SGGS INSTITUTE OF ENGINEERING & TECHNOLOGY,

VISHNUPURI, NANDED

T.Y. B.Tech. (Instrumentation Engineering) Curriculum Structure: CBCS, (Effective from Academic Year 2020-21)

Semester V						
Course Code	**Course Title**	**Lectures (L)**	**Tutorials (T)**	**Practical (P)**	**Credits**	
					Th.	**Pr.**
PCC-IN301	Feedback Control Systems	3	-	2	3	1
PCC-IN302	Industrial Instrumentation	3	-	2	3	1
PCC-IN303	Digital Signal Processing	3	-	2	3	1
PCC-IN304	Microprocessor and Microcontroller	3	1	2	4	1
PCC-IN305	Industrial Data Communications	3	-	-	3	-
PCC-IN306	Unit Operations and Instrumentation	3	-	2	3	1
Total		**18**	**01**	**10**	**24**	

Semester VI						
Course Code	**Course Title**	**Lectures (L)**	**Tutorials (T)**	**Practical (P)**	**Credits**	
					Th.	**Pr.**
PCC-IN307	Process Control	3	-	2	3	1
PCC-IN308	Control System Components	3	-	2	3	1
PCC-IN309	Distributed Control System	3	-	2	3	1
PCC-IN310	Power Electronics	3	-	2	3	1
PEC-IN3**	Elective – I	3	-	-	3	-
SEM-IN319	Seminar	-	-	2	-	1
AUD-IN320	Indian Ancient Science	2	-	-	Audit	
Total		**17**	**00**	**10**	**20**	

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

Elective – I	
PEC-IN311	Power Plant Instrumentation
PEC-IN312	Digital System Design
PEC-IN313	Optical Instrumentation
PEC-IN314	Automotive Instrumentation
PEC-IN315	Mechatronics
PEC-IN316	Material Science
PEC-IN317	Microelectronics
PEC-IN318	Data Structure and Algorithms

CONTENTS

Semester-V

PCC-IN301 Feedback 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	2	hrs/week	
Credits	4		

Course objectives:	
1.	Introduction to concepts of modeling of physical systems.
2.	Introduction to time domain and frequency domain modeling.
3.	Analyze the system response and stability in time domain and frequency domain.
Course outcomes: On successful completion of this course students will be able to,	
1.	Exhibit the capability to represent the mathematical model of physical systems using linear differential equations; Laplace transform and use block diagram algebra, Mason's gain formula to simplify complicated control systems.
2.	To determine time response of first, second and higher order systems to standard test signals and to specify control system performance in terms of time and frequency domain specifications.
3.	Construct Hurwitz determinant, Routh array, root-locus, polar plot, Bode plot and Nyquist plot for single variable feedback control systems and investigate system stability.
4.	Realize lead, lag and lag lead compensators using electrical, electronic and mechanical components.
5.	Validate the concepts of time domain, frequency domain and stability analysis using MATLAB.
6.	Gain **some** practical experience in control engineering which might become a future research point for them. **(Some is not specific and measurable)**

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-IN301.1	3	2	-	2	-	-	-	-	1	1	-	-	3	3	1	1
PCC-IN301.2	3	2	2	3	1	-	-	-	1	1	-	-	3	3	1	1
PCC-IN301.3	2	2	2	3	1	-	-	-	1	1	-	-	2	2	1	1
PCC-IN301.4	1	1	2	-	-	-	-	-	1	1	-	-	1	1	3	1
PCC-IN301.5	1	2	-	-	3	-	-	-	2	2	-	1	1	3	2	2
PCC-IN301.6	1	2	2	2	3	-	-	-	2	2	-	3	1	3	2	2
PCC-IN301	**2**	**2**	**1**	**2**	**1**	**-**	**-**	**-**	**1**	**1**	**-**	**1**	**2**	**3**	**2**	**1**

Syllabus:	
Unit 1	**Introduction to control systems (04 Hours)**
	Definition, history, elements of control systems, examples of control systems, open-loop (non feedback) and closed loop (feedback) control systems, effect of feedback on overall gain, parameter variations, external disturbances or noise and control over system dynamics, regenerative feedback, linear versus nonlinear control systems, time- invariant versus time- varying systems, SISO and MIMO systems.
Unit 2	**Mathematical modeling of dynamic systems (10 Hours)**
	Introduction, canonical form of feedback, control systems, transfers function and

	impulse response. differential equations and transfer functions of physical systems such as mechanical, electrical, electromechanical, thermal, pneumatic and liquid-level systems, analogous systems, force-voltage, force-current and torque- current analogies, loading effects in interconnected systems, systems with transportation lags, linearization of nonlinear mathematical models, block diagram representation of control system, rules and reduction techniques, signal flow graph: elements, definition, properties, masons gain formula, application of gain formula to block diagrams.
Unit 3	**Time- domain analysis of control systems (08 Hours)**
	Standard test signals, transient response, steady state error and error constants, dynamic error series, time response of first and second order systems and transient response specifications, effect of adding poles and zeros to transfer functions, dominant poles of transfer function, basic control actions and response of control systems, effects of integral and derivative control action on system performance, higher order systems.
Unit 4	**Stability of linear control systems (04 Hours)**
	Concept of stability, BIBO stability: condition, zero input and asymptotic stability, Hurwitz stability criterion, Routh-Hurwitz criterion in detail, relative stability analysis. Effect of adding poles and zeros to transfer functions on stability.
Unit 5	**The Root–Locus technique (04 Hours)**
	Introduction, basic properties of the root loci, general rules for constructing root loci, Root- Locus analysis of control systems.
Unit 6	**Frequency domain analysis (12 Hours)**
	Frequency response of closed loop systems, frequency domain specifications of the prototype second order system, correlation between time and frequency response, effect of adding a pole and a zero to the forward path transfer function, polar plots, Bode plots, phase and gain margin, stability analysis with Bode plot, Nyquist stability criterion: mathematical preliminaries, stability and relative stability analysis.
Unit 7	**Compensators (03 Hours)**
	Introduction, different types of compensators, Realization of lead, lag and lag lead compensators (Electrical, Electronic and Mechanical type), their transfer functions and frequency responses.
Text/Reference Books:	
1.	K. Ogata, "Modern Control Engineering", Fourth Edition Pearson education India, 2002.
2.	B. C. Kuo, "Automatic control systems", Seventh Edition, Prentice –Hall of India, 2000.
3.	Norman S. Nise, "Control systems Engineering", Third Edition, John Wiley and Sons. Inc, Singapore, 2001.
4.	R. C. Dorf and R. H. Bishop, "Modern Control systems", Eighth Edition, Addison Wesley, 1999.
5.	I. J. Nagrath and M. Gopal, "Control systems Engineering", Third Edition, New age International Publishers, India, 2001.
Term Work:	
It will consist of at least eight experiments/assignments/programs from the following list:	
1.	Determination of transfer function of an armature controlled d. c. motor.
2.	Determination of transfer functions of D. C. generator.
3.	Effect of feedback on D. C. generator.
4.	Transient response of second order system.
5.	Study of D. C. positional servo system.

6.	Study of A. C. servo voltage stabilizer.
7.	Study the performance of an open and closed loop control system using electronic amplifiers using OPAMPs.
8.	Study the performance of a second order system (Use any OPAMP based electronic system such as an active second order Butterworth filter).
9.	Study the performance of any first order and second order system.
Experiments based on software (programs)	
1.	Introduction to MATLAB, MATLAB's simulink and control systems toolbox (with some examples) or any other control system related software package.
2.	Compare and plot the unit-step responses of the unity-feedback closed loop systems with the given forward path transfer function. Assume zero initial conditions. Use any computer simulation program.
3.	Study of effect of damping factor on system performance by obtaining unit step response and unit impulse response for a prototype standard second order system. Consider five different values for x = 0.1, 0.3, 0.5, 0.7 and 1.0. Also study the effect of varying undammed natural frequency by taking three different values. Comment on the simulations obtained.
4.	Write a program that will compute the step response characteristics of a second order system i.e. percent overshoot, rise time, peak time and settling time. Generalize it for accepting different values of undammed natural frequency and damping factor.
5.	Study and plot the unit step responses of addition of a pole and a zero to the forward path transfer function for a unity feedback system. Plot the responses for four different values of poles and zeros. Comment on the simulations obtained.
6.	Study and plot the unit step responses of addition of a pole and a zero to the closed loop transfer function. Plot the responses for four different values of poles and zeros. Comment on the simulations obtained.
7.	Program for compensator design using Bode plot.
8.	Program for compensator design using Root Locus analysis.
9.	Plot and comment on various properties of any three systems (problems) using • Routh-Hurwitz criterion • Root locus technique • Bode plots • Nyquist plots Use any software package.

PCC-IN302 Industrial 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	2	hrs/week	
Credits	4		

Course objectives:

1.	To get an adequate knowledge about various techniques used for various parameters measurement in industries and select the proper transducer.

2.	To provide exposure to various state of art process parameters measuring transducers and their selection procedures.
3.	To understand, analyze and design various measurement schemes that meet the desired specifications and requirements of real time processes.
Course outcomes:	
1.	To recall the knowledge of temperature transducers like, thermocouples, thermistors, RTDs, pyrometry and other temperature measuring techniques.
2.	To understand the construction and working principle of various type of transducers/sensor to measure physical quantities.
3.	To apply the adequate knowledge of pressure and strain transducers.
4.	To analyze, formulate and select suitable sensor/transducer for the given industrial applications.
5.	To demonstrate working knowledge of safety practices used in the measurement and control of industrial processes.
6.	To develop skills to trouble shoot the problems with measurement and control of industrial processes.

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-IN302.1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCC-IN302.2	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
PCC-IN302.3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCC-IN302.4	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PCC-IN302.5	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
PCC-IN302.6	-	-	-	2	-	-	-	-	-	-	-	3	-	-	-	-
PCC-IN302	1	1	1	1	-	-	-	1	-	-	-	1	-	-	-	-

Syllabus:	
Unit 1	**Temperature sensor selection and applications**
	Design of temperature instrumentation system using RTD, thermocouple, thermistor, selection criteria, self heating effects in resistive temperature transducers, power-dissipation constant and its calculations, thermocouple with thermowell assembly, time-constant calculation, protection-tubes, types, materials, design considerations for thermowell, types, manufacturing process of T/C, RTD, thermistor, testing of RTD as per the standard. Radiation measurement: radiation thermometers, introduction, definition of terms, general form of radiation measurement system, radiation thermometer types, photo electric radiation thermometers, signal conditioning for radiation thermometers, remote reading thermometers. Sensor calibrators and simulators.
Unit 2	**Pressure measurement**
	Basics, mechanical type instruments, electromechanical type, low pressure measurement, related accessories, pressure measuring standards, selection and application. Transmitter definition, classification, pneumatic transmitter-force balance type, torque balance type, two wire and four wire transmitters, I/P and P/I converters. Design of pressure instrumentation using diaphragm, bourdon tubes and bellows.
Unit 3	**Flow measurement**

