	1	3	1	3	2	2	-	2	1	2	-	3	3	2	1
PRJ-IN418.3	3	3	3	2	3	-	2	1	3	1	2	-	3	3	3	2
PRJ-IN418.4	3	3	3	2	3	1	-	-	3	1	2	1	3	3	3	2
PRJ-IN418.5	3	3	3	2	3	1	-	-	3	1	2	2	3	3	3	1
PRJ-IN418.6	3	3	3	3	3	1	1	1	2	1	3	2	3	3	3	1
PRJ-IN418	**3**	**3**	**3**	**2**	**3**	**1**	**1**	**1**	**2**	**1**	**2**	**1**	**3**	**3**	**3**	**1**

Term Work:	
Term work will be carried out by a batch of at the most two candidates. Itshall consists of a report based on –	
1.	Laboratory work involving design and construction aspects for any instrumentation applications.
2.	Design modification with fabrication of an existing equipment.
3.	Investigation of practical problems in the manufacture and or testing of electronic or process equipment.
4.	Proposing a theoretical design methodology/or existing method for any instrumentation and control application and development of software for its simulation showing the validity of the results obtained.
5.	The candidates will have to complete at least the design methodology and aspects of the project work.
Term Work Assessment:	
	The following shall be the break up for term work. The presentation will be given by the candidate. The presentation will be attended andevaluated by a group of three teachers, one of whom shall be the guide and the remaining two will be appointed by Director of the Institute. The guide will assess the report based on Quantum of work, Quality of the report Regularity of the candidate in the project work and in submission and discussion with guide.

Semester-VIII

PCC-IN421 Instrumentation Project Management

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination : 30 marks End Semester Examination : 50 marks
Tutorials	0	hrs/week	
Practical	2	hrs/week	
Credits	4		

Course objectives:

1.	To get awareness about various domains in Industrial project Management.
2.	To understand concept of Designing of Instrument, Designing of control panel.
3.	To get awareness about various designing criteria in industry.

Course outcomes: After successfully completing the course students will be able to,

1.	Remembering the basic concepts to address specific management needs at the individual, team, division and/or organizational level.
2.	Understand the ethical responsibilities of practicing engineering managers and the impact of their decisions within a global and societal context.
3.	Apply systems engineering to solve complex technical and operational problems to meet both business and customer needs.
4.	Analyze and design complex systems and operations using both qualitative and quantitative tools and perspectives.
5.	Evaluate industry-related problems by applying their knowledge of business, mathematics, science and engineering.
6.	Create skills to manage creative teams and project processes effectively and efficiently.

Course Articulation Matrix: Mapping of Course Outcome and Program Outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PCC-IN421.1	3	-	-	-	-	3	1	1	3	-	1	2	3	2	2	2
PCC-IN421.2	3	-	-	-	-	2	1	1	2	-	1	2	3	2	2	2
PCC-IN421.3	3	1	1	1	1	1	-	-	-	-	3	1	3	1	1	1
PCC-IN421.4	3	2	-	2	2	3	2	-	2	3	2	2	3	2	1	3
PCC-IN421.5	3	2	3	2	3	-	-	3	-	-	3	1	3	1	1	2
PCC-IN421.6	3	-	-	-	-	3	2	2	3	3	2	2	3	1	2	3
PCC-IN421	**3**	**1**	**2**	**2**	**2**	**2**	**2**	**2**	**3**	**3**	**2**	**2**	**3**	**2**	**2**	**2**

Syllabus:

Unit 1	**Concept study and definition of Project Engineering and Management**
	Basics of Project Management, Definition and objectives of Project Management, Stages of Project Management, Project Planning Process, Establishing Project organization. Organization Structure, The Project team, Roles and responsibilities of project team members and team leader, Interactions involved in Project and their co-ordination project statement.
Unit 2	**Work definition**

	Defining work content, Time Estimation Method, Project Cost Estimation and budgeting, Project Risk Management, Project scheduling and Planning Tools: Work Breakdown structure. Program evaluation and review techniques (PERT) and Critical path method (CPM), Life cycle phases, Statement of work (SOW), Project Specification, milestone scheduling. Project cash flow analysis, Project scheduling with resource Constraints: Resource Leveling and Resource Allocation. Project Implementation: Project Monitoring and Control with PERT/Cost, Computers applications in Project Management, Contract Management, Project Procurement Management; Post Project Analysis.
Unit 3	**Project engineering documents and drawing**
	P & I diagram based on Process Flow Sheet, P & ID symbols for process loops like temperature, flow, level, pressure, etc. Material balance sheet and Temperature pressure sheet, Methods of tagging and nomenclature scheme based on ANSI / ISA standards. Standards used in instrumentation project: ISA S5.1, S5.3, S5.4, S5.5 and S5.20, ANSI, & NFPA. Instrument index sheet, installation sketches, specification sheets. Collection and study of project engineering documents and software like INTools, MS-Project, Primavera.
Unit 4	**Detailed Project engineering**
	Plant layouts and General arrangement drawing (Plans and Elevation), Isometric of instrument piping, installation sketches of filed instrument. Cable Engineering (Class of conductors, Types, Specification and Application), Selection of cables with respect to specific application, Cable identification schemes, Cable trays, Basic Wiring Practice, wire numbering & numbering methods. Failsafe wiring Practice, Hazardous area classifications & its effect on design, Loop wiring diagrams, BOM and MBOM. Earthling and Grounding for General, Power and Signal.
Unit 5	**Procurement activities**
	Vendor registration, Tendering and bidding process, Bid evaluation, Purchase orders, Pre-Qualification Evaluation of Vendor, Kick-off meeting, Vendor documents, drawing and reports as necessary at above activities. Construction activities: Site conditions and planning, Front availability, Installation and commissioning activities and documents require at this stage. Cold Commissioning and hot commissioning.
Unit 6	**Control Centers and Panels**
	Types, Design, Inspection and Specification, Control room layout and engineering, Types of operating Stations, Intelligent Operator Interface (IOI). Panel testing Procedure. Onsite inspection and testing (SAT), Customer Acceptance Test (CAT), Factory Acceptance Test (FAT), Performance trials and final hand over. Calibration records, Test and inspection reports.
Text/Reference Books:	
1.	Andrew and William, "Applied Instrumentation in the Process Industries.Volume II" Gulf Publishing Company.
2.	Liptak B. G., "Instrument Engineers Handbook, Process MeasurementVolume I and Process Control Volume II" Chilton Book Company, 2001 Hiller and Lieberman.
3.	"Introduction to Operations Research", Tata McGrawHill. 7th Edition, 2003.
4.	B.D. Shinde, K.V. Gitapathi, "Electronic & Instrument system design, "Centre of Technical coordination Pune.
5.	B.M. Naik, "Project Management Scheduling and Monitoring byPERT/CPM", Vani Educational books, New Delhi.
6.	Harold Kerzner, "Project Management- A systems approach to planning,scheduling

	and controlling", 5th Edition.
7.	John Bacon, "Management Systems", ISA Publications.
8.	Fisher T. G., "Batch Control System", ISA Publications.
9.	Instrument Installation Project Management, ISA Publications.
10.	Michael D. Whitt, "Successful Instrumentation and Control Systems Design", ISA; 2nd edition, 2012.

Term Work:

It will consist of at least eight experiments/assignments/programs based on above syllabus.

Elective-V

Control Stream

PEC-IN422 System Identification

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory
Tutorials	0	hrs/week	In Semester Evaluation : 20 Marks
Practical	0	hrs/week	Mid Semester Examination : 30 marks
Credits	3		End Semester Examination : 50 marks

Course objectives:

1.	To get better understanding of the physical mechanism generating the signal (for example, speech signals).
2.	To infer about some of the signal parameters. For example, a radar echo from a moving target contains information about the target motion.
3.	To track changes in the signal's source and help identify their cause. For example, certain diseases affect the electrical signal generated by the human brain.

