B. Tech. Degree

IN

INSTRUMENTATION AND CONTROL ENGINEERING

SYLLABUS
FOR
CREDIT BASED CURRICULUM
(For students admitted in 2013-14)

DEPARTMENT OF INSTRUMENTATION AND CONTROL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

TIRUCHIRAPPALLI – 620 015
TAMIL NADU, INDIA

VISION AND MISSION OF THE INSTITUTE

VISION

- To provide valuable resources for industry and society through excellence in technical education and research.

MISSION

- To offer state-of-the-art undergraduate, postgraduate and doctoral programmes.
- To generate new knowledge by engaging in cutting-edge research.
- To undertake collaborative projects with academia and industries.
- To develop human intellectual capability to its fullest potential.

VISION AND MISSION OF THE DEPARTMENT

VISION

- To constantly strive to make this department a world class school in Instrumentation and Control Engineering.

MISSION

- To provide high quality education which inspire the students to realize their aspiration and potential.
- To enhance knowledge, create passion for learning, foster innovation and nurture talents towards serving the society and the country.
- To encourage faculty members to update their knowledge and carryout advanced research in cutting edge technologies
- To exhibit excellence in research projects and consultancy services, for the benefit of the global community

Programme Educational Objectives (PEOs)

The major objectives of the 4-year B.Tech (ICE) programme offered by the department of Instrumentation & Control Engineering are, to prepare students

1. for employment in the core industrial/manufacturing sector
2. for employment in research and development organizations
3. for employment in electronics & IT/ITES industry
4. for graduate studies in engineering and management
5. for entrepreneurship in the long run

Programme Outcomes (POs)

The students, after undergoing the 4-year B.Tech (ICE) programme,

1. would have developed an ability to apply the knowledge of mathematics, sciences, and engineering fundamentals to the field of instrumentation & control,
2. would have possessed a comprehensive understanding of a wider range of electronic devices, analog and digital electronic circuits and the state-of-the-art advanced electronic systems invariably found in every measurement and instrumentation system,
3. would have the right knowledge of and exposure to a variety of sensors, data acquisition systems, actuators, and control methodologies to readily provide innovative solutions to the day-to-day problems in the core industry (e.g. processes, power plants, automotive),
4. would have gained adequate knowledge in microprocessors and microcontrollers, embedded systems, data structures, algorithms, computer programming and simulation software to be able to offer services in IT and management sectors,
5. would have learnt necessary skills to develop mathematical models, and deploy appropriate techniques and IT tools to design advanced control systems and associated instrumentation for problems dealt in R & D organizations,
6. would be thoroughly prepared and confident to take up complex problems in the field of I & C and provide sustainable solutions by (i) surveying the literature and patents, (ii) designing and conducting experiments, (iii) interpreting the data, (iv) drawing relevant conclusions, with due consideration and responsibility towards the immediate social, cultural, environmental and legal issues, and (v) documenting the research carried out,
7. would be able to evaluate and deliver the solutions by optimally utilizing the available resources, including finances and project time, by adapting appropriate resource management techniques,
8. would be competent to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
9. would be proficient in English language (spoken and written) in order to communicate effectively on complex engineering activities on a global scale, make comprehensive reports and presentations, and give and receive clear instructions,
10. would have committed to be professionally ethical,
11. would pledge to function efficiently in various capacities as members, leaders, and directors in multi-disciplinary teams to accomplish projects of different magnitudes, and
12. would have recognized the need for engaging themselves in independent and life-long learning in the broadest context of technological change.

CURRICULUM

The total minimum credits required for completing the B.Tech. Programme in Instrumentation and Control Engineering is 181 (45 + (136))

SEMESTER III

CODE	COURSE OF STUDY	L	T	P	C
MA 209	Mathematics III	3	1	0	4
ME 283	Thermodynamics & Fluid Mechanics	4	0	0	4
IC 201	Sensors & Transducers	3	0	0	3
IC 203	Circuit Theory	3	1	0	4
IC 205	Digital Electronics	3	0	0	3
MT 211	Material Science	3	0	0	3
IC 207	Devices & Circuits Laboratory	0	0	3	2
ME 285	Thermodynamics & Fluid Mechanics Laboratory	0	0	3	2
	TOTAL	19	2	6	25

SEMESTER IV

CODE	COURSE OF STUDY	L	T	P	C
MA 202	Numerical Methods	3	1	0	4
IC 202	Signals & Systems	3	0	0	3
IC 204	Industrial Instrumentation – 1	3	0	0	3
IC 206	Analog Electronic Circuits	3	0	0	3
IC 208	Microprocessors & Microcontrollers	3	0	0	3
IC 210	Electrical & Electronic Measurements	3	0	0	3
IC 212	Sensors & Transducers Laboratory	0	0	3	2
IC 214	Microprocessors & Microcontrollers Laboratory	0	0	3	2
	TOTAL	18	1	6	23

SEMESTER V

CODE	COURSE OF STUDY	L	T	P	C
IC 301	Control System – 1	3	0	0	3
IC 303	Data Structures & Algorithms	3	1	0	4
IC 305	Linear Integrated Circuits	3	0	0	3
IC 307	Industrial Instrumentation – II	3	0	0	3
EC 317	Principles of Communication Systems	3	0	0	3
	Elective 1	3	0	0	3
IC 309	Linear Circuits Laboratory	0	0	3	2
IC 311	Instrumentation Laboratory	0	0	3	2
	TOTAL	18	1	6	23

SEMESTER VI

CODE	COURSE OF STUDY	L	T	P	C
CS303	Computer Networks	3	0	0	3
IC 302	Control System – II	3	0	0	3
IC 304	Process Control	3	1	0	4
IC 306	Product Design & Development (T)	2	0	3	2
	Elective 2	3	0	0	3
	Elective 3	3	0	0	3
IC 308	Interfacing and Signal Processing Laboratory	0	0	3	2
IC 310	Control Engineering Laboratory	0	0	3	2
	Industrial Lectures	0	0	0	1
	Internship / Industrial Training / Academic Attachment [#] (2 to 3 months duration during summer vacation)	0	0	0	2
	TOTAL	17	1	9	25

[#] To be evaluated at the beginning of VII semester by assessing the report and conducting seminar presentations.

SEMESTER VII

CODE	COURSE OF STUDY	L	T	P	C
IC 401	Industrial Psychology	3	0	0	3
IC 403	Logic & Distributed Control Systems	3	1	0	4
IC 405	Analytical Instrumentation	3	0	0	3
	Elective 4	3	0	0	3
	Elective 5*	3	0	0	3
IC 407	Product Design & Development (P)	0	0	3	2
IC 409	Process Control Laboratory	0	0	3	2
IC 411	Comprehensive Examination	0	0	0	2
	TOTAL	15	1	6	22

SEMESTER VIII

CODE	COURSE OF STUDY	L	T	P	C
IC 408	Industrial Economics and Management	3	0	0	3
	Elective 6	3	0	0	3
	Elective 7*	3	0	0	3
	Elective 8*	3	0	0	3
IC 488	PROJECT WORK	0	0	15	6
	TOTAL	12	0	15	18

* GLOBAL ELECTIVES ALSO

LIST OF ELECTIVES

GROUP 1 (INSTRUMENTATION STREAM)					
CODE	**COURSE OF STUDY**	**L**	**T**	**P**	**C**
IC001	Virtual Instrument Design	3	0	0	3
IC002	Micro System Design	3	0	0	3
IC003	Smart Materials & Systems	3	0	0	3
IC004	Opto-Electronics & Laser Based Instrumentation	3	0	0	3
IC005	MEMS & Nanotechnology	3	0	0	3
IC006	Power plant Instrumentation and Control	3	0	0	3
IC007	Biomedical Instrumentation	3	0	0	3
IC008	SMART and Wireless Instrumentation	3	0	0	3
GROUP 2 (CONTROL STREAM)					
CODE	**COURSE OF STUDY**	**L**	**T**	**P**	**C**
IC021	Computational Techniques in Control Engineering	3	0	0	3
IC022	System Identification	3	0	0	3
IC023	Fault Detection & Diagnosis	3	0	0	3
IC024	Cooperative Control Systems	3	0	0	3
IC025	Digital Control Systems	3	0	0	3
IC026	Robotics	3	0	0	3
IC027	Neural Networks and Fuzzy Logic Control	3	0	0	3
IC028	Design of Automotive Systems	3	0	0	3
GROUP 3 (COMMON STREAM)					
CODE	**COURSE OF STUDY**	**L**	**T**	**P**	**C**
IC041	Electron Devices	3	0	0	3
IC042	Electrical Machines	3	0	0	3
IC043	Digital Signal Processing	3	0	0	3
IC044	Power Electronics	3	0	0	3
IC045	Embedded Systems	3	0	0	3
IC046	Engineering Optimization	3	0	0	3
IC047	Sensor Networks	3	0	0	3
IC048	Uncertainty Analysis in Engineering	3	0	0	3
IC049	Probability & Computing	3	0	0	3
IC050	Image Processing	3	0	0	3
IC051	ARM System Architecture	3	0	0	3
IC052	Introduction to Chemical Processes	3	0	0	3
IC053	Disaster Management	3	0	0	3

LIST OF ADVANCED LEVEL COURSES FOR B.Tech. HONOURS

For the students with consistent academic record of GPA $\geq$ 8.5 from I to IV semesters, and applied for B.Tech. Honours.

i. Can opt to study any 3 of the listed advanced level courses from V semester.
ii. In 7th semester, B.Tech. Honours students are permitted to take one M.Tech. (Process Control and Instrumentation) core course offered during that semester.