	Design of flow instrumentation using orifice, rotameter, venturimeter, different flow coefficient like Cd Cc, and Cv and their calculation. Types of orifice designs, Types of pressure taps to measure Dp, design of orifice used in tank outflow and pipe-flow measurements, different design considerations in orifice, venturimeter and rotameter design. Anemometers: Hot wire/hot film anemometer, laser doppler anemometer (LDA), electromagnetic flow meter, turbine and other rotary element flow meters, ultrasonic flow meters, doppler flow meters, cross correlation flow meters, vortex flow meters. Measurement of mass flow rate: radiation, angular momentum, impeller, turbine, constant torque hysteresis clutch, twin turbine coriolis, gyroscopic and heat transfer type mass flow meters. Target flow meters, V-cone flow meters, purge flow regulators, flow switches, flow meter calibration concepts, flow meter selection and application.
Unit 4	**Level measurement**
	Introduction, float level devices, displacer level detectors, rotating paddle switches, diaphragm and differential pressure detectors, resistance, capacitance and RF probes, radiation, conductivity, field effect, thermal, ultrasonic, microwave, radar and vibrating type level sensors. Level sensor selection and application.
Unit 5	**Strain measurement**
	Strain gauge and design of piezo-electric crystal, analysis of piezo-electric crystal for its use in dynamic measurement, time-constant of crystal assembly along with cable and amplifier, calculation of crystal capacitance. Applications of strain gauge in various industries.
Unit 6	**Measurement of viscosity and Density**
	Definitions, units, Newtonian and Non-Newtonian behavior, measurement of viscosity using laboratory viscometers, industrial viscometers. Viscometer selection and application. Liquid density measurement, gas densitometers, its application and selection.
Unit 7	**Electromagnetic compatibility**
	Introduction, interference coupling mechanism, basics of circuit layout and grounding, concepts of interfaces, filtering and shielding. Safety: introduction, electrical hazards, hazardous areas and classification, nonhazardous areas, enclosures-NEMA types, fuses and circuit breakers. Protection methods: purging, explosion proofing and intrinsic safety.
Text Books:	
1.	Nakra Chowdhari, "Instrumentation", Prentice Hall of India, New Delhi.
2.	Considine D. M., "Process Instrumentation, and Control Handbook", McGraw Hill International.
3.	Doeblin E. O. and D. Mannik, "Measurement Systems" Fifth Edition, Application and Design, McGraw Hill International Edition, 2006.
4.	Bentley J. P., "Principles of Measurement Systems" Third Edition, Pearson Education, New Delhi, 2000.
5.	Sawhney A. K. and Puneet Sawhney "A Course in Mechanical Measurements and Instrumentation" Dhanpat Rai and Co. (P) Ltd., New Delhi, 1998.
Reference Books:	
1.	Liptak B. G., "Instrument Engineers Handbook, Process Measurement Volume I and Process Control Volume II" Chilton Book Company, 2001
2.	Warren Boxleitner, IEEE press: Electrostatic Discharge and Electronic Equipment.
3.	Walter C Bosshart , "Printed Circuit Boards", CEDT Series, Tata McGraw Hill.
4.	S. Soclop, "Applications of Analog Integrated Circuit", Prentice Hall of India.

Term Work:	
The term work shall consist of a record of at least eight experiments/designs and drawings based on the syllabus given above. Some of the experiments may be from the following list.	
1.	**Case study:** One lab instrument/field instrument and its detailed engineering drawings, circuit diagrams on a drawing sheet.
2.	Design of a mini project like design of instrument/electronic device/ transducer/instrumentation component/system, its procedure starting from preparation of specifications, designing, testing, and erection. Drawings dimensional sketches, circuit diagram, details of different component on drawing sheet, testing its specifications, determining practical static and dynamic characteristics.

PCC-IN303 Digital Signal Processing

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.	To provide better understanding of discrete-time signals with representation in time and frequency domain.
2.	To provide knowledge for analysis and design of linear and time-invariant (LTI) systems using mathematical tools like Fourier Transform and z-transform.
3.	To provide knowledge for efficient realization of digital systems (FIR and IIRfilters) using hardware and software.

Course Outcomes: On successful completion of this course students will be able to	
1.	Understand benefits and limitations of processing signals digitally and properties of discrete-time LTI systems.
2.	Represent and analyze the discrete-time signals and LTI systems in the frequency domain using Discrete-Time Fourier Transform (DTFT), z-transform and Discrete Fourier transform (DFT) tools.
3.	Implement DFT efficiently using Fast Fourier Transform (FFT) algorithms and use in practical applications.
4.	Design an FIR or IIR filter for the specifications given in frequency domain.
5.	Realize digital system whose coefficients are known using hardware or software.
6.	Propose and design a digital system for simple real application.

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-IN303.1	3	1	-	-	-	-	-	-	-	-	-	-	2	1	2	-
PCC-IN303.2	3	2	-	2		-	-	-	-	-	-	-	2	1	1	-
PCC-IN303.3	2	2	1	-	2	-	-	-	-	-	-	-	2	1	1	-
PCC-IN303.4	3	3	3	-	1	-	-	-	-	-	-	-	2	1	-	-
PCC-IN303.5	2	2	2	-	1	-	-	-	-	-	-	-	2	1	-	-
PCC-IN303.6	2	3	3	1	2	-	-	-	-	-	-	1	2	1	1	-
PCC-IN303	3	3	2	1	1	-	-	-	-	-	-	1	3	1	1	-

Syllabus:	
Unit 1	**Introduction**
	Discrete-time signals and systems, time-domain characterization of discrete-time LTI systems, sampling theorem, benefits and limitations of processing signal digitally. Correlation of signals. The Z-transform: inverse Z-transform and Z-transform properties for one-sided and two-sided z-transforms. Discrete-Time Fourier Transform (DTFT) and its properties.
Unit 2	**LTI Discrete-Time Systems in Transform Domain**
	The frequency response, the transfer function, types of transfer functions, Allpass transfer function, minimum-phase and maximum-phase transfer functions, inverse systems.
Unit 3	**Discrete Fourier Transform**
	Discrete Fourier Transform (DFT) and its properties. Computation of DFT (FFT algorithms), Decimation-In-Time (DIT), Decimation-In-Frequency (DIF) and radix-n algorithms of FFT.
Unit 4	**Digital filter structures**
	Digital filter structures: block diagram representation, equivalent structures ,basic FIR structures, basic IIR structures, All pass filters, IIR tapped cascaded lattice structures, FIR cascaded lattice structures.
Unit 5	**Digital filter design**
	IIR Filter Design: Analog Filter Approximations – Butterworth and Chebyshev approximations. **Frequency Transformations**: low-pass to low-pass, low-pass to high-pass, low-pass to band-pass and low-pass to band-stop transformations. **Analog to Digital Transformations**: Impulse Invariant Technique and Bilinear Transformation Technique. **FIR Filter Design**: windowing technique, frequency sampling technique, and computer aided design.
Unit 6	**Digital Signal Processor**
	Harvard architecture and modified Harvard architecture. Introduction to fixed-point and floating-point DSP processors, architectural features, computational units, bus architecture and memory architecture, data addressing, address generation unit, pipelining, on-chip peripherals.
Text/Reference Books:	
1.	A. V. Oppenheim, R. W. Schafer, “Discrete-Time Signal Processing”, Prentice-Hall of India, 2001
2.	J. G. Proakis, D. G. Manolakis, “Digital Signal Processing – Principles, Algorithms and Applications”, Prentice Hall of India, 2002.
3.	S. K. Mitra, “Digital signal processing- A computer based approach”, Tata McGraw Hill, 2002.
4.	E. C. Ifeachor, B. W. Jarvis, “Digital Signal Processing- A Practical Approach”, Second Edition, Pearson Education, New Delhi, 2002.
5.	Johnny R Johnson, “Introduction to Digital Signal Processing”, Prentice-Hall of India, 2011
6.	Sen M Kuo and Bob H. Lee, “Real-Time Digital Signal Processing: Implementation Applications and Experiments with the TMS 320C55X” John Wiley and Sons, New York
Term Work:	
Term work shall consist of at least six to eight assignment/tutorials/practical based on above syllabus. Some of the experiments may be from the following list. Students are supposed to write	

the programs (at least eight) on general-purpose computer using any development environment (C/C++/Matlab) or on any DSP processor and development environment.	
1.	Digital signal generation.
2.	Simple operations on signals.
3.	Linear and Circular Convolutions.
4.	Discrete time Fourier transform (DTFT) and its properties.
5.	Discrete Fourier Transform (DFT) – Direct computation, DIT algorithm, DIF algorithm.
6.	Linear and Circular Convolutions using DFT.
7.	FIR filters design and software realization using (i) Rectangular Window (ii) Generalized Hamming Window (iii) Bartlet Window and (iv) Kaiser Window.
8.	Frequency Sampling Design of FIR Filter.
9.	IIR filter design and software realization using Butterworth Filter Approximation with (i) Impulse Invariance Method and (ii) Bilinear Transformation Method.
10.	IIR filter design and software realization using Chebyshev Approximation with (i) Impulse Invariance Method and (ii) Bilinear Transformation Method.

PCC-IN304 Microprocessor and Microcontroller

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	1	hrs/week	
Practical	2	hrs/week	
Credits	5		

Course objectives:	
1.	To teach the students to familiarize with microprocessor and microcontroller architecture and functioning.
2.	To train the students to program the microprocessor and microcontrollers for any application.

Course Outcomes: On successful completion of this course students will be able to	
1.	To describe basics of 8085, 8051 and its instruction set.
2.	To understand historical development of microcontrollers and to know different 8, 16, 32 bit microcontrollers.
3.	To solve assembly language programs based on the instruction set of 8085 and 8051.
4.	To get insight of 8051 based hardware system and so to study ADC, keyboard etc.
5.	To execute assembly language programs based on the instruction set of 8051
6.	To develop 8085, 8051 based instrumentation system.

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-IN304.1	3	1	-	-	-	-	-	-	-	-	-	2	3	1	1	-
PCC-IN304.2	3	1	-	-	-	-	-	-	-	-	-	1	2	1	-	2
PCC-IN304.3	2	2	3	2	3	-	-	-	-	-	-	-	3	2	-	2
PCC-IN304.4	2	2	3	2	3	-	-	-	-	-	-	-	3	2	2	3
PCC-IN304.5	1	3	3	3	2	-	-	-	3	1	2	3	2	3	3	1
PCC-IN304.6	1	3	3	3	2	3	3	-	3	2	3	2	3	3	3	1
PCC-IN304	**3**	**3**	**3**	**2**	**2**	**3**	**3**	**-**	**1**	**1**	**1**	**1**	**3**	**3**	**2**	**2**

Syllabus:	
Unit 1	**Introduction to 8085**
	Architecture and operation, pin out diagram. Assembly language programming for 8085 microprocessor, instruction classification, instruction set study in details, addressing modes, writing assembly language programs, stacks subroutines, instruction set timing diagrams, a minimum configuration for 8085, interrupt structure of 8085, internal interrupt circuit, hardware and software interrupts.
Unit 2	**Interfacing memories to 8085**
	Interfacing memories EPROM and RAM with 8085 with exhaustive and partial decoding techniques.
Unit 3	**Peripheral devices used in 8085 systems**
	Following structure programmable peripheral devices are to be studied in details as regards block diagram, software for their interfacing with 8085: 8255, 8253, 8279, ADC.
Unit 4	**Introduction to microcontrollers and Programming 8051**
	8051 Architecture, pin out diagram, 8051 oscillator and clock, Program counter and Data pointer, A and B CPU registers, flags and PSW, internal memory, stack and stack pointer, SFRS, internal ROM, I/P and O/P ports. Assembly language programming for 8051 microcontroller, instruction classification, instruction set Arithmetic and Logical operations, jump and call instructions etc., writing assembly language programming based on instruction set, stacks and subroutines.
Unit 5	**Timers in 8051 and Serial data transmission**
	Interrupts of 8051, counters and timers, timer modes, timer/counter programming. Introduction to serial data transmission methods.
Unit 6	**Interfacing peripherals to 8051 and Design of 8051 based systems**
	8051 microcontroller interfacing with: keyboard and display, A/D and D/A chips. Design of dedicated systems using 8051 for temperature indication OR/AND control, flow indication, OR/AND control, stepper motor control, embedded control systems, Smart transmitters.
Text/ Reference Books:	
1.	K. L. Short, "Microprocessor and programming logic", Second Edition, Prentice- Hall India Pvt. Ltd
2.	R. S. Gaonkar, "Microprocessor Architecture, Programming and application with 8085/8085A", Fourth Edition, Willey Eastern Ltd.
3.	B. Ram, "Fundamentals of microprocessor and Microcomputer", Dhanpat Rai and Sons, Eighth Edition, New Delhi.
4.	Ayala K. J., "8051 Microcontroller: Architecture, Programming and applications" Second Edition, Penram international.
5.	Muhammad Ali Mazidi, Janice G. Mazidi and Rolin D. McKinlay, "The Microcontroller and Embedded Systems", Second Edition, Pearson, 2012.
Reference Books:	
1.	B. Ram, "Advanced Microprocessor and Interfacing" Tata McGraw-Hill Publishing Company Ltd., First Edition, New Delhi.
2.	Ajit Pal, "Microprocessor Principles and Applications", Tata Mc-Graw Hill, First Edition New Delhi.
3.	U. V. Kulkarni and T. R. Sontakke, "The 8085A Basics: Programming and Interfacing", Sadusudha Prakashan, First Edition, Nanded.