Course Outcomes: After successfully completing the course students will be able to,

1.	Students get Knowledge of a variety of mathematical models for random phenomenon.
2.	To develop Ability to classify such models as to issues of stationary, Markovianness, kinds of asymptotic behavior, and sample function continuity and differentiability.
3.	Ability to make optimal inferences and estimates with respect to such criteria as minimum error probability, and least mean square error (e.g., Wiener and Kalman filtering). Elements of optimal design are introduced.
4.	Predict the signal's future behavior. For example, a good probabilistic model of stock market behavior may help one to predict its future trends and take advantage of them.
5.	Improve the quality of the signal (for example, reduction of noise and reverberation of a voice signal).
6.	Achieve data compression for storage or transmission.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN422.1	2	-	-	-	-	-	-	-	-	-	-	1	3	2	2	1
PEC-IN422.2	3	2	-	-	2	-	-	-	-	-	-	2	3	2	2	1
PEC-IN422.3	3	2	-	-	3	-	-	-	-	-	-	2	3	2	2	1
PEC-IN422.4	2	2	3	-	2	-	-	-	-	-	-	1	3	2	1	1
PEC-IN422.5	1	1	1	-	3	-	-	-	-	-	-	1	3	2	1	1

PEC-IN422.6	2	2	3	2	2	1	-	-	-	-	-	1	3	2	1	1
PEC-IN422	**2**	**2**	**2**	**2**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**3**	**2**	**1**	**1**

Syllabus:	
Unit 1	**Discrete Time Random Process**
	Random Variables Definitions, Ensemble Averages, Jointly Distributed Random Variables, Joint Moments Independent, Uncorrelated and Orthogonal random variable, Linear Mean Square, estimation, Gaussian Random Variables, Parameters Estimation- Definitions, Ensemble Averages, Gaussian Processes, Stationary Processes, the Covariance and autocorrelation matrices, Ergodicity, White Noise, the Power Spectrum, Filtering Ransom Processes, Spectral Realization, Special Types of Random Processes- MA, AR, ARMA, and Harmonic.
Unit 2	**Linear Predication and Optimum Linear Filters**
	Rational Power Spectrum, Relationship between the Filter Parameters and the Autocorrelation Sequence, Forward and Backward Linear Prediction, Solution of the Normal, Equations- Levinson-Durbin Algorithm, the Shur algorithm, Properties of Linear-Prediction Error Filters, AR Lattice and ARMA Lattice Ladder filters, Wiener Filters for Filtering and Prediction- FIR Wener Filter, IIR Wener Filter, Non-causal Wener Filter.
Unit 3	**Signal Modeling and System Identification**
	System Identification based on FIR(MA), All-Pole (AR) and Pole-Zero (ARMA) Models- Pade Approximation, Prony's method, Shank's Method, Least-Square Filtering Design for Prediction and Deconvolution.
Unit 4	**Solution for Least Sequences, Estimation Problems**
	Definition and Basic Concepts, Matrix Formulation of Least Square Estimation Algorithm, Cholesky Decomposition, LDV Decomposition, QR Decomposition, Gram-Schmilt Orthogonalization, Givers Rotation, Householder's Reflection, Singular Valve Decomposition (SVD).
Unit 5	**Power Spectrum Estimation**
	Estimation of Spectra form Finite Duration Observations of Signals, Nonparametric Methods for Power Spectrum Estimation, Parametric Method for power spectrum estimation, Minimum variance spectral estimation, Eigen analysis algorithms for spectrum estimation.
Text/Reference Books:	
1.	Proakis J. G., Rander C. M., f. Ling and Nikins C. L., Advanced Digital Signal Processing, Macmillan Publishing Company, New York, 1992.
2.	Hayes M. H., Statical Digital Signal Processing and Modelling, John Wiley and Sons INC. New York, 1996.

Control Stream

PEC-IN423 Non-linear Control Systems

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory
Tutorials	0	hrs/week	In Semester Evaluation : 20 Marks
Practical	0	hrs/week	Mid Semester Examination : 30 marks
Credits	3		End Semester Examination : 50 marks

Course Objectives:

1.	To introduce students to nonlinear dynamical systems and phenomena with examples drawn from mechanical systems.
2.	To provide methods of characterizing and understanding the behavior of systems that can be described by nonlinear ordinary deferential equations.
Course outcomes: After successfully completing the course students will be able to,	
1.	Derive and describe the methods for PPA and DF.
2.	Apply the PPA and DF method to specific systems.
3.	Derive and describe the feedback linearization.
4.	Apply the method of feedback linearization to specific systems.
5.	Provide the necessary methods for designing controllers for such systems.
6.	Provide applications relevant to the mechanical engineering disciplines where the course material can be applied (aerospace control, vehicle control, process control, control of dynamical systems . . .)

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN423.1	3	-	-	-	-	-	1	-	-	-	-	2	3	3	2	2
PEC-IN423.2	3	-	-	-	-	-	-	-	-	2	-	2	3	3	2	2
PEC-IN423.3	3	2	2	2	2	-	-	-	-	-	-	1	3	1	2	1
PEC-IN423.4	3	-	-	-	-	-	1	-	-	-	-	1	3	2	2	1
PEC-IN423.5	3	-	-	1	1	-	-	-	-	-	-	2	3	1	1	1
PEC-IN423.6	3	3	2	3	2	-	-	-	-	2	-	1	3	3	2	2
PEC-IN423	**3**	**1**	**1**	**1**	**1**	**-**	**1**	**-**	**-**	**1**	**-**	**2**	**3**	**3**	**3**	**2**

Syllabus:	
Unit 1	**Introduction**
	Introduction to nonlinearities and nonlinear phenomenon, Nonlinearsystem behavior, Why nonlinear control?, Examples.
Unit 2	**Phase Plane Analysis**
	Concepts of Phase Plane Analysis: Phase Portraits; SingularPoints; Symmetry in Phase Plane Portraits, Methods of Constructing Phase Portraits: Analytical method, the method of Iscolines, Determining time form Phase Portraits, Phase Plane Analysis of linear systems, Phase Plane Analysis of nonlinear systems, limit cycles and existence of limit cycle: Poincare, Bendixsons theorem.
Unit 3	**Describing Function Method**
	Describing function fundamentals: An example ofdescribing functions; Computing describing functions, Derivations of describingfunctions of common nonlinearities, Describing function analysis of nonlinear systems: The Nyquist Criterion and its extension: Existence of limit cycles; Stability of limit cycles; Reliability of describing function analysis, Introduction to dual input describing functions, Subharmonic and jump resonance.
Unit 4	**Fundamentals of Lyapunov Theory**
	Introduction, Nonlinear Systems and Equilibrium Points. Autonomous and Non-autonomous systems, Concept of Stability, Asymptotic stability and exponential stability, Local and global stability, Linearization and Local stability, Lyapunov's linearization method, Lyapunov's direct method, Positive definite functions, and Lyapunov's functions, Equilibrium Point theorems; Lyapunov theorem for local and global stability, Invariant set theorems, System Analysis based on Lyapunov Direct

	method. Lyapunov analysis of linear time-invariant systems, Generation of Lyapnov functions. Krasovski's Method, The variable gradient method Physically motivated Lypunov functions, control design based on Lyapunov's direct method.
Unit 5	**Advanced Stability Theory**
	Concepts of stability for non-autonomous systems, Lyapunov analysis of Non-autonomous systems, Lyapunov like analysis using Barbalat's Lemma, Positive linear system: PR and SPR transfer functions, The Kalman – Yakubovich Lemma, The Passivity formulation.
Unit 6	**Feedback Linearization**
	Intuitive concepts: Feedback linearization and canonical form; Input-state; Input-output linearization, Mathematical tools, Input-state linearization of SISO systems; Generating a linear input-output relation. Normal forms, The zerodynamics. Stabilization and tracking; Inverse dynamics and Non-minimum phase systems; Case study: Trajectory Control of Robot Manipulator.
Text/Reference Books:	
1.	J. E. Slotine and w. Li, Applied Nonlinear Control., Prentice Hall Inc. Englewood cliffs, New Jersey 1995.
2.	M. Vidyasagar, Nonlinear System Analysis, Prentice-Hall Inc. Englewood cliffs, New Jersey 1978.
3.	Gelb A. and Vander Velde W. E., Multiple Input describing Function and Nonlinear System Design, Machrao-Hill (1968).
4.	A. Isidori, Nonlinear Control System: An Introduction, Springer Yerlag, 1989.
5.	Gibson, Nonlinear Automatic Control, Tata Ma-Graw Hill, 1963.