LIST OF ADVANCED LEVEL COURSES FOR B.Tech. HONOURS					
CODE	**COURSE OF STUDY**	**L**	**T**	**P**	**C**
IC 090	Instrumentation System Design	3	0	0	3
IC 091	Additional Topics in Control Engineering	3	0	0	3
IC 092	Advanced Process Control	3	0	0	3
IC 093	Nonlinear Control Systems	3	0	0	3
IC 094	Physiological Control Systems	3	0	0	3

COURSES OFFERED TO OTHER DEPARTMENTS

DEPT.	CODE	COURSE OF STUDY	L	T	P	C
ECE	IC218	Control Systems	3	0	0	3
MME	IC216	Instrumentation & Control	3	0	0	3
MME	IC220	Instrumentation & Control Laboratory	3	0	2	2

SEMESTER III

CODE	COURSE OF STUDY	L	T	P	C
MA 209	Mathematics III	3	1	0	4
ME 283	Thermodynamics & Fluid Mechanics	4	0	0	4
IC 201	Sensors & Transducers	3	0	0	3
IC 203	Circuit Theory	3	1	0	4
IC 205	Digital Electronics	3	0	0	3
MT 211	Material Science	3	0	0	3
IC 207	Devices & Circuits Laboratory	0	0	3	2
ME 285	Thermodynamics & Fluid Mechanics Laboratory	0	0	3	2
	TOTAL	19	1	6	25

MA 209 MATHEMATICS III

L	T	P	C
3	1	0	4

Course Objectives:

To learn the concepts of vector spaces, inner product spaces, matrices, probability models, basic statistics and academic applications of these concepts.

Linear Algebra and Applications – Vector spaces, subspaces, linear independence, basics and dimension, inner product spaces, orthogonality.

Matrices, solution of linear equations, determinants, eigenvalues and eigenvectors, characteristic polynomial, minimal polynomial, positive definite matrices and canonical forms, QR decomposition.

Probability Models – Sample spaces, events, probability, discrete and continuous random variables, conditioning and independence, Baye’s formula.

Binomial, Poisson, Gaussian, uniform, exponential and other standard probability models.

Moments and the moment generating function, characteristic function, laws of large numbers, Chebyshev’s inequality, central limit theorem, Introduction to Monte-Carlo methods, Introduction to Statistical tools.

Text Books:

1. Strang. G, *Linear Algebra and its Applications*, Thomson-Brooks/Cole, 2006.
2. Ross, S.M., *Introduction to Probability and Statistics for Engineers & Scientists*, 2^{nd} Edition, Elsevier, 2006

Course Outcomes:

Students will be able to use the above concepts to solve the real world industrial application.

ME 283 THERMODYNAMICS AND FLUID MECHANICS

L	T	P	C
4	0	0	4

Course Objectives:

1. To further develop your understanding of principles of work and energy, appreciation of the design principles in thermo-fluid systems, analysis of existing thermo-fluid systems and contribution of these to new designs.
2. Explain the physical properties of a fluid and the consequence of such properties on fluid flow.
3. State the conservation principles of mass, linear momentum, and energy for fluid flow.
4. Determine the basic forces and moments acting on simple profiles and shapes in an in viscid, steady fluid flow.

Basic concepts of thermodynamics: 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.
Fundamentals of Fluid mechanics: Ideal fluid - velocity field - stream line, streak line and path line, continuity equation - Rotational and irrotational flow, stream function and potential function, Euler’s 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 Theorem and its applications. Laminar flow – Losses – Hagen-Poiseuille equation – Turbulent pipe flow.
Fluid machinery: Centrifugal pumps, Reciprocating pumps, Hydraulic ram, Impulse turbine, Reaction turbine.

Text Books:
1. Zemansky, *Heat and Thermodynamics*, 7th edition, McGraw Hill, New York, 1997.
2. Ojha C.S.P., Berndtsson R., Chandramouli P.N., *Fluid Mechanics and Machinery,* Oxford University Press,2010.

Reference Books:
1.Van Wylen G.A., Fundamentals of classical Thermodynamics, 4thEdition, John Wiley and Sons,1994.
2.Cengal Y.A., Bogles M.A., Micheal Boles, Thermodynamics, 2ndedition, McGraw Hill Book Company, 1994.
3. Nag P.K., Engineering Thermodynamics, 2nd Edition, Tata McGraw Hill, 1995.
4. Crowe C.T., Elger D.F., Williams B.C., Roberson J.A., *Engineering Fluid Mechanics* 9th Edition, John Wiley & Sons, 2009.

Course Outcomes:
By the end of this course, students will be able to
1.The ability to develop and understand thermodynamic behavior of continua by applying conservation laws to fixed control volumes and use of empirical models is also developed.

2. The ability to properly structure an analysis strategy and apply physical laws to various situations of interest in engineering.
3. The ability to document the use of thermodynamic models such that the work can be checked and understood by peers. These skills are developed through required homework and exams.
4. The ability to understand how standard instrumentation, refrigeration and energy generation hardware functions.
5. Construct solutions to fluid dynamics problems applicable to their research using methods from the fluids literature.
6. List and explain the assumptions behind the classical equations of fluid dynamics.
7. Identify and formulate the physical interpretation of the mathematical terms used in solutions to fluid dynamics problems.
8. To achieve this goal, students will learn to categorize solutions to fluids problems by their fundamental assumptions.

IC 201 SENSORS AND TRANSDUCERS

L	T	P	C
3	0	0	3

Course Objective:

1. To introduce the student to the different types of sensors, signal conditioning circuits.
2. The student should be capable of designing the required signal conditioning for a particular sensor.
3. By the end of the course, students should be able to identify and describe several types of sensors
4. To master the physical properties and engineering characteristics by analyzing the needs of a sensor system and choose sensors accordingly.

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,* Pearson Education, *4th* Edition, 2005.
2. Doebelin E.0, *Measurement Systems - Application and Design,* McGraw-Hill, 4th Edition, 2004.
3. S.M. Sze, *Semiconductor sensors*, John Wiley & Sons Inc., 1994.

Reference Books:

1. Murthy D. V. S, *Transducers and Instrumentation,* Prentice Hall, *2nd Edition,* 2011
2. Neubert H.K.P, *Instrument Transducers - An Introduction to their Performance and Design,* Oxford University Press, 2nd Edition, 1999.
3. Patranabis, *Sensors and Transducers,* Prentice Hall, 2nd Edition, 2003.
4. Waldemar Nawrocki, *Measurement Systems and Sensors,* Artech House, 2005

Course Outcomes:

When completed this course, students will be able to:

1. Explain the principles of sensors and transducers with their technical characteristics and constraints
2. Design, implement and critically evaluate methods for sensor from preprocessing to classification, field data collection and accuracy assessment
3. Generate system information by processing sensed data and critically evaluate its use for applications

IC 203 CIRCUIT THEORY

L	T	P	C
3	1	0	4

Course Objectives:

1. To introduce and impart problem solving techniques, through linear passive electrical circuits, useful for other core and elective courses of the department.
2. To introduce algorithmic and computer-oriented methods for solving large scale circuits.

Pre-requisites: Basic Physics and Mathematics learnt during +2 and B.Tech. 1st year**.**

Review of Networks and Circuits, Elemental laws (v-i characteristics) for Resistors, Inductors, and Capacitors, Circuital laws (Kirchhoff's laws), Sign convention, Basic signals (dc and ac), Elementary signals (impulse, step, ramp, exponential), Synthesis of arbitrary waveforms (rectangular, triangular etc.) from elementary signals, Voltage and Current sources (Independent and Dependent), Ladder and Bridge Circuits.