4.	Intel Mcs, "8085 users manual", Intel Corporation.
5.	Myke Predko, "Programming and customizing the 8051 Microcontroller", Tata McGraw-Hill, First Edition, New Delhi.
6.	N.G. Palan, "8031 Microcontroller – Architecture, Programming and Hardware Design", Technova publishing House.
Term Work:	
It will consist of a record of at least eight of the following experiments based on the Prescribed syllabus.	
1.	Study of Dyralog 8085 kit.
2.	Writing simple programs based on 8085 Instruction set.
3.	Write a program to find largest number from a series of numbers.
4.	Write a program to transfer a block of data.
5.	Write a program for arranging numbers in ascending / descending order.
6.	To study interfacing of 8255 with LEDs, 7-Segment display.
7.	To study interfacing of 8255 with Keyboard, ADC.
8.	To study 8051 Simulator.
9.	To write simple programs using 8051 simulator like- a. Finding largest/smallest number. b. arranging numbers in ascending / descending order. c. Arithmetic of 16-bit numbers.
10.	Interfacing of stepper motor with microcontroller.
11.	Mini project based on 8051.

PCC-IN305 Industrial Data Communication

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 insight about networks, topologies, and the key concepts used in instrumentation industries.
2.	To gain comprehensive knowledge about the layered communication architectures (OSI and TCP/IP) and its functionalities.
3.	To understand the principles, key protocols, design issues, and significance of each layers in ISO and TCP/IP.
4.	To know the basic concepts of network security and its various security issues related with each layer.
Course Outcomes: On successful completion of this course students will be able to	
1.	To remember and describe how the physical, data link, and network layers operate in a typical data communication system.
2.	To understand the setting of a network environment with all the necessary data communication components, procedure, conflicting issues and resolution techniques that make it functional.
3.	To apply the operation and technique of various communication protocols such as multiple access protocols, TCP, UDP, FTP, etc.

4.	To analyze the services and features of the various layers of data networks.
5.	To evaluate communication protocols for route calculations and be able to perform such calculations of data transmission.
6.	To create the suitable transmission route for different internetworking 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
PCC-IN305.1	3	-	-	-	-	-	-	-	-	-	-	2	3	3	2	2
PCC-IN305.2	3	-	-	-	-	-	-	-	-	-	-	2	3	2	2	2
PCC-IN305.3	3	1	2	2	1	-	-	-	-	-	-	2	3	2	2	1
PCC-IN305.4	3	1	-	2	-	-	-	-	-	-	-	1	3	1	1	1
PCC-IN305.5	3	-	1	2	2	-	-	-	-	-	-	2	3	1	3	1
PCC-IN305.6	3	-	3	2	3	-	-	-	-	-	-	2	3	1	3	1
PCC-IN305	**3**	**1**	**1**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**2**	**3**	**2**

Syllabus:	
Unit 1	**Communication Concepts**
	Serial and parallel transmission, data organization: signals, digital standard signals, data organization: communication codes, data organization: error coding, data organization: Protocol concepts.
Unit 2	**Communication Modes and Serial communication standards**
	ISO OSI model, mail analogy, OSI model, IEEE 802 models, Basic concepts, TIA/EIA standards, interface signal functions, PC serial Communications
Unit 3	**Local Area Networks**
	Layer 1 the physical layer, topologies, transmission media, 802 and industrial LANs, wireless LANs 802.11, Hub, Bridge, Ethernet Switch, Router, IEEE 802.3/Ethernet: A Layer1 and 2 Standard 10BASE5, 10BASE2, 10BASE-T, 10 GbE-10 Gigabit Ethernet Over Fiber, 10 GbE-10 Gigabit Ethernet Over Copper.
Unit 4	**Industrial networks and field buses**
	Industrial network requirements, HART, ControlNet, EtherNet/IP, PROFIBUS/PROFINET, Foundation Fieldbus, Ethernet-TCP/IP, Modbus RTU Protocol, IEC 61850.
Unit 5	**Wide Area Networks**
	Wireline transmission, carrier concepts, wireline modems, modem types, WAN digital lines, cable modems, WANs for mobile and the hinterlands.
Unit 6	**Internetworking**
	Layer 2: internetworking equipment, Layer 3 devices, Routing topologies, managed switches, gateways.
Unit 7	**Cybersecurity**
	Overview, security vulnerabilities, methods of attack, risk analysis, IACS countermeasures, firewalls, network address translation, monitoring network traffic, hardening, internet and VPN countermeasures, network management and security, IEC/ANSI/ISA-62443 cybersecurity standards, ISA secure certification program.
Reference Books:	
1.	Lawrence M. Thompson and Tim Shaw, “Industrial Data Communications”, ISA Fifth Edition.

2.	A. S. Tanennbaum, "Computer Networks", Fourth Edition, Prentice Hall of India, New Delhi, 2002.
3.	W. Stallings, "Data and Computer communication, Sixth Edition, Pearson Education, New Delhi, 2001.
4.	Comer, "Computer Networks and Internets", Second Edition, Pearson Education, 2001.
5.	Behrouz A. Forouzen, "Data Communication and Networking" Fourth Edition, McGraw Hill Publications, 2007.

PCC-IN306 Unit Operations and 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	2	hrs/week	
Credits	4		

Course objectives:

1.	To study the concept of unit and Unit Operations.
2.	To study the constructions of different equipments used for unit operation.
3.	To observe the principle of operations of different units.
4.	To know the applications of unit operations.
5.	To understand the different manufacturing processes in different industries.

Course Outcome: On successful completion of this course students will be able to,

1.	Understand the concept of unit and unit operation.
2.	Recognize the basic operations of different chemical processes.
3.	Know the constructions/mechanisms of different equipments used for unit operation.
4.	Use the knowledge of constructions and working of different equipments in studying the operations of different mass transfer and heat transfer operations.
5.	Select the process equipment for particular unit operation.
6.	Compare different mass transfer and energy transfer operations.

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-IN306.1	3	3	2	-	2	2	-	-	-	2	2	2	3	3	3	1
PCC-IN306.2	3	3	2	2	2	2	-	-	-	2	2	2	3	3	3	1
PCC-IN306.3	3	2	2	2	2	2	-	-	-	2	2	2	3	3	3	1
PCC-IN306.4	3	1	2	1	1	-	-	1	1	1	2	2	3	1	2	1
PCC-IN306.5	3	3	2	2	2	-	-	-	2	2	3	2	3	3	2	1
PCC-IN306.6	3	3	2	2	2	-	-	-	2	2	2	2	3	2	2	1
PCC-IN306	**3**	**3**	**3**	**2**	**2**	**1**	**-**	**1**	**1**	**2**	**3**	**3**	**3**	**3**	**3**	**1**

Syllabus:	
Unit 1	**Introduction**
	Unit operation and unit process concept: block diagram of chemical process, classification of unit operation, material and energy balance, batch and continuous process, endothermic and exothermic reaction, reversible and irreversible process.

Unit 2	**Evaporation and Distillation**
	Liquid characteristics, types of evaporators, principle and operation of single and multiple effect evaporators equipment setup, Flash Distillation, Batch Distillation, Continuous Distillation, operational features, construction and working only.
Unit 3	**Drying, Filtering ans Mechanical Operations**
	Principle of drying, classification of dryers, temperature patterns in dryers, types of drying equipments, selection of drying equipment, Mechanism of filtration, types of filters. **Mechanical Operations:** Size reduction, Different crushers and grinders, working principle. Mixing , Types of mixers, construction and working.
Unit 4	**Crystallization, Leaching and Extraction**
	Construction, types, principle of working and operations of these equipments
Unit 5	**Gas absorption, Adsorption, Humidification and dehumidification**
	Construction, types, principle of working and operations of these equipments
Unit 6	**Introduction to process industries**
	Study of manufacturing process of cement plant, paper and pulp industries, petrochemical refinery industries, fertilizer industries, iron and steel industries, pharmaceutical industries, sugar industries etc. only study of flow diagram.
Text/Reference Books:	
1.	McCabe, W.L., Smith, J. C., and Harriot, P., “Unit Operations in Chemical Engineering”, McGraw- Hill Seventh Edition, 2004.
2.	George T. Austin: "Shreve's Chemical Process Industries ", McGraw-Hill International Editions, Chemical Engineering Series, 1985
3.	M. G. Rao and Misting, “Outline of Chemical Technology”, Second Edition, East west, 1973.
4.	Perry, “Chemical Engineer’s Handbook”, McGraw Hill, 1984.
Term Work:	
It will consist of a record of at least eight of the following experiments based on the prescribed syllabus, assignments and report on industrial visit.	
1.	Study of evaporator and its operation.
2.	Study of distillation equipment and its operation.
3.	Study of Crystallizer and its operation.
4.	Study of liquid extractor and its operation.
5.	Study of dryer and its operation.
6.	Identify applications of all above equipments.
7.	Study of humidifier and dehumidifier.
8.	Study of heat exchanger and its working.
9.	Study of continuous stirred tank reactor(CSTR) and its working.
10.	Study of process flow diagram of any one industry.

Semester-VI

PCC-IN307 Process 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	2	hrs/week	
Credits	4		

Course objectives:	
1.	To study different strategies of process control.
2.	To understand the modeling of dynamic processes and to develop the fundamental and empirical models.
3.	To analyze and design advanced control systems.
4.	To know the design of PID controller and it's tuning.
5.	To study digital implementations of these controllers.
Course Outcomes: On successful completion of this course students will be able to	
1.	To develop fundamental and empirical models for dynamic processes and apply control systems in processes
2.	To analyze different strategies of process control and understand their implementation for analog control and digital control.
3.	To analyze and design advance control systems viz. cascade, selective and split range control; feed forward and ratio control; adaptive and inferential control systems.
4.	To design and tune PID controllers
5.	To design digital control systems using digital PID controllers and other controllers.
6.	To set up career options, potential job functions, contemporary and professional issues.