Industrial Stream

PEC-IN424 Batch Process Control

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory
Tutorials	0	hrs/week	In Semester Evaluation : 20 Marks
Practical	0	hrs/week	Mid Semester Examination : 30 marks
Credits	3		End Semester Examination : 50 marks

Course objectives:	
1.	Examine the different techniques required for Batch process control.
2.	Study different standards for batch process control.
3.	Implement the standards for different batch process P&IDs.

Course Outcomes: After successfully completing the course students will be able to,

1.	Acquired knowledge of standards used for Batch process control.
2.	Development of control schemes for different batch process P&IDs.
3.	Develop a deep understanding of the application of statistical techniques to process control.
4.	Studydesign of batch control systems and the concepts upon which they are based.
5.	Know the constructional details, principle of operation, and performance of different unit operations and their Instrumentation.
6.	Introduce the use of real-time databases for decision support.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4

PEC-IN424.1	3	-	-	2	-	-	-	1	-	1	-	1	3	3	2	-
PEC-IN424.2	3	-	2	1	-	-	-	2	-	2	-	1	3	3	2	-
PEC-IN424.3	-	1	2	2	1	-	-	1	-	1	-	2	3	3	3	2
PEC-IN424.4	3	2	3	1	2	-	-	2	-	1	-	2	3	3	3	2
PEC-IN424.5	3	2	3	2	1	-	-	2	-	1	-	2	3	3	3	1
PEC-IN424.6	-	2	-	-	2	-	-	2	-	1	-	1	2	2	2	-
PEC-IN424	**3**	**2**	**2**	**2**	**2**	**-**	**-**	**2**	**-**	**1**	**-**	**2**	**3**	**3**	**3**	**1**

Syllabus:	
Unit 1	**Introduction**
	Introduction to batch control system, batch control system terminology, and characteristics of batch processes, hierarchical batch model, control structure for batch systems.
Unit 2	**S88 standard**
	Role of standards in batch control systems, study of international standards and practices such as S88, S 95, USA FDA regulation, 21CFR 11, etc.
Unit 3	**Control of batch Process**
	General control requirements, safety interlocking, regulatory & discrete controls, sequential control of batch processes, control activities and process management, information handling for a batch process.
Unit 4	**Design of batch control systems**
	Batch management, recipe management, and production scheduling & information management. Batch control system design, system requirements, system hardware/reliability requirement.
Unit 5	**Specifications and data management**
	Batch control system specifications and implementation, Information/display requirements, cost justification and benefits, data management.
Unit 6	**Implementation & case studies**
	Generic implementation of batch processes, case study of batch control system implementation for applications in food and beverages, pharmaceuticals etc.
Text/Reference Books:	
1.	Thomas .G. Fisher William M. Hawkins, ―Batch Control Systems‖, ISA series, 1st ed., 2008.
2.	Thomas .G. Fisher William M. Hawkins, ―Batch Control Systems‖, ISA series, 2nd ed., 2012.

Industrial Stream

PEC-IN425 Industrial Internet of Things (IIoT)

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory
Tutorials	0	hrs/week	In Semester Evaluation : 20 Marks
Practical	0	hrs/week	Mid Semester Examination : 30 marks
Credits	3		End Semester Examination : 50 marks

Course objectives:	
1.	To Learn advanced Web Technologies.
2.	To apply technologies while solving problems..

Course Outcomes: After successfully completing the course students will be able to,	
1.	Present a survey on building blocks of Web Technologies and open source tools.
2.	Write test cases to use technologies for solving problems using Web Technologies.
3.	Write presentations on using Web Technologies with case studies.
4.	Understand the Vulnerabilities of IoT.
5.	Develop Architectural Approach for IoT Empowerment Introduction.
6.	Train and encourage the students to present and discuss the computer assignments and projects to their classmates and on the web.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN425.1	3	2	3	1	2	1	1	-	2	1	2	1	3	3	3	2
PEC-IN425.2	3	1	3	1	3	2	2	-	2	2	2	1	3	2	2	1
PEC-IN425.3	3	1	3	-	2	1	-	-	3	-	2	2	3	2	1	1
PEC-IN425.4	3	2	3	1	3	2	-	-	3	-	2	2	3	2	2	1
PEC-IN425.5	3	2	3	1	3	1	-	-	2	-	2	3	3	1	1	1
PEC-IN425.6	3	1	1	1	3	-	-	-	3	-	2	1	3	2	3	2
PEC-IN425	**3**	**2**	**3**	**1**	**3**	**2**	**1**	**-**	**3**	**1**	**2**	**2**	**3**	**3**	**3**	**1**

Syllabus:	
Unit 1	**IoT Web Technology**
	The Internet of Things Today, Time for Convergence, Towards the IoT Universe, Internet of Things Vision, IoT Strategic Research and Innovation Directions, IoT Applications, Future Internet Technologies, Infrastructure, Networks and Communication, Processes, Data Management, Security, Privacy & Trust, Device Level Energy Issues, IoT Related Standardization, Recommendations on Research Topics.
Unit 2	**IoT Applications for Value Creation**
	Introduction, IoT applications for industry: Future Factory Concepts, Brown field IoT, Smart Objects, Smart Applications, Four Aspects in your Business to Master IoT, Value Creation from Big Data and Serialization, IoT for Retailing Industry, IoT for Oil and Gas Industry, Opinions on IoT Application and Value for Industry, Home Management, eHealth.
Unit 3	**Internet of Things**
	Privacy, Security and Governance Introduction, Overview of Governance, Privacy and Security Issues, Contribution from FP7 Projects, Security, Privacy and Trust in IoT-Data-Platforms for Smart Cities, First Steps Towards a Secure Platform, Smartie Approach. Data Aggregation for the IoT in Smart Cities, Security.
Unit 4	**Architectural Approach for IoT Empowerment**
	Introduction, Designing a Common Architectural Ground, IoT Standardization, M2M Service Layer Standardization, OGC Sensor Web for IoT, IEEE, IETF and ITU-T standardization activities, Interoperability Challenges, Physical vs Virtual,Solve the Basic First, Data Interoperability, Semantic Interoperability, Organizational Interoperability, Eternal Interoperability, Importance of Standardisation, Plan for validation and testing, Important Economic Dimension, Research Roadmap for IoT Testing Methodologies. Semantic as an Interoperability Enabler and related work.
Unit 5	**Vulnerabilities of IoT**

	Introduction, Vulnerabilities of IoT, Security requirements, Challenges for a secure Internet of Things, identity management, Identity portrayal, Different identity management model: Local identity, Network identity, Federated identity, Global web identity, Identity management in Internet of Things, User-centric identity management, Device-centric identity management, Hybrid identity management.
Unit 6	**Trust Management in IoT**
	Introduction, Trust management life cycle, Identity and trust, Third party approach,Public key infrastructure, Attribute certificates, Web of trust models, Web servicessecurity, SAML approach, Fuzzy approach for Trust, Access control in IoT, Different access control schemes, Authentication and Access control policies modeling.
Text/Reference Books:	
1.	Dr. Ovidiu Vermesan, Dr. Peter Friess, Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems, River Publishers, 2013,ISBN: 978-87-92982-96-4 (E-Book), ISBN: 978-87-92982-73-5.
2.	Vijay Medishetti, Arshadeep Bahga, Internet of Things: A Hands-On Approach (Paperback).
3.	Cuno Pfister, Getting Started with the Internet of Things, O'Reilly Media, 2011, ISBN: 978-1-4493-9357-1.
4.	Poonam Railkar, Identity Management for Internet of Thing, River Publishers, 2015, ISBN: 978-87-93102-91-0 (EBook), ISBN:978-87-93102-90-3.
5.	BoS Content: Books, Course Notes, Digital contents, Blogs developed by the BoS for bridging the gaps in the syllabus, problem solving approaches and advances in the course.

Instrumentation Stream

PEC-IN426 Agricultural Instrumentation

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory
Tutorials	0	hrs/week	In Semester Evaluation : 20 Marks
Practical	0	hrs/week	Mid Semester Examination : 30 marks
Credits	3		End Semester Examination : 50 marks

Course Objectives:

1.	To introduce the soil measurement systems.
2.	To deal with green house instrumentation.
3.	To discuss the working of automation equipment in agriculture.