Analysis of Resistive Circuits energized by dc voltages and currents – Source Transformations, Nodal and Mesh Analysis, Principle of Superposition, Network Theorems (Thevenin's and Norton's, Maximum Power Transfer), Circuits with dependent dc Sources.

Transients with Energy Storage Elements, First and Second Order Circuits – Time-constant, Damping Ratio, Natural Frequency, Emphasis on Linear Ordinary Differential Equations, Step response of RC, RL, and RLC (series and parallel) Circuits, Resonance in Second Order Circuits.

Sinusoidal Sources and Response – Behaviour of elements with ac signals, Impedance and Admittance, Generalization of Network Theorems and Circuit Analysis, Introduction to 3-ф power systems.

Transient and Steady-state Response of Circuits – Laplace Transformation and its application to circuit analysis, State Variables, Network Functions (Driving point impedance and admittance), Transfer function, Two-port Networks, Applications of Two-port networks, Introduction to General Linear Systems.

Text Books:

1. Hayt, W.H, Kemmerly J.E. & Durbin, *Engineering Circuit Analysis,* McGraw Hill Publications, 8th edition, 2013.
2. Ramakalyan, A., *Linear Circuits: Analysis & Synthesis,* Oxford Univ. Press**,** 2005.

Reference Books:

1. Van Valkenburg, *Network Analysis,* Prentice Hall, 3rd Edition, 2006
2. Van Valkenburg, M.E., *Introduction to Modern Network Synthesis,* Wiley, 1960.

Course Outcome:

1. The student is motivated to study circuits in a systematic manner suitable for engineering analysis and design.
2. The student understands to formulate circuit analysis problems in a mathematically tractable way with an emphasis on solving linear systems of equations.
3. The student is exposed to subtle details in the responses of circuits subjected to sudden changes in excitation, and understanding the transient phenomena.
4. The student is exposed to the steady-state behaviour of circuits, generalization of ideas from simple dc to complex exponential signals, and learns the basic principles of power systems.
5. The student is motivated to understand the general behaviour of circuits in a unified framework, learn about input-output modeling, and extend the concepts to more general linear systems to be taught in future semesters.

L	T	P	C
3	0	0	3

IC 205 DIGITAL ELECTRONICS

Course Objectives:

To impart the essential knowledge on the fundamentals and applications of digital circuits and digital computing principles and provide an overview on the design principles of digital computing systems.

Prerequisites: Basic level course on electron devices and basic algebra.

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, *Logic and Computer Design Fundamentals* , Pearson, 4th Edition, 2014
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.

Reference Books:

1. J.M. Rabaey, *Digital Integrated Circuits: A Design Perspective*, 2nd Edition, Prentice Hall of India, 2003.
2. N.H.E. Weste, and K. Eshraghian, *Principles of CMOS VLSI Design: A Systems Perspective*, 3rd Edition, Pearson Education Inc., (Asia), 2005

Course Outcomes:

On completion of the course, the student will

1. Understand how digital and logic computing is built from the fundamentals of semiconductor electronics and learn the capability to use abstractions to analyze and design digital electronic circuits
2. Gain knowledge on the basic logics and techniques related with digital computing
3. Develop expertise to design and implement various complicated digital systems to be applicable for signal measurement and processing

MT 211 MATERIAL SCIENCE

L	T	P	C
3	0	0	3

Course Objectives:

To develop an understanding of the basic principles of Material Science and apply those principles to engineering applications.

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 behaviour, 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. Dielectric 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. Smith W.F.and Hashemi J., *Foundations of Materials Science and Engineering*, 4th Edition, Mc Graw Hill, United States, 2005

Course Outcomes: Upon completion of this class, students are expected to

1. Understand the geometry and crystallography of crystalline materials using Bravais lattices and Miller Indices.

2. Differentiate the basic crystal structures (BCC, FCC, and HCP), recognize other crystal structures.
3. Interpretation of phase diagram and iron-carbon system.
4. Define various mechanical properties and the associated testing methods.
5. Define electrical, magnetic and optical properties of materials.
6. Select suitable materials for specific instrumentation devices.

IC 207 DEVICES AND CIRCUITS LABORATORY

L	T	P	C
0	0	3	2

Course Objectives:

1. To enable the students to understand the behavior of semiconductor device based on experimentation
2. To impart knowledge on solving circuits using network theorems

List of Experiments:

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

Course Outcomes:

1. Ability to understand and analyze electronic circuits.
2. Choose the appropriate equipment for measuring electrical quantities and verify the same for different circuits.
3. Ability to understand and apply circuit theorems and concepts in engineering applications
4. Prepare the technical report on the experiments carried.

ME 285 THERMODYNAMICS AND FLUID MECHANICS LABORATORY

L	T	P	C
0	0	3	2

Course Objectives:

1. To understand the principles of thermal and mechanical energy. And transformations
2. Thermodynamics - concepts and properties, first and second law
3. It provides a working knowledge of thermodynamics & fluid mechanics.

List of Experiments:

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

Course Outcomes:

1. An understanding of heat, work, internal energy, 1st and 2nd law of thermodynamics
2. An understanding of Dimensional Analysis, fluid statics and dynamics
3. An understanding of fluid mechanics fundamentals, including concepts of mass and momentum conservation.
4. An ability to apply the Bernoulli equation & control volume analysis to solve problems in fluid mechanics.

SEMESTER IV

CODE	COURSE OF STUDY	L	T	P	C
MA 202	Numerical Methods	3	1	0	4
IC 202	Signals & Systems	3	0	0	3
IC 204	Industrial Instrumentation - 1	3	0	0	3
IC 206	Analog Electronic Circuits	3	0	0	3
IC 208	Microprocessors & Microcontrollers	3	0	0	3
IC 210	Electrical & Electronic Measurements	3	0	0	3
IC 212	Sensors & Transducers Laboratory	0	0	3	2
IC 214	Microprocessors & Microcontrollers Laboratory	0	0	3	2
	TOTAL	18	1	6	23

MA 202 NUMERICAL METHODS

L	T	P	C
3	1	0	4

Course Objectives:

To develop the basic understanding of numerical algorithms and skills to implement algorithms to solve mathematical problems using the computer.

Digital representation of numbers, Finite precision arithmetic, Machine Precision, Measuring errors, convergence of iterative sequences, Taylor series, Order Notation. Numerical Solution of f(x)=0: Bisection method, Secant method, Newton's method , Newton's method for f(x,y)=0,g(x,y)=0. Order of convergence.

Solution of linear system of equations – Direct method: Gaussian elimination, Gauss-Jordan methods, LU Decomposition method- Crout's method. Algorithm for tri-diagonal system, Iterative method: Jacobi and Gauss-Seidal's method - sufficient conditions for convergence - Eigen Value problems- power method.

Interpolation: Lagrange's method, Newton's divided difference, forward and backward difference interpolation method. Least squares fitting of a curve to data-Polynomial curve fitting, exponential curve ($y = ae^{bx}$) fitting to data.
Numerical Differentiation based on interpolation and finite difference. Numerical Integration-Closed and open type integration rules - Trapezoidal rule, Simpson's 1/3 rule and 3/8 rule, mid-point and two-point rule. Adaptive integration based on Simpson's rule. Gauss quadrature methods, Integrals with infinite limits ($\int_0^\infty e^{-x} f(x) dx$).

Numerical solution of ordinary differential equations: Taylor's series method, Single step method-Euler's method, Euler's modified method, Fourth order Runge-Kutta method. Fourth order R-K method for simultaneous equations and 2^{nd} order ODE. Multi step methods: Milne's and Adams method.

Computer based exercise are recommended in all units.

Text Books

1. M.K. Jain, S.R.K. Iyenger, R.K. Jain, *Numerical Methods for scientific and Engineering computation*, 5^{th} Edition, New Age International Publishers, 2009.
2. S.S. Sastry, *Introductory methods of numerical Analysis*, 4^{th} Edition, Prentice Hall of India, New Delhi, 2005.
3. Ward Cheney and David Kincaid, *Numerical Mathematics and Computing*, 6^{th} Edition, Cengage Learning, 2007.

Course Outcomes:

The student will be capable to

Solve linear, nonlinear equations and real life engineering problems.