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-IN307.1	3	3	3	3	2	-	-	-	-	2	-	2	3	3	2	2
PCC-IN307.2	3	1	1	1	-	-	-	-	-	1	-	2	3	3	2	2
PCC-IN307.3	3	1	3	2	3	-	-	-	-	-	-	2	3	3	2	2
PCC-IN307.4	2	2	3	2	3	-	-	-	-	-	-	2	3	2	1	1
PCC-IN307.5	3	1	2	2	1	-	-	-	-	2	-	2	3	2	2	2
PCC-IN307.6	2	1	1	1	1	1	-	-	-	2	-	2	2	2	2	2
PCC-IN307	**3**	**2**	**3**	**2**	**2**	**1**	**-**	**-**	**-**	**1**	**-**	**3**	**3**	**3**	**2**	**2**

Syllabus:	
Unit 1	**Introduction to chemical process control and its Modeling**
	Incentives for chemical process control, design aspects and hardware for a process control system, introduction to ISA symbols: P & I D for process control. Development of a mathematical model, necessity, state variables and state equations, additional equations, additional elements of the mathematical models; dead time; modeling difficulties; the input-output model; degrees of freedom and process controllers; transfer function of a process with single/multiple outputs

Unit 2	**Dynamic behavior of systems**
	Dynamic behavior of first order, second order and higher order systems; dynamic systems with dead time/inverse response, computer simulation of process dynamics, linearization of nonlinear systems.
Unit 3	**Controller modes**
	Controller principles, process characteristics, control system parameters, discontinues controller modes, two-position, multi position, floating control mode, continues controller mode, P, I and D, composite control mode, P+I, P+D, P+I+D controller modes, analog and digital controllers.
Unit 4	**Dynamic behavior of feedback controlled processes**
	Input output models of feedback controllers, common measuring devices, transmission lines, final control element effect of on-off, proportional, integral, derivative and composite control actions on the response of a controlled process. Generation of control action: control action generation in electronic and pneumatic controllers.
Unit 5	**Design of feedback controllers**
	Outline of design problems; simple performance criteria, time integral performance content; selection of a feedback controller; controller tuning using Cohen-Coon method; Bode Stability criterion, gain and phase margins, Ziegler-Nichols tuning technique.
Unit 6	**Analysis and design of advanced control systems and control systems for multi variable processes**
	Feedback control systems with large dead time or inverse response; cascade, selective and split range control; feed forward and ratio control; adaptive and inferential control systems. Synthesis of alternative control, configurations for multiple input-multiple output processes, interaction and decoupling of control loops; design of control systems for complete plants, some case studies.
Text/Reference Books:	
1.	G. Stephanopoulos, "Chemical Process Control: An Introduction to Theory and Practice", Prentice Hall of India, New Delhi, 2001.
2.	Curtis D. Johnson, "Process Instrumentation Technology", Fourth Edition, Prentice Hall of India, New Delhi, 1996.
3.	T. E. Marlin, "Process Control: Designing Processes and Control Systems for Dynamic Performance", McGraw Hill International Edition, 2000.
4.	Luyben W. L., "Simulation and Control for Chemical Engineering", Second Edition Mc Graw Hill 1989.
5.	E. Umez- Eronini, "System Dynamics and Control", Thomason Learning, 2002
Term Work:	
The term work shall consist of a record of at least eight experiments based on the syllabus given above. Some of the experiments may be from the following list.	
1.	Design of an electronic ON-OFF controller and plot the characteristics of natural zone of controller.
2.	Design an electronic PID controller and study its response for step input.
3.	Design electronic temperature transmitter for transmitting temperature from 500°C to 900°C to 4 to 20mA.
4.	**Cascade control trainer (P, PI, PID, On / off)** Study of Cascade Control trainer (Flow & Level control)
5.	**Level control trainer**

	a) Study of open loop response (Manual control) b) Study of on/off controller c) Study of proportional controller d) Study of proportional integral controller e) Study of proportional derivative controller f) Study of proportional integral derivative controller g) Tuning of controller (Open loop method) h) Tuning of controller (Closed loop method)
6.	**Flow control trainer** a) Study of open loop response (Manual control) b) Study of on/off controller c) Study of proportional controller d) Study of proportional integral controller e) Study of proportional derivative controller f) Study of proportional integral derivative controller g) Tuning of controller (Open loop method) h) Tuning of controller (Closed loop method)
7.	**Flow measurement** a) To Calculate coefficient of discharge of Venturi meter. b) To Calculate coefficient of discharge of Orifice meter. c) To Calculate coefficient of discharge of Pitot tube. d) To calibrate and find accuracy of Rotameter. e) To find accuracy of Water meter.
8.	Determine the time-constant of RTD for given step-input.
9.	To determine the mathematical model of the given process.
10.	To determine the constants of PID controllers by given method.
11.	Use of dead beat algorithm and other algorithms in the controller design.
12.	Use of optimum controller methods for tuning of PID controller.

PCC-IN308 Control System Components

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 enable the students to understand the fundamentals of various types of components being used in control systems.
2.	To identify, select and design a suitable devices and components for use in process industries.

Course outcomes:

1.	To know the mechanical, hydraulic, pneumatic and electrical components of control the systems.
2.	To understand control valve construction, valve terminologies, valve actuators/accessories and valve characteristics.
3.	To apply the knowledge of mathematical modeling to prepare transfer function of AC & DC motors.

4.	To classify various kinds of electrical motors and outline their applications in the field of control systems.
5.	To explain importance of different types of relays in control applications.
6.	To design and construct the mathematical model of control system components and execute the instrumentation requirements in process industries.

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-IN308.1	3	-	-	-	-	-	1	-	-	-	-	2	3	3	2	2
PCC-IN308.2	3	-	-	-	-	-	-	-	-	2	-	2	3	3	2	2
PCC-IN308.3	3	2	2	2	2	-	-	-	-	-	-	1	3	1	2	1
PCC-IN308.4	3	-	-	-	-	-	1	-	-	-	-	1	3	2	2	1
PCC-IN308.5	3	-	-	1	1	-	-	-	-	-	-	2	3	1	1	1
PCC-IN308.6	3	3	2	3	2	-	-	-	-	2	-	1	3	3	2	2
PCC-IN308	**3**	**1**	**1**	**1**	**1**	**-**	**1**	**-**	**-**	**1**	**-**	**2**	**3**	**3**	**3**	**2**

Syllabus:	
Unit 1	**Motors**
	Types, working principle, characteristic, and mathematical model of following: motors AC/DC motors, stepper, servo, synchronous generators and alternator.
Unit 2	**Types, working principle, characteristics, and symbolic representation of following**
	Switches: toggle, slide, DIP, rotary, thumbwheel, selector, limit, proximity, combinational switches, zero speed, belt sway, pull cord, Relays: Electromechanical, Solid state relays, relay packages, Contactors :Comparison between relay and contactor, contactor size and ratings, Timers : On delay, off delay and retentive.
Unit 3	**Sequencing and interlocking for motors**
	Concept of sequencing and Interlocking, Standard symbols used for Electrical Wiring Diagram, electrical wiring diagrams for starting, stopping, emergency shutdown, (Direct on line, star delta, soft starter) protection devices for motors: short circuit protection, over load protection, over/ under voltage protection, phase reversal Protection, high temperature and high current Protection, over speed, Reversing direction of rotation, braking, starting with variable speeds, Jogging/Inching. Motor control center: concept and wiring diagrams.
Unit 4	**Pneumatic components**
	Pneumatic power supply and its components: Pneumatic relay (Bleed and Non bleed, Reverse and direct), single acting and double acting cylinder, special cylinders: cushion, double rod, tandem, multiple position, rotary Filter Regulator Lubricator (FRL), pneumatic valves (direction controlled valves, flow control etc), special types of valves like relief valve, pressure reducing etc.
Unit 5	**Hydraulic components**
	Hydraulic supply, hydraulic pumps, actuator (cylinder and motor), hydraulic valves. Introduction, basic types of hydraulic transmission lines, servo motors, power supply, hydraulic circuits and transmission, applications like motor speed control, reciprocating, loading, unloading, sequencing of cylinders and direction control. Symbols used in hydraulic circuits.
Unit 6	**Control valves**

	Valve terminologies, classification of valves. Valve actuators and accessories, detail study of valve characteristics. Study of valve construction by considering examples from hydraulic, pneumatic and electrical types. Introduction to valve selection and specifications. Selection of characteristics to suit the process, for gas, vapor and liquid. Valve sizing with mathematical treatment. Cavitations, effects and remedies of cavitations. Introduction to analog and digital fluidic devices.
Text Books:	
1.	M. D. Desai, "Control system components", PHI.
2.	S. R. Majumdhar, "Pneumatic Systems", Tata McGraw-Hill Publisher, 2009.
3.	B. L. Theraja, "A text book of Electrical Technology", S. Chand & Company Ltd., Vol II First Edition 1959.
Reference Books:	
1.	Douglas M. Considine, "Process Instruments and Control Handbook", McGraw Hill.
2.	H. Meixner, E. Sauer, "Intro to Electro-Pneumatics", Festo didactic, First Edition 1989.
3.	J. P. Hasebrink, R. Kobler, "Fundamentals of Pneumatic Control Engineering", Festo Didactic: Esslinger(W Germany),1989.
4.	Petruzella, "Industrial Electronics", McGraw-Hill International First Edition, 1996.
5.	E. A . Parr, "Industrial control Handbook",volume 2, BSP Professional Books.
6.	Ernest O. Doebelin, "Measurement Systems – Application and Design", Fourth Edition, McGraw Hill.
7.	I. J. Nagrath, M. Gopal, "Control system Engineering", New Age International Publication Fourth Edition, 2006.(W.E)
8.	B. G. Liptak, "Process Measurement and Analysis", Fourth Edition, CRC Press, Washington, 2003.
9.	John E. Gibson (Purdue) and Franz B. Tuteur (Yale), "Control System Components", McGraw-Hill, New York, 1958.
10.	Hans D. Baumann, "Control valve primer", ISA; Fourth Revised Edition (15 November 2008).
11.	Les Driskell, "Control – Valves Selection and Sizing", ISA 1983.
12.	W. G. Andrew and H. B. Williams, "Applied Instrumentation in the Process Industries", Gulf Publishing Company, 1982.
13.	C. D. Johnson, "Process Control Instrumentation Technology", Fourth Edition, Prentice.
Term Work:	
It will consist of at least eight experiments/assignments/programs from the following list:	
1.	Study of cut section views of different control system components.
2.	Study of stepper motor.
3.	Study of AC/ DC servo motors.
4.	Study of motor speed torque characteristics.
5.	Study of hydraulic control valves and accessories.
6.	Study of pneumatic control valves and accessories.
7.	Study of ON/OFF, linear and equal percentage valve characteristics.
8.	Study of logic fluidic devices.
9.	Study of flapper nozzle system.
10.	Study of different types of relays.

PCC-IN309 Distributed 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	--	hrs/week	
Practical	2	hrs/week	
Credits	4		

Course objectives:

1.	This course is designed to expose students to understand the process automation concepts like programmable logic controller and distributed control system.