Course outcomes: After successfully completing the course students will be able to,

1.	Design sensors for soil moisture measurement.
2.	Automate agricultural applications.
3.	Measure characteristics of leaves.
4.	Application of SCADA for DAM parameters & control.
5.	Automation in earth moving equipment & farm equipment.
6.	Infrared & UV bio sensor methods in agriculture.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN426.1	3	3	3	3	2	2	2	-	1	-	3	3	3	2	1	1

PEC-IN426.2	3	2	2	2	1	2	2	-	1	-	2	2	3	3	1	1
PEC-IN426.3	3	1	3	2	3	2	1	1	1	1	-	1	3	3	1	2
PEC-IN426.4	3	2	3	3	1	3	2	1	2	-	3	1	3	2	2	2
PEC-IN426.5	3	2	3	3	2	2	2	1	1	1	3	1	3	3	3	2
PEC-IN426.6	3	1	3	2	1	2	2	-	1	-	2	1	3	3	3	2
PEC-IN426	**3**	**1**	**3**	**3**	**2**	**3**	**2**	**1**	**1**	**1**	**3**	**2**	**3**	**3**	**2**	**2**

Syllabus:	
Unit 1	**Introduction**
	Necessity of instrumentation & control for agriculture, engineering properties of soil: fundamental definitions & relationships, index properties of soil, permeability & seepage analysis, shear strength, Mohr's circle of stress, active & passive earth pressures, stability & slopes, Sensors: introduction to sonic anemometers, hygrometers, fine wire thermocouples, open & close path gas analyzers, brief introduction m to various bio-sensors.
Unit 2	**Case studies**
	Flow diagram of sugar plant & instrumentation set up for it, flow diagram of fermenter & control(batch process),flow diagram of dairy industry & instrumentation set up for it, juice extraction control process & instrumentation set up for it.
Unit 3	**Irrigation systems**
	Necessity, irrigation methods: overhead, center pivot, lateral Move, micro irrigation systems &its performance, comparison of different irrigation systems, soil moisture measurement methods: resistance based method, voltage based method, thermal based method, details of gypsum block soil moisture sensor, irrigation scheduling, irrigation efficiencies, design considerations in irrigation channels.
Unit 4	**Application of SCADA for DAM parameters & control**
	Irrigation control management up- stream & down - stream control systems, green houses &instrumentation: ventilation, cooling & heating, wind speed, temperature & humidity, rain gauge carbon dioxide enrichment measurement & control.
Unit 5	**Automation in earth moving equipment & farm equipment**
	Application ofSCADA & PLC in packing industry and cold storage systems, implementation ofhydraulic, pneumatic & electronics control circuits in harvesters cotton pickers, tractor etc. classification of pumps: pump characteristics, pump selection & installation.
Unit 6	**Green houses & instrumentation**
	ventilation, cooling & heating, wind speed, temperature & humidity, rain gauge, carbon dioxide enrichment measurement & control Leaf area length evaportranspiration, temperature, wetness & respiration measurement & data logging, electromagnetic radiations photosynthesis, infrared & UV bio sensor methods in agriculture, agrometrological instrumentation weather stations, surface flux measurement, soil water content measurement using time-domain reflectrometery(TDR),ground water occurrence confined & unconfined aquifers, evolution of aquifer properties, ground water recharge.
Text/Reference Books:	
1.	Patranabis, "Industrial instrumentation", TMH.
2.	B.G. Liptak, "Instrumentation handbook-process control", Chilton Book Company.
3.	C.D. Johnson, "Process control and instrumentation technology", PHI.
4.	Wills B.A., "Mineral Processing Technology", 4th Ed., Pergamon Press.

Instrumentation Stream

PEC-IN427 Energy Harvesting

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory
Tutorials	0	hrs/week	In Semester Evaluation : 20 Marks
Practical	0	hrs/week	Mid Semester Examination : 30 marks
Credits	3		End Semester Examination : 50 marks

Course objectives:

1. The objective of the course "Energy Harvesting" is to familiarize students with basic principles of energy harvesting systems as well as methods of electro-mechanical conversion, principle of photovoltaic cells and thermoelectric generators.
2. The emphasis is on understanding the physical principles of energy harvesting methods mainly electro-mechanical conversion and simulation modelling of such mechatronic systems.

Course outcomes: After successfully completing the course students will be able to,

1. The "Energy harvesting" deals with overview of independent ways of generating energy from surroundings for autonomous supplying of wireless sensors, remote electronics and low power devices.
2. Students will be able to: Analyze of ambient energy for energy harvesting from the concrete industrial system. Select the best way of supplying of modern autonomous electronics.
3. Simulation modeling of electro-mechanical conversion.
4. Able to understand unique ways of the energy generating from surroundings.
5. Able to understand, how to overcome energy limitations of batteries or possibly fully substitute batteries is to harvest energy from the environment to power the electronics.
6. Got to know about energy harvesting from mechanical energy of vibrations, shocks, deformation, human behavior etc., and simulation modelling of energy harvesting systems.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN427.1	3	3	3	3	2	2	2	-	1	-	3	3	3	2	1	1
PEC-IN427.2	3	2	2	2	1	2	2	-	1	-	2	2	3	3	1	1
PEC-IN427.3	3	1	3	2	3	2	1	1	1	1	-	1	3	3	1	2
PEC-IN427.4	3	2	3	3	1	3	2	1	2	-	3	1	3	2	2	2
PEC-IN427.5	3	2	3	3	2	2	2	1	1	1	3	1	3	3	3	2
PEC-IN427.6	3	1	3	2	1	2	2	-	1	-	2	1	3	3	3	2
PEC-IN427	**3**	**1**	**3**	**3**	**2**	**3**	**2**	**1**	**1**	**1**	**3**	**2**	**3**	**3**	**2**	**2**

Syllabus:

Unit 1	**Solar energy**
	Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and

	equivalent circuits, and sun tracking systems. Carbon captured technologies, cell, batteries, power consumption, Environmental issues and Renewable sources of energy, sustainability.
Unit 2	**Wind Energy harvesting**
	Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.
Unit 3	**Ocean Energy**
	Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.
Unit 4	**Geothermal Energy**
	Geothermal Resources, Geothermal Technologies. Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources.
Unit 5	**Piezoelectric Energy harvesting**
	Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power.
Unit 6	**Harvesting applications**
	Human power,Electromagnetic Energy Harvesting: Linear generators, physics mathematical models, recent applications.
Text/Reference Books:	
1.	G.D. Rai, “Non-conventional energy sources” Khanna Publishers, New Delhi.
2.	M P Agarwal , “Solar energy”, S Chand and Co. Ltd.
3.	Suhas P Sukhative, “Solar energy” Tata McGraw - Hill Publishing Company Ltd.
4.	Godfrey Boyle, “Renewable Energy, Power for a sustainable future”, 2004, Oxford University Press, in association with The Open University.
5.	Dr. P Jayakumar, “Solar Energy: Resource Assessment Handbook”, 2009.

Signal Processing Stream

PEC-IN428 Digital Signal Processors and Applications

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory
Tutorials	0	hrs/week	In Semester Evaluation : 20 Marks
Practical	0	hrs/week	Mid Semester Examination : 30 marks
Credits	3		End Semester Examination : 50 marks

Course Objectives:	
1.	To provide better understanding of discrete-time and digital signal in time and frequency domain.
2.	To provide knowledge to analyze linear systems with difference equations.
3.	To provide knowledge to analyze linear systems with difference equations.
Course outcomes: After successfully completing the course students will be able to,	
1.	An ability to apply knowledge for analyzing the signals in both time and frequency domain.
2.	An ability to design FIR and IIR filters for signal pre-processing.
3.	An ability to implement and realize the filters using different structures.
4.	Explain the selection of DSP processor for signal processing applications.