IC 202 SIGNALS AND SYSTEMS

L	T	P	C
3	0	0	3

Course Objectives:

1. This course introduces the student to general theory of signals and systems and makes the student familiar with the mathematical tools available to analyze the signals and systems in the first three units.
2. The student is introduced to random phenomena in real-world and the mathematical models to classify them in the fourth unit.
3. The use of pseudo-random signals in identifying systems is introduced in the fifth unit of the course.

INTRODUCTION TO SIGNALS AND SYSTEMS

Introduction to signals – Transformation of the independent variable – Basic continuous-time signals – Basic discrete-time signals – Step and Impulse functions – Sampling theorem.

Introduction to systems – Properties of systems – Classification of systems – Mathematical model of systems – Concept of state variable – Normal form of system equations – Initial conditions.

ANALYSIS OF SYSTEMS USING TRANSFORMS

Impulse response of physical systems – Stability analysis of dynamic systems – Introduction to convolution – Convolution integral – System impulse response and step response using Laplace transform – Numerical convolution.

Z-transform – Convergence of Z-transform – Properties of Z-transform – Inversion of Z-transform –Application of Z-transform in analysis of discrete-time systems – Evaluation of discrete-time system frequency response – Inverse systems – Deconvolution.

ANALYSIS OF SIGNALS USING TRANSFORMS

Representation of signals in terms of elementary signals – Condition of orthogonality – Representation of signals by elementary sinusoids – Fourier series representation of periodic signals – Power spectrum.

Fourier transform – System frequency response – Realizability of frequency response – Energy spectrum. Calculation of simple transforms. Discrete-Fourier transform (DFT) – Properties of Discrete Fourier Transform – Circular convolution.

STATISTICAL SIGNAL ANALYSIS

Classification of random signals – Auto-correlation function – Properties of auto-correlation function – Measurement of auto-correlation function – Application of auto-correlation functions. Cross correlation functions. Sum of random processes.

Spectral density – Relation of spectral density to auto-correlation function

SYSTEM IDENTIFICATION BY RANDOM SIGNAL TESTING

Auto-correlation function of system output - Cross-correlation between system input and output. White noise - Analysis of linear systems in time-domain using white noise - Mean and mean square value of system output.

Generation of pseudo random binary noise (PRBN) and its use in system identification - Analysis in the frequency domain.

Text Books:

1. Gabel R.A. and Robert R.A., *Signals and Linear Systems*, John Wiley and Sons, 3rd Edition, 2009
2. Oppenheim A.V., Wilsky and Nawab, *Signals and Systems*, Prentice Hall, 2nd Edition, 1997.
3. Chen C.T., *Systems and Signal Analysis - A Fresh Look*, Create Space, 3rd Edition, 2011.

Reference Book:

1. Cooper G.R and Mc Gillem C.D, *Probabilistic Methods of Signals and System Analysis*, Oxford University Press, 3rd Edition, 1999.
2. Chesmond, Wilson and Lepla, *Advanced Control System Technology*, Viva Books, 1st Edition, 1998.
3. Ziemer R.E., Tranter W.H., and Fannin D.R., *Signals and Systems: Continuous and Discrete*, Prentice Hall, 4th Edition, 1998.

Course Outcomes:

1. The student will get a general understanding of continuous-time and discrete-time signals and systems.
2. The student will be able to analyze signals and systems using mathematical transform tools.
3. The student will be able to classify random signals using statistical concepts and characterize systems using pseudo-random signals.

IC 204 INDUSTRIAL INSTRUMENTATION - I

L	T	P	C
3	0	0	3

Course Objectives:

To enable the students to understand the fundamentals of various types of industrial measurements.

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, connecting leads, 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, suction and acoustic 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*, Tata McGraw Hill publishing company, 2008.
2. Patranabis D, *Principles of Industrial Instrumentation,* Tata McGraw Hill, 3rd Edition, 2010.

Reference Books:

1. B.E.Noltingk, *Instrumentation Reference Book*, 2ndEdition, Butterworth Heinemann, 1995.
2. B.G.Liptak, *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.

Course Outcomes:

1. To have a sound knowledge on thermocouples, pyrometry and other temperature measuring techniques.
2. To have an adequate knowledge on pressure transducers
3. Exposure to various density and viscosity pick-ups.

IC 206 ANALOG ELECTRONIC CIRCUITS

L	T	P	C
3	0	0	3

Course Objectives:

The aim of this course is to familiarize the student with the analysis and design of

1. Diode circuits, various biasing schemes and small signal model of BJT, FET, MOSFET,
2. Single stage amplifier design,
3. Multistage amplifier and differential amplifier
4. Feedback configuration and Oscillators, Power amplifiers

Rectifier circuits- Filter circuits-Zener voltage regulator- Biasing BJT, FET MOS FET amplifiers-Small signal and high frequency model of BJT, FET &MOS FET

Single stage BJT, FET and MOSFET amplifiers with and without active loads- Source follower-Emitter follower

Multistage amplifiers- Differential amplifiers- CMRR

Advantages of negative feedback- Four basic feedback configurations-Basic principle of oscillators- RC oscillators.

Power amplifier -class A , Class B, Class AB & class C

Text Books:

1. Sedra A.S.and Smith K.C., *Microelectronic circuits, Oxford university press*, 6th edition, 2011.
2. David A Bell, *Electronic devices and circuits*, Oxford university press, 2010.
3. Robert L. Boylested, *Electronic devices and circuit theory*, Pearson, 10th edition, 2012.

Reference Books:

1. Milman J. and Grabel A., *Microelectronics*, Tata McGraw Hill, 2nd edition, 2009.

Course Outcomes:

On completion of this course, the student will understand

1. Diode circuits, various biasing schemes and small signal model of BJT, FET, MOSFET,
2. Single stage amplifier design,
3. Multistage amplifier and differential amplifier

IC 208 MICROPROCESSORS AND MICROCONTROLLERS

L	T	P	C
3	0	0	3

Course Objectives:

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

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.

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

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, programming the ports, Timers, serial interface, LCD interface, ADC interface, interrupt programming, Programming exercises, Applications.

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*, Thomson Delmar Learning, *3rd Edition*, 2004.

3. Douglas V. Hall, *Microprocessors and Interfacing-Programming and Hardware*, 2nd Edition, Mc Graw Hill, 1999.

Reference Books:

1. Ram.B, *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 2007.
3. Frank Vahid/Tony Givargis, Embedded System Design – A Unified Hardware/Software Introduction, John Wiley & Sons, Inc, 2005 ISBN 9971-51-405-2.
4. Prasad K.V.K.K., *Embedded/Real-Time Systems: Concepts, Design & Programming*, Dreamtech Press, 2005.

Course Outcomes:

Students completing this course will demonstrate competence and ability to design a stand-alone computing device for any non -real time applications.

IC 210 ELECTRICAL AND ELECTRONIC MEASUREMENTS

L	T	P	C
3	0	0	3

Course Objectives:

The course is designed to equip the students to apply and design all types of common electrical and electronic instruments with the knowledge about the construction, working and error analysis of the instruments

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

Electronic measurements: Digital voltmeter, Analog and digital multimeters, DMM with auto ranging and self-diagnostic features ,digital wattmeter/energy meter. Signal Generators. Frequency measurement, measurement of period, time and phase angle.

Waveform analyzing instruments: Distortion meter, Spectrum analyzer, Oscilloscopes: Classification - Sampling and storage scopes. Seven segment LED and LCD dispalys

Text Books:

1. Golding, E.W. and Widdis, F.C., *Electrical Measurements and Measuring Instruments*, A.H.Wheeler and Co, 5th Edition, 2011.
2. David A. Bell, *Electronic Instrumentation and Measurements,* Oxford University Press, 2nd Edition, 2009.
3. Shawney A K, *A course in Electrical and Electronic Measurements and Instrumentation*, Dhanpat Rai and Sons.

Reference Books:

1. Cooper, W.D. and Helfric , A.D., *Electronic Instrumentation and Measurement Techniques,* Prentice Hall, 1st Edition, 2009.
2. Kalsi.H.S, *Electronic Instrumentation*, Tata Mcgraw Hill Education Private Limited, 3rd Edition, 2012.

Course Outcomes:

Completion of this course, the student will be:

1. Familiar with various measuring instruments (ammeters, voltmeters, current and voltage transformers, different types of power and energy meters) used to detect electrical quantities
2. Able to perform experiments to determine various types of errors in measurements, as well as to analyze and interpret results.
3. Able to design suitable DC and AC bridges for the measurement of R, L, C and Frequency
4. Able to design analog and digital measurement systems
5. Familiar with the operation and usage of various waveform analyzing instruments.

IC 212 SENSORS AND TRANSDUCERS LABORATORY

L	T	P	C
0	0	3	2

Course Objectives:

The aim of this lab is to fortify the students with an adequate work experience in the measurement of different quantities and also then expertise in handling the instruments involved.

List of Experiments:

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 and Gyroscope

Course Outcomes:

1. Ability to model and analyze transducers.
2. Ability to review, prepare and present technological developments.

IC 214 MICROPROCESSOR AND MICROCONTROLLERS LABORATORY

L	T	P	C
0	0	3	2

Course Objective:
The aim of this laboratory course is to make students:

1. Familiar with a microprocessor simulator to learn how a program gets executed in a Microprocessor /micro-controller.
2. Fabricate a micro-controller circuit board using KiCAD open-source PCB design tool.
3. Program a micro-controller using a C language based compiler.

As a part of this laboratory course the students will have to simulate their 8085 assembly level programs using GNUSim 8085 simulator.

Simultaneously, they have to fabricate a 8051-based hardware board to download their software from a C language based compiler through a programmer and test it.

The 8085 microprocessor based programs are executed using GNU Sim 8085 simulator and the 8051 micro-controller based programs are executed on the hardware board they fabricate themselves.

List of Experiments:
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 to programmable peripheral interface.
5. Programming exercises using interrupts.
6. Programming an EPROM for a specific application.
7. Programming exercises to use the timer.
8. Familiarization 8051 micro-controller board and its assembler.
9. Programming exercises using 8051 micro-controller.
10. Basic I/O operations and ADC Interfacing using KEIL software.
11. Counting Pulses using Interrupt and Serial Data Transmission.

Course Outcome:
After completing this laboratory course, the students will be able to design, fabricate, implement, and test their own micro-controller based systems.

SEMESTER V

CODE	COURSE OF STUDY	L	T	P	C
IC 301	Control System – I	3	0	0	3
IC 303	Data Structures & Algorithms	3	1	0	4
IC 305	Linear Integrated Circuits	3	0	0	3
IC 307	Industrial Instrumentation – II	3	0	0	3
EC 317	Principles of Communication Systems	3	0	0	3
	Elective 1	3	0	0	3
IC 309	Linear Circuits Laboratory	0	0	3	2
IC 311	Instrumentation Laboratory	0	0	3	2
	TOTAL	18	1	6	23

IC 301 CONTROL SYSTEMS-I

L	T	P	C
3	0	0	3

Course Objectives:

1. To teach a variety of classical methods and techniques for designing control systems.
2. To introduce and teach the iterative nature of most designs in order to achieve working systems.

Pre-requisites: Circuit Theory, Signals & Systems, Basic Electrical & Electronics Engg.

Review of Systems, Mathematical Models – Differential Equations, Linear Approximations, and Transfer Functions, Block Diagrams and Signal Flow Graphs

Feedback Control System Characteristics, and Performance Specifications on transients and steady-state, Stability of Linear Feedback Systems – Routh-Hurwitz criterion.

The Root Locus Method, Feedback Control System Analysis & Performance Specifications in Time-Domain, Design of Lead, Lag, and PID Controllers using Root Locus.

Frequency Response Methods, Nyquist's Stability Criterion, Bode Plots, Performance Specifications in Frequency-Domain, Stability Margins.

Design of Lag and PID controllers in Frequency Domain, Design of Lag-Lead Controllers using time-domain and frequency-domain methods.

Text Books:

1. Porf, R.C., & Bishop, R.H., *Modern Control Systems*, 12th edition, Prentice Hall, 2010.
2. Franklin, G.F., David Powell, J., & Emami-Naeini, A., *Feedback Control of Dynamic Systems*, 6th edition, Prentice Hall, 2009.

Reference Books:

1. Nise, N.S., *Control Systems Engineering*, 6th edition, Wiley, 2011.
2. Dutton, K., Thompson, S., & Barralough, B., *The Art of Control Engineering***,** Prentice Hall, 1997.

Course Outcomes:

1. The student understands translating physical phenomena into corresponding mathematical descriptions, and applies appropriate tools to analyze the behaviour of systems.
2. The student learns to deploy classical graphical tools to analyze and design control systems in time-domain.
3. The student understands that the frequency domain is a complementary point of view, and learns to design control systems in frequency-domain.
4. The student is exposed to the PID controllers prevalent in the Industry.

IC 303 DATA STRUCTURES AND ALGORITHMS

L	T	P	C
3	0	1	4

Course Objectives:

1. To introduce various techniques for representation of the data in the real world and expose the student to efficient storage mechanisms of data for an easy access.
2. To instill strong problem solving techniques using data structures, algorithms, and time-complexity.

Pre-requisites: Programming in C/C++ during first year B.Tech.

Introduction, Insertion sort, Time complexity, Growth of Functions, Recurrences, Merge sort

Heap sort, Quick sort, Counting sort, Radix sort, Bucket sort

Stacks and Queues, Linked lists, Pointers, Objects, Hash Tables, Binary Search Trees

Dynamic Programming, Greedy Algorithms, B-Trees, Graph Algorithms

Selected Topics – Fast Matrix multiplications & other operations, FFT, Number theoretic Algorithms, Binomial heaps, Fibonocci heaps, Introduction NP completeness.

Text Books:

1. Cormen, Leiserson, and Rivest, *Introduction to Algorithms*, 2nd Edition, Mc Graw Hill, New York, New Delhi, 1990.
2. Ronald L. Rivest, *Algorithms, Data structures and Programs*, Prentice Hall, New Jersey, 1990.
3. Horowitz, Sahni, and Rajasekaran, *Fundamentals of Algorithms*, Galgotia Publications, New Delhi, 1999.

Course Outcome:

Upon completion of this course, the student shall be equipped with

1. Designing and implementing various basic and advanced data structures.
2. A vast set of sorting and searching algorithms useful for various engineering applications.
3. An ability to choose appropriate algorithms for a given problem based on their complexity.
4. A flair to understand instrumentation & control engineering problems from a computational perspective.

IC 305 LINEAR INTEGRATED CIRCUITS

L	T	P	C
3	0	0	3

Course Objectives:

To provide in-depth analysis of

1. Various op-amp circuits with resistive feedback
2. Various op-amp circuits with dynamic feedback
3. Various signal conditioning circuits with A/D &D/A converter
4. Realization of controllers
5. Study of PLL

Op-amp model- characteristics- analysis op-amp circuits – Instrumentation amplifier- V/I &I/V converter- Transducer bridge amplifier

Analysis and design of First order and second order filter circuits and Oscillator circuits

Schmitt triggers- A/D &D/A converter- Sample and hold amplifiers - V/F &F/V converter

Log amplifier- Multivibrators- Realization of PID Controller, Lead compensator, Lag compensator, Analog multiplier- 555 Timer and its application, voltage regulators.

Principles and description of individual blocks of PLL and its application

Text Books:

1. Sergio Franco, *Design with operational amplifiers and analog integrated circuits,* 3rd edition Mc-Graw Hill Inc. 2014.
2. Roy D.Choudary and Shail Jain, *Linear Integrated Circuits*, New Age International, 2010.
3. Ramakant A. Gayakwad, *OP-AMP and Linear ICs*, 4th edition Prentice Hall, 2001.

Course Outcomes:

Upon the completion of course, the student will be able to

1. Various op-amp circuits with resistive feedback
2. Various op-amp circuits with dynamic feedback
3. Various signal conditioning circuits with A/D &D/A

IC 307 INDUSTRIAL INSTRUMENTATION – II

L	T	P	C
3	0	0	3

Course Objectives:

1. To enable the students to understand the fundamentals of various types of industrial measurements.
2. To equip the student with relevant practical knowledge to implement instrumentation requirements in process industries.

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 Books:

1. Doebelin E.O, *Measurement Systems: Application and Design*, McGraw Hill, 5th Edition, 2004.

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. Andrew W.G, *Applied Instrumentation in Process Industries – A survey*, Vol I &Vol II, Gulf Publishing Company, Houston, 2001
4. Spitzer D. W., Industrial Flow measurement, ISA press, 3rd Edition, 2005
5. Patranabis D., *Principles of Industrial Instrumentation*, Tata McGraw Hill Publishing Company Ltd, 2008.

Course Outcomes:

1. Sound knowledge on various flow and level measurement techniques.
2. Ability to prepare design documentation and execute the instrumentation requirements in process industries.

EC 317 PRINCIPLES OF COMMUNICATION SYSTEMS

L	T	P	C
3	0	0	3

Course Objectives:

To introduce the principles of analog and digital communication systems involving different modulation and demodulation schemes.