Course Outcomes: On successful completion of this course students will be able to

1.	To describe the basics of PLC and Ladder diagram programming language.
2.	To explain the basics of SCADA and different SCADA/HMI software available.
3.	To apply the knowledge of basics of ladder diagram to solve various instrumentation problems.
4.	To design SCADA PLC based systems for process control application.
5.	To explain the basics of Distributed Control System architecture and programming.
6.	To analyze various programming languages used in industrial automation 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
PCC-IN309.1	3	-	-	-	1	-	-	-	-	-	-	1	3	3	2	-
PCC-IN309.2	3	-	-	-	1	-	-	-	-	-	-	1	3	3	2	-
PCC-IN309.3	1	3	2	2	3	-	-	-	-	-	-	2	3	3	3	2
PCC-IN309.4	1	2	3	1	3	-	-	-	-	-	-	2	3	3	3	2
PCC-IN309.5	3	2	3	2	3	-	-	-	-	-	-	2	3	3	3	1
PCC-IN309.6	1	2	1	-	2	-	-	-	-	-	-	1	2	2	2	-
PCC-IN309	**3**	**2**	**2**	**1**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**3**	**3**	**3**	**1**

Syllabus:

Unit 1	**Programmable Logic Controllers (PLC)**
	Introduction, architecture, definition of discrete-state process control, discrete – state variables, process specifications, event sequence description..
Unit 2	**Industrial PLC- Allen Bradely and Ladder diagram**
	Studies of Allen Bradely make Micrologix1200c and 1100 PLC. Background, ladder diagram elements, ladder diagram examples, programmable controllers: relay sequencer, programmable controllers, programmable controller operation, programming, advanced features, ladder diagrams.
Unit 3	**Study of ABB, GE Fanuc and Siemens make PLC**
	Introduction, programming.
Unit 4	**Supervisory Control And Data Acquisition(SCADA)**
	Introduction to supervisory control and data acquisition (SCADA) as applied to process control systems: Introduction to various SCADA packages, study of RSVIEW32 (AB make package) development of mimics using RSVIEW32 SCADA package, Study of iFix SCADA package WinCC
Unit 5	**Distributed Control Systems (DCS)**
	Introduction, difference between DCS and centralized computing system. Block diagram of

	DCS, data highways, multiplexers and remote sensing terminal units Study of various aspects of DCS like communication protocol, displays, cables etc., various system architectures of DCS. **Yokogawa Centum VP:** Architecture, study of FCS, programming using FBD, typical examples based on FBD programming, development of HMI's, process applications of Centum VP. **Other DCS systems:** Study of EPKS Honeywell DCS, Emerson's Delta V DCS, hardware and software basics of these DCS systems, introduction to Hybrid DCS.
Unit 6	**Network protocols and Design consideration**
	Introduction, study of various protocols like HART, Device net, Control net, Ethernet, Modbus, Profibus, Field Bus: Introduction, study of foundation field bus. Design of PLC/DCS system, design of marshalling cabinet, power consumption calculation, power distribution diagrams, functional design specification.
Text/Reference Books:	
1.	Gary Dunning, "Introduction to Programmable Logic Controllers" Second Edition, Thomson Delmar learning, 2002.
2.	C. D. Johnson, "Process Control Instrumentation Technology" Seventh Edition, Pearson Education, New Delhi 2003.
3.	B. G. Liptak, "Instrument Engineers Handbook" (Edition) Vol-II and III, Chilton book Company.
4.	Technical Manual –Yokogoawa, centum VP.
5.	Webb J. W. and Ronald A. Reis "Programmable Controllers: Principles and Applications", Prentice Hall of India Pvt. Ltd. Fifth Edition, 2005.
6.	John R. Hackworth and Frederick D. Hackworth "Programmable Logic Controllers", Jr. Third India Reprint 2005.
7.	Parr A., Newnes, "Programmable Controllers: An Engineer's Guide", Butterwoth-Heinmen Ltd. 1993.
8.	C. D. Johnson, "Microprocessor based Process Control", Prentice Hall International Edition.
9.	Manual of Hybrid DCS-AB Control Logix.
Term Work:	
Term work shall consist of at least six to eight assignment/tutorials/practical based on above syllabus. Some of the experiments may be from the following list.	
1.	Study of AB Micrologix 1200c and 1100 PLC.
2.	Development of simple ladder diagrams like AND/OR gate.
3.	Developments of ladder diagram for the controlling motor operation.
4.	Development of ladder diagram and simulation for the level control system.
5.	Development of ladder diagram for bottling plant.
6.	Study of software package RSVIEW32 (AB make) for SCADA.
7.	Development of mimic diagram for a particular process using SCADA software.
8.	Study of Hybrid controller control logix (AB MAKE).
9.	Development of programs for control of processes using Hybrid controller.
10.	Study of Yokogowa Centum VP.
11.	Development of FBD programs on Centum VP for ON/OFF control.
12.	Development of FBD programs on Centum VP for simple process control applications.

PCC-IN310 Power Electronics

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.	Study different power electronic devices.
2.	To extend simple power electronic converters to realize rectifiers and inverters.
3.	To develop and quantify common performance objectives for power electronic circuits such as efficiency, power factor, etc.
4.	To analyze and design DC/DC converter (chopper) circuits.
5.	To analyze and evaluate the operation of cycloconverters and voltage controllers.
6.	To outline operating principles of application of power electronic circuits as motor drives, UPS systems, etc.

Course Outcomes: On successful completion of this course students will be able to	
1.	To understand the basic principle, characteristics and applications of power electronic and switching devices.
2.	Analytical study of different types of Power Converter systems.
3.	Solve the numerical problems on semiconductor switches, rectifier, converter, inverter, choppers and cycloconverter, circuits.
4.	Simulate DC-DC converters.
5.	Simulate and Design DC-AC Inverters.
6.	Apply PWM technique.

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-IN310.1	3	2	2	1	1	-	-	-	-	-	-	-	3	3	3	2
PCC-IN310.2	3	1	2	2	-	1	-	-	-	-	-	-	3	2	2	1
PCC-IN310.3	3	1	2	-	-	-	-	-	-	-	-	-	3	2	1	1
PCC-IN310.4	3	2	3	1	1	-	-	-	-	-	-	-	3	2	2	1
PCC-IN310.5	3	2	3	1	1	-	-	-	-	-	-	-	3	1	1	1
PCC-IN310.6	3	1	1	1	-	-	-	-	-	-	-	-	3	2	3	2
PCC-IN310	**3**	**2**	**3**	**1**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**3**	**1**

Syllabus:	
Unit 1	**Power Semiconductor Devices (06 Hours)**
	Modern power semiconductor devices and their characteristics, gate drive specifications, ratings, applications, turn ON and turn OFF methods, design of gate triggering circuits using UJT and thyristor protection circuits.
Unit 2	**Phase controlled rectifiers (06 Hours)**
	Single phase rectifiers: Half wave, center tapped, bridge (half controlled and fully controlled) with R and RL load. Three phase rectifiers: half wave, bridge with R and RL load effect of source inductance, dual converters, power factor improvement methods.
Unit 3	**DC chopper (08 Hours)**

	Basic chopper, continuous and discontinuous current conduction, TRC, CLC methods, classification of choppers, step-up chopper, switching mode regulators.
Unit 4	**AC voltage controller & cycloconverters (06 Hours)**
	AC voltage controller: types of ac voltage controllers, single-phase and three phase ac voltage controllers with R and RL load, transformer tap changers, single phase to single phase cycloconverters, three phase to single phase cycloconverters, three phase to three phase cycloconverterswith circulating and non-circulating mode.
Unit 5	**Inverters (08 Hours)**
	Single phase inverters: series, parallel and bridge configurations with R load, PWM inverters. Three phase inverters: 120° and 180° conduction with R and load RL, voltage control and harmonics reduction.
Unit 6	**Application in power electronics (06 Hours)**
	UPS and SMPS, basic characteristics of DC motors, operating modes, DC motor control using different rectifiers, induction motor drives, performance characteristics, stator voltage control, rotor voltage control, frequency control, voltage and frequency control.
Text/Reference Books:	
1.	P. S. Bhimra "Power Electronics", , Khanna Publishers (2010).
2.	M.H. Rashid "Power Electronics, Circuits, Devices and Applications", Pearson Education Inc., 3rd Edition.
3.	M. D. Singh and K. B. Khanchandani, Power Electronics, Tata McGraw-Hill Publishing Company Limited, New Delhi (India), 1998.
4.	P.C. Sen, "Power Electronics",Tata McGraw-Hill Publications India
5.	Mohan, Undeland& Robins "Power Electronics, Converter Applications and Design", , John Wiley and sons (Asia) Pvt. Ltd
6.	"G. K. Dubey and Others Thyristorised Power Controller", Wiley Eastern Ltd
7.	B.K. Bose, "Modern Power Electronics and A.C. Drives", Prentice Hall of India Pvt. Ltd. Publication
8.	B.W.Williams, "Power Electronics", John Willey.
Term Work:	
It will consist of a record of at least six to eight experiments based on the following list..	
1.	UJT characteristics.
2.	SCR characteristics.
3.	Triac characteristics.
4.	Power control using SCR.
5.	Power control using Triac.
6.	Single phase half controlled Rectifiers.
7.	Single phase fully controlled Rectifiers.
8.	Single phase inverter using transistor/ MOSFET/SCR.
9.	Basic step-down chopper.
10.	Basic step-up chopper.
11.	Study of D.C. motor control using controlled rectifiers.
12.	Study of D.C. motor control using choppers.
13.	Study of A.C. motor control using inverter.

PEC-IN311 Elective-I Power Plant 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 create awareness about the various methods of power generation and its control methods in instrumentation engineering.
2.	To study the role of Instrumentation in power plants.
3.	To be familiar about the important parameters that has to be monitored and controlled.
4.	To impart knowledge about different types of controls and control loops.
5.	To get detailed knowledge about power plant management

Course outcomes:

1.	To remember the innovative ideas to improve plant efficiency reduce leakages and losses and use technologies for designing and developing pollutant free industrial environment.
2.	To understand the operation of traditional power plants and describe the instruments that makes up their measurement and control systems.
3.	To apply the knowledge of mathematics for deriving mathematical models for different processes in the power plant.
4.	To analyze the various instruments used in power plant and make recommendations for improving the control processes.
5.	To evaluate the performance of boilers and turbines.
6.	To design instrumentation systems for electricity generating plants.

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-IN311.1	3	1	1	1	1	1	1	1	1	1	1	3	2	2	1	1
PEC-IN311.2	2	1	1	1	1	1	1	1	1	1	1	2	3	3	1	1
PEC-IN311.3	2	1	1	2	3	1	1	1	1	1	2	1	3	3	1	2
PEC-IN311.4	1	2	2	3	1	3	2	1	2	2	2	1	1	2	2	2
PEC-IN311.5	1	1	2	3	2	2	2	1	3	3	3	1	2	3	3	2
PEC-IN311.6	1	1	2	2	1	2	2	1	3	3	3	1	3	3	3	2
PEC-IN311	**2**	**1**	**2**	**3**	**2**	**2**	**2**	**1**	**2**	**2**	**3**	**2**	**3**	**3**	**2**	**2**

Syllabus:

Unit 1	**Overview of Power Generation**
	Various types of power plants based on the methods of power generation example- thermal, nuclear, solar, wind, geothermal, magneto hydraulic, fuel cells, biomass; Introduction of process in power plant: Raw materials, different fuels, water feed, water steam cycle, gas air cycle, steam generators, different types of turbine, types of hydro turbines, steam turbines and gas turbines, power generating and distributing system, cooling towers; Importance of Instrumentation and control in power generation-P&I diagrams-P&I diagram of boiler-co-generation.