5.	Represent discrete-time signals analytically and visualize them in the time domain.
6.	Understand the meaning and implications of the properties of systems and signals.
7.	Understand the Transform domain and its significance and problems related to computational complexity.
8.	Be able to specify and design any digital filters using MATLAB.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN428.1	2	-	-	-	-	-	-	-	-	-	-	1	3	2	2	1
PEC-IN428.2	3	2	-	-	2	-	-	-	-	-	-	2	3	2	2	1
PEC-IN428.3	3	2	-	-	3	-	-	-	-	-	-	2	3	2	2	1
PEC-IN428.4	2	2	3	-	2	-	-	-	-	-	-	1	3	2	1	1
PEC-IN428.5	1	1	1	-	3	-	-	-	-	-	-	1	3	2	1	1
PEC-IN428.6	2	2	3	2	2	1	-	-	-	-	-	1	3	2	1	1
PEC-IN428	**2**	**2**	**2**	**2**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**3**	**2**	**1**	**1**

Syllabus:	
Unit 1	**Signal Processing Fundamentals**
	Discrete-time and digital signals, A/D, D/A conversion and Nyquist rate, Frequency aliasing due to sampling, Need for anti-aliasing filters. Discrete Time Fourier transform and frequency spectra, Spectral computation, Computational complexity of the DFT and the FFT, Algorithmic development and computational advantages of the FFT, Inverse FFT, Implementation of the FFT, Correlation of discrete-time signals.
Unit 2	**Discrete-time systems**
	Difference equations and the Z-transform, Analysis of discrete-time LTIL systems, Stability and Jury's test.
Unit 3	**FIR Filters**
	Ideal digital filters, Realizability and filter specifications, Classification of linear phase FIR filters, Design using direct truncation, window methods and frequency sampling, Least-squares optimal FIR filters, Minimax optimal FIR filters, Design of digital differentiators and Hilbert transformers, comparison of design methods.
Unit 4	**IIR Filters**
	Design of analog prototype filters, Analog frequency transformations, Impulse invariance method and digital frequency transformations, Bilinear transformation, Analog prototype to digital transformations, Difficulties in direct IIR filter design, Comparisons with FIR filters.
Unit 5	**IIR Filters design**
	Design of analog prototype filters, Analog frequency transformations, Impulse invariance method and digital frequency transformations, Bilinear transformation, Analog prototype to digital transformations, Difficulties in direct IIR filter design, Comparisons with FIR filters.
Unit 6	**Filter Realization**
	Structures for FIR filters, Structures for IIR filters, State-space analysis and filter structures, Fixed point and floating-point representation of numbers, Errors resulting from rounding and truncating, Quantization effects of filter coefficients, Round-off effects of digital filters.
Unit 7	**DSP Processors**
	Computer architectures for signal processing – Harvard architecture and pipelining,

	General purpose digital signal processors, Selection of DSPs, Implementation of DSP algorithms on a general purpose DSP, Special purpose hardware – hardware digital filters and hardware FFT processors, Evaluation boards for real-time DSP.
Reference Books:	
1.	Chen, C.T., Digital Signal Processing: Spectral Computation & Filter Design, Oxford Univ. Press, 2001 (Available as an Indian reprint).
2.	Proakis, J.G., & Manolakis, D.G., Digital Signal Processing: Principles, Algorithms, & Applications, 3/e Prentice Hall of India, 2007.
3.	Ifeachor, E.C., & Jervis, B.W., Digital Signal Processing: A Practical Approach, 2/e, Pearson Education Asia, 2009.
4.	McClellan, J.H., Schafer, R.W., & Yoder, M.A., DSP First: A Multimedia Approach, 2/e Prentice Hall Upper Saddle River, NJ, 2003.
5.	Mitra, S.K., Digital Signal Processing: A Computer-Based Approach, 4/e ,McGraw Hill, NY, 2011 (A low-cost Indian reprint is available).
6.	Embree, P.M., & Danieli, D., C++ Algorithms for Digital Signal Processing, 2/e, Prentice Hall Upper Saddle River, NJ, 1999.

Elective-VI

Control Stream

PEC-IN429 AI based Control Systems

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory
Tutorials	0	hrs/week	In Semester Evaluation : 20 Marks
Practical	0	hrs/week	Mid Semester Examination : 30 marks
Credits	3		End Semester Examination : 50 marks

Course objectives:	
1.	To provide students with an understanding of the fundamental theory of neural networks and fuzzy systems.
2.	The objective is intended for students to apply neural networks and fuzzy systems to model and solvecomplicated practical problems such as recognition.

Course outcomes: After successfully completing the course students will be able to,	
1.	Comprehend the concepts of feed forward neural networks
2.	Analyze the various feedback networks.
3.	Understand the concept of fuzziness involved in various systems and fuzzy set theory.
4.	Comprehend the fuzzy logic control and adaptive fuzzy logic and to design the fuzzy control using genetic algorithm.
5.	Analyze the application of fuzzy logic control to real time systems.
6.	Implementneural networksand fuzzy systems to solvepractical problems.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN429.1	3	3	-	1	2	-	-	1	3	3	3	3	3	3	1	3
PEC-IN429.2	3	-	-	2	-	-	-	-	2	3	3	2	3	2	1	-
PEC-IN429.3	3	-	-	2	-	-	-	-	2	3	3	3	3	3	2	-
PEC-IN429.4	3	2	3	2	3	-	-	-	2	3	3	3	3	2	3	2
PEC-IN429.5	3	3	3	2	3	-	-	2	3	3	3	3	3	3	3	2
PEC-IN429.6	3	3	3	2	3	-	-	2	3	3	3	3	3	3	3	3

PEC-IN429	3	2	2	2	2	-	-	1	3	3	3	3	3	3	3	2

Syllabus:	
Unit 1	**Artificial Neural Systems**
	Preliminaries, fundamentals concepts and models of artificial neural system, neural network learning rules, Hebbian, Perceptron, delta Windrow-Hoff learning rules.
Unit 2	**Single layer Perceptron Classification**
	Classification model, features and decision regions, training and classification using discrete perception, algorithm and example, single layer continuous Perceptron networks for linear separable classification.
Unit 3	**Multilayer Feed forward Networks**
	Generalized delta learning rule, feed forward recall and error back propagation training, learning factors. Single layer feedback networks: Basic concepts of dynamical systems mathematical foundation of discrete time and gradient type Hopfield networks, transient response of continuous time networks solution optimization problems.
Unit 4	**Neural network in control system**
	Neuro control approaches, training algorithms, evaluation of training algorithms, through simulation, self-running neuro-control scheme, self-tuning PID neuro controller, neuro control scheme feed water bath temperature control system.
Unit 5	**Introduction of fuzzy control**
	Introduction fuzzy control from an industrial perspective, mathematical of fuzzy control fuzzy sets, fuzzy relation, approximate reasoning representing a set of rules. Fuzzy knowledge based controllers FKBS design parameters: Structure of FKBC fuzzification and defuzzification module, rule base choice of variable and contents of rules, derivation of rules, data base choice of membership unction and scaling factors, choice of fuzzification, defuzzification procedure.
Text/Reference Books:	
1.	Kosko, B, "Neural Networks and Fuzzy Systems: A Dynamical Approach to Machine Intelligence", PrenticeHall, NewDelhi, 2004.
2.	Timothy J Ross, "Fuzzy Logic with Engineering Applications",John Willey and Sons, West Sussex, England, 2005.
3.	M. T. Hagan, H. B. Demuth and M. Beale, "Neural Network Design" Thomson Learning, Vikas Publishing House, New Delhi, 2002.
4.	J. M. Zurada, "Introduction to Artificial Neural Systems", Jaico Publication House 1997.
5.	S. Haykin, "Neural Networks: A Comprehensive Foundation", Pearson Education, New Delhi, 2002.
6.	John Yen and Reza Langari, "Fuzzy Logic: Intelligence, Control and Information", Pearson Education New Delhi, 2003.
7.	S. Rajsekaran, G. A. Vijayalaxmi Pai, "Neural Networks, Fuzzy Logic, and Genetic Algorithms, Synthsis and Applications", Prentice Hall of India, 2003.
8.	S. Omatu, M. Khalid and R Yusof, "Neuro Control and its Applications", Springer – Verlag, London Limited 1996.
9.	D. Driankov H. Hellendoorn and M. Reinfrank, "An Introduction to Fuzzy Control", Narosa Publication House, Second Reprint, New Delhi, 1997.

Industrial Stream

PEC-IN430 Product Design and Development

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory
Tutorials	0	hrs/week	In Semester Evaluation : 20 Marks
Practical	0	hrs/week	Mid Semester Examination : 30 marks
Credits	3		End Semester Examination : 50 marks

Course objectives:

1.	To Competence with a set of tools and methods for product design and development.
2.	To develop Confidence in abilities to create a new product.
3.	To create Awareness of the role of multiple functions in creating a new product (e.g. marketing, finance, industrial design, engineering, production).