Amplitude modulation: AM, generation of AM waves, demodulation, DSBSC, SSB, VSB, FDM, AM receivers, Optical Communication, Microwave communications and Satellite Communications

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*, 3rd Edition, Tata McGraw Hill, 2007
3. J.S.Beasley&G.M.Miler, *Modern Electronic Communication, 9th Edition, Prentice-Hall, 2008.*

Reference Books:
1. B.P.Lathi,Modern Analog And Digital Communication systems, 3rd *Edition*, Oxford University Press, 2007
2. B.Carlson, *Communication Systems*, 3rd Edition, McGraw Hill Book Co., 1986.
3. Sam Shanmugam, *Digital and analog Communication Systems*, John Wiley, 1985.

Course Outcomes:

Students are able to

1. Develop an understanding of need for modulation and generation & detection of Analog modulation techniques.
2. Explore AM and FM Super heterodyne receiver working principle.
3. Discuss the techniques for generation and detection of pulse Analog modulation techniques
4. To understand the basic operation involved in PCM like sampling, quantization & encoding and are able to calculate and derive entropy and channel capacity.
5. To compare different communication system with various modulation techniques in the presence of noise by analytically.

IC 309 LINEAR CIRCUITS LABORATORY

L	T	P	C
0	0	3	2

Course Objectives :

Working Practice in simulation tools & Experiment test bench to learn the design and testing of various circuits (like amplifiers, filters, PLL and signal conditioning circuits) with digital and analog ICs

List of Experiments:

1. Op-Amp circuits with resistive feedback
2. Instrumentation Amplifier
3. Op-Amp filters
4. compensator circuits - Lead, Lag & PI
5. Schmitt trigger & Precision rectifiers
6. Waveform generators
7. Multivibrators
8. Phase Locked Loops
9. Combinatorial & Sequential circuits
10. Multiplexers & Demultiplexers
11. A/D and D/A converters

Course outcomes:

Ability to understand and analyze various electronic circuits and build electronic circuits for the purpose of control and processing of measured signal.

IC 311 INSTRUMENTATION LABORATORY

L	T	P	C
0	0	3	2

Course Objectives:

The aim of this lab is to impart an adequate knowledge and expertise to handle equipment generally available in an industry.

List of Experiments:

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 analyzer.
11. PC based ECG, pulse analyzer.
12. Audio tone analyzer.
13. Blood pressure calibrator.
14. Characteristics of I/P and P/I.
15. Measurement of flow using orifice, electromagnetic and positive displacement flowmeters

Course Outcomes:

Ability to understand and analyze Instrumentation systems and their applications to various industries.

SEMESTER VI

CODE	COURSE OF STUDY	L	T	P	C
CS 303	Computer Networks	3	0	0	3
IC302	Control System – II	3	0	0	3
IC304	Process Control	3	0	0	3
IC306	Product Design & Development (T)	2	0	3	2
	Elective 2	3	0	0	3
	Elective 3	3	0	0	3
IC308	Interfacing and Signal Processing Laboratory	0	0	3	2
IC310	Control Engineering Laboratory	0	0	3	2
	Industrial Lectures	0	0	0	1
	Internship / Industrial Training / Academic Attachment # (2 to 3 months duration during summer vacation)	0	0	0	2
	TOTAL	17	1	9	25

To be evaluated at the beginning of VII semester by assessing the report and conducting seminar presentations.

CS 303 COMPUTER NETWORKS

L	T	P	C
3	0	0	3

Objectives

1. To provide insight about networks, topologies, and the key concepts.
2. To gain comprehensive knowledge about the layered communication architectures (OSI and TCP/IP) and its functionalities.
3. To understand the principles, key protocols, design issues, and significance of each layers in ISO and TCP/IP.
4. To know the basic concepts of network security and its various security issues related with each layer.

Introductory Concepts - Network hardware - Network software - Physical layer - Guided transmission media - Cable television.

Data Link Layer - Design issues - Channel allocation problem - Multiple access protocols - Ethernet - Wireless LAN - 802.11 architecture.

Network Layer - Design issues - Routing algorithms - Congestion control algorithms - Quality of Service - Internetworking.

Transport Layer - Transport service - Elements of transport protocols - User Datagram Protocol - Transmission Control Protocol.

Application Layer - DNS - Electronic mail - World Wide Web - Multimedia - Network security.

Text Books

1. Tanenbaum A. S., Computer Networks, Pearson Education, Fourth Edition, 2003
2. Stallings W., Data and Computer Communication, Pearson Education, Fifth Edition, 2001

Reference Book:

Behrouz A. Foruzan, Data Communication and Networking, Tata McGraw Hill, 2004

Outcomes

Knowledge of basic network theory and layered communication architectures.
Ability to solve problems in networking

IC 302 CONTROL SYSTEMS -II

L	T	P	C
3	0	0	3

Course Objectives:

1. To introduce and teach advanced methods and techniques of linear system analysis and design from modern and digital control theory, and emphasize their interrelation.
2. To introduce mathematical modeling, analysis, and design of a larger class of systems in a unified framework.

Pre-requisites: Control Systems Design – I

State-space Models – Review of vectors and matrices, Canonical Models from Differential Equations and Transfer Functions, Interconnection of subsystems.

Analysis of Linear State Equations – First order scalar differential equations, System modes and modal decomposition, State Transition Matrix, Time-varying matrix case.

Lyapunov's stability theory for Linear Systems – Equilibrium points and stability concepts, Stability definitions, Linear system stability, The Direct method of Lyapunov, Use of Lyapunov's method in feedback design.

Controllability & Observability – Definitions, Controllability/Observability Criteria, Design of state feedback control systems, Full-order and Reduced-order Observer Design, Kalman canonical forms, Stabilizability & Detectability.

Digital Control Systems, Closed-loop Feedback Sampled-Data Systems, Stability Analysis, Implementation of Digital Controllers.

Text Books:

1. Hespanha, J.P., *Linear Systems Theory*, Princeton Univ. Press, 2009.
2. Brogan, W.L., *Modern Control Theory*, 3/e, Prentice Hall, 1990.

References:

1. Sontag, E.D., *Mathematical Control Theory*, 2/e, Springer Verlag, 2014.
2. Hinrichsen, D., & Pritchard, A.J., *Mathematical System Theory – I*, Springer, 2010.

Course Outcomes:

1. The student is exposed to an appropriate modern paradigm for the study of larger scale multi-input-multi-output systems.
2. The student understands the importance of linear algebra and matrix theory in designing practical control systems.
3. The student is motivated to study more general systems and their stability using Lyapunov's theory.
4. The student learns to implement modern control systems using a digital computer in the loop.

IC 304 PROCESS CONTROL

L	T	P	C
3	0	0	3

Course Objective:

1. To introduce students to the terminology, concepts and practices of input/output modeling and automatic process control.
2. To impart knowledgeable in the design of control systems and controller tuning for chemical processes.

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 and electrical actuators, Valve positioners. Pneumatic and electrical dampers, Control valves types, construction details, various plug characteristics. Valve sizing. Selection of control valves. Inherent and installed valve characteristics. Fail-safe operation, Cavitation and flashing in control valves 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. G.Stephanopoulos, *Chemical Process Control-An Introduction to Theory and Practice* Prentice Hall of India, New Delhi, 2nd Edition, 2005.
2. D.R. Coughanowr, *Process Systems Analysis and Control*, McGraw Hill, Singapore, 2nd Edition, 1991.
3. B.W. Bequette, *Process Control Modeling, Design and Simulation*, Prentice Hall of India, New Delhi, 2004.

Reference Books:

1. C.L.Smith and A.B Corripio., *Principles and Practice of Automatic Process Control*, John Wiley and Sons, New York, 2nd Edition 1998.
2. Paul W.Murril, *Fundamentals of Process Control Theory*, 3rd Edition, ISA press, New York, 2000.

Course Outcome:

1. To write balance equations using first principles modelling. and study various control modes.
2. To gain the knowledge of various controller designs and methods of controller tuning
3. To describe the different types of control valves and can identify the types by their inherent flow curves and study various control schemes and processes used in Chemical Industries.

IC 306 PRODUCT DESIGN AND DEVELOPMENT (T)

L	T	P	C
3	0	0	3

Course Objectives:

1. The aim of this course is to inculcate into the student the spirit of innovation and entrepreneurship. This is achieved in this course by making the students to develop a marketable product on their own as a group. At the end of this two semester course, the students will learn how to know the needs of the society and solve them using the technical knowledge at their disposal.
2. In this semester the students will learn some of the general concepts needed for new product development and simultaneously learn how to interact with the society outside the campus to learn about its needs. They also learn about how to get prototypes fabricated outside the campus.