Unit 2	**Measurements in Power Plants**
	Importance of measurement and instrumentation in power plant, flow measurement, feed water, fuel, airflow, steam flow measurement and correction factor for temperature and pressure, temperature measurement, pressure measurement, level measurement, smoke, density measurement, radiation detection instrument.
Unit 3	**Turbine Monitoring and Control**
	Electrical parameters-Current, Voltage, Power, Energy, Frequency, Power factor etc- Nonelectrical parameters-Flow of feed water, fuel, air and steam with correction factor for temperature and pressure-Speed, vibration, shell temperature monitoring and control-Steam pressure control-Lubricant oil temperature control- cooling system.
Unit 4	**Control Loops and Interlocks in Boiler**
	Combustion control, air/fuel ratio, furnace draft and excess air control, drum level control or three element control, reheat steam temperature control, super heatercontrol, attemperator- deaerator control, Water recirculation and types of water cooling methods, Distributed Control System in power plant interlocks in boiler operation.
Unit 5	**Auxiliaries in Power Plants**
	Air system, ID, FD fans, make up water treatment plant, de-super heaters, air pre-heaters, soot blowers, different control valves and efficiency. Use of feed forward and cascade control. Instrumentation and control in reactors, their types, which are used in, process industries.
Unit 6	**Power Plant Management**
	Master control, boiler efficiency, maintenance of measuring instruments, intrinsic and electrical safety, computer based control and data logging systems, distributed control systems (DCS) and its applications in power plants.
Text/Reference Books:	
1.	Krishnaswamy, K., and M. PonniBala, "Power Plant Instrumentation" PHI Learning Pvt. Ltd., 2013.
2.	Nag, P. K., "Power Plant Engineering", Tata McGraw-Hill Education, 2002.
3.	Sam. G. Dukelow, "The Control of Boilers", Second Edition, ISA Press, New York, 1991.
4.	Domkundwar, A. S. "Power plant Engineering." Dhanpat Raj & Sons, India, 2000.
5.	Liptak, Bela G., and Béla G. Lipták, "Process measurement and analysis" Vol. 20. Boca Raton, FL: CRC press, 2003.
6.	Black & Veatch, "Power Plant Engineering" Chapman & Hall, 1996.
7.	Central Electricity Generating Board, "Modern Power Station Practice" Pergamon Press, 1971.
Term Work:	
Eligibility for attending examination on this course is as follows:	
1.	Student should submit minimum 5 assignments out of 8 assignments given by course coordinator.

PEC-IN312 Elective-I Digital System Design

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

Credits	3	End Semester Examination : 50 marks

Course objectives:	
1.	To familiarize with the basic components that constitute digital systems.
2.	To learn basic techniques for the design of digital circuits and fundamental concepts used in the design of digital systems.
3.	To understand the different types of PLDs and design of digital circuits using PLDs.
4.	To design and modeling of combinational, sequential digital systems and Finite State Machines.
5.	To understand the constructs and conventions of the Verilog / VHDL programming.
Course outcomes:	
1.	To remember the basic knowledge of combinational and sequential logic design.
2.	To understand advanced features of verilog HDL and apply them to design complex real time digital systems.
3.	To execute program codes for structural and behavioral modeling of combinational and sequential logic using Verilog HDL in any problem identification, formulation and solution.
4.	To examine various abstraction levels of Verilog HDL in modeling digital hardware.
5.	To evaluate and design the modeling of combinational, sequential digital systems and Finite State Machines.
6.	To design and apply the concept of test-benches to create testing behavioral environments for simulation based verification.

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 -IN312.1	3	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1
PEC -IN312.2	1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	1
PEC -IN312.3	1	3	3	2	3	1	1	1	3	1	1	1	1	3	3	1
PEC -IN312.4	1	2	2	3	2	1	1	1	3	1	2	1	1	3	3	3
PEC -IN312.5	1	1	2	3	2	2	1	1	3	1	3	1	1	3	3	3
PEC -IN312.6	1	1	2	2	2	1	2	2	3	1	3	1	1	3	3	3
PEC-IN312	**1**	**2**	**2**	**3**	**2**	**1**	**1**	**1**	**3**	**1**	**2**	**1**	**1**	**3**	**3**	**3**

Syllabus:	
Unit 1	**Introduction to Digital Systems**
	Evolution of digital systems, design process, design of digital hardware, computer aided design tools.
Unit 2	**Combinational and Sequential Logic Design**
	Adders subtractors, ALU, decoder, encoder, multiplier, comparator, Barrel shifters, multiplier design and its VHDL implementation multi-operand addition, sequential multiplication with sign and magnitude, two's complement, partially combinational implementation, MAC, saturating multiplier, truncating multiplier, rectangular multiplier.
Unit 3	**Sequential Machines**
	Introduction to State Machines: The Need for State Machines, The State Machine, Basic Concepts in State Machine Analysis. Finite State Machines: Standard model, synchronous and asynchronous machines, Moore and Mealy machines.

Unit 4	**Programmable Logic Devices**
	Combinational logic design using PLDs like ROM array, PLA, PAL, preliminary design concepts using CPLDs and FPGAs, Combinational PLD-Based State Machines
Unit 5	**Hardware Description Languages**
	Introduction to HDL, Combinational logic description: Structure, combinational behavior, test benches. Sequential logic description: registers, oscillators, controllers. Data path component description: full adders, carry – ripple adders, up counters.
Unit 6	**Control Unit design**
	Constructing the control unit, standalone controllers, ASM charts and state action tables, VHDL implementation of control unit. Examples of manual design of dedicated microprocessors.
Text/Reference Books:	
1.	Jain Rajendra Prasad "Modern Digital Electronics." Tata McGraw-Hill Education, 2003.
2.	Tocci, Ronald J., Neal S. Widmer, and Gregory L. Moss. "Digital Systems: Principles and Applications, Pearson Education Limited, 2018.
3.	Ciletti, Michael D., and M. Morris Mano. "Digital Design." Prentice-Hall, 2007.
4.	Vahid, Frank. "Digital design with RTL design, VHDL, and Verilog." John Wiley & Sons, 2010.
5.	Vranesic, Zvonko G., and Stephen Brown. "Fundamentals of digital logic with VHDL design." McGraw Hill, 2000.
6.	Bhasker, Jayaram. "A VHDL Primer." Prentice-Hall, 1999.
7.	Roth CH, John K. Lizy,"Digital System Design using VHDL", Thomson. International Student Edition. 2008.

PEC-IN313 Elective-I Optical 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 working of optical fiber as a sensor.
2.	To apply and usage of optical fiber to measure various physical parameters.
3.	To study and identify applications of LASER in instrumentation & measurement.
Course outcomes:	
1.	To know the basic concepts of optical fibers and to provide knowledge about optical sources and optical detectors.
2.	To classify the optical sources and detectors and to discuss their principle and understand the industrial applications of optical fibers.
3.	To apply LASER and optical fiber for various physical parameter measurements.
4.	To analyze the optical sensor technology on various parameters of measurements.
5.	To explain the basic elements of optical fiber transmission link, fiber modes configurations and structures.
6.	To familiar with design considerations of fiber optic 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 -IN313.1	3	1	-	-	-	-	-	-	-	-	-	2	3	1	1	-
PEC -IN313.2	3	1	-	-	-	-	-	-	-	-	-	1	2	1	-	2
PEC -IN313.3	3	2	3	2	3	-	-	-	-	-	-	-	3	2	-	2
PEC -IN313.4	3	2	3	2	3	-	-	-	-	-	-	-	3	2	2	3
PEC -IN313.5	3	3	3	3	2	-	-	-	3	1	2	3	2	3	3	1
PEC -IN313.6	3	3	3	3	2	3	3	-	3	2	3	2	3	3	3	1
PEC-IN313	**3**	**3**	**3**	**2**	**2**	**1**	**1**	**-**	**1**	**1**	**1**	**1**	**3**	**3**	**2**	**2**

Syllabus:	
Unit 1	**Introduction**
	Light and elements of solid state physics nature of light, wave nature of light, light sources black body radiation, units of light Energy bands in solids, semiconductor types, works function, functions.
Unit 2	**Display devices**
	Luminescence, insertion luminescence and the light emitting diode, radiative recombination processes LED materials, commercial LED materials LED construction, response time of LEDs, LED drive circuitry plasma display liquid crystal displays.
Unit 3	**Lasers**
	Emission population inversion, optical feedback classes of laser, doped insulator lasers semiconductor lasers, gas lasers, liquid dye lasers, laser applications, measurement of distance holography.
Unit 4	**Photodetectors**
	Thermal detectors: thermoelectric detectors, the bolometer, pneumatic detector, pyroelectric detector photo devices photoemissive devices vacuum photo diodes photo multipliers, noise in photo multipliers, image intensifier photo conductive detection photo transistor etc.
Unit 5	**Optical fibers**
	Classification of optical fiber, principle of light transmission through a fiber, fabrication of optical fibers, material consideration loss and band width limiting mechanism, preform fabrication technique, fiber drawing, fiber optic communication system introduction to fiber optic sensors: temperature pressure, level etc.
Unit 6	**Opto electronic power devices and Opto isolators**
	Solar cells and their application, different types of opto isolators and their configuration applications.
Reference Books:	
1.	Pallab Bhattacharya, "Semiconductor Optoelctronic Devices", Second Edtion, Pearson Education, New Delhi, 2002.
2.	J. Wilson J.F.B.Hawkes, "Opto Electronics – An Introduction", Prentice Hall of India New Delhi, 1996.
3.	Deboo Burrous, "Integrated circuits and semiconductor devices: theory and application", McGraw Hill Second Edition.
4.	J. M. Senior, "Optical fiber communications Principals and Practice", Prentice Hall of India, Second Edition, 1996.
5.	H. Zanger and C. Zanger, "Fiber optics – communication and other application",

	McGraw Publication.
6.	Gerd Keiser, "Optical Fiber Communication".

PEC-IN314 Elective-I Automotive 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 concepts of automotive electronics and its evolution and trends.
2.	To understand, design and model various automotive control systems using Model based development technique.
3.	To describe various communication systems, wired and wireless protocols used in vehicle networking.
4.	To understand safety standards, advances in towards autonomous vehicles.
5.	To understand vehicle on board and off board diagnostics.

Course outcomes:

1.	To acquire knowledge of various automotive standards and Protocols.
2.	To understand the basic knowledge of sensor and measuring system.
3.	Ability to understand electronic control unit.
4.	To analyze and understand the overview of automotive components, subsystems, design cycles, communication protocols and safety systems employed in today's automotive industry
5.	To select the basic modeling and control scheme for automotive systems.
6.	Design aspects of measurement and control strategies in automotive application.