Course outcomes: After successfully completing the course students will be able to,

1.	Understand the integration of customer requirements in product design.
2.	Apply structural approach to concept generation, selection and testing.
3.	Understand various aspects of design such as industrial design, design for manufacture, economic analysis and product architecture.
4.	Ability to coordinate multiple, interdisciplinary tasks in order to achieve a common objective.
5.	Reinforcement of specific knowledge from other courses through practice and reflection in an action-oriented setting.
6.	Enhanced team working skills.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN430.1	3	3	3	3	3	3	3	2	3	1	1	3	3	3	3	1
PEC-IN430.2	3	3	3	2	3	3	2	3	2	2	2	3	3	3	2	2
PEC-IN430.3	3	3	3	2	3	3	2	1	2	1	2	3	3	2	2	1
PEC-IN430.4	3	3	3	3	3	3	2	-	2	2	3	3	3	3	2	2
PEC-IN430.5	3	3	3	2	3	3	2	-	2	1	2	3	3	3	2	1
PEC-IN430.6	3	3	3	3	3	3	2	-	3	2	3	3	3	3	3	2
PEC-IN430	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**1**	**3**	**2**	**3**	**3**	**3**	**3**	**3**	**2**

Syllabus:

Unit 1	**Introduction**
	Product Planning. Identifying Customer Needs. Project Selection. Concept Generation. Concept Testing. Concept Selection. Product Specification. Product Architecture. Industrial Design. Robust Design. Product Development Economics. Design for Manufacturing. Supply Chain Design. Intellectual Property. Design for Environment.
Unit 2	**Product Development Schedule**
	Customer base for customer needs survey, Project Proposal, Mission statement and customer needs, Concepts sketch and target specification, Preliminary concept selection, Drawings, plans and revised schedule, financial model and patent review.
Unit 3	**Submission and Evaluation**
	Alpha prototype and test report, Beta prototype and customer evaluation, demonstration of working model.

Text/Reference Books:	
1.	Karl T. Ulrich and Steven D. Eppinger, “Product Design and Development”, 3rd Edition, Tata McGraw- Hill, 2003, ISBN 0-07-058513-X.
2.	Kevin Otto and Kristin Wood, “Product Design”, Pearson Education, 2003, ISBN: 8129702711.

Industrial Stream

PEC-IN431 Automobile Instrumentation

Teaching scheme:			Examination scheme:
Lectures	3	hrs/week	Theory
Tutorials	0	hrs/week	In Semester Evaluation : 20 Marks
Practical	0	hrs/week	Mid Semester Examination : 30 marks
Credits	3		End Semester Examination : 50 marks

Course objectives:	
1.	To understand the concepts of Automotive Electronics and its evolution and trends, Automotive systems & subsystems overview.
2.	To understand Safety standards, advances in towards autonomous vehicles.
3.	To understand sensors and sensor monitoring mechanisms aligned to automotive systems, different signal conditioning techniques, interfacing techniques and actuator mechanisms.

Course outcomes: After successfully completing the course students will be able to,	
1.	Obtain an overview of automotive components, subsystems, design cycles, communication protocols and safety systems employed in today’s automotive industry.
2.	Describe the working of various instruments, sensors and actuators used in automobile systems.
3.	Illustrate the test procedures and instrumentation for emission standards.
4.	Discuss about different types instruments used in industry.
5.	Gain the knowledge of Automobile chassis electronic control system.
6.	Understand Auto Body Electronic Control Technology.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN431.1	3	2	3	2	3	-	-	2	3	1	1	3	3	3	3	1
PEC-IN431.2	3	1	2	-	3	-	-	3	2	2	2	3	3	3	2	2
PEC-IN431.3	3	2	1	-	2	-	-	1	2	1	2	3	3	2	2	1
PEC-IN431.4	3	3	3	3	2	-	-	-	2	2	3	3	3	3	2	2
PEC-IN431.5	3	3	2	2	1	-	-	-	2	1	2	3	3	3	2	1
PEC-IN431.6	3	3	3	2	2	-	-	-	3	2	3	3	3	3	3	2
PEC-IN431	**3**	**3**	**3**	**2**	**3**	**-**	**-**	**1**	**3**	**2**	**3**	**3**	**3**	**3**	**3**	**2**

Syllabus:	
Unit 1	**Fundamentals of Automotive Electronics**
	Open loop and closed loop systems components for electronic engine management, vehicle motion control, Current trends in modern Automobiles.

Unit 2	**Electronic Fuel Injection and ignition systems**
	Introduction, Carburetor control system,throttle body ignition and multi-port or point fuel injection, Advantages of electronicignition system, Types of solid state ignition systems and their principle of operation,electronic spark timing control system.
Unit 3	**Engine control system**
	Engine cranking and warm up control, Acceleration enrichment –De-acceleration leaning and idle speed control, integrated engine control system, exhaust emission control system, Engine performance testing.
Unit 4	**Automobile chassis electronic control system**
	Principle of electronic braking, automatictransmission electronic control circuit, cruise control circuit, the electronic steeringcontrol theory, ABS, ASR, ESP, and other electronic control method.
Unit 5	**Auto Body Electronic Control Technology**
	Automotive central locking and anti-theft system control technology, electronically controlled windows and doors and airbag technology, principle of control circuit components and characteristics.
Unit 6	**Ergonomics and safety**
	Driver information system, lighting system components, batterymonitoring and control, Air conditioning, steering control techniques, Automatic gearcontrol systems, Emission standards.
Text/ Reference Books:	
1.	William B. Riddens, "Understanding Automotive Electronics", 5th Edition,(Butterworth Heinemann Woburn), (1998).
2.	Tom Weather Jr and Cland C. Hunter, "Automotive Computers and Control System", Prentice Hall Inc., New Jeresy.
3.	Jiri Marek, Hans Peter trah, "Sensors Applications, Sensors for AutomotiveTechnology" 1st Edition, Wiley.
4.	T. Mellard, Automotive Electronic Systems"1987 by Heinenmann Professional.

Instrumentation Stream

PEC-IN432 Intelligent Sensors

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory
Tutorials	0	hrs/week	In Semester Evaluation : 20 Marks
Practical	0	hrs/week	Mid Semester Examination : 30 marks
Credits	3		End Semester Examination : 50 marks

Course Objectives:	
1.	To train the students to the variousintelligent sensors principle.
	To train the students using intelligent sensors for wellness and industrial applications.
2.	To study fusion of multi sensors make them understand their applications.
3.	To train the students selection of sensors for specific application using Artificial intelligent techniques.
Course outcomes: After successfully completing the course students will be able to,	
1.	Understand Intelligent measurement system.
2.	Identify, define, names various types of smart sensors, biosensors, fiber optic sensors,

	MEMS, robotics sensors.
3.	Describe, draw, and explain the working principle and its possible application of various Intelligent sensors.
4.	Analyse problem and develop projects by using various types of intelligent sensors in Agriculture, Environmental, and Automotive industries and Wellness.
5.	Evaluate asses and compare various types of intelligent sensors and decide the test selection for particular application like biosensors, environmental sensors.
6.	Create, design, formulate, generate and deliver the best possible solution using various types of intelligent sensors for example wellness, automation, economic bio-sensors, robotic applications.
7.	Evaluate the fusion of multisensors for various applications and selection of intelligent sensors using Artificial intelligence for any applications.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN432.1	3	-	-	-	-	-	-	-	-	-	-	2	3	3	2	1
PEC-IN432.2	3	2	2	-	1	-	-	-	-	-	-	2	3	3	2	1
PEC-IN432.3	3	3	-	2	1	-	2	-	-	-	-	2	3	2	2	1
PEC-IN432.4	3	2	2	2	2	1	2	-	1	-	-	2	3	3	2	2
PEC-IN432.5	3	2	3	2	3	1	2	-	1	-	-	2	3	3	2	2
PEC-IN432.6	3	-	-	-	-	-	-	-	-	-	-	2	3	3	2	1
PEC-IN432	**3**	**3**	**3**	**3**	**3**	**3**	**2**	**-**	**1**	**-**	**-**	**3**	**3**	**3**	**3**	**3**