TOPICS COVERED BY LECTURES

Introduction to product design – 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.

PRACTICAL WORK

Interaction with public outside the campus – Identifying customer needs – Product selection based on customer needs – Concept generation – Concept testing

Identifying fabrication requirements – Identifying fabricators for the project – Costing – Financial model for the product development – Finding outside finance for product development if possible. Patent search for the product.

SUMMER VACATION WORK

Students shall actively get information about fabrication of their product prototypes, especially if it involves outstation fabrication units. If they have decided on the final design, they may start work on their alpha prototypes.

EVALUATION

Only the theoretical component is evaluated during this semester. The practical component is evaluated at the end of the next semester.

Text Books:

1. Karl T. Ulrich and Steven D. Eppinger, *Product Design and Development*, 3rd Edition, Tata McGraw Hill.
2. Kevin Otto and Kristin Wood, *Product Design,* Pearson Education, 2003.

IC 308 INTERFACING AND SIGNAL PROCESSING LABORATORY

L	T	P	C
0	0	3	2

Course Objectives

1. To provide students with hands-on experience with building, programming, testing, and debugging Microcontroller, hardware construction and system evaluation.
2. To provide practical experience to the students in simulation softwares and real time interfacing cards and also to make them familiar with important programming/interfacing technique.

Prerequisites: Design of Signal conditioning circuits for sensors, Microcontroller programming.

List of Experiments

1. Tank level control simulation in LABVIEW.
2. Data acquisition and calibration of a given sensor using LABVIEW DAQ card
3. Temperature control of a water bath using LABVIEW DAQ card
4. Stepper motor interfacing and control with MC8051
5. ON/OFF Temperature control of a water bath using MC8051
6. Vibration control of a cantilever beam using MCCDAQ card in MATLAB.
7. On line system identification of a given system using MCCDAQ card in MATLAB.
8. Development of simple database application and publishing it in the web.
9. position and speed control of servomotor using MATLAB RTW.
10. Stabilizing inverted pendulum using MATLAB RTW.
11. ARM (ADC, DAC/keypad and LCD) interfacing.
12. Study of Filter response and FFT.

Course Outcomes:

On completion of this lab students will be familiar with

- LABVIEW and MATLAB simulation
- Different interfacing cards work with MATLAB and LABVIEW
- Modeling of a given system
- Implementation of simple closed loop control system in real time
- Publishing on line data in the web
- Microcontroller and ARM based real time control application

After studying the basics of interfacing through this lab the students will be able to apply their practical knowledge in designing, testing and simulation of any embedded and real time control system.

IC 310 CONTROL ENGINEERING LABORATORY

L	T	P	C
0	0	3	2

Course Objectives:

1. To provide knowledge on analysis and design of control system.
2. Students can apply MATLAB Real-time programming to collect process data.

List of Experiments:

1. Time response characteristics of a second order system.
2. Frequency 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 - Lead, Lag, Lead-lag
6. Design of state feedback controller.
7. Observer design - full order and reduced order

Course Outcomes:

1. Develop an ability to design control systems
2. Students can design and implement controller designs to regulate and control various processes and systems.

SEMESTER VII

CODE	COURSE OF STUDY	L	T	P	C
IC 401	Industrial Psychology	3	0	0	3
IC 403	Logic & Distributed Control Systems	3	1	0	4
IC 405	Analytical Instrumentation	3	0	0	3
	Elective 4	3	0	0	3
	Elective 5*	3	0	0	3
IC 407	Product Design & Development (P)	0	0	3	2
IC 409	Process Control Laboratory	0	0	3	2
IC 411	Comprehensive Examination	0	0	0	2
	TOTAL	15	1	6	22

IC 401 INDUSTRIAL PSYCHOLOGY

L	T	P	C
3	0	0	3

Course Objectives:

This course intends to inform the student about the psychological forces that shape the thoughts and actions of a human-being. This helps the students to apply this knowledge in the work-place and outside for the benefit of the employers and employees in the industry.

Definition – Development of psychology as a scientific discipline – Methods and application of psychology. Use of industrial psychology in recruitment, training, and performance evaluation of workers.

Process of perception and attitude – Perception organization – Gestalt approach – Attitude development.
Training – Aims – Principles of learning applicable to training – Effective training program. Meaning of intelligence – Factors of intelligence – Intelligence tests – Emotional intelligence – Creativity.

Personality – Definition – Determinants – Psychoanalytic theory – Assessment – Training.
Motivation – Concept – Theories (Maslow, Herzberg, and X, Y, Z, theory). Leadership – Styles – Power – Effectiveness – Guidance and counseling. Communication – Channels – Feedback

Scope and aims of ethics in engineering – Moral reasoning and ethical theories – Code of ethics for engineers. Rights and responsibilities of employers and employees – Engineers as managers, consultants, and leaders.

Safe working environment for men and women in industry – Responsibility for safety – Safety in material handling – Personal protective equipment (PPE) – Safety and productivity – Accident prevention.

Text Book:

1. Tiffin, J. and McCormick, E.J. *Industrial Psychology,* 7th Edition, Prentice Hall, 1980.
2. Blum, M.L. and Naylor, J.C. *Industrial Psychology,* CBS Publishers Distributors, New Delhi, 2004.
3. BHEL Occupational Safety Manual

Course Outcomes:

After studying this course the student knows how to:

1. Apply industrial psychology in the work-place
2. Lead, motivate, communicate, and train
3. Be an ethical professional
4. Make the work-place safe

IC 403 LOGIC AND DISTRIBUTED CONTROL SYSTEMS

L	T	P	C
3	1	0	4

Course Objectives:
This course is designed to expose students to understand the process automation concepts like Programmable logic controller and Distributed control system.

Prerequisite: Fundamental knowledge of process control.

Review of PC based control design for process automation: Functional Block diagram of Computer control of process - Mathematical representation – Sampling Consideration- Data Acquisition system (DAS) and SCADA, Hybrid, Direct Digital Control System, Distributed Control system architecture and Comparison with respect to different performance attributes.

Programmable logic controller (PLC) basics: Definition, overview of PLC systems, Block diagram of PLC. General PLC programming procedures: Examine ON/OFF instruction, Timer instruction sets, Counter Instruction sets -Design, development and simulation of PLC programme using above instruction sets for simple applications.

PLC Data manipulation instruction - Arithmetic and comparison instruction- Skip, MCR and ZCL instruction – PID and other important instruction set. PLC Installation, troubleshooting and maintenance. Design of alarm and interlocks, networking of PLC – Case studies using above instruction sets.

Distributed Control system: Local Control Unit (LCU) architecture - Comparison of different LCU architectures – LCU Process Interfacing Issues: - Block diagram, Overview of different LCU security design approaches, secure control output design, Manual and redundant backup designs.

LCU communication Facilities - Communication system requirements – Architectural Issues – Operator Interfaces – Engineering Interfaces. Development of FCU diagram for simple control applications. Introduction to HART and Field bus protocol.

Text Books:

1.John W. Webb and 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.

Course Outcomes:
Upon completion of the course, the student will be able to

1. Understand the popular process automation technologies.
2. Design and development of PLC ladder programming for simple process applications.
3. Understand the different security design approaches, Engineering and operator interface issues for designing Distributed control system.
4. Know the latest communication technologies like HART and Field bus protocol.

IC405 ANALYTICAL INSTRUMENTATION

L	T	P	C
3	0	0	3

Course Objectives:
This course teaches the student about the analysis of materials which is an important requirement of process control and quality control in industry. The objective of this course is to make the student understand the basic principles used in various analytical methods. The student is then exposed to the various instruments used in the analysis of materials.

Electromagnetic radiation and its interaction with matter – Beer's law – Spectral methods of analysis –Absorption spectroscopy – Radiation sources – Monochromators – Filters – Prisms – Diffraction gratings – Detectors – Choice of solvents. UV-Visible spectrometers – single-beam and double-beam instruments.

Infrared spectrophotometer – IR sources – Cells – detectors – sample preparation. Analysis using Attenuated Total Reflectance (ATR). Atomic absorption spectrometry (AAS) – Wavelength choice –Sources – Cells – Detectors. Flame emission spectrometry. Atomic fluorescence spectrometry.