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 -IN314.1	3	2	3	1	3	2	2	3	2	3	1	3	3	3	1	3
PEC -IN314.2	3	2	1	1	2	1	-	-	-	-	-	2	3	2	1	-
PEC -IN314.3	3	2	2	1	2	-	-	-	-	-	-	3	3	3	2	-
PEC -IN314.4	3	3	3	3	2	-	2	-	2	2	3	3	3	2	3	2
PEC -IN314.5	3	3	3	3	3	-	-	-	2	2	3	3	3	3	3	2
PEC -IN314.6	3	3	3	3	3	-	-	1	3	3	3	3	3	3	3	3
PEC-IN314	**3**	**3**	**3**	**3**	**3**	**1**	**1**	**1**	**2**	**2**	**2**	**3**	**3**	**3**	**3**	**2**

Syllabus:

Unit 1	**Introduction of automobile system**
	Current trends in automobiles with emphasis on increasing role of electronics and software, overview of generic automotive control ECU functioning, overview of typical automotive subsystems and components, AUTOSAR.
Unit 2	**Engine management systems**
	Basic sensor arrangement, types of sensors such as oxygen sensors, crank angle position sensors, fuel metering/ vehicle speed sensors, flow sensor, temperature, air mass flow sensors, throttle position sensor, solenoids etc., algorithms for engine

	control including open loop and closed loop control system, electronic ignition, EGR for exhaust emission control.
Unit 3	**Vehicle power train and motion control**
	Electronic transmission control, adaptive power steering, adaptive cruise control, safety and comfort systems, anti-lock braking, traction control and electronic stability, active suspension control.
Unit 4	**Active and passive safety system**
	Body electronics including lighting control, remote keyless entry, immobilizers etc., electronic instrument clusters and dashboard electronics, aspects of hardware design for automotive including electro-magnetic interference suppression, electromagnetic compatibility etc., (ABS) antilock braking system, (ESP) electronic stability program, air bags.
Unit 5	**Automotive standards and protocols**
	Automotive standards like CAN protocol, Lin protocol, flex ray, OBD-II, CAN FD, automotive Ethernet etc. automotive standards like MISRA, functional safety standards (ISO 26262).
Unit 6	**System design and energy management**
	BMS (battery management system), FCM (fuel control module), principles of system design, assembly process of automotives and instrumentation systems.
Text Books:	
1.	William B. Ribbens, "Understanding Automotive Electronics", Sixth Edition, 2003.
Reference Books:	
1.	Young A.P., Griffiths, "Automotive Electrical Equipment", ELBS & New Press, 1999.
2.	Tom Weather Jr. & Cland c. Ilunter, "Automotive computers and control system", Prentice Hall Inc., New Jersey.
3.	Crouse W.H., "Automobile Electrical Equipment", McGraw Hill Co. Inc., New York, 1995.
4.	Bechhold,"Understanding Automotive Electronic", SAE, 1998.
5.	Robert Boshe, "Automotive Hand Book", Bentely Publishers, Fifth Edition, Germany, 2005.

PEC-IN315 Elective-I Mechatronics

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 aim of the module is to introduce the basic elements of mechatronics and illustrate with case study material.
Course outcomes:	
1.	To recalling the basic techniques, skills and modern tools in mechatronics engineering technology.
2.	To understand customer requirements and effectively integrate multiple mechanical and electrical systems.
3.	To apply concepts of circuit analysis, analog and digital electronics, automation and

	controls, motors, power systems, instrumentation and computers to aid in the design, characterization, analysis and troubleshooting of mechatronics systems.
4.	To analyze advanced principles of statics, dynamics, fluid mechanics, and strength of materials, engineering standards and manufacturing processes to aid in the design.
5.	To calculate the interfacing parameters required to connect digital and analogue sensors to computers.
6.	To design a system component or process to meet desired needs within realistic constraints, such as economic, environmental and/or social.

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 -IN315.1	3	3	3	3	3	3	3	2	3	1	1	3	3	3	3	1
PEC -IN315.2	3	3	3	2	3	3	2	3	2	2	2	3	3	3	2	2
PEC -IN315.3	3	3	3	2	3	3	2	1	2	1	2	3	3	2	2	1
PEC -IN315.4	3	3	3	3	3	3	2	-	2	2	3	3	3	3	2	2
PEC -IN315.5	3	3	3	2	3	3	2	-	2	1	2	3	3	3	2	1
PEC -IN315.6	3	3	3	3	3	3	2	-	3	2	3	3	3	3	3	2
PEC-IN315	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**1**	**3**	**2**	**3**	**3**	**3**	**3**	**3**	**2**

Syllabus:	
Unit 1	**Introduction**
	Meachatronics, measurement system, overview of mechatronics, mechatronics design approach, system interfacing, instrumentation and control systems, microprocessor-based controllers. Various transducers used for measurement of displacement, position, velocity, force, pressure, temperature, signal conditioning, data presentation and data logging system, introduction to various actuators, comparison of various actuators, selection of actuators. Temperature switches, pressure switches, flow switches, level switches, electrically operated switches, magnetic switches, solid state switches and solenoids.
Unit 2	**Systems models review**
	Mathematical models, mechanical system building blocks, electrical system building blocks, fluid system building blocks, thermal system building blocks, rotational translational systems, electromechanical systems, hydraulic mechanical systems, system transfer function, dynamic response of systems, frequency response.
Unit 3	**Study of advance process control blocks**
	Statistical process control, model predictive control, fuzzy logic based control, neural-network based control. Higher level operations: control & instrumentation for process optimization, applications of the above techniques to the some standard units/processes.
Unit 4	**Fault finding**
	Fault detection techniques, watchdog timer, parity and error coding checks, common hardware faults, microprocessor systems, emulation and simulation, PLC systems.
Unit 5	**Robotics**
	Introduction to robots, classification of robots, and anatomy of robots, degree of freedom, robot joints and robot coordinates various applications of robots.

Unit 6	**Mechatronics systems**
	Case study-1: Design of electrically controlled robot arm for sorting application Cast Study-2: Design of a robotic walking machine Case study-3: Design of control scheme for automatic bottle filling plant Case study-4: Design of control scheme for automatic baggage handling system. Case study-5: Design of control scheme home automation
Text Books:	
1.	Mittal R. K. and Nagrath I. J. , "Robotics and Control", TMH Pub., New Delhi, 2003.
2.	M. D. Singh, J. G. Joshi, Mechatronics, PHI.
Reference Books:	
1.	W. Bolton, "Mechatronis: Electronic Control Systems in mechanical and electrical engineering", Third Edition, Pearson education (Singapore) Ltd., 2005.
2.	Tsunco Yoshikawa, "Foundations of Robotics, Analysis and Control", prentice Hall of India, 2001.
3.	David Alciatore and Histand, "Introduction to Mechatronics and measurment system", TMH.
4.	Dan Necsulescu, "Mechatronics", Pearson Education, Asia.
5.	Robert H. Bishop, "The Mechatronics Handbook", CRC Press, with ISA–The Instrumentation, Systems, Automation Society, 2002.
6.	B.G. Liptak 'Handbook of Instrumentation- Process Control'.
7.	Atkeson C. G. & Hollerbach J. M., "Model based control of a Robot manipulator", MIT Press, Mass., 1988.

PEC-IN316 Elective-I Material Science

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 know the fundamental science and engineering principles relevant to materials.
2.	To understand the relationship between nano /microstructure, characterization, properties and processing and design of materials.
3.	To develop an understanding of the basic principles of material science and apply those principles to engineering applications.
Course outcomes:	
1.	To define electrical, magnetic and optical properties of materials.
2.	To identify, formulate, and solve engineering problems.
3.	To apply core concepts in Materials Science to solve engineering problems.
4.	To examine general math, science and engineering skills to the solution of engineering problems.
5.	To select suitable materials for specific instrumentation devices.
6.	To design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

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 -IN316.1	3	3	3	3	3	3	3	2	3	1	1	3	3	3	3	1
PEC -IN316.2	3	3	3	2	3	3	2	3	2	2	2	3	3	3	2	2
PEC -IN316.3	3	3	3	2	3	3	2	1	2	1	2	3	3	2	2	1
PEC -IN316.4	3	3	3	3	3	3	2	-	2	2	3	3	3	3	2	2
PEC -IN316.5	3	3	3	2	3	3	2	-	2	1	2	3	3	3	2	1
PEC -IN316.6	3	3	3	3	3	3	2	-	3	2	3	3	3	3	3	2
PEC-IN316	**3**	**3**	**3**	**3**	3	**3**	**3**	**1**	**3**	**2**	**3**	**3**	**3**	**3**	**3**	**2**

Syllabus:	
Unit 1	**Introduction to engineering materials**
	Materials classification and engineering requirements of materials, factor affecting the selection of materials for engineering purposes, properties of engineering materials , testing of materials, tensile test, torsion and shear test, compression test, impact test, hardness test, fatigue test, S-N diagram, creep of materials, Erichsen test.
Unit 2	**Materials and their applications**
	Electrical and electronic component, materials for resistors, properties and applications, superconducting materials, transducers materials, semiconductors-commonly used type working applications. thermistors, piezoelectric, ferro electric and ferro ceramic materials, die electric materials and dielectric constant, capacitor insulating materials, properties of fibrous material, ceramic, mica glass, rubber, plastics, thermosetting and thermoplastic resins, insulating waxes, varnishes and coolants. Effects of carbon composition and applications.
Unit 3	**Magnetic materials**
	Soft material and hard magnetic materials, ferrites and Di para antiferro, ferromagnetism.
Unit 4	**Thermocouple materials**
	Soldering materials, fuse materials, contact materials, fluorescent and phosphorescent materials, processing of electronic materials, crystal growth, purification junction, IC fabrication processes of galvanizing and impregnatism.
Unit 5	**Nanomaterials**
	Introduction to nanotechnology, Nanowire and Nanotube, carbon nanotubes, single wall carbon nanotubes, Multiwall carbon nanotubes, fabrications, properties and applications.
Unit 6	**Introduction to manufacturing processes**
	Casting, cold working and hard working processes like rolling, forging, extrusion etc., crystal structure of metals and alloys: FCC, BCC, HCP.
Text Books:	
1.	Alagappan W., Kumar N. T.,"Electrical Engineering Materials", McGraw Hill 1998.
2.	Agrawal B. K., "Engineering Material", Mc-Graw Hill Publishing company, 2000.
3.	Raghavan V., "Materials Science and Engineering – A first course", Fifth Edition, Prentice Hall, New Delhi, 1998.
4.	Dr. V. D. Kodgire, "Material science and Metallurgy", Everest Publishing House, Twelveth Edition 2002.
Reference Books:	
1.	Raymond A. Higgins, "Material for Engineering Technician", Second Edition, ELBS,

	1998.
2.	R. M. Rose, L. A. Shepard, "The structure and Properties of Materials", Vol. IV, John Wulff, John Wiely and Son Inc.198.
3.	Smith W. F. and Hashemi J., "Foundations of Materials Science and Engineering", Fourth Edition, Mc Graw Hill, United States, 2005.
4.	VanVlack L. H., "Elements of material science and engineering," Pearson Education India.

PEC-IN317 Elective-I Microelectronics

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 make the students familiar with the properties behaviour and applications and implementation of microelectronic technology into integrated circuits.
2.	A sound knowledge of the fundamental scientific principles involved in the operation, design and fabrication.
3.	An ability to use the techniques, skills and modern engineering tools necessary for engineering practice.
4.	Understand the basic and advanced circuit and system design techniques for digital and analog domain.

Course outcomes:

1.	To know the semiconductor concepts of drift, diffusion, donors and acceptors, majority and minority carriers, excess carriers, low level injection, minority carrier lifetime.
2.	To discuss the electronic analysis of CMOS logic gates, delay analysis, analysis of complex logic gates, power dissipation.
3.	To apply simple large signal circuit models for metaloxide-semiconductor (MOS) capacitors devices which include charge storage elements and analyze the secondary effects of MOSFET.
4.	To analyze the basic structures to create MOSFETs, cell concepts, physical design of logic gates, design hierarchies.
5.	To evaluate VLSI design flow and transistor level CMOS logic design, discuss the physical structure of IC layers to create MOSFETs.
6.	To design and verify schematic and layout simulation of analog and digital CMOS VLSI circuits.