Syllabus:	
Unit 1	**The General measurement system**
	Measurement system-purpose, structure and elements.
Unit 2	**An introduction to Multi-sensor**
	Data fusion Techniques, Application of Data Fusion, Process models for Data Fusion, Limitation of Data Fusion system.
Unit 3	**Smart Sensors**
	Introduction, Primary sensors, Excitation, Amplification, Filters, Converters, Compensation, Nonlinearity, Approximation and regression, Noise and interference, response time, drift, cross-sensitivity, Information Coding/Processing, Data communication, standards for smart sensor interface, the Automation.
Unit 4	**Recent trends in sensor technology**
	Introduction, film sensors, thick film sensors, thin film sensors, semiconductor IC technology-standard methods.
Unit 5	**MEMS/NANO**
	Microelectromechanical systems (MEMS), Micromachining, Biomedical Applications, Nano-sensors, Carbon Nanotubes.
Unit 6	**Chemical Sensors**
	Introduction, semiconductor gas detectors, Ion Selective electrodes, Conductometric sensors, Mass sensors.
Unit 7	**Robotics sensors**
	Introduction, characteristics, types of sensors, touch or tactile sensors, binary and analog sensors, proximity sensors, types of proximity sensors, contact and non-contact proximity sensors, robotic vision. Fiber optic sensors: Fiber optic sensors for

	the measurement of temperature, Pressure, turbidity, pollution. Biosensors: Enzyme sensors, Cell based biosensors using Microelectrodes, Biosensors in Food Analysis.
Text/Reference Books:	
1.	Principles of Measurement systems John P. Bentley, Third edition 2000, Pearson.
2.	D. Patranabis, "Sensors and Transducers", Second Edition Prentice Hall of India Pvt. Ltd. New Delhi, 2006.
3.	Middlehook S. and Audet S. A., "Silicon Sensors", Academic Press, London 1999.
4.	Richard C. Dorf, "Sensors, Nanoscience, Biomedical engineering and instruments", CRC Press, Taylor and Francis group USA, third edition, 2006.
5.	Henry Zanger, Cynthia Zanger, "Fiber optics Communication and other applications", Macmillan publishing company, New York, 1991.
6.	Raj Mohan Joshi, "Biosensors", First Edition, ISHA Books, Delhi, 2006.
7.	R. K. Rajput, "Robotics and Industrial Automation", S. Chand & company Ltd., First edition, 2008.
8.	D. V. S. Murty, "Transducers and Instrumentation", Second edition, PHI publication, Second edition, 2010.

Signal Processing Stream

PEC-IN433 Biomedical Signal Processing

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory
Tutorials	0	hrs/week	In Semester Evaluation : 20 Marks
Practical	0	hrs/week	Mid Semester Examination : 30 marks
Credits	3		End Semester Examination : 50 marks

Course objectives:	
1.	To understand Biomedical Signal Processing Course with the fundamental tools that are used to describe, analyze and process biomedical signals.
2.	To understand fundamental principles in the analysis and design of filters, power spectral density estimation and non-stationary signal processing techniques with applications to biomedical signals.
Course outcomes: After successfully completing the course students will be able to,	
1.	Understand linear system theory.
2.	Understand transfer functions and state models.
3.	Understand time-domain and frequency-domain models.
4.	Understand the concept of signal filtering.
5.	Develop the skill to model complex biomedical systems.
6.	Learn to use signal processing methods to analyze signals originating in biomedical systems.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PEC-IN433.1	2	-	-	-	-	-	-	-	-	-	-	1	3	2	2	1
PEC-IN433.2	3	2	-	-	2	-	-	-	-	-	-	2	3	2	2	1
PEC-IN433.3	3	2	-	-	3	-	-	-	-	-	-	2	3	2	2	1
PEC-IN433.4	2	2	3	-	2	-	-	-	-	-	-	1	3	2	1	1
PEC-IN433.5	1	1	1	-	3	-	-	-	-	-	-	1	3	2	1	1

PEC-IN433.6	2	2	3	2	2	1	-	-	-	-	-	1	3	2	1	1
PEC-IN433	**2**	**2**	**2**	**2**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**1**	**3**	**2**	**1**	**1**

Syllabus:	
Unit 1	**Basic Neurology**
	Nervous system, neuron, resting potential, biopotential, Nernst equation, electrical equivalents.Electrical activity of the heart: Cardiac system, bipolar and unipolar lead system, Einthoven triangle, electrodes, electrocardiogram-normal and abnormal, exercise ECG, lead positioning, electrode positioning for Holter ECG recording, vector cardiography, signal conditioning and processing.
Unit 2	**Electrical activity of neuromuscular system**
	muscular system, electrical signals of motor unit and gross muscle, human motor coordination system, electrodes, correlation of force and work, EMG integrators, signal conditioning and processing.
Unit 3	**Electrical activity of the brain**
	Sources of brain potential, generation of signals, waves, EEG recording electrodes, 10-20 electrode system, EEG under Grand mal and petit mal seizures, signal conditioning and processing. Electrical signals from visual system: Sources of electrical signals in eye, generation of signals, electro-retinogram, eletro-occulogram.
Unit 4	**Electrical signals from auditory system**
	Generation of cochlear potential and nature, evoked responses, auditory nerves, signal conditioning and processing. Noise and interference in biomedical signals: Sources of noise in biomedical signal recordings, filtering techniques-active and passive filters, digital filtering, grounding and shielding.
Unit 5	**Computer applications and Bio-telemetry**
	Real time computer applications, data acquisition, compression and processing, remote data recording and management.
Unit 6	**Digital signal processing and data compression**
	Typical signal processing operations, time-domain operations, correlation and covariance, convolution, Digital filters: Smoothing filters, least square polynomial smoothing, windowing, FFT, DFT, data compression methods, Tolerance-comparison data compression techniques, polynomial predictors: Zero order predictor (ZOP), First order predictor (FOP), Polynomial interpolation: Zero order interpolator ZOI and FOI. AZTEC, MAZTEC, TP, CORTES, FAN, SAPA, DPCM, Entropy coding method, Peak picking method, cycle-to-cycle compression technique, Huffman coding, EBP-ANN based technique: Data compression-retrieval performance indices.
Unit 7	**Medical imaging**
	Diagnostic X-rays, CAT, MRI, thermography, ultrasonography, medical uses of isotopes, endoscopy.
Text/Reference Books:	
1.	W. J. Jonkins, “Biomedical Digital Signal Processing”, Prentice Hall of India,New Delhi.
2.	G. F. Ihbar, “Signal Analysis and Pattern Recognition in BiomedicalEngineering”, John Wiley and Sons.
3.	R.S. Khandpur , “Hand Book of Biomedical Instrumentation.”, Tata Mcgraw Hill Publ.
4.	H.K. Wolf and P.W. Macfarlane (Editors), “Optimization of Computer ECG Processing.”, North Holland Publishing Co., Amsterdam.
5.	Carr and Brown, “Biomedical Instrumentation.”
6.	M.J. Goldman, “Principles of Clinical Electrocardiography.”

PRJ-IN434 Project (In house)			
Teaching scheme:			**Examination scheme:**
Lectures	0	hrs/week	Practical Continuous Evaluation : 50 marks, End Term Evaluation : 50 marks
Tutorials	0	hrs/week	
Practical	14	hrs/week	
Credits	7		

Course objectives:

1.	Understand &Apply the theoretical concepts to solve industrial problems with teamwork and multidisciplinary approach.
2.	Get capable of self-education and clearly understand the value of achieving perfection in project implementation & completion.

Course outcomes: After successfully completing the course students will be able to,

1.	Identify, formulate and solve a problem of Instrumentation Engineering and allied areas.
2.	Understand social impact of automation, safety aspects and hazards associated with various processes in core instrumentation industry.
3.	Apply new and emerging technologies to analyze, design, maintain reliable, safe, and cost effective solution for research and industry problems.
4.	Analyze parametric optimization of manufacturing process.
5.	Reframe work to accomplish projects in multidisciplinary areas.
6.	Design need based project for industry.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PRJ-IN434.1	3	2	1	2	3	-	-	-	1	1	1	-	3	3	3	1
PRJ-IN434.2	1	1	3	1	3	2	2	-	2	1	2	-	3	3	2	1
PRJ-IN434.3	3	3	3	2	3	-	2	1	3	1	2	-	3	3	3	2
PRJ-IN434.4	3	3	3	2	3	1	-	-	3	1	2	1	3	3	3	2
PRJ-IN434.5	3	3	3	2	3	1	-	-	3	1	2	2	3	3	3	1
PRJ-IN434.6	3	3	3	3	3	1	1	1	2	1	3	2	3	3	3	1
PRJ-IN434	**3**	**3**	**3**	**2**	**3**	**1**	**1**	**1**	**2**	**1**	**2**	**1**	**3**	**3**	**3**	**1**

Term work:

PROJECT (In house) will be the continuation of mini project undertaken by thecandidates in the first term. The term work shall consist of report of the work carried out bythe candidates in respect of the project assigned. The candidate must bring the mini projectreport along with project (In house) report while appearing for project (In house)submission.