X-ray spectroscopy – X-ray absorption methods – X-ray fluorescence methods – X-ray diffraction. Radioactive measurement – Units of radioactivity – Application of radio-nuclides in analysis – Radioactivity detectors. Nuclear magnetic Resonance (NMR) spectroscopy – Basic principles – Continuous-wave NMR spectrometer – Pulsed Fourier Transform NMR spectrometer – NMR applications.

Sampling – Sample collection for gas, liquid, and solid analysis. pH measurement – Basic principles –Ion selective electrodes – Glass and reference electrodes – pH meter and its calibration. Electrical conductivity measurement – Measuring circuit – Water and steam purity measurement using electrical conductivity. Oxygen measurement – Paramagnetic oxygen analyzers – Ceramic electrode for high temperature oxygen measurement – Dissolved oxygen measurement.

Flue gas analysis for pollution control – Measurement of CO, carbon di-oxide, NOX and SOX, dust and smoke measurement. Chromatography – Basic principles of liquid and gas chromatography – Column details – Detectors for chromatography – Thermal conductivity detector – Flame ionization detector – Flame photometric detector – Electron capture detector – Effect of temperature programming – High pressure liquid chromatography (HPLC).

Text Books:
1. Braun, Robert D., *Introduction to Instrumental Analysis,* Pharma Book Syndicate, Hyderabad. 2006.
2. Ewing, G.W., *Instrumental Methods of Analysis*, 5^{th} Edition, McGraw Hill, Singapore, 1992.
3. Jain, R.K., *Mechanical and Industrial Measurements*, Khanna Publishers, Delhi,1999

Reference Books:
1. Liptak, B.G. *Process Measurement and Analysis,* 4^{th} Edition, CRC Press, Washington, 2003.
2. Considine, D.M. *Process/Industrial Instruments and Controls Handbook*, 4^{th} Edition, McGraw Hill, Singapore, 1993.
3. Sherman, R.E. and Rhodes L.J., *Analytical Instrumentation,* ISA Press, New York, 1996.

Course Outcomes:
After studying this course:
1. The student learns the relevance of material sampling and analysis in process control and quality control in industry.
2. The student knows the various physical principles behind the various widely used analytical methods in the industry.
3. The student becomes familiar with the various analytical instruments used widely in the industry.

IC407 PRODUCT DESIGN AND DEVELOPMENT (P)

L	T	P	C
0	0	3	2

Course Objectives:

The aim of this course is to inculcate into the student the spirit of innovation and entrepreneurship. This is achieved in this course by making the students to develop a marketable product on their own as a group. At the end of this two semester course, the students will learn how to know the needs of the society and solve them using the technical knowledge at their disposal. In this semester the students will learn how to get prototypes fabricated outside the campus. They will learn how to fabricate an alpha prototype and test it for its conformity to the design specifications. Then proceed to fabricate a beta prototype that is acceptable at the market place.

PRACTICAL WORK

1. Alpha prototype fabrication and testing
2. Beta prototype fabrication and customer acceptance survey

Course Outcomes:

After this two semester course:

1. The student will know how to make market surveys for new product development
2. The student will know the entire cycle of new product design and development.
3. The student will know how to fabricate prototypes of new products and test them.

IC 409 PROCESS CONTROL LABORATORY

L	T	P	C
0	0	3	2

Course Objectives:

The course aims to give the students

1. Practical experience in PC based data acquisition, analysis and control of different process trainers.
2. To understand the industrial automation concept and programming techniques.

List of Experiments:

1. Identification of FOPDT and SOPDT process using time domain and frequency domain techniques.
2. Design of different PID controller for FOPDT and SOPDT process using different standard technique and evaluate qualitative & quantitative performance.
3. Study of Different Process trainers.
4. Design and Verification of Combinational & Sequential Circuits Using PLC.
5. Design of PID Controller for a Level Process/Temperature/Flow/Pressure process stations and evaluate servo/regulatory responses.
6. Study the effect of different PID Controller Parameters.
7. Study of Pressure to Current & Current to Pressure Convertor.
8. Design of Timer and Counter Using PLC.
9. Design of PLC programming for practical applications.
10. Design of Cascade and Feed forward-feedback Controller using simulation software.
11. Study of Control Valve Characteristics.
12. Study of Distributed control system.

Course Outcomes:

After completing this course, the student can able to

1. Design the PID controller for different real time process trainers using standard techniques and able to evaluate servo-regulatory responses.
2. Design PLC ladder logic program for simple Real-time applications.
3. Understand the different DCS programming techniques.

SEMESTER VIII

CODE	COURSE OF STUDY	L	T	P	C
IC 408	Industrial Economics and Management	3	0	0	3
	Elective 6	3	0	0	3
	Elective 7*	3	0	0	3
	Elective 8*	3	0	0	3
IC 488	PROJECT WORK	0	0	15	6
	TOTAL	12	0	15	18

* GLOBAL ELECTIVES ALSO

IC408 INDUSTRIAL ECONOMICS AND MANAGEMENT

L	T	P	C
3	0	0	3

Course objectives:

1. This course teaches the student how to scientifically manage men and materials to achieve the productive use of both.
2. The student also learns how to sell the produced goods in a competitive market place to sustain the productive process financially.

INDUSTRIAL ECONOMICS

Fundamental concepts – Demand and supply – Cost and revenue – Price and income. Consumer behavior – Elasticity of demand and demand forecasting. Cost concepts – Cost, volume, profit analysis– Break even analysis. Engineering economy – Equivalence – Value of time – Present value and annual equivalent cost – Rate of return – Replacement analysis – Generation and evaluation of alternatives in engineering situations and projects - Replacement and inventory.

PRINCIPLES OF MANAGEMENT

Managerial functions – Scientific management – Types of organizations – Plant organization – Organization design – Authority, responsibility and span of control – Types of ownership – Advantages and disadvantages.

FINANCIAL MANAGEMENT

Nature and functions of money – Functions of commercial and central banks – Credit creation in banks – Sources of finance for industries – Cash flow statement – Principles of accounting – Inventory Management, Preparation of balance sheet – Management accounting.

QUALITY CONTROL AND MARKETING MANAGEMENT

Quality and quality control – Quality assurance – ISO 9000 and total quality management (TQM) – reliability, maintainability, and maintenance management. Marketing – Definition – Market research – Need for marketing – Sales forecasting – Product life cycle – Market segmentation - Relationship between quality and market share.

PERSONNEL MANAGEMENT

Functions of personnel management – Selection and recruitment – Training and development – Job Evaluation and merit rating. Concepts of industrial relations – Causes of industrial disputes – Grievance handling procedures –Employee participation in management – Welfare measures – Union-management relations.

Text Books:

1. Gupta, G.S. *Managerial Economics*, 2nd Edition, Tata McGraw Hill, 2011.
2. Prasad, L.M. *Principles and Practice of Management*, 7th Edition, Sultan Chand & Sons, 2007.
3. Kotler, P. and Keller, K. *Marketing Management*, 14th Edition, Pearson Education, 2011.
4. Davar, R.S. *Personnel Management and Industrial relations*, 10th Edition,
Vikas Publishing House, 2009.
5. Koontz, H. *Essentials of Management*, 8th Edition, Tata McGraw Hill, 2010.

Course Outcomes:

After completing this course, the student will know how to:

1. Manage an industrial facility
2. Raise finance to start a company
3. Assure the quality of a manufactured product and market it.

LIST OF ELECTIVES

GROUP 1 (INSTRUMENTATION STREAM)					
CODE	**COURSE OF STUDY**	**L**	**T**	**P**	**C**
IC001	Virtual Instrument Design	3	0	0	3
IC002	Micro System Design	3	0	0	3
IC003	Smart Materials & Systems	3	0	0	3
IC004	Opto-Electronics & Laser Based Instrumentation	3	0	0	3
IC005	MEMS & Nanotechnology	3	0	0	3
IC006	Power Plant Instrumentation and Control	3	0	0	3
IC007	Biomedical Instrumentation	3	0	0	3
IC008	SMART and Wireless Instrumentation	3	0	0	3
GROUP 2 (CONTROL STREAM)					
CODE	**COURSE OF STUDY**	**L**	**T**	**P**	**C**
IC021	Computational Techniques in Control Engineering	3	0	0	3
IC022	System Identification	3	0	0	3
IC023	Fault Detection & Diagnosis				
IC024	Cooperative Control Systems	3	0	0	3
IC025	Digital Control System	3	0	0	3
IC026	Robotics	3	0	0	3
IC027	Neural Networks and Fuzzy Logic Control	3	0	0	3
IC028	Design of Automotive Systