B.Tech. DEGREE

INSTRUMENTATION AND CONTROL ENGINEERING

SYLLABUS

FOR

CREDIT BASED

CURRICULUM

(For students admitted in **2008 & 2009**)

DEPARTMENT OF INSTRUMENTATION AND CONTROL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

TIRUCHIRAPPALLI - 620 015

INDIA

SEMESTER - III

CODE	COURSE OF STUDY	L	T	P	C
MA209	Mathematics III	3	1	0	4
IC 201	Sensors and Transducers	3	0	0	3
IC 203	Circuit Theory	3	0	0	3
IC 205	Electron Devices	3	0	0	3
CE 283	Thermo Dynamics and Fluid Mechanics	4	0	0	4
MT 211	Material Science	3	0	0	3
CE 285	Thermo Dynamics and Fluid Mechanics Laboratory	0	0	3	2
IC 207	Circuits and Devices Laboratory	0	0	3	2
	Total	19	1	6	24

SEMESTER - IV

CODE	COURSE OF STUDY	L	T	P	C
MA202	Numerical Methods	3	0	0	3
IC 202	Signals and Systems	3	0	0	3
IC 204	Industrial Instrumentation-I	3	0	0	3
IC 206	Analog Electronic Circuits	3	0	0	3
IC 208	Digital Techniques	3	0	0	3
IC 210	Electrical and Electronic Measurements	3	0	0	3
IC 212	Sensors and Transducers Laboratory	0	0	3	2
IC 214	Electronic Circuits Laboratory	0	0	3	2
	Total	18	0	6	22

SEMESTER - V

CODE	COURSE OF STUDY	L	T	P	C
IC 301	Industrial Instrumentation-II	3	0	0	3
EC 317	Principles of Communication Systems	3	0	0	3
IC 303	Microprocessors and Microcontrollers	3	0	0	3
IC 305	Analog Integrated Circuits	3	0	0	3
IC 307	Digital Signal Processing	3	0	0	3
IC 309	Control Systems	3	0	0	3
IC 311	Analog Integrated Circuits Laboratory	0	0	3	2
IC 313	Microprocessor and Microcontrollers Lab	0	0	3	2
	Total	18	0	6	22

SEMESTER - VI

CODE	COURSE OF STUDY	L	T	P	C
IC 302	Modern Control Theory	3	0	0	3
IC 304	Process Control	3	0	0	3
IC 306	Product Design and Development (T)	2	0	3	2
IC 308	MEMS and Nanotechnology	3	0	0	3
CS 320	Computer Networks	3	0	0	3
IC 310	Interfacing Laboratory	0	0	3	2
IC 312	Control Engineering Laboratory	0	0	3	2
IC 35X	Elective – 1	3	0	0	3
	Total	17	0	9	21

SEMESTER - VII

CODE	COURSE OF STUDY	L	T	P	C
IC 401	Logic and Distributed Control Systems	3	0	0	3
IC 403	Analytical Instrumentation	3	0	0	3
HM 401	Industrial Economics	3	0	0	3
IC 405	Biomedical Instrumentation	3	0	0	3
IC 407	Product Design and Development (P)	0	0	3	2
IC 409	Instrumentation Laboratory	0	0	3	2
IC 411	Process Control Laboratory	0	0	3	2
IC 447	Comprehensive Examination	0	0	0	3
IC 45X	Elective - 2	x	x	0	3
IC 45X	Elective - 3	x	x	0	3
	Total	(12+x)	x	9	27

SEMESTER - VIII

CODE	COURSE OF STUDY	L	T	P	C
IC 402	Opto-Electronics and Laser based Instrumentation	3	0	0	3
MB 790	Management Concepts and Practices	3	0	0	3
IC 45X	Elective – 4	x	x	0	3
IC 45X	Elective – 5	x	x	0	3
IC 498	Project Work	0	0	18	6
	Total	(6+x)	x	18	18

The total minimum credits required for completing the B.Tech. programme in Instrumentation and Control Engineering is 134 + 45 = **179.**

ELECTIVE LIST

CODE	COURSE OF STUDY	L	T	P	C
Elective - 1:					
IC 352	Power Electronics	3	0	0	3
IC 354	Data Structures and Algorithms	3	0	0	3
IC 356	Neural Networks and Fuzzy Logic Control	3	0	0	3
IC 358	Embedded Systems	3	0	0	3
Electives - 2 & 3:					
IC 451	Automotive Instrumentation and Control	3	0	0	3
IC 453	Virtual Instrumentation	2	0	2	3
IC 455	Optimization Techniques	3	0	0	3
IC 457	Digital Control Systems	3	0	0	3
IC 459	Robotics	3	0	0	3
IC 461	Sensor Networks	3	0	0	3
IC 463	Micro System Design	2	0	2	3
IC 465	Advanced Process Control	3	0	0	3
IC 467	Smart Materials and Systems	3	0	0	3
IC 469	Nonlinear Control	3	0	0	3
EC 451	Image Processing	3	0	0	3
EC 453	ARM System Architecture	3	0	0	3
CS 451	Principles of Cryptography	3	0	0	3

Electives - 4 & 5:

IC 452	Power Plant Instrumentation and Control	3	0	0	3
IC 454	System Identification	2	0	2	3
IC 456	Fault Detection and Diagnosis	3	0	0	3
IC 458	Piping and Instrumentation Diagrams	2	0	2	3
IC 460	Computational Techniques in Control Engineering	3	0	0	3
IC 462	Uncertainty Analysis in Engineering	3	0	0	3
IC 464	Probability and Computing	3	0	0	3
EC 308	VLSI Systems	3	0	0	3
EC 454	Display Systems	3	0	0	3
CS 357	Network Multimedia Systems	3	0	0	3

SUBJECTS OFFERED TO OTHER DEPARTMENTS

IC 216	Instrumentation and Control
IC 218	Control Systems
IC 220	Instrumentation and Control Laboratory
IC 315	Mechatronics
IC 317	Mechatronics Laboratory
IC 423	Instrumentation Systems
IC 425	Instrumentation Laboratory

MA 209 MATHEMATICS III

Laplace Transformation: Definition, one-sided and two sided transformation, properties, inverse Laplace transformation, convolution theorem, Heaviside function, Dirac-delta function, solutions to ordinary differential equations. Initial value and final value theorems.

Linear Algebra – Vector spaces, Subspaces, Basis and Dimension - Systems of Linear Equations, Linear Transformations - Kernel and Image - Geometric Ideas. Inner Product spaces - Orthogonality - Orthonormal basis - Reflections and Orthogonal maps of the plane - Orthogonal complements and Projections. Bilinear, Quadratic, Hermitian, and Skew-Hermitian forms.

Probability – Introduction, axioms of probability, elementary theorems, conditional probability. Baye's theorem, mathematical expectation, mean, variance, moment and moment generating function.

Discrete and continuous random variables: Cumulative distribution function, probability mass function, probability density function. Independent random variables and conditional density functions.

Standard probability models: Binomial, Poisson, exponential, Weibull, normal and log normal. Inequalities of Chebyshev's , central limit theorem.

Text Books:

1. Kumaresan, S.,*"Linear Algebra: A Geometric Approach"*, Prentice Hall of India, 2003, ISBN- 8120316282.

2. Ross, S.M., *"Introduction to Probability and Statistics for Engineers and Scientists"*, 2nd Edition, Elsevier, 2006, ISBN-1428814078.

Reference Books:

1. Hoffman, K. and Kunze, R.,*"Linear Algebra"*, 2nd Edition, 1992, Prentice Hall of India.

2. Kreyszig, E., *"Advanced Engineering Mathematics"*, Rev, John Wiley, 2005.

IC 201 SENSORS AND TRANSDUCERS

General concepts and terminology of measurement systems, transducer classification, general input-output configuration, static and dynamic characteristics of a measurement system, Statistical analysis of measurement data. Standards and Calibration.

Variable resistance transducers: Potentiometers, metal and semiconductor strain gauges and their signal conditioning circuits, strain gauge applications: Load and torque measurement.

Inductive transducers- Transformer type, synchros, eddy current transducers, proximity detectors. capacitive transducers, tacho generators and stroboscope.

Piezoelectric transducers and their signal conditioning, photoelectric transducers, Hall effect sensors, Magnetostrictive transducers, Basics of Gyroscope, Seismic instrument and accelerometers.

Digital displacement sensors, Fibre optic sensor, Semiconductor sensor and Smart sensors.

Text Books:

1. John P. Bentley, "*Principles of Measurement Systems*", 3rd Edition, Pearson Education, 2000.
2. Doebelin E.O, "*Measurement Systems - Application and Design*", 4th Edition, McGraw-Hill, New York, 2003.
3. S.M. Sze, "*Semiconductor sensors*", John Wiley & Sons Inc., Singapore, 1994.

Reference Books:

1. Murthy D. V. S, "*Transducers and Instrumentation*", Prentice Hall, New Delhi, 1995
2. Neubert H.K.P, "*Instrument Transducers - An Introduction to their Performance and Design*", 2nd Edition, Oxford University Press, Cambridge, 1999.
3. Patranabis, "*Sensors and Transducers*", 2nd Edition, Prentice Hall India Pvt. Ltd., 2003.
4. Waldemar Nawrocki, "*Measurement Systems and Sensors",* Artech House, 2005.

IC 203 CIRCUIT THEORY

Circuit Analysis Techniques: Lumped circuits, Models of physical systems, Circuit elements, Network topology, Element and Circuit rules, Source transformations, Star-Delta Transformations, Nodal analysis, Mesh analysis, Principle of linearity, Network theorems and applications, Circuits with controlled (dependent) sources.

Transient Response: Application of Laplace transforms to circuit analysis, Circuits with capacitors, Circuits with inductors, Time-constant, Source-free and Step response of RC, RL, and RLC circuits.

Sinusoidal Response: Behavior of elements with sinusoidal signals, Impedance and admittance, Circuit analysis using phasors, Sinusoidal steady state response of circuits, Magnitude and phase, Power and energy calculations, Three phase circuits, Resonance, Solution of A.C. steady state network equations using complex frequency concept.

Generalized Frequency Response: One- port and two- port networks, impedance and admittance parameters, hybrid parameters, ABCD parameters, image impedance. State variables, Transfer functions, Network functions - poles and zeros of network functions, Complex Frequency, scaling Network functions, Analysis of ladder network.

Causality, Stability, Realizability of one port networks, Hurwitz polynomials, positive real functions, Reciprocal and symmetric networks, Conditions for existence of networks. Network Synthesis: Properties of RC, RL, and LC driving point functions, Synthesis of networks from given transfer functions.

Text Books:

1. Hayt,W.H. and Kemmerly,J.E., "*Engineering Circuit Analysis*", McGraw Hill, New York, 5th edition, 1993.

2. Mahmood Nahvi, Joseph, A. Edminister, "*Theory and Problems of Electric Circuits – Schaum's outline series*", McGraw Hill International, 4th edition, 2003.

3. Ramakalyan, A., "*Linear Circuits: Analysis & Synthesis*", Oxford Univ. Press, India, 2005.

Reference Books:

1. Van Valkenburg, "*Network Analysis*", 3rd Edition, Prentice Hall, New Delhi, 1998.

2. D.Roy Chaudhry, "*Networks and Systems*", New Age International Publishers, New Delhi, 1997.

3. DeCarlo, R.A., & Lin, "*Linear Circuit Analysis*", 2nd Edition, OUP Indian Edition 2003.

IC 205 ELECTRON DEVICES

Semiconductor: Different semiconductor materials. Impurity doping. Intrinsic and extrinsic semiconductors. Conductivity, Carrier concentration. Charge densities. Kronig – penny model. E-K relation. Fermi level in semiconductors. Diffusion. Carrier life time. Continuity equation. Hall effect and its applications.

P-N junction diodes: P-N junction diodes, Contact potential, Current components, Forward and reverse biased junctions, V-I characteristics, Equivalent circuits. Transition and diffusion capacitance. SPICE diode model, Metal semiconductor contacts. Hetero junctions. Zener diodes, Schottky diode, Photo diode, LED. Varactor diode. Breakdown diodes. Transferred electron devices. Hot electron devices.