Practical Examination:

It shall consist of presentation and oral examination based upon the project work reportsubmitted by the candidates and or upon the demonstration of the fabricated/designedequipment or software developed for simulation. The said examination will be conductedby a panel of two examiners, consisting of preferably guide working as internal examinersand another external examiner preferably from an industry or other university.

PRJ-IN435 Project (In Industry/Research Institute)

Teaching scheme:			**Examination scheme:**
Lectures	0	hrs/week	Practical Continuous Evaluation : 50 marks, End Term Evaluation : 50 marks
Tutorials	0	hrs/week	
Practical	34	hrs/week	
Credits	17		

Course objectives:

1.	Understand &Apply the theoretical concepts to solve industrial problems with teamwork and multidisciplinary approach.
2.	Get capable of self-education and clearly understand the value of achieving perfection in project implementation & completion.

Course outcomes: After successfully completing the course students will be able to,

1.	Identify, formulate and solve a problem of Instrumentation Engineering and allied areas.
2.	Understand social impact of automation, safety aspects and hazards associated with various processes in core instrumentation industry.
3.	Apply new and emerging technologies to analyze, design, maintain reliable, safe, and cost effective solution for research and industry problems.
4.	Analyze parametric optimization of manufacturing process.
5.	Reframe work to accomplish projects in multidisciplinary areas.
6.	Design need based project for industry.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
PRJ-IN435.1	3	2	1	2	3	-	-	-	1	1	1	-	3	3	3	1
PRJ-IN435.2	1	1	3	1	3	2	2	-	2	1	2	-	3	3	2	1
PRJ-IN435.3	3	3	3	2	3	-	2	1	3	1	2	-	3	3	3	2
PRJ-IN435.4	3	3	3	2	3	1	-	-	3	1	2	1	3	3	3	2
PRJ-IN435.5	3	3	3	2	3	1	-	-	3	1	2	2	3	3	3	1
PRJ-IN435.6	3	3	3	3	3	1	1	1	2	1	3	2	3	3	3	1
PRJ-IN435	**3**	**3**	**3**	**2**	**3**	**1**	**1**	**1**	**2**	**1**	**2**	**1**	**3**	**3**	**3**	**1**

Term work:

	PROJECT (In Industry/Research Institute) will be based upon the work allotted by the industry/research institute where student is working for whole semester. The term work shall consist of report of the work carried out bythe candidates in respect of the project assigned by the industry/ research institute. The candidate must bring detail projectreport while appearing for project (In Industry/Research Institute)submission.

Practical Examination:

	It shall consist of presentation and oral examination based upon the project work reportsubmitted by the candidates and or upon the demonstration of the fabricated/designedequipment or software developed for simulation in industry/research institute. The said examination will be conductedby a panel of two examiners, consisting of preferably guide working as internal examinerand another external examiner preferably from an industry, other university or research institute.

Open Elective Course

OEC-IN436 Introduction to MEMS/NEMS

Teaching scheme:			**Examination scheme:**
Lectures	3	hrs/week	Theory In Semester Evaluation : 20 Marks Mid Semester Examination : 30 marks End Semester Examination : 50 marks
Tutorials	0	hrs/week	
Practical	0	hrs/week	
Credits	3		

Course objectives:

1.	To develop a concept on the scope and recent developments in the science and technology of micro- and nano-systems.
2.	To gain a basic understanding of construction and mechanics underlying these systems.
3.	To learn some potentially applicable micro- and nano-systems at the frontier of the development of the field.
4.	To acquire the knowledge about design and fabrication of MEMS / NEMS.

Course outcomes: After successfully completing the course students will be able to,

1.	Understand the operation of micro devices, micro systems and their applications.
2.	Design the micro devices, micro systems using the MEMS fabrication process.
3.	Gain knowledge of basic approaches for various sensor designs.
4.	Gain knowledge of basic approaches for various actuator designs.
5.	Develop experience on micro / nano systems.
6.	Gain the technical knowledge required for computer-aided design, fabrication, analysis and characterization of micro- and nano-scale devices.

Course Articulation Matrix: Mapping of Course outcome and Program outcome

PO/PSO → ↓ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
OEC-IN436.1	3	1	1	1	2	2	1	3	2	3	1	1	3	1	2	1
OEC-IN436.2	2	2	2	1	2	1	2	1	1	1	1	1	3	1	3	1
OEC-IN436.3	2	3	1	2	1	2	1	1	1	1	3	1	3	1	2	1
OEC-IN436.4	2	3	2	1	1	1	3	2	1	2	1	1	3	1	2	1
OEC-IN436.5	1	2	2	1	3	2	1	2	2	1	2	1	1	1	3	1
OEC-IN436.6	1	1	1	2	3	3	1	1	2	1	1	2	2	1	3	1
OEC-IN436	**2**	**3**	**2**	**1**	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**3**	**1**	**3**	**1**

Syllabus:

Unit 1	**Introduction**
	Micro and Nano scale systems Introduction to Design of MEMS and NEMS, Overview of Nano and Micro electromechanical Systems, Applications of Micro and Nano electro mechanical systems, Micro electromechanical systems, devices and structures Definitions, Materials for MEMS: Silicon, silicon compounds, polymers, metals. Scaling effects.
Unit 2	**MEMS Fabrication Technologies**
	Microsystem fabrication processes: Photolithography, Ion Implantation, Diffusion, Oxidation, Thin film depositions: LPCVD, Sputtering, Evaporation, Electroplating; Etching techniques: Dry and wet etching, electrochemical etching; Micromachining: Bulk Micromachining, Surface Micromachining, High Aspect-Ratio (LIGA and LIGA-

	like) Technology; Non-conventional micromachining – microelectrodischarge machining, ultrasonic machining, laser micromachining, nano imprinting, focused ion beam machining, screen printing, soft lithography, injection molding, hot embossing, stereolithography.
Unit 3	**MEMS Sensors**
	Design of Acoustic wave sensors, resonant sensor, Vibratory gyroscope, Capacitive and Piezoresistive Pressure sensors- engineering mechanics behind these Microsensors.
Unit 4	**Design of Actuators**
	Mechanics at microscale – microstructural elements, Stiction and control. Actuation principles – Electrostatic, Piezoresistive, Piezoelectric, Thermal, Electromagnetic, Resonant and tunneling. Shape memory Alloys, piezoelectric crystals, Parallel plate, Torsion bar, Comb drive actuators, Micromechanical Motors, Microaccelerometers, microphones, ink-jet printer heads, resonators, digital micromirrors, etc.
Unit 5	**Microfluidics**
	Fluid dynamics at the microscale, electrokinetics, surface tension driven transport, microfluidics for DNA analysis, Lab-on-Chip applications, Microfluidic devices: Micropumps, microvalves, micromixers.
Unit 6	**Packaging**
	Microsystems packaging, Essential packaging technologies, Selection of packaging materials. Wafer bonding and packaging, Assembly techniques for MEMS
Text/Reference Books:	
1.	G.K. Ananthasuresh, K.J. Vinoy, S. Gopalakrishnan, K.N. Bhat and V.K. Aatre, “Micro and Smart Systems”, John Wiley & Co. Indian Edition New Delhi, ISBN: 978 81265 27151, 2010, 385p.
2.	Marc Madou, “Fundamentals of Micro fabrication”, CRC press 1997.
3.	Stephen D. Senturia,” Micro system Design”, Kluwer Academic Publishers,2001.
4.	Tai Ran Hsu, “MEMS and Microsystems Design and Manufacture”,Tata McGraw Hill, 2002.
5.	Chang Liu, “Foundations of MEMS”, Pearson education India limited, 2006.
6.	N. Maluf, “An introduction to microelectromechanical systems engineering”, Artech House 2000.