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 -IN317.1	3	-	-	-	-	-	-	-	-	-	-	2	3	3	3	2
PEC -IN317.2	3	1	1	1	-	-	-	-	-	-	-	2	3	2	2	1
PEC -IN317.3	3	-	2	2	2	-	-	-	-	-	-	2	3	2	1	1
PEC -IN317.4	3	2	2	1	2	-	-	-	-	-	-	2	3	2	2	2
PEC -IN317.5	3	-	-	-	-	-	-	-	-	-	-	2	3	1	1	1

PEC -IN317.6	3	1	3	-	-	1	-	-	-	-	2	2	3	2	3	2
PEC -IN317	**3**	**1**	**2**	**1**	**1**	**1**	**-**	**-**	**-**	**-**	**1**	**3**	**3**	**3**	**3**	**2**

Syllabus:	
Unit 1	**Technology of semiconductor devices**
	Materials, crystal growth, film formation, lithography, etching and doping. conductivity, charge densities, E-K relation, fermi level, continuity equation, Hall effect and its applications.
Unit 2	**pn junction and metal semiconductors**
	The pn junction and metal semiconductor contact, basic structure of pn junction, metal semiconductor contact, doped pn junction.
Unit 3	**Fundamentals**
	Fundamentals of MOSFET, MOSFET action, MOS capacitor, MOSFET operations, small signal equivalent circuit, MOSFET scaling, non-ideal effects, threshold voltage modifications, additional electrical characteristics, CMOS circuits, Bi-CMOS circuits, CCDs.
Unit 4	**Power devices, operation and characteristics**
	Thyristor family, power diodes, power transistors, GTOs and IGBTs. Display devices, operation of LCDs, LED, HDTV, plasma displays.
Text Books:	
1.	Donald Neamen, "An introduction to semiconductor devices", McGraw Hill International Edition, 2006.
2.	S. M. Sze, "Semiconductors Devices, Physics and Technology", Second Edition, Wiley, 2002.
3.	A. S. Sedra & K. C. Smith, "Microelectronic Circuits" Sixth Edition, Oxford, 2010.
4.	B. G. Streetman, S. K. Banerjee, "Solid state Electronic devices", Sixth Edition, PHI, 2010.
Reference Books:	
1.	J. Millman and C. C. Halkias, "Electronic devices and Circuits", McGraw Hill, 1976.
2.	Adir Bar-Lev, "Semiconductors and Electronic Devices", Third Edition, Prentice Hall, 1993.
3.	L. Macdonald & A. C. Lowe, "Display Systems", Wiley, 2003.

PEC-IN318 Elective-I Data Structure and Algorithms

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 various techniques for representation of the data in the real world and expose the student to efficient storage mechanisms of data for an easy access.
2.	To instill strong problem solving techniques using data structures, algorithms, and time-complexity.
Course outcomes:	
1.	To define and analyze various data structures and abstract data types including lists, stacks, queues, trees, and graphs.

2.	To understand instrumentation & control engineering problems from a computational perspective.
3.	To execute vast set of sorting and searching algorithms useful for various engineering applications.
4.	To analyze and implement learned algorithm design techniques and data structures to solve problems.
5.	To select the appropriate data structure and algorithm design method for a specified application.
6.	To design and implement various basic and advanced data structures.

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-IN318.1	3	3	1	2	3	3	-	1	3	2	1	2	3	-	1	1
PEC -IN318.2	3	3	2	2	3	3	-	2	2	2	1	2	3	-	1	2
PEC -IN318.3	3	3	2	2	3	3	-	1	1	2	1	2	3	-	1	1
PEC -IN318.4	3	3	3	3	3	3	-	1	3	2	2	2	3	-	-	1
PEC -IN318.5	3	3	3	3	3	3	-	2	3	3	2	2	3	-	-	2
PEC -IN318.6	3	3	3	3	3	3	-	2	3	3	2	2	3	-	-	2
PEC -IN318	3	**3**	**3**	**3**	**3**	**3**	**-**	**2**	**3**	**3**	**2**	**3**	**3**	**-**	**1**	**2**

Syllabus:	
Unit 1	**Introduction**
	Need of data structures, hardware and software implementations of data structures, various existing data structures and their related operations, compile time memory allocation and dynamic (run time) memory allocation, garbage collection.
Unit 2	**Linked list**
	Linked array and pointer representations their advantages and disadvantages, creation traversal, insertion and deletion, sorting, concatenation, merging, searching, header node, link list with grounded header node, circular link list, Josephus doubly linked (two way) link, its advantages and disadvantages.
Unit 3	**Stack**
	Array representation, overflow and underflow, push and pop operations, recursion its advantages, converting a recursive procedure to a non-recursive procedure.
Unit 4	**Queue**
	Simple queue, addition to a queue, removal from a queue, de-queues, input restricted and output restricted de-queues, addition and removal w.r.t. de-queue.
Unit 5	**Tree**
	Basic definitions, representation in computer memory, creating a binary tree, traversal algorithms threading in a binary tree, heap tree, creation of heap tree, inserting a node in a heap tree, deleting the root of heap tree, heap sort algorithm, link list representation using binary tree, multi-way search tree, representation in computer memory and its advantages.
Unit 6	**Graph**
	Basic definitions, representation in computer memory, creation of a graph, traversal in a graph, depth first traversal and breadth first traversal, sorting, inserting an arc in a graph, deleting an arc from a graph, searching a node and an arc in a graph.

Unit 7	**Searching algorithms and Table data structure**
	Sequential search, binary search, efficiency of searching algorithms, improving the efficiency of sequential search by move to front, move forward, indexed sequential search. Hash function and hashing, selection of hash function, collision and collision resolving methodologies, linear probing, quadratic probing, buckets, chaining, storing (inserting) data in table, searching a data record in a table, deleting a data record from a table, efficiency of search.
Unit 8	**Sorting algorithms**
	Bubble sort, quick sort, heap sort, insertion sort, selection sort, merge sort, efficiency of sorting algorithms.
Reference Books:	
1.	Cormen, Leiserson, and Rivest, "Introduction to Algorithms", Second Edition, Mc Graw Hill, New York, New Delhi, 1990.
2.	Ronald L. Rivest, Algorithms, "Data structures and Programs", Prentice Hall, New Jersey, 1990.
3.	Horowitz, Sahni, and Rajasekaran, "Fundamentals of Algorithms", Galgotia Publications, New Delhi, 1999.

SEM-IN319 Seminar

Teaching scheme:			**Examination scheme:**
Lectures	0	hrs/week	
Tutorials	0	hrs/week	
Practical	2	hrs/week	
Credits	1		

Syllabus:
The seminar will consist of a report of about 25 typewritten pages based on Survey of latest developments in a specific field of instrumentation and control systems.
OR
Investigation of practical problems in the manufacturing and or testing of an instrument.
OR
Design modification of an existing equipment/instrument.
AND
Seminar on one of the following topics should be delivered (without report)
Entrepreneurship
Personality development
Value education
Life profiles of eminent personalities like Lokmanya Tilak, Swami Vivekanand, Arvind Ghosh, A.P. J. Abdul Kalam
Stories of successful Entrepreneurs
Stories of scientists/renowned persons

AUD-IN320 Indian Ancient Science

Teaching scheme:		Examination scheme:
Lectures	2 hrs/week	
Tutorials	0 hrs/week	
Practical	0 hrs/week	
Credits	**Audit Course**	

1.	Importance of attitude: building positive attitude, self esteem.
2.	Cultural heritage of India: cultural tenets, values, peculiarities, family unit, old scriptures.
3.	Ancient science and technology: astronomy, physics, chemistry, mathematics, ayurveda, Kanad's atom theory, Aryabhatt, viman shastra surgery etc.
4.	Vedic mathematics.
5.	Life management techniques as preached by Saints, western philosophers etc.
6.	Motivation: How does it work, stages from motivation to demotivation, motivational stories.
7.	Goal setting of life: Why goals are important?, Why don't more people set goals, goals must be balanced.
8.	Problems before the nation and role of an individual.
9.	Culture and different isms: Indian culture, communism, Socialism, capitalism.
10.	Role of media and expectations.
11.	Theory "i" Management.
12.	Science and spirituality: stress management.

Reference Books:

1.	India vision 2020 by Dr APJ Abdul Kalam.
2.	Ancient science and technology By Dr. Gopalkrishnan.
3.	Theory of I management by Arindam Choudhary.
4.	India: what it can teach us by Maxmuller.
5.	Third way by Datopant Tengati.
6.	Swami Vivekananda(2004), Collected Works (Commentary on Yogasutras, vol.), Ramakrishna Mission, Kolkata.
7.	Gita-pravacane.
8.	Upanishadaancaa Abhyaasa.
9.	Gitaaii Cintanikaa.
10.	A Constructive Survey of Upanishadic Philosophy.
11.	Bhagvadgita: Saakshaatkaaradarshana.

Annexure-I

List of Equivalent Subjects from SWAYAM/NPTEL for Credit Transfer

Sr. No.	Institute Course		Details of course from SWAYAM/NPTEL
	Course Code	Title of the Course	
Semester-I			
1.	PCC-IN301	Feedback Control Systems	Control engineering Prof. Ramkrishna Pasumarthy, IIT Madras
			Control systems Prof. Shankar Raman, IIT Madras
2.	PCC-IN302	Industrial Instrumentation	5 week course on Coursera: Sensors and Sensor Circuit Design Dr. James Zweighft and Dr. Jay Mendelson University of Colorado
3.	PCC-IN303	Digital Signal Processing	Discrete-Time Signal Processing Prof. MrityunjayChakraborty, IIT Kharagpur
4.	PCC-IN304	Microprocessor and Microcontroller	Microprocessor and Microcontroller Prof. Santanu Chattopadhyay, IIT Kharagpur
5.	PCC-IN305	Industrial Data Communications	Data Communication Prof. Ajit Pal, IIT Kharagpur
6.	PCC-IN306	Unit Operations and Instrumentation	Mass Transfer Operations-II Dr. Chandan Das, IIT Guwahati
			Mechanical Unit Operation Prof Nanda Kishore, IIT Guwahati
Semester-II			
1.	PCC-IN307	Process Control	Industrial Automation and Control Prof. S. Mukhopadhyay, IIT Kharagpur
2.	PCC-IN308	Control System Components	Industrial Safety Engineering Prof. Jhareswar Maiti, IIT Kharagpur
3.	PCC-IN309	Distributed Control System	Industrial Automation and Control Prof. S. Mukhopadhyay, IIT Kharagpur Prof. S. Sen, IIT Kharagpur
4.	PCC-IN310	Power Electronics	Power Electronics Prof. G. Bhuvaneshwari, IIT Delhi
5.	PEC-IN311	Power Plant Instrumentation	Steam Power Engineering Prof. Vinayak N Kulkarni, IIT Guwahati
6.	PEC-IN312	Digital System Design	Digital Circuits Prof. Santanu Chattopadhyay, IIT Kharagpur
			Digital Electronic Circuits Prof. Goutam Saha, IIT Kharagpur
7.	PEC-IN313	Optical Instrumentation	Semiconductor Optoelectronics Prof. M. R. Shenoy, IIT Delhi
			Fiber Optics Communication Technology Prof. Deepa Venkitesh, IIT Madras