BJTs: Basic BJT theory, Different modes of operation and configurations. Transistor current components. Ebers – Moll model and Gummel – Poon model of BJTs. Transistor α, Current amplification β. Bipolar transistor switch, SPICE BJT model, Punch through and other breakdown mechanisms, Photo-voltaic effect, Photo-cell transistors.

MOSFETs: Device structure and physical operation, Current – voltage characteristics, MOSFET circuits at DC, MOSFET as an amplifier and as a switch, Small signal model, MOSFET internal capacitance and high frequency model, Depletion type MOSFET, SPICE MOSFET model, CMOS structure, operation, BiCMOS operation, CCDs.

Power devices: Thyristor family – UJT, SCR, TRIAC, DIAC – operation and V-I characteristics. Triggering. Power diodes, power transistors, IGBTs and GTOs fabrication and V-I characteristics.

Text Books:

1. S.M.Sze, "*Semiconductor Devices, Physics and Technology*", 2nd Edition, Wiley, 2002.

2. A.Bar-Lev, "*Semiconductor and Electronic Devices*", 3rd Edition, PHI, 1993.

3. L.Macdonald and A.C.Lowe, "*Display Systems: Design and Applications*", John Wiley and Sons, 2003.

Reference Books:

1. D.A.Neamen, "*Semiconductor physics and devices*", 2nd Edition, Irwin, 1997.

2. B.G.Streetman, "*Solid state devices*", 4th Edition, PHI, 1995.

3. D.A.Pucknell & K.Eshraghian, "*Basic VLSI Design*", 3rd Edition, PHI, 1996.

CE 283 THERMO DYNAMICS AND FLUID MECHANICS

Basic concepts: Thermodynamic equilibrium, quasi-static process, zeroth law, work and heat interactions, first law for a cycle and a process, steady flow processes, second law statements, reversibility, Carnot theorem, Clausius inequality, entropy principle.

Available energy: Availability and irreversibility, properties of pure substances, phase equilibrium diagrams, Rankine cycle, reheat and regenerative cycle, properties of ideal gas, Stirling and Ericson cycles.

Heat engines: Otto, diesel and dual cycles, Brayton cycle with regeneration, inter cooling and reheat, Joule-Thompson effect. Classification of fluids and their physical properties, Fluid statics, manometers, pressure on submerged bodies.

Ideal fluid – velocity field – stream line, streak line and path line, continuity equation – Rotational and irrotational motion, stream function and potential function, Eulers equations of motion, Bernoulli's equation and its application. Classification of open channel flows – measurement of discharge using rectangular and V notches.

Dimensional analysis – Rayleigh's method – Buckinghan π Theorem and its applications. Laminar flow – Losses – Hagen-Poiseuille equation - Turbulent pipe flow – friction Darcy weisbach equation – moody's diagram, minor losses – Boundary layer and its basic concepts.

Text Books:

1. Zemansky, "*Heat and Thermodynamics*" 7th edition , McGraw Hill, New York, 1997.
2. Streeter V.L. and Wylie E.B., "*Fluid Mechanics*", 9th edition , McGraw Hill, New York, 1997 ISBN 0070625379.

Reference Books:

1. Van Wylen,G.A.,etal, "*Fundamentals of classical Thermodynamics*", 4th Edition, John Wiley & Sons, 1994.
2. Cengal,Y.A., Bogles,M.A., Micheal Boles, "*Thermodynamics*", 2nd Edition, McGraw Hill Book Company, 1994.
3. Nag,P.K., "*Engineering Thermodynamics*", 2nd Edition, Tata McGraw Hill, 1995.
4. ShamesI.H., "*Mechanics of Fluids*", Third Edition, McGraw Hill, New York, 1992.

MT 211 MATERIAL SCIENCE

Introduction to crystal structure of materials, density computations, polymorphism and allotropy, Miller indices for crystallographic planes and directions, isotropy and anisotropy with respect to material properties. X-ray diffraction for determination of crystal structure. Defects in solids: point, line and planar defects and their effect on properties of materials. Phase diagrams, mono component and binary systems, Interpretation of phase diagrams, the Gibbs phase rule, the iron-carbon system.

Development of micro structure – equilibrium and non equilibrium cooling. Time-temperature-transformation curves and their applications. Mechanical properties of materials, anelasticity, elastic and plastic behavior, stress-strain relationship, fatigue and creep, strengthening mechanisms and fracture. Thermal properties, heat capacity, thermal expansion, thermal conductivity and thermal stresses.

Electrical properties of materials: electron energy band structures for solid materials, conduction in terms of band and atomic bonding models. Intrinsic and extrinsic semiconductors, the temperature variation of conductivity and carrier concentration. Electrical properties of polymers. Dieelectric behavior, Ferro electricity and Piezoelectricity.

Magnetic properties, diamagnetic, paramagnetic, ferro magnetic, anti-ferromagnetic, ferromagnetic materials and their applications. Influence of temperature on magnetic characteristics of materials. Superconductivity in materials Optical properties of materials: Absorption, transmission, refraction, reflection; opacity and translucency in materials Absorption, transmission, refraction, reflection; opacity and translucency in materials. Mechanism of photon absorption. Environmental effect on materials.

Zone refining for purification of materials, Synthesis and growth of Group-III-V compounds and their applications. Selection of specific materials required for instrumentation devices, sensors, pumps, valves, pipelines and coatings.

Text Books:

1. Callister W.D., "*Materials Science and Engineering: An introduction*", 6th Edition, John Wiley & Sons Inc., New York 2002
2. Raghavan V. " *Materials Science and Engineering – A first course*" 5th Edition, Prentice Hall, New Delhi, 1998
3. Van Vlack, LH, " *Elements of Materials Science and Engineering*". 6th Edition, Addison – Wesley Singapore, 1989

Reference Books:

1. Askeland D.R. " *The Science and Engineering of Materials*", 2nd Edition, Chapman and Hall, London, 1989
2. W.F.Smith and J.Hashemi. "*Foundations of Materials Science and Engineering*", 4th Edition, Mc Graw Hill, United States, 2005.

CE 285 THERMO DYNAMICS AND FLUID MECHANICS LABORATORY

Thermodynamics:

1. Performance test on Petrol and Diesel Engines with Mechanical and Electrical Dynamometers
2. Morse test on multi-cylinder petrol engine
3. Determination of volumetric efficiency on Diesel engine and Two stage reciprocating Air compressor
4. COP in compression refrigerator cycle
5. Test on Air conditioning system
6. Viscosity index of lubricant
7. Study of steam power plant

Fluid Mechanics:

1. Determination of pipe friction
2. Calibration of flow meters – Venturimeter and Orifice meter
3. Determination of discharge coefficients for notches
4. Determination of minor losses
5. Centrifugal pump
6. Submersible pump
7. Jet pump
8. Gear pump
9. Screw pump

IC 207 CIRCUITS AND DEVICES LABORATORY

1. Verification of Circuit theorems.
2. Step response of RC and RL circuits.
3. Frequency response of a second order circuit
4. Resonance.
5. Currents and voltages in unbalanced and balanced star and delta circuits.
6. Transfer function of simple R, L, C circuits from frequency response characteristics.
7. Determination of Z, Y and h parameters of a two port network.
8. Volt-ampere characteristics of semi conductor diode and zener diodes.
9. Transistor characteristics – CE.
10. Transistor characteristics – CB.
11. Characteristics of FET.
12. Characteristics of UJT.

MA202 NUMERICAL TECHNIQUES

Solution of linear system - Gaussian elimination and Gauss-Jordan methods - LU - decomposition methods - Crout's method - Jacobi and Gauss-Seidel iterative methods - sufficient conditions for convergence - Power method to find the dominant eigen value and eigen vector.

Solution of nonlinear equation - Bisection method - Secant method - Regula falsi method - Newton-Raphson method for $f(x) = 0$ and for $f(x,y) = 0$, $g(x,y) = 0$ - Order of convergence - Horner's method - Graeffe's method - Bairstow's method.

Newton's forward, backward and divided difference interpolation – Lagrange's interpolation – Numerical Differentiation and Integration – Trapezoidal rule – Simpson's 1/3 and 3/8 rules - Curve fitting - Method of least squares and group averages.

Numerical Solution of Ordinary Differential Equations- Euler's method - Euler's modified method - Taylor's method and Runge-Kutta method for simultaneous equations and 2^{nd} order equations - Multistep methods - Milne's and Adams' methods.

Numerical solution of Laplace equation and Poisson equation by Liebmann's method - solution of one dimensional heat flow equation - Bender - Schmidt recurrence relation - Crank - Nicolson method - Solution of one dimensional wave equation.

Computer based exercises are recommended in all units.

Text Books:

1. S.S.Sastry, *Introductory methods of Numerical Analysis*, 3^{rd} edition, PHI, 2003, ISBN 812031266X

2. Terrence J Akoy, Applied Numerical Method for Engineers, 1^{st} Edition, John Weily & Sons, ISBN 0471575234

Reference Books:

1. Gerald, C.F., and Wheatley, P.O., *"Applied Numerical Analysis"*, Addison Wesley.

2. Jain, M.K., Iyengar, S.R. and Jain, R.K., *"Numerical Methods for Scientific and Engineering Computation"*, Wiley Eastern.

3. Kandasamy, P., Thilagavathy, K., and Gunavathy, *S., "Numerical Methods"*, Chand and Company.

IC 202 SIGNALS AND SYSTEMS

Introduction to signals and systems: Introduction to signals, classification of signals, basic continuous- time and discrete- time signals, step and impulse functions, transformation of independent variable. Introduction to systems, properties of systems, classification of systems, mathematical model for systems, normal form of system equations, initial conditions.

Impulse response of a physical system, introduction to convolution, system impulse response and convolution integral, numerical convolution. Sampling theorem, Z-transform, convergence of Z-transform, properties of Z-transform, inversion of Z-transform , evaluation of system frequency response, applications of Z-transform.

Representation of signals in terms of elementary signals, condition for orthogonality, representation of signals by elementary sinusoids, Fourier series representation, power spectrum, Fourier Transform, system function, energy spectrum. Calculation of simple transforms, Discrete Fourier Transform (DFT), properties of Discrete Fourier Transform.

Statistical Signal Analysis: Classification of random signals, auto correlation function, properties of auto correlation function, measurement of auto correlation function, application of autocorrelation functions, cross correlation functions, properties of cross correlation functions, sum of random processes**.**

Spectral density, relation of spectral density to autocorrelation function. Auto correlation function of system output, cross- correlation between input and output, white noise, generation of pseudo-random binary noise, analysis of linear systems in time domain using white noise, mean and mean square value of system output, analysis in the frequency domain.

Text Books:

1. Gabel R.A. and Robert R.A, "*Signals and Linear Systems*", 3rd Edition, John Wiley and Sons, New York, 1987.
2. Oppenheim, Wilsky and Nawab, "*Signals and Systems*", 2nd Edition, Prentice Hall, New Delhi, 1997.
3. C.T.Chen, "*Systems and Signal Analysis*", Oxford University Press, India, 3rd Edition, 2004, ISBN 100195156617.

Reference Books:

1. Cooper G.R and McGillem C.D, "*Probabilistic Methods of Signals and System Analysis*", 3rd Edition, Oxford University Press, Cambridge, 1999.
2. Chesmond, Wilson, & Lepla "*Advanced Control System Technology*", ISBN-8176490326, Viva Books, India, 1998.
3. Ziemer R.E., Tranter W.H., and Fannin D.R., "*Signals and Systems*", 4th Edition, Pearson Education Asia, Singapore, 1998.

IC 204 INDUSTRIAL INSTRUMENTATION - I

Introduction to industrial instrumentation: Temperature and heat, definitions, temperature scales, bimetallic thermometers, filled- bulb and glass stem thermometers. Thermocouples: Thermoelectric effects, laws of thermocouple, cold junction compensation techniques, thermocouple types, construction, installation and protection, measuring circuits, thermocouple burn out detection and high temperature measurement methods.

Temperature measurement: Resistance temperature detector (RTD), principle and types, construction requirements for industry, measuring circuits. Thermistors, principle and sensor types, manufacturing techniques, measuring circuits, linearization methods and applications. Pneumatic and suction pyrometers, integrated circuit sensors, diode type sensors, ultrasonic thermometers, Johnson noise thermometer, fluidic sensors, spectroscopic temperature measurements, thermograph, temperature switches and thermostats.

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. Temperature sensor selection and applications, sensor calibrators and simulators.

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.

Measurement of viscosity: definitions, units, Newtonian and Newtonian behavior, measurement of viscosity using laboratory viscometers, industrial viscometers. Viscometer selection and application. Measurement of density, definitions, units, liquid density measurement, gas densitometers, its application and selection.

Text Books:

1. Doebelin E.O, "*Measurement Systems: Application and Design*", 4th Edition, McGraw Hill, New York, 2003.
2. Patranabis D, "*Principles of Industrial Instrumentation*", 2nd Edition, Tata McGraw Hill, New Delhi, 1997.

Reference Books:

1. Noltingk B.E., "*Instrumentation Reference Book*", 2nd Edition, Butterworth Heinemann, 1995.
2. Liptak B.G, "*Process Measurement and Analysis*", 4th Edition, Chilton Book Company, Radnor, Pennsylvania, 2003.
3. Douglas M. Considine, "*Process / Industrial Instruments & Controls Handbook*", 5th Edition, McGraw Hill, Singapore, 1999.
4. Andrew W.G, *"Applied Instrumentation in Process Industries – A survey"*, Vol I & Vol II, Gulf Publishing Company, Houston, 2001

IC 206 ANALOG ELECTRONIC CIRCUITS

Diode and Amplifier circuits: Rectifier circuits. Filter circuits. Limiting and clamping circuits. Special Diode types. Zener voltage regulator. MOSFET and BJT circuits at DC. MOSFET and BJT as amplifier. Biasing MOS and BJT amplifiers. Small signal operation and models for MOSFET and BJT. Single stage MOS amplifiers and BJT amplifiers. High frequency model for MOSFET and BJT.

Single stage integrated circuit amplifiers: Comparison of MOSFET and BJT. Bi CMOS circuits. IC biasing. High frequency response. CS and CE amplifier with active loads. High frequency response of CS and CE amplifier. CG and CB amplifiers with active loads. Cascode amplifier. CS and CE amplifiers with source de-generation. Source and emitter follower.

Differential and multi stage amplifiers: MOS differential pair and its small operation. BJT differential pair. Non ideal characteristics of differential amplifier. Differential amplifier with active load. Two stage amplifiers using MOS and two stage amplifiers using BJT.

Feedback amplifiers, Sinusoidal oscillators: General feedback structure. Properties of negative feedback. Four basic feedback topologies. Loop gain. Stability problem. Basic principle of sinusoidal oscillators. RC oscillator. LC and crystal oscillator.

Output stages and power amplifiers: Class A, class B, class AB output stages. Biasing class AB circuits. Power BJTs, MOS power transistor. Variations on the class AB configuration. IC power amplifiers. Class AB operation.

Text Books:

1. J. Millman and A. Grabel, "*Microelectronics*", 2nd Edition, Tata McGraw Hill, 1987.

2. David A.Bell, "*Solid State Pulse Circuits*", PHI, 4th Edition, 1992.

3. A.S.Sedra and K.C.Smith, "*Microelectronics circuits*", 5th Edition, Oxford University Press, India, 2004.

Reference Books:

1. D.L.Schilling and C. Belove, "*Electronic Circuits*", Tata McGraw Hill, 3rd Edition, 1989.

2. R.Spencer and Mohammed S.Ghausi, "*Introduction to Electronic Circuit Design*", Pearson, 2003.

3. Robert L. Boylestad, "*Electronic Devices and Circuit Theory*", 8th Edition, Pearson, 2002.

IC 208 DIGITAL TECHNIQUES

Review of number systems and logic gates: Number systems and data representation, Binary, Octal, Hexadecimal representations and their conversions, Signed numbers and floating point number representation. Codes, Basic logic operations, Boolean algebra, De-Morgan theorems, Algebraic reductions, NAND and NOR based logic, Digital logic gates.

Combinational Logic: Canonical logic forms, Extracting canonical forms, Karnaugh maps and Tabular methods, Don't care conditions, minimization of multiple output functions.

Synthesis of combinational functions: Arithmetic circuits-Adder, carry look-ahead adder, number complements subtraction using adders, signed number addition and subtraction, BCD adders. IC adders. Multiplexers, implementation of combinational functions using multiplexers, de-multiplexers, decoders, code converters. Combinational logic with MSI and LSI. Programmable logic devices.

Sequential Logic: Flip-Flops- Basic latch circuit. Debouncing of a switch, flip-flop truth table and excitation table, integrated circuit flip-flops. Race in sequential circuits, Analysis of clocked sequential circuits, State reduction and assignment. Registers, Counters - Synchronous, Asynchronous, Up-Down, Design of counters, Design with state equations.

Digital Hardware: Logic levels, Digital integrated circuits, Logic delay times, Fan-Out and Fan-In, Logic families, Interfacing between different families.
CMOS Electronics: CMOS electronics and Electronic logic gates, The CMOS inverter, Logic formation using MOSFETs, CMOS memories. Design and analysis procedures, Logic arrays.

Text Books:

1. M.M. Mano, "*Digital logic and Computer Design* ", 3rd Edition, Prentice Hall of India, 1999

2. Floyd, "*Digital Fundamentals*", 4th Edition, Universal Book Stall, New Delhi, 1992.

3. J.P. Uyemura, "*A First Course in Digital Systems Design*", Brooks/Cole Publishing Co. (Available from Vikas Publishing House in India).

Reference Books:

1. J.M. Rabaey, "*Digital Integrated Circuits: A Design Perspective*", 2nd Edition, Prentice Hall of India, 2002.

2. D. Hodges and H. Jackson, "*Analysis and Design of Digital Integrated Circuits*", 2nd Edition, McGraw Hill, 1988.

3. N.H.E. Weste, and K. Eshraghian, "*Principles of CMOS VLSI Design: A Systems Perspective*", 2nd Edition, Pearson Education Inc., (Asia), 2002.

IC 210 ELECTRICAL AND ELECTRONIC MEASUREMENTS

Electro mechanical instruments: Moving coil, moving iron, dynamometer type, rectifier type, thermal instruments. Application of PMMC meter. Current transformer and Potential transformer.

Power and Energy Measurements: Electrodynamic wattmeters, Hall effect wattmeter, thermal type wattmeter, compensated wattmeter, single and three phase power measurement, calibration of wattmeter. Energy measurement, maximum demand meter, P.F meter, Megger.

D.C bridges: Low, high and precise resistance measurement. A.C bridges: Inductance and capacitance measurements. Detectors in bridge measurement, Wagner ground connections, transformer ratio bridges. Series and shunt type ohmmeter.

Electronic measurements: Analog and digital multimeters, digital wattmeter/energy meter. Signal Generators. Frequency measurement, measurement of period, time and phase angle.

Waveform analyzing instruments: Distortion meter, Spectrum analyzer, Oscilloscopes: Analog and Digital.

Text Books:

1. Golding, E.W. and Widdis, F.C., "*Electrical Measurements and Measuring Instruments*" A.H.Wheeler and Co, 5th Edition, 1993.

2. Baldwin, C.T., "*Fundamentals of electrical measurements*" – Lyall Book Depot, New Delhi, 1973.

3. David.A.Bell, "*Electronic Instrumentation and Measurements*", 2nd Edition, Prentice Hall, New Jersy, 1994.

Reference Books:

1. Cooper, W.D. and Helfric, A.D., "*Electronic Instrumentation and Measurement Techniques*" Prentice Hall of India, 1991.

2. Kalsi.H.S., "*Electronic Instrumentation*", Tata McGraw Hill, New Delhi, 1995.

IC 212 SENSORS AND TRANSDUCERS LABORATORY

1. Characteristics of (Resistive and Thermo emf) temperature sensor
2. Characteristics of Piezoelectric measurement system
3. Measurement of displacement using LVDT
4. Characteristics of Hall effect sensor
5. Measurement of strain using strain gauges
6. Measurement of torque using Strain gauges
7. Measurement using proximity sensors
8. Characteristics of capacitive measurement systems
9. Loading effects of Potentiometer
10. Design of Opto-coupler using photoelectric transducers
11. Characteristics of Micro pressure and Micro accelerometer sensing device
12. Study of speed measuring devices
13. Study of Gyroscope

IC 214 ELECTRONIC CIRCUITS LABORATORY

1. Clipping and clamping circuits.
2. Half wave and Full wave rectifiers.
3. Bridge Rectifiers.
4. Single-stage Amplifiers
5. Multistage Amplifiers
6. Feedback Topologies
7. Frequency Response of Amplifiers
8. Oscillator Circuits
9. PSPICE Simulations

IC301 INDUSTRIAL INSTRUMENTATION - II

Flow measurement: Introduction, definitions and units, classification of flow meters, pitot tubes, orifice meters, venture tubes, flow tubes, flow nozzles, positive displacement liquid meters and provers, positive displacement gas flow meters, variable area flow meters.

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.
Level measurement: introduction, float level devices, displacer level detectors, rotating paddle switches, diaphragm and deferential 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.

EMC: 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.

Specification of instruments, preparation of project documentation, process flow sheet, instrument index sheet, instrument specifications sheet, panel drawing and specifications, instrument specifications. Project procedure, schedules, vendor drawing, tender documentation, selection of measurement method and control panels.

Text Book:

1. Doebelin E.O, "*Measurement Systems: Application and Design*", 4th Edition, McGraw Hill, New York, 2003.

Reference Books:

1. Noltingk B.E., "*Instrumentation Reference Book*", 2nd Edition, Butterworth Heinemann, 1995.

2. Liptak B.G, "*Process Measurement and Analysis*", 4th Edition, Chilton Book Company, Radnor, Pennsylvania, 2003.

3. Douglas M. Considine, "*Process / Industrial Instruments & Controls Handbook*", 5th Edition, McGraw Hill, Singapore, 1999.

4. Andrew W.G, *"Applied Instrumentation in Process Industries – A survey"*, Vol I & Vol II, Gulf Publishing Company, Houston, 2001

5. Spitzer D. W., Flow measurement, ISA press, New York, 1998.

EC 317 PRINCIPLES OF COMMUNICATION SYSTEMS

Amplitude modulation: AM, generation of AM waves, demodulation, DSBSC, SSB, VSB, FDM, AM receivers.

Angle modulation: Phase and Frequency modulation, Single-tone, narrow band, wide band and multi tone FM, generation and demodulation of FM, FM receivers.

Pulse Analog modulations: Sampling theorem, Time Division Multiplexing, PAM, Pulse time modulation.

Pulse Digital modulation: PCM, Measure of Information, Channel capacity, DPCM, DM, Digital multiplexers.

Noise: SNR, Noise in AM and FM receivers, Noise in FM reception, FM Threshold effect, Pre-emphasis and de-emphasis, Noise in PCM system, Destination SNR in PCM system with quantization and channel noise, output SNR in DM system.

Text Books:

1. S.Haykin, "*Communication Systems*", 4th Edition, John Wiley & Sons, 2000.

2. H.Taub & D.Schilling, "*Principles of Communication System*", 2nd Edition, Tata McGraw Hill, 1991.

Reference Books:

1. B.Carlson, "*Communication Systems*", 3rd Edition, McGraw Hill Book Co., 1986.

2. Sam Shanmugam, "*Digital and analog Communication Systems*", John Wiley, 1985.

3. H.Stark & F.B.Tuteur, "*Modern Electrical Communication*", 2nd Edition, PHI.

IC 303 MICROPROCESSORS AND MICROCONTROLLERS

Introduction to computer architecture and organization: Architecture of 8-bit and 16 bit microprocessors, bus configurations, CPU module, introduction to assembly language and machine language programming, instruction set of a typical 8-bit and 16 bit microprocessor, subroutines and stacks, programming exercises.

Memory technology: Timing diagrams, Memory families, memory interfacing, programmable peripheral interface chips, interfacing of input-output ports, programmable interval timer.

Data transfer schemes: Serial and parallel data transfer schemes, interrupts and interrupt service procedure. Programmable interrupt controller. Programmed and interrupt driven data transfer. Programmable DMA controller.

Architectures of 8051 Microcontroller: Bus configuration, instruction sets, programming exercises.

Embedded System software and hardware design, development and trouble shooting tools.

Text Books:

1. Ramesh Goankar, "*Microprocessor Architecture, Programming and applications, with the 8085/8080A*", 3rd Edition, Penram International Publishing house, 2002.

2. Kenneth J.Ayala, "*The 8051 Micro controller*", Penram Interfacing Publishing, 1996.

3. Douglas V.Hall, "*Microprocessors and Interfacing – Programming and Hardware*", 2nd Edition, Mc Graw Hill, 1992.

4. Dr. K.V.K.K.Prasad, *"Embedded/Real-Time Systems: Concepts, Design & Programming"* Dreamtech Press, 2005.

Reference Books:

1. B.Ram, "*Fundamentals of Microprocessors and Microcontrollers*", 4th Edition, Dhanpatrai and sons, 1994.

2. Myke Predko, "*Programming and Customizing the 8051 micro controller*", Tata-McGraw Hill, 3rd reprint 2002.

3. Frank Vahid/Tony Givargis, *"Embedded System Design – A Unified Hardware/Software Introduction"*, John Wiley & Sons, Inc, 2005 ISBN 9971-51-405-2

4. www.intel.com

IC 305 ANALOG INTEGRATED CIRCUITS

Resistive Feedback: Introduction, The 741 Op-Amp as a circuit element, Basic Op-Amp configurations, Ideal Op-Amp circuit analysis, Negative feedback, Loop gain and sensitivity, I/V and V/I converters, Instrumentation Amplifier and applications, Transducer bridge amplifier.

Dynamic Feedback: The integrator and the differentiator circuits, Transfer function H(jω), First-order circuits and some applications, Second-order circuits, constant Gain RC filters, Multiple feedback filters, State-variable and Biquad filters, Switched-capacitor filters.

Op-Amp Limitations: The Op-Amp circuit diagram, Input bias and offset currents, Input offset voltage, Input offset error compensation, Maximum ratings, Open-loop and closed-loop response, Input and output impedances, Transient response, Effect of finite gain-bandwidth product, Current feedback amplifiers, Op-Amp noise, Low-noise Op-Amps.

Comparators and Signal Generators: Voltage comparators, Schmitt triggers, Precision rectifiers, Peak detectors, Sample-and-hold amplifiers, Multivibrators and IC 555, Waveform generators, V/F and F/V converters, Voltage references, Linear regulators, D-to-A and A-to-D converters and ICs.

Other Op-Amp Circuits: Log/Antilog amplifiers, Analog multipliers, Transconductance Amplifiers, Voltage Controlled Oscillators, Phase detectors, Phase-Locked Loops, PLL ICs and applications.

Text Books:

1. S. Franco, "*Design with Operational Amplifiers and Analog Integrated Circuits*", 3rd Edition, Mc-Graw Hill Inc., 2002. (Available from Tata McGraw Hill in India).

2. Roy,D. Choudary and Shail Jain, "*Linear Integrated Circuits*", New age International, 2001.

Reference Books:

1. J. Dostal, "*Operational Amplifiers*", 2nd Edition, Butterworth-Heinemann, Stoneham, MA 1993.

2. T.M. Frederiksen, "*Intuitive Operational Amplifiers: From Basics to Useful Applications*", McGraw Hill Inc., 1988.

IC 307 DIGITAL SIGNAL PROCESSING

Signal Processing Fundamentals: Discrete-time and digital signals, A/D, D/A conversion and Nyquist rate, Frequency aliasing due to sampling, Need for anti-aliasing filters. Discrete Time Fourier transform and frequency spectra, Spectral computation, Computational complexity of the DFT and the FFT, Algorithmic development and computational advantages of the FFT, Inverse FFT, Implementation of the FFT, Correlation of discrete-time signals.

Discrete-time systems, Difference equations and the Z-transform, Analysis of discrete-time LTIL systems, Stability and Jury's test.
FIR Filters: Ideal digital filters, Realizability and filter specifications, Classification of linear phase FIR filters, Design using direct truncation, window methods and frequency sampling, Least-squares optimal FIR filters, Minimax optimal FIR filters, Design of digital differentiators and Hilbert transformers, comparison of design methods.

IIR Filters: Design of analog prototype filters, Analog frequency transformations, Impulse invariance method and digital frequency transformations, Bilinear transformation, Analog prototype to digital transformations, Difficulties in direct IIR filter design, Comparisons with FIR filters.

Filter Realization: Structures for FIR filters, Structures for IIR filters, State-space analysis and filter structures, Fixed point and floating-point representation of numbers, Errors resulting from rounding and truncating, Quantization effects of filter coefficients, Round-off effects of digital filters.

DSP Processors: Computer architectures for signal processing – Harvard architecture and pipelining, General purpose digital signal processors, Selection of DSPs, Implementation of DSP algorithms on a general purpose DSP, Special purpose hardware – hardware digital filters and hardware FFT processors, Evaluation boards for real-time DSP.

Text Books:

1. Chen, C.T., "*Digital Signal Processing: Spectral Computation & Filter Design*", Oxford Univ. Press, 2001 (Available as an Indian reprint)
2. Proakis, J.G., & Manolakis, D.G., "*Digital Signal Processing: Principles, Algorithms, & Applications*", 3/e Prentice Hall of India, 1996.
3. Ifeachor, E.C., & Jervis, B.W., "*Digital Signal Processing: A Practical Approach*", 2/e, Pearson Education Asia, 2002.

Reference Books:

1. McClellan, J.H., Schafer, R.W., & Yoder, M.A., "*DSP First: A Multimedia Approach*", Prentice Hall Upper Saddle River, NJ, 1998 (A low-cost Indian reprint is available).
2. Mitra, S.K., "*Digital Signal Processing: A Computer-Based Approach*", McGraw Hill, NY, 1998 (A low-cost Indian reprint is available).
3. Embree, P.M., & Danieli, D., "*C++ Algorithms for Digital Signal Processing*", 2/e, Prentice Hall Upper Saddle River, NJ, 1999.

IC 309 CONTROL SYSTEMS

Systems and their representation: Terminology and basic structure of control system, Open loop and Closed loop systems, servomechanism, regulatory system, analogous systems, electrical analogy of physical systems, Physical Systems and their models, transfer function, Block diagram representation of physical systems, Block diagram algebra, Signal Flow graph and Mason's formula.

Time response: Types of test inputs, Response of first and second order system, Time domain specifications, Error coefficients, generalized error series.
Concepts of stability: Characteristic equation, location of roots in s-plane for stability, Asymptotic stability and relative stability, Routh-Hurwitz stability criterion.

Root Loci: Effect of pole zero addition, desired closed loop pole location, Root locus plot, Properties of Root loci and applications, Stability range from the loci. Determination of roots of the closed loop system, transient response and stability from root locus, design of compensators.

Frequency response: Frequency-domain techniques - Bode and Nyquist plots, Frequency response for systems with transportation lag, Frequency-domain specifications.

Nyquist stability criterion, Bode plots- gain margin and phase margin, design of compensators.

Text Books:

1. Ogata K, "*Modern Control Engineering*", 4th Edition, Prentice Hall, New Delhi, 2002.

2. Richard Dorf & Robert Bishop, "*Modern control system*", 10th edition, Pearson Education, 2005.

3. B.C Kuo, "*Automatic control systems*", 7th Edition, Prentice Hall, New Delhi, 2002.

Reference Books:

1. Shinners S. M., "*Modern Control Engineering*", Prentice Hall, New Jersey, 1995

1. Chen C. T, "*Analog and Digital Control System Design*", Saunders College Publishing, Japan, 1993.

2. D'azzo and Houpis, "*Linear Control System Analysis and Design*", 4th Edition, McGraw Hill, Singapore, 1995.

IC 311 ANALOG INTEGRATED CIRCUITS LABORATORY

1. Op-Amp circuits with resistive feedback
2. Instrumentation Amplifier
3. Op-Amp filters
4. Waveform generators
5. Schmitt trigger & Precision rectifiers
6. Multivibrators
7. Phase Locked Loops
8. Combinatorial & Sequential circuits
9. Multiplexers & Demultiplexers
10. A/D and D/A converters
11. TTL and other logic gates
12. PSPICE simulations

IC 313 MICROPROCESSOR AND MICROCONTROLLERS LABORATORY

1. Familiarization with 8085 microprocessor kit and its keyboard.
2. Exercises with entry and manipulation of data (Different addressing modes).
3. Programming exercises using 8085 microprocessor.
4. Programming exercises using 8086 microprocessor
5. Programming exercises to programmable peripheral interface.
6. Programming exercises using interrupts.
7. Programming an EPROM for a specific application.
8. Programming exercises to programmable timer
9. Familiarization 8051 Microcontroller kit and its assembler
10. Programming exercises using 8051 Microcontroller.
11. Basic I/O operations using KEIL software
12. Counting Pulses using Interrupt & Serial Data Transmission
13. ADC Interfacing using KEIL

IC 302 MODERN CONTROL THEORY

Systems in state space: Concept of states and state model, State equation from transfer function, Modeling of dynamical systems, State space representation of multivariable systems, Building blocks of state space models. Modeling through energy approach of electrical, mechanical and electromechanical systems.

Canonical forms, Solution to state-space equations, state transition matrix, properties of state transition matrix, computation of state transition matrix.

Equilibrium points and stability concepts, stability definitions, Modeling energy of the system in terms of quadratic functions, Direct method of Lyapunov criterion for LTI systems.

Definition of controllability, observability, stabilizability and detectability. State feedback control for controllable canonical form, State feedback control in general, Output feedback controller. Full-order and reduced-order observers, Introduction to Linear Quadratic problems.

Introduction to Discrete time systems, analogies with continuous-time systems, mathematical models for LTI discrete-time systems, Z-transformation of difference equations, analysis of first, second order and higher order systems. State space modeling of discrete-time dynamical systems.

Text Books:

1. Brogan W. L, "*Modern Control Theory*", 3rd Edition, Prentice Hall Inc., New Jersey, 1990.

2. Raymond A. DeCarlo, "*Linear Systems, A state variable approach with numerical implementation*", Prentice Hall Inc., New Jersey, 1987.

3. Dr.A.Ramakalyan *"Control Systems"*, Vikas Publishing House, New Delhi, 2003.

Reference Books:

1. Skelton R. E, "*Dynamic System Control and Linear Systems Analysis and Synthesis*", John Wiley 1993.

2. C.T. Chen, "*Linear System Theory and Design*", 3rd Edition, Oxford University Press, India, 1998.

3. Ogata K., "*Discrete-time Control Systems*", 2nd Edition, Prentice Hall Inc., New Jersey, 1992

IC 304 PROCESS CONTROL

Process Control System: Terms and objectives, piping and Instrumentation diagram, instrument terms and symbols. Regulator and servo control, classification of variables. Process characteristics: Process equation, degrees of freedom, modeling of simple systems – thermal, gas, liquid systems. Process lag, load disturbance and their effect on processes. Self-regulating processes, interacting and non-interacting processes.

Controller modes: Basic control action, two position, multiposition, floating control modes. Continuous controller modes: proportional, integral, derivative. Composite controller modes: P-I, P-D, P-I-D, Integral wind-up and prevention. Auto/Manual transfer, Bumpless transfer. Response of controllers for different test inputs. Selection of control modes for processes like level, pressure, temperature and flow.

Controller tuning Methods: Evaluation criteria - IAE, ISE, ITAE. Process reaction curve method, continuous oscillation method, damped oscillation method. Auto tuning. Closed loop response of I & II order systems, with and without valve, measuring element dynamics.

Final control elements: Pneumatic control valves, construction details, types, various plug characteristics. Valve sizing. Selection of control valves. Inherent and installed valve characteristics. Cavitation and flashing in control valves. Valve actuators and positioners. Instrument air supply specifications.

Advanced control system: Cascade control, ratio control, feed forward control. Over-ride, split range and selective control. Multivariable process control, interaction of control loops.
Case Studies: Distillation column, boiler drum level control and chemical reactor control.

Text Books:

1. Stephanopoulos, "*Chemical Process Control*, 2nd edition, Prentice Hall, New Delhi, 2003.

2. Coughanowr, "*Process Systems Analysis and Control*", 2nd Edition, McGraw Hill, Singapore, 1991.

3. Peter Harriott, "*Process Control*", Tata McGraw Hill, New Delhi, 1985.

Reference Books:

1. Smith C.L and Corripio.A..B, "*Principles and Practice of Automatic Process Control*", 2nd Edition, John Wiley and Sons, New York, 1998.

2. Shinskey, "*Process Control Systems*", 4th Edition, McGraw Hill, Singapore, 1996.

3. Paul W.Murril, "*Fundamentals of Process Control Theory*", 3rd Edition, ISA press, New York, 2000.

IC 306 PRODUCT DESIGN AND DEVELOPMENT

Product Design: Introduction. Product Planning. Identifying Customer Needs. Project Selection. Concept Generation. Concept Testing. Concept Selection. Product Specification. Product Architecture. Industrial Design. Robust Design. Product Development Economics. Design for Manufacturing. Supply Chain Design. Intellectual Property. Design for Environment.

Product Development Schedule: Customer base for customer needs survey, Project Proposal, Mission statement and customer needs, Concepts sketch and target specification, Preliminary concept selection, Drawings, plans and revised schedule, financial model and patent review

Submission and Evaluation of Alpha prototype and test report, Beta prototype and customer evaluation, demonstration of working model

Text Books:

1. Karl T. Ulrich and Steven D. Eppinger, "*Product Design and Development*", 3rd Edition, Tata McGraw- Hill, 2003, ISBN 0-07-058513-X

2. Kevin Otto and Kristin Wood, "*Product Design*", Pearson Education, 2003, ISBN : 8129702711.

IC 308 MEMS AND NANOTECHNOLOGY

Introduction, emergence, devices and application, scaling issues, materials for MEMS, Thin film deposition, lithography and etching.

Bulk micro machining, surface micro machining and LIGA process.

MEMS devices, Engineering Mechanics for Micro System Design, Micro Pressure Sensor, Micro accelerometer.

Electronic interfaces, design, simulation and layout of MEMS devices using CAD tools.

Introduction to Nanotechnology, Nano sensors, Molecular Nanotechnology, CNT types, Synthesis and applications.

Reference Books:

1. Tai Ran Hsu, "*MEMS & Microsystem Design and Manufacture*", Tata McGraw Hill, New Delhi 2002.

2. Marc Madou, "*Fundamentals of Micro fabrication*", CRC Press, 1999.

3. Julian W. Gardner and Vijay K. Varadan, "*Microsensors, MEMS, and Smart Devices*", John Wiley & Sons Ltd, 2001.

4. Michael Wilson, Kamali Kannangara,Geoff Smith, Michelk Simon, "*Nanotechnology: Basic Science and Emerging technologies*".

5. Bharat Bhushan, "*Handbook of Nanotechnology*", 1st Edition, Springer, 2004.

CS 320 COMPUTER NETWORKS

Introduction to computer networks: Networks – Components and Categories – Types of Connections – Topologies – Tranmission Media – Coaxial Cable – Fiber Optics – ISO/OSI Model.

Data link layer: Error- Detection and correction – Parity –LRC-CRC – Hamming code – Low Control and Error control – Stop and wait – ARQ – Sliding window – HDLC – LAN – IEEE 802 Standards – Wireless LAN – Bridges.

Network layer: Internetworks – Packet Switching and Datagram approach – IP addressing methods – Subnetting – Routing – Distance Vector Routing – Link State Routing – Routers.

Transport layer: Duties of transport layer – Multiplexing – Demultiplexing – Sockets – User Datagram Protocol (UDP) – Transmission Control Protocol (TCP) – Congestion Control – Quality of Services (QOS)

Application layer: Domain Name Space (DNS) – SMTP –FTP – HTTP _ WWW – Network Security.

Text books:

1. Andrew S. Tanenbaum, " *Computer Networks*". PHI, Fourth Edition, 2003.

Reference Books:

1. Behrouz A. Forouzan, " *Data communication and Networking*". Tata Mc Graw Hill, 2004

2. William Stallings, " *Data and Computer Communication*", Sixth Edition, Pearson Education, 2000

IC 310 INTERFACING LABORATORY

1. Data acquisition using PC-add on cards under different operating systems.
2. Data transfer via Modem under various operating systems.
3. Installation of device drivers under various operating systems. e.g. mouse, CD-ROM, scanner, process controller.
4. Setting up a PC based LAN network, System integration with various operating systems.
5. Development of simple database applications.
6. Development of a virtual instrument using GUI and Sub VIs.
7. Measurement and logging of a process data and generating a report.
8. Measurement of vibration of a given structure and analyzing the data.
9. Measurement of strain of a given structure and publishing it in the web.
10. Control of temperature using Multifunction RT Data Acquisition card
11. Control of a given process using Real Time Embedded controller
12. Control of temperature using Distributed input/output modules.

IC 312 CONTROL ENGINEERING LABORATORY

1. Frequency response characteristics of a second order system.
2. Time response characteristics of a second order system.
3. Constant gain compensation in time and frequency domain.
4. Compensating Networks – Characteristics
5. Design of compensation networks
6. Design of state feedback.
7. Observer design.
8. Study of PD, PI, PID controller (Electronic Version and Process Simulator)
9. Microprocessor based servo system.
10. Speed Control system (Open loop & closed loop).
11. Real time control of Inverted Pendulum.
12. Real time control of Gyroscope.
13. Control of Piezo Actuated System using dSPACE 1104

IC 401 LOGIC AND DISTRIBUTED CONTROL SYSTEMS

Review of computers in process control: Data loggers, Data Acquisition Systems (DAS), Direct Digital Control (DDC). Supervisory Control and Data Acquisition Systems (SCADA), sampling considerations. Functional block diagram of computer control systems.

Programmable logic controller (PLC) basics: Definition, overview of PLC systems, input/output modules, power supplies and isolators. General PLC programming procedures, programming on-off inputs/ outputs. Auxiliary commands and functions, PLC Basic Functions, register basics, timer functions, counter functions.

PLC intermediate functions: Arithmetic functions, comparison functions, Skip and MCR functions, data move systems. PLC Advanced intermediate functions: Utilizing digital bits, sequencer functions, matrix functions. PLC Advanced functions: Alternate programming languages, analog PLC operation, networking of PLC, PLC-PID functions, PLC installation, troubleshooting and maintenance. Design of interlocks and alarms using PLC.

Distributed Control Systems (DCS): Definition, Local Control Unit (LCU) architecture, LCU languages, LCU - Process interfacing issues, communication facilities, redundancy concept.

Introduction – Evolution of signal standards – HART communication protocol – communication modes – HART networks. Introduction – General field bus architecture – basic requirements of field bus standard. Case studies of PLC and DCS with industrial applications.

Text Books:

1. John.W. Webb Ronald A Reis, "*Programmable Logic Controllers - Principles and Applications*", 4th Edition, Prentice Hall Inc., New Jersey, 1998.

2. Lukcas M.P, "*Distributed Control Systems*", Van Nostrand Reinhold Co., New York, 1986.

3. Frank D. Petruzella, "*Programmable Logic Controllers*", 2nd Edition, McGraw Hill, New York, 1997.

Reference Books:

1. Deshpande P.B and Ash R.H, "*Elements of Process Control Applications*", ISA Press, New York, 1995.

2. Curtis D. Johnson, "*Process Control Instrumentation Technology*", 7th Edition, Prentice Hall, New Delhi, 2002.

3. Krishna Kant, "*Computer-based Industrial Control*", Prentice Hall, New Delhi, 1997.

IC 403 ANALYTICAL INSTRUMENTATION

Electromagnetic radiation and its interaction with matter: Spectral methods of analysis, absorption spectroscopy, Beer's law, radiation sources, monochromators, flitters, prisms, diffraction grating, ultraviolet spectrometer, single beam and double beam instruments, detectors, choice of solvent.

Infrared spectrophotometer: Sources, cells, detectors, sample preparation, analysis using Attenuated Total Reflectance (ATR). Atomic absorption spectrometry: Wavelength choice, sources, cells and detectors. Flame emission spectrometry. Atomic fluorescence spectrometry. Applications of spectroscopy techniques.

Radioactive measurement: Measurement of radioactivity, application of radio nuclides in analysis. X-ray spectroscopy: X-ray absorption methods, X-ray fluorescence methods, X-ray diffraction. Nuclear Magnetic Resonance (NMR) spectroscopy: Basic principles, continuous wave NMR spectrometer, pulsed Fourier transform NMR spectrometer and its applications.

Sampling: Sample collection for gas, liquid and solid analysis, pH measurement: Basic principles, ion selective electrodes, glass and reference electrodes, measuring circuit. Electrical conductivity measurement: Measuring circuit, water and steam purity measurement. Oxygen measurement: Paramagnetic oxygen analysers, ceramic electrode for high temperature oxygen measurement and dissolved oxygen measurement.

Flue gas analysis: Measurement techniques for CO, carbon dioxide, NOX and SOX. Dust and smoke measurement, moisture measurement in solids, liquids and gases. Chromatography: Basic principles of gas and liquid chromatography, column details. Detectors: Thermal conductivity detector, flame ionization detector, flame photometric detector, electron capture detector. Effect of temperature. High pressure liquid chromatography: Basic principles, precolumn, separation column, detectors.

Text Books:

1. Braun, Robert D., "*Introduction to Instrumental of Analysis*", Pharma Book Syndicate, Hyderabad, ISBN: 81-88449-15-6.

2. Ewing G.W, "*Instrumental Methods of Analysis*", 5th Edition, McGraw Hill, Singapore, 1992.

3. Jain R. K, "*Mechanical and Industrial Measurements*", Khanna Publishers, Nai Sarak, Delhi, 1985.

Reference Books:

1. Considine D.M, "*Process / Industrial Instruments and Controls Handbook*", 4th Edition, McGraw Hill, Singapore, 1993.

2. Liptak B.G, "*Process Measurement and Analysis*", 3rd Edition, Chilton Book Company, Pennsylvania, 1995.

3.Sherman R.E. and Rhodes L.J. (Eds), "*Analytical Instrumentation*", ISA Press, New York, 1996.

HM 401 INDUSTRIAL ECONOMICS

Demand and Supply – Forecasting techniques – Cost and Revenues – competitive nature of the firms – Keynesian economics – National income – Trade cycle – Inflation – Index numbers – Capital budgeting – Cash flow analysis – Balance sheet – Risk and Decision Making – Technical Change in Global Economy – Locating the Firm in a global Economy – Taxes and Decision Making – Exchange Rate determination – Product life cycle.

Reference Books:

1. Manb Adhikari, "*Business Economics*", Excel Books, 2004.

2. Misra.S.K. and Puri.V.K., "*Economics Environment of Business*", HP,2003.

IC 405 BIOMEDICAL INSTRUMENTATION

Electro physiology: Review of physiology and anatomy, resting potential, action potential, bioelectric potentials, cardiovascular dynamics, electrode theory, bipolar and uni-polar electrodes, surface electrodes, physiological transducers. Systems approach to biological systems.

Bioelectric potential and cardiovascular measurements: EMG - Evoked potential response, EEG, foetal monitor. ECG phonocardiography, vector cardiograph, BP, blood flow cardiac output, plethysmography, impedance cardiology, cardiac arrhythmia's, pace makers, defibrillators.

Respirator and pulmonary measurements and rehabilitation: Physiology of respiratory system, respiratory rate measurement, artificial respirator, oximeter, hearing aids, functional neuromuscular simulation, physiotheraphy, diathermy, nerve stimulator, artificial kidney machine.

Patient monitoring systems: Intensive cardiac care, bedside and central monitoring systems, patient monitoring through bio-telemetry, implanted transmitters, telemetering multiple information. Sources of electrical hazards and safety techniques.

Recent trends: Medical imaging, X-rays, laser applications, ultrasound scanner, echo cardiography, CT Scan MRI/NMR, cine angiogram, colour doppler systems, Holter monitoring, endoscopy.

Text Book:

1. Leslie Cromwell, Fred J. Weibell and Erich A. Pfeiffer, "*Biomedical Instrumentation and Measurements*", 2nd Edition, Prentice Hall, New Delhi, 1998.

Reference Books:

1. Geddes L. A. and Baker L. E., "*Principles of Applied Biomedical Instrumentation*", 3rd Edition, John Wiley, New York, 1989.

2. Richard Aston, "*Principles of Bio-medical Instrumentation and Measurement*", Merril Publishing Company, New York, 1990.

3. Kandpur R. S, "*Handbook of Biomedical Instrumentation*", Tata McGraw Hill, New Delhi, 1987.

IC 409 INSTRUMENTATION LABORATORY

1. Design of temperature transmitter using RTD.
2. Design of cold junction compensation circuit.
3. Design of IC temperature transmitter.
4. Design of Linearization circuit for thermistor.
5. Design of pressure transmitter.
6. Performance evaluation of pressure gauges using Dead weight tester.
7. Measurement of level using capacitance probe, differential pressure transmitter.
8. Design of alarms and annunciators.
9. Measurement of pH, conductivity and turbidity.
10. PC based respiratory analyser.
11. PC based ECG, pulse analyser.
12. Audio tone analyser.
13. Blood pressure calibrator.
14. Characteristics of I/P and P/I.
15. Measurement of flow using orifice, electro magnetic and positive displacement flowmeters.

IC 411 PROCESS CONTROL LABORATORY

1. Experimental study of PID controller response on a level loop.
2. Experimental study of ON-OFF and Proportional controller responses on temperature loop.
3. Tuning of controllers on a pressure loop.
4. Control valve characteristics with and without positioner.
5. Modeling of flow process.
6. Study of complex control systems (Ratio, Feedforward, and Cascade).
7. Study of Distillation column.
8. Study of basic logic operations, timer, counter, arithmetic operations in PLC.
9. Study of analog operations in PLC.
10. Problem solving in PLC.

The following experiments will be conducted on virtual DCS.

11. Three – element boiler control
12. Binary distillation column control
13. Level control in coupled tanks
14. Pressure control in different sized vessels
15. Heat exchanger control
16. Control of rotary dryer

IC 402 OPTO-ELECTRONICS AND LASER BASED INSTRUMENTATION

Introduction: Characteristics of optical radiation, luminescence. Light emitting diode, heterojunction diode, internal and external photo effects.

Optical Sources: Photo diode, PIN diode, schottky, barrier diode, heterojunction diode, APD, photo-transistor, photo-thyristor, photo- thermistor.

Charge coupled devices: Opto-couplers and their application in analogue and digital devices. Optical fibre fundamentals, modes, types of optical fibres, fibre coupling, Optrodes, Fibre optic sensors for temperature , pressure, flow and level measurement.

Characteristics of LASERS: Laser rate equation, properties, modes, two, three and four level system, Resonator configuration, Q switching and mode locking, cavity dumping, simple frequency operation. Types of Lasers.

Industrial applications of LASERS: Lasers for measurement of distance and length, velocity, acceleration, atmospheric effects, sonic boom, pollutants, current and voltage. Material processing: Laser heating, melting, scribing, splicing, welding and trimming of materials, removal and vapourization, calculation of power requirements.

Text Books:

1. Wilson and Hawkes, "*Opto Electronics - An Introduction*", 3rd Edition, Prentice Hall, New Delhi, 1998.

2. Bhattacharya P, "*Semiconductor Optoelectronics*", 2nd Edition, Prentice Hall, New Delhi, 1998.

3. Djafar.K.Mynbaev, Lowell.L.Scheiner, "*Fiber-Optic Communications Technology*", 2nd Indian Reprint, Pearson Education Pte. Ltd., 2001.

Reference Books:

1. Culshaw B. and Dakin J.(Eds.), "*Optical Fibre Sensors Vol I, II and III*", Artech House, 1989.

2. Fukuda, "*Optical Semiconductor Devices*", Allied Publishers Limited, Chennai, 1999.

3. Kasap, "*Optoelectronics and Photonics: Principles and practices*", Allied Publishers Limited, Chennai, 2001.

4. R.P.Khare, *"Fibre Optics and Optoelectronics", Oxford Press,* July 2004.

MB 790 MANAGEMENT CONCEPTS AND PRACTICES

Introduction to Management, Evolution of Scientific and Modern Management Principles – Functions of Management – Types of Business Organization – Managerial Roles – Levels of Management.

Decision Making. Nature, Purpose & Steps involved in Planning. Objectives – Strategies & Planning Premises. Nature and purpose of Organizing. Formal and informal organization, Span of control – Delegation of Authority.

Introduction of Human Resource Management. Creativity and Innovation. Motivation theories (Hierarchy of Needs by Maslow, Herzberg's Two-Factor theory)- Motivational Techniques – Monetary & Non-monetary, Job Enrichment.

Types of Leadership – Leadership theories. Communication – Process of Communication – Barriers and Breakdown – Effective Communication.

System and Process of Controlling – Requirements for effective control – The Budget as Control Technique. Globalization and Liberalization – International Management and Global theory of Management, Corporate Social Responsibility.

Reference Books:

1. Harlod Kooritz and Heinz Weihrich "*Essentials of Management*". Tata Mc Graw-Hill, 1998

2. L.M. Prasad, "*Principles of Management*", Sultan Chand & Sons, New Delhi.

3. Sherlekar and Sherlekar, "*Principles of Management*", Himalaya Publishing House, New Delhi

4. Stephen Robbins, "*Organisational Behaviour*", Pearson Education, New Delhi.

ELECTIVES

IC 352 POWER ELECTRONICS

Power semiconductor switches: SCRs - series and parallel connections, driver circuits, turn-on characteristics, turn off characteristics.

AC to DC converters: Natural commutation, single phase and three phase bridge rectifiers, semi controlled and fully controlled rectifiers, dual converters, inverter operation.

DC to DC converters: Voltage, Current, load commutation, thyristor choppers, design of commutation elements, MOSFET/IGBT choppers, AC choppers.

DC to AC converters: Thyristor inverters, McMurray-Mc Murray Bedford inverter, current source inverter, voltage control, inverters using devices other than thyristors, vector control of induction motors.

AC to AC converters: Single phase and three phase AC voltage controllers, integral cycle control, single phase cyclo-converters - effect of harmonics and Electro Magnetic Interference (EMI).
Applications in power electronics: UPS, SMPS and Drives.

Text Books:

1. Rashid M. H, "*Power Electronics - Circuits, Devices and Applications*", 2nd Edition, Prentice Hall, New Delhi, 1995.

2. Dubey G. K, Doradla S.R, Joshi and Sinha R.M, "*Thyristorised Power Controllers*", New Age International Publishers, New Delhi, 1996.

Reference Books:

1. Vedam Subramanyam K, "*Power Electronics*", 2nd Edition, New Age International Publishers, New Delhi, 1997.

2. Mohan, Undeland and Robbins, "*Power Electronics*", John Wiley and Sons, New York, 1995.

3. Joseph Vithyathil, "*Power Electronics*", McGraw Hill, New York, 1995.

IC 354 DATA STRUCTURES AND ALGORITHMS

Development of algorithm, notation analysis. Sorting and searching algorithms and their implementation under C/C++.

Stacks, queues, linked lists and their implementation under C/C++

Binary tree, B-trees. Tree traversal operations. Implementation under C/C++. Graphs, minimum cost spanning tree construction. Implementation under C/C++.

Formal definition of an algorithm in terms of Turing machines.

Introduction to the complexity classes P and NP.

Text Books:

1. Tremblay and Sorenson, "*An Introduction to Data Structures with Applications*", 2nd Edition, Tata McGraw Hill, New Delhi, 1997.

2. Cormen, Leiserson, and Rivest, "*Introduction to Algorithms*", 2nd Edition, Mc Graw Hill, New York, New Delhi, 1990.

3. Horowitz, Sahni, and Rajasekaran, "*Fundamentals of Algorithms*", Galgotia Publications, New Delhi, 1999.

Reference Books:

1. Ronald L. Rivest, "*Algorithms, Data structures and Programs*", Prentice Hall, New Jersey, 1990.

2. Knuth D. E, "*Fundamental algorithms*", 3rd edition, Addition Wesely, New Delhi, 1997.

3. Mark Nelson, "*STL*", Golgotia Publications, New Delhi, 1995.

IC 356 NEURAL NETWORKS AND FUZZY LOGIC CONTROL

Introduction to neural networks, different architectures of neural networks, Rosenblott's perceptrons, multi layer perceptrons, back propagation algorithm, Hopfield's networks, Kohnen's self organising maps, adaptive resonance theory.

Neural networks for control systems: Schemes of neuro-control, identification and control of dynamical systems, case studies.

Introduction to fuzzy logic: Fuzzy sets, fuzzy relations, fuzzy conditional statements, fuzzy rules, fuzzy learning algorithms.

Fuzzy logic for control systems: Fuzzy logic controllers, fuzzification interface, knowledge/rule base, decision making logic, defuzzification interface, design of fuzzy logic controllers, case studies.

Neuro-fuzzy and fuzzy-neural control systems: Adaptive fuzzy systems, optimising the membership functions and the rule base of fuzzy logic controllers using neural networks, fuzzy transfer functions in neural networks, elements of evolutionary computation, case studies.

Text Books:

1. Bose and Liang, "*Artificial Neural Networks*", Tata Mcgraw Hill, New Delhi, 1996

2. Kosko, B, "*Neural Networks and Fuzzy Systems: A Dynamical Approach to Machine Intelligence*", Prentice Hall, New Delhi, 1991.

3. Driankov D, Hellendoorn H. and Reinfrank M., "*An Introduction to Fuzzy Control*", Narosa Publishing House, New Delhi, 1996.

Reference Books:

1. S. Haykin, "*Neural Networks: A comprehensive Foundation*", 2nd Edition, Prentice Hall Inc., New Jersey, 1999.

2. Klir G.J and Folger T.A, "*Fuzzy sets, Uncertainty and Information*", Prentice Hall, New Delhi, 1994.

3. Negoita, "*Expert Systems and Fuzzy Systems*", Benjamin Cummings, USA, 1985.

IC 358 EMBEDDED SYSTEMS

Introduction to embedded systems: Embedded systems, description, definition, design consideration & requirements, embedded processor selection and tradeoffs. Embedded design life cycle. Product specifications, Hardware/Software partitioning, Iterations and Implementations, Hardware software integration, Product testing techniques, Co-design concept.

Real Time Operating System: Fundamentals. Multitasking application – Threads: execution suspension, sharing, resources between tasks: posix timers, message queues. Concurrent programming concepts – Tasks and Events: Synchronization and communication, task scheduling: Time slicing: priority: pre-emption scheduling interrupts and background tasks. Main features of QNX, Vx WORKS and LynxOS, Real Time Embedded System design and development.

Embedded system design using Microcontrollers: Intel's series of micro-controllers. Internal architecture of 8051, instruction set instruction organization, timing and hardware capabilities, assembly language programs, stacks, subroutines, interrupts, interrupt vector, and interrupt service routines. Design case study using 8051, A/D converters & other peripherals devices.

DSP based Embedded system design: Understanding fixed and floating –point number formats and precision: dynamic range of signals, intermediate products and number formats: q-notation for fixed point representation: native and fixed point arithmetic operations: fixed point analysis of recursive and non-recursive DSP algorithms and implementation in embedded systems. The state of the art of FPGA architecture and it's development.

Case studies and Applications: Design of embedded systems using 8051 core family controllers, PIC controllers, Applications.

Text Books:

1. Arnold S Berger, "*Embedded system design: An introduction to processors, Tools, Techniques*", 4th edition, CMP Books, 1st Edition, 2001.

2. Muhammad Ali Mazidi, Janice Mazidi and Janice Gillispie Mazidi , "*8051 Microcontroller and Embedded Systems*", PHI, 1999.

3. John G. Proakis and Dimitris K Manolakis, "*Digital Signal Processing: Principles Algorithms and Applications*", PHI, 3rd Edition, 1995.

IC 451 AUTOMOTIVE INSTRUMENTATION AND CONTROL

Sensor for Fuel Level in Tank, Engine Cooling,Water Temperature Sensors Design, Engine Oil Pressure Sensor Design, Speed Sensor, Vehicle Speed Sensor Design, Air Pressure Sensors, Engine Oil Temperature Sensor, Odometer and Taximeter Design

Brake Actuation Warning System. Traficators, Flash System, Oil Pressure Warning System, Engine Overheat Warning System, Air Pressure Warning System, Speed Warning System. Door Lock Indicators, Gear Neutral Indicator, Horn Design, Permanent Magnet Horn, Air Horn, Music Horns.

Basic driveline equations, Modeling of neutral gear, State-space formulation, Driveline speed control, Driveline control for gear shifting.

Vehicle modeling, wheel model, tyre characteristics, complete vehicle model, validation of the model, velocity estimation.

Vehicle control system, Antilock Braking Systems (ABS), control cycles of ABS, road model, PID driver model, hybrid driver model, model of human information acquisition, complete driver model.

Text Books:

1. U.Kiencke, and L. Nielson, "*Automotive Control Systems*", Springer Verlag Berlin, 2000

Reference Books:

1. T.Kailath, "*Linear Systems*", Prentice Hall Inc., New Jersy, 1996

2. J.M.Maciejowski, "*Multivariable Feedback Design*", Addison Wesley, Singapore, 1989

3. J.L.Meriam and L.G.Kraige, "*Engineering Mechanics, Dynamics*", John Wiley and sons, 5th Edition, New York, 2002.

IC 453 VIRTUAL INSTRUMENTATION

Virtual Instrumentation: Historical perspective, advantages, block diagram and architecture of a virtual instrument, data-flow techniques, graphical programming in data flow, comparison with conventional programming. Development of Virtual Instrument using GUI, Real-time systems, Embedded Controller, OPC, HMI / SCADA software, Active X programming.

VI programming techniques: VIs and sub-VIs, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, local and global variables, string and file I/O, Instrument Drivers, Publishing measurement data in the web.

Data acquisition basics: Introduction to data acquisition on PC, Sampling fundamentals, Input/Output techniques and buses. ADC, DAC, Digital I/O, counters and timers, DMA, Software and hardware installation, Calibration, Resolution, Data acquisition interface requirements.

VI Chassis requirements. Common Instrument Interfaces: Current loop, RS 232C/ RS485, GPIB. Bus Interfaces: USB, PCMCIA, VXI, SCSI, PCI, PXI, Firewire. PXI system controllers, Ethernet control of PXI. Networking basics for office & Industrial applications, VISA and IVI.

VI toolsets, Distributed I/O modules. Application of Virtual Instrumentation: Instrument Control, Development of process database management system, Simulation of systems using VI, Development of Control system, Industrial Communication, Image acquisition and processing, Motion control.

Text Books:

1. Gary Johnson, "*LabVIEW Graphical Programming*", 2nd Edition, McGraw Hill, New York, 1997.

2. Lisa K. wells & Jeffrey Travis, "*LabVIEW for everyone*", Prentice Hall, New Jersey, 1997.

3. Jane W. S. Liu, *"Real-time Systems"*, Pearson Education India, 2001.

4. Jean J. Labrosse, *"Embedded Systems Building Blocks: Complete and Ready-to-use Modules in C",* 2nd Edition, CMP Books, 1999

Reference Books:

1. Kevin James, "*PC Interfacing and Data Acquisition: Techniques for Measurement, Instrumentation and Control*", Newnes, 2000.

2. Jean J. Labrosse, *"MicroC/OS-II. The Real-time Kernal"*, CMP Books, 2002.

Web Resources:

1. www.ni.com
2. www.ltrpub.com

IC 455 OPTIMIZATION TECHNIQUES

Introduction to Optimization –statement of optimization problems, engineering applications-classical optimization techniques-single and multivariable objective function with and without constraints.

Linear Programming: Graphical method, Simplex method, Revised simplex method, Duality in linear programming (LP), Sensitivity analysis, other algorithms for solving LP problems, transportation, assignment and other applications.

Non-linear programming- one dimensional search, unconstrained optimization tech-gradient approach, steepest descent method, constrained problem- penalty function method, Lagrangian method.

Dynamic programming- multistage decision process, principle of optimality, computational procedure in Dynamic programming.

Further topics in optimization- Queuing theory, Game theory optimal control theory, calculus of variation, multi-objective optimization, Introduction to genetic algorithm, Case Studies.

Reference Books:

1. Kanti Swarup, Gupta,P.K and Man Mohan, "*Operation Research*", Sultan Chand, 11th Edition, 2003.
2. Rao,S.S., "*Optimization: Theory and Applications*", Wiley Eastern,1978.
3. David E. Goldberg, "*Genetic Algorithms in Search, Optimization & Machine Learning* ", Addison Wesley Publishing Company, Inc., 1989

IC 457 DIGITAL CONTROL SYSTEMS

Introduction to Discrete time systems, analogies with continuous-time systems, mathematical models for LTI discrete-time systems, convolution representation and difference equations in advanced and delayed form, Z-transformation of difference equations, analysis of first, second, and higher order systems, stability of discrete-time systems, the Jury's criterion.

State space modeling of discrete-time dynamical systems, canonical forms, solution to state space equations, properties of the state transition matrix, analysis of discrete-time state equations.

Equilibrium points and stability definitions, direct method of Lyapunov, definitions of controllability and observability, equivalent controllability/observability conditions. Design of state feedback and output feedback control. Design of observers.

Numerical Computations, digital simulation of state-space models, QR decomposition, singular value decomposition, digital control using digital signal processors.

Introduction to Optimal Control, statement of the optimal control problem, dynamic programming, general introduction to the principle of optimality, application to DTS, discrete-time linear quadratic problem, Riccati equation and its solution, optimal state feedback solution.

Text Books:

1. Ogata K., "*Discrete-time Control Systems*", 2nd Edition, Prentice Hall Inc., New Jersey, 1992.

2. Kuo B. C, "*Digital Control Systems*", 2nd Edition, Saunders College Publishing, Japan, 1992.

Reference Books:

1. Phillips C. L. and Nagle H. T, "*Digital Control System Analysis and Design*", 3rd Edition, Prentice-Hall, New Jersey, 1995.

2. Astrom K. J and Wittenmark, "*Computer Controlled Systems Theory and Design*", 2nd Edition, Prentice Hall, New Delhi, 1990.

3. Gopal M., "*Digital Control and State Variable Methods*", Tata McGraw Hill, New Delhi, 1997.

IC 459 ROBOTICS

Introduction: Basic concepts, definition and origin of robotics, different types of robots, robot classification, applications, robot specifications.

Introduction to automation: Components and subsystems, basic building block of automation, manipulator arms, wrists and end-effectors. Transmission elements: Hydraulic, pneumatic and electric drives. Gears, sensors, materials, user interface, machine vision, implications for robot design, controllers.

Kinematics, dynamics and control: Object location, three dimensional transformation matrices, inverse transformation, kinematics and path planning, Jacobian work envelope, manipulator dynamics, dynamic stabilization, position control and force control, present industrial robot control schemes.

Robot programming: Robot programming languages and systems, levels of programming robots, problems peculiar to robot programming, control of industrial robots using PLCs.

Automation and robots: Case studies, multiple robots, machine interface, robots in manufacturing and non-manufacturing applications, robot cell design, selection of a robot.

Text Books:

1. Spong and Vidyasagar, "*Robot Dynamics and Control*", John Wiley & Sons, 1990.

2. Asfahl C.R, "*Robots and Manufacturing Automation*", John Wiley & Sons, New York, 1992.

3. Klafter R.P, Chmiclewski T.A, Negin M, "*Robotics Engineering: Integrated approach*", Prentice Hall, New Jersey, 1994.

Reference Books:

1. Mikell P, Weiss G.M, Nagel R.N and Odrey N.G, "*Industrial Robotics*", McGraw Hill, New York, 1986.

2. Deb S.R, "*Robotics Technology and Flexible Automation*", Tata McGraw Hill, New Delhi, 1994.

3. Isaac Asimov I, "*Robot*", Bahtam Books, New York, 1994.

IC 461 SENSOR NETWORKS

Introduction to Sensor networks: Introduction to wired and wireless networks, Challenges of sensor networks, Network topologies, Performance analysis of Network. Applications of sensor networks.

Hardware and software for wireless sensor platform: Smart dust, Embedded sensor board - microcontroller, RF antennas, and signal conditioning circuits. Software- Tiny OS, NesC programming, different simulating Tools.

Energy Efficient Medium access: Energy consumption and life time, Energy efficient MAC- Channelization based, contention based and hybrid protocols, cellular network concepts.

Positioning and localization: Self organization network, local positioning, Global positioning with no distances estimates, Different localization techniques, GPS.

Data security, Advances in WSN- MEMS- Micro sensor, RF-MEMS- Micro radios.

Reference Books:

1. C.S.Ragavendra, Krishna M.Sivalingam, Taieb F.Znati, "*Wireless sensor Networks*", Springer, ISBN:1402078838.

2. Laurie Kelly, Mohammad Ilyas, Imad Mahgoub, "*Handbook of Sensor Networks: Compact Wireless and Wired Sensing Systems*", Published 2004,CRC Press ISBN:0849319684

3. Nirupama Bulusu, Sanjay Jha, "*Wireless Sensor Networks*", 2005, ISBN:1580538673

4. Holger Karl, Andreas Willig, "*Protocols and Architecture for Wireless Sensor Networks*" 2005, John Wiley and Sons, ISBN:0470095105

IC 463 MICRO SYSTEM DESIGN

Introduction, An approach to MEMS design, Basic introduction to fabrication, Process Integration

Energy conserving transducer, Mechanics of membranes and beams

Electrostatic Actuation and Sensing, Effects of electrical excitation

Design of Micro pressure sensor and Micro accelerometer

Electronic Integration and Packaging

Text Book:

1. Peter D. Senturia, "*Microsystem Design*", Kluwer Academic Publishers, Boston, 2001

Reference Books:

1. Minhang Bao, "*Analysis and Deisgn Principles of MEMS Devices*", Elsevier, 2005

2. M. Elwenspoek, R. Wiegerink, "*Mechanical Microsensors***"**, Springer, Berlin, 2001

3. Tai-Ran Hsu, "*MEMS and Microsystems: Design and Manufacture***,"** McGraw-Hill, Boston, 2002 (ISBN 0-07-239391-2)

IC 465 ADVANCED PROCESS CONTROL

Model Identification Techniques for SISO: Step response model- impulse response model –least square algorithm –recursive least square algorithm for both off line & on line - frequency response identification.

Auto Tuning: Motivation- basic description- describing function (relay, relay with hysteresis, relay with saturation)- model identification-tuning procedure .

Adaptive Control : Gain scheduling – Model reference adaptive control-Self tuning regulator.

Model Identification and Adaptive Control for typical case studies: Simulation studies using Matlab package- validation of model identification and adaptive control techniques in simple laboratory set-ups.

Model Predictive Control: Motivation- basic description-optimization problem formulation (objective function, model)- selection of prediction horizon and control horizon- algorithm investigation.

Reference Books:

1. B. Wayne Bequette, "*Process Control – Modeling, Design and Simulation*", Prentice Hall of India,2006.

2. M.Chidambaram, "*Applied Process Control*", Allied Publishers,1998.

3. Karl.J.Astrom , "*Adaptive Control*", Pearson Education Asia,2001

IC 467 SMART MATERIALS AND SYSTEMS

Piezoelectric materials: Properties - Piezoelectricity, characteristics, applications – vibration control, health monitoring, energy harvesting.

Shape-memory materials: Properties, shape memory materials, characteristics, applications – vibration control, shape control, health monitoring.

Electro-Rheological (ER) fluids: Suspensions and ER fluids, ER phenomenon, charge migration mechanism, ER fluid actuators, applications of ER fluids.

Magneto-Rheological (MR) fluids: Composition of MR fluid, applications of MR fluids.

Other smart materials: Magnetostrictive materials, Electrostrictive materials, Magnetic Shape Memory Alloy, Composites, Ionic Polymer Metal Composites.

Reference Books:

1. Mukesh V Gandhi, Brian S Thompson, "*Smart Materials and Structures*"**,** Kluwer Academic Publishers, 1992.

2. Mel Schwartz**, "***Encyclopedia of smart materials*", John Wiley and Sons, 2001**.**

4. A.V. Srinivasan, D. Michael McFarland, "*Smart Structure analysis and design*", Cambridge University Press, 2001

5. www.iop.org/sms

6. www.jim.sagepub.com

IC 469 NON-LINEAR CONTROL

Non-linear system analysis: Concepts of phase plane analysis:- phase portraits- construction of phase portrait- singular points- phase plane analysis of linear system and non-linear system- existence of limit cycles.

Describing function analysis: describing function fundamentals-computing describing functions-common nonlinearities in control systems- describing functions of common nonlinearities- describing functions analysis of non linear systems-stability analysis.

Lyapunov theory: Lyapunov's Direct method- stability analysis based on Lyapunov's Direct method-Krasovskii's method- variable gradient method.

Lyapunov analysis of Non –Autonomous system.

Non-linear control system design: feedback linearization.

Text Book:

1. Jean-Jacques E. Slotine, "*Applied Non-Linear Control*", Prentice Hall Englewood Cliffs, New Jercy, 1991

Reference Book:

1. Vidyasagar.M, "*Nonlinear System Analysis*", Prentice Hall Englewood Cliffs, New Jercy, 1978.

IC 452 POWER PLANT INSTRUMENTATION AND CONTROL

Brief survey of methods of power generation-hydro, thermal, nuclear, solar and wind power – Introduction to thermal power plant processes – building blocks - ideal steam cycles – Boiler – types, Boiler - turbine units and its range systems, feed water systems, steam circuits, combustion process, products of combustion process, fuel systems, treatment of flue gases, steam turbine, condensate systems, alternator, feed water conditioning, turbine bypass valves. Importance of instrumentation in power generation – details of boiler processes, P & I diagram of boiler – combined cycle power plant, power generation and distribution.

Measurement in boiler and turbine: Metal temperature measurement in boilers, piping system for pressure measuring devices, smoke and dust monitor, flame monitoring. Introduction to turbine supervising system, pedestal vibration, shaft vibration, eccentricity measurement. Installation of non-contracting transducers for speed measurement, rotor and casing movement and expansion measurement.

Controls in boiler: Problems associated with control of multiple pulverizers. Draught plant: Introduction, natural draught, forced draught, induced draught, power requirements for draught systems. Fan drives and control, control of air flow. Combustion control: Fuel/Air ratio, oxygen, CO and CO_2 trimming, combustion efficiency, excess air, parallel and cross limited combustion control, control of large systems.

Controls in boiler: Boiler drum level measurement methods, feedwater control, soot-blowing operation, steam temperature control, Coordinated control, boiler following mode operation, turbine following mode operation, sliding pressure mode operation, selection between boiler and turbine following modes. Distributed control system in power plants-interlocks in boiler operation. Turbine control: Shell temperature control-steam pressure control – lubricant oil temperature control – cooling system.

Nuclear power plant instrumentation: Piping and instrumentation diagram of different types of nuclear power plant, Nuclear reactor control loops, reactor dynamics, excess reactivity, pulse channel and logarithmic instrumentation, control and safety instrumentation, reliability aspects.

Text Books:

1. Sam. G.Dukelow, "*The Control of Boilers*", 2nd Edition, ISA Press, New York, 1991

2. Gill A.B, "*Power Plant Performance*", Butterworth, London, 1984.

3. P.C Martin, I.W Hannah, "*Modern Power Station Practice*", British Electricity International Vol. 1 & VI, Pergamon Press, London, 1992.

Reference Books:

1. David Lindsley, "*Boiler Control Systems*", McGraw Hill, New York, 1991.

2. Jervis M.J, "*Power Station Instrumentation*", Butterworth Heinemann, Oxford, 1993.

3. Modern Power Station Practice, Vol.6, "*Instrumentation, Controls and Testing*", Pergamon Press, Oxford, 1971.

IC454 SYSTEM IDENTIFICATION

Nonparametric Identification: Transient and frequency analysis methods, impulse and step response methods, correlation method, spectral analysis.

Parametric identification: Steps in identification process, determining model structure and dimension, Linear and nonlinear model structures, Input signals: commonly used signals, spectral properties, persistent excitation.

Parametric estimation: Linear regression, least square estimation, statistical analysis of LS methods, Minimizing prediction error- identifiability, bias, Least squares, relation between minimizing the prediction error and the MLE, MAP, Convergence and consistency, asymptotic distribution of parameter estimates, Instrumental Variable Method.

Recursive estimation, Forgetting Factor method, Kalman Filter interpretation
Identification in practice: Aliasing due to sampling, closed loop data, model order estimation, robustness considerations, model validation.

Case studies: Electro mechanical systems.

Text Books:

1. Ljung .L, *System Identification: Theory for the user,* Prentice Hall, Englewood Cliffs, 1987.

2. Torsten Soderstrom, Petre Stoica, *System Identification*, Prentice Hall International (UK) Ltd. 1989.

3. Juang, Jer-Nan, *Applied System Identification*, Prentice Hall PTR, Englewood Cliffs, New Jercy, 1994.

IC 456 FAULT DETECTION AND DIAGNOSIS

Introduction to Fault Detection and Diagnosis: Scope of FDD:- Types of faults and different tasks of Fault Diagnosis and Implementation - Different approaches to FDD: Model free and Model based approaches. Classification of Fault and Disturbances- Different issues involved in FDD- Typical applications.

Analytical Redundancy Concepts: Introduction- Mathematical representation of Fault and Disturbances: Additive and Multiplicative types – Residual Generation: Detection, Isolation, Computational and stability properties – Design of Residual generator – Residual specification and Implementation.

Design of Structured Residuals: Introduction- Residual structure of single fault Isolation: Structural and Canonical structures- Residual structure of Multiple fault Isolation: Diagonal and Full Row canonical concepts – Introduction to parity equation implementation and alternative representation.

Design of Directional structured Residuals: Introduction – Directional Specifications: Directional specification with and without disturbances – Parity Equation Implementation – Linearly dependent column.

Advanced level issues and design involved in FDD: Introduction of Residual generation of parametric fault – Robustness Issues –Statistical Testing of Residual generators – Application of Neural and Fuzzy logic schemes in FDD – Case study.

Text Books:

1. Janos J. Gertler "Fault *Detection and Diagnosis in Engineering systems*" – 2nd Edition, Macel Dekker, 1998.

Reference Books:

1. Sachin. C. Patwardhan, "*Fault Detection and Diagnosis in Industrial Process*" – Lecture Notes, IIT Bombay, February 2005.

2. Rami S. Mangoubi, "*Robust Estimation and Failure detection*". Springer-Verlag-London 1998.

IC 458 PIPING AND INSTRUMENTATION DIAGRAMS

P&I Diagram objectives. Industry Codes and Standards. Government regulations.

Engineering fluid diagrams. Electrical Diagrams, Electronic diagrams, Logic diagrams. DCS diagrams, Construction diagrams.

Format. Equipment. Instrumentation and Controls.

Applications of P&I diagrams in HAZOPS and Risk analysis.

Laboratory: Students are required to produce P&I diagrams using software packages during the laboratory period of the course.

References:

Industry Codes and Standards

- American National Standards Institute (ANSI)
  - ANSI/FCI 70-2-2003 - Control Valve Seat Leakage
- American Society of Mechanical Engineers (ASME)
  - ASME Boiler and Pressure Vessel Code. Section VIII - Pressure Vessels
- The Instrumentation, Systems and Automation Society (ISA)
  - ISA 5.1 - Instrumentation Symbols and Identification
  - ISA 5.2 - Binary Logic Diagrams for Process Operations
  - ISA 5.3 - Graphic Symbols for Distributed Control/ Shared Display

  Instrumentation, Logic and Computer Systems
  - ISA 84.01 - Application of Safety Instrumented Systems for the Process Industries
- Tubular Exchanger Manufacturers Association (TEMA)
  - TEMA Standards

  Government Regulations
- Occupational Safety and Health Administration (OSHA)
  - OSHA 29 CFR 1910.119 - Occupational Safety and Health Standards, Process Safety Management of Highly Hazardous Chemicals.

IC 460 COMPUTATIONAL TECHNIQUES IN CONTROL ENGINEERING

Review of Linear Algebra – Vector spaces, Orthogonality, Matrices, Vector and Matrix Norms, Kronecker Product

Numerical Linear Algebra – Floating point numbers and errors in computations, Conditioning, Efficiency, Stability, and Accuracy, LU Factorization, Numerical solution of the Linear system Ax = b, QR factorization, Orthogonal projections, Least Squares problem, Singular Value Decomposition, Canonical forms obtained via orthogonal transformations.

Control Systems Analysis – Linear State-space models and solutions of the state equations, Controllability, Observability, Stability, Inertia, and Robust Stability, Numerical solutions and conditioning of Lyapunov and Sylvester equations.

Control Systems Design – Feedback stabilization, Eigenvalue assignment, Optimal Control, Quadratic optimization problems, Algebraic Riccati equations, Numerical methods and conditioning, State estimation and Kalman filter.

Large scale Matrix computations, Some Selected Software – MATLAB, MATHEMATICA, SCILAB.

Text Books/References/Resources:

1. B.N. Datta, "*Numerical Methods for Linear Control Systems"*, Academic Press/Elsevier, 2005 (Low cost Indian edition available including CD ROM).
2. G.H. Golub & C.F. Van Loan, "*Matrix Computations*", 4/e, John Hopkins University Press, 2007 (Low cost Indian edition available from Hindustan Book Agency).
3. A. Quarteroni, F. Saleri, "*Scientific Computing with MATLAB*", Springer Verlag, 2003.
4. www.scilab.org

IC 462 UNCERTAINTY ANALYSIS IN ENGINEERING

Importance of uncertainty in science and technology, Measurement matters, Measurement fundamentals, terms used in measurement, Introduction to uncertainty in measurement, Uncertainty-types, model and measures.

Experimentation, Errors and uncertainty- Experimental approach, Basic concepts and definitions, Recent developments in uncertainty analysis.

Statistical consideration in measurement uncertainty, Planning an experiment: General uncertainty analysis, Design an experimentation: Detailed uncertainty analysis

Additional considerations in experimental design, debugging and execution of experiments, data analysis, regression and reporting of results.

Uncertainty in engineering problems- Interval based approach, Interval analysis-Basic concepts, arithmetic operation of intervals, Applications.

Reference Books:

1. Hugh W Coleman, W.Glenn Steele "Experimentation *and Uncertainty analysis for engineers*" 2nd Edition, Wiely-Interscience, 1999.
2. L.Kirkup, RB.Frickel "*An Introduction to Uncertainty in measurement: Using GUM*", Cambridge University Press, 2006.
3. Alefeld G, Herzberger.J, "*Introduction to Interval computations*", Academic Press Newyork, 1983.

IC 464 PROBABILITY AND COMPUTING

Events and Probability: Verifying Polynomial Identites, Verifying Matrix Multiplication, A Randomized mini-cut Algorithm
Discrete Random Variables and Expectations: The Bernoulli and Binomial Random Variables, Conditional Expectation. The Geometric Distribution, The Expected Run-time of Quick-Sort.

Moments and Deviations: Markov's Inequality, Variance and Moments of a Random Variable, Chebyshev's Inequality. A Randomized Algorithm for Computing the Median
Chernoff Bounds: Moment Generating Functions, Deriving and Applying Chernoff Bounds, Better Bounds for Special cases

Balls, Bins and Random Graphs: Poisson Distribution, Poisson Approximation, Hashing, Random Graphs
The Probabilistic Method: Basic Counting Argument, Expectation Argument, De randomization using Conditional Expectations, Sample and Modify, Second Moment Method. The Conditional Expectation Inequality, Lovasz Local Lemma

Markov Chains and Random walks: Definition and Representations, Classification of States, Stationary Distributions, Random walks on undirected Graphs.
Continuous Distributions and the Poisson Process: Continuous Random Variables Uniform Distribution, Exponential Distribution, Poisson Process, Continuous Time Markov Processes, MArkovian Quevues.

Entropy, Randomness and Information: The Entropy Function, Entropy Function, Entropy and Binomial Coefficients, A measure of Randomness, Compression
The Monte Carlo Method, The DNF Counting Problem, From Approximate Sampling to Approximate Counting, The Markov Chain Monte Carlo Method.

Text Book:

1. Mitzenmacher M. & Upfal E., Probability and Computing, Cambridge Univ. Press, 2005 (Cheaper Indian Edition is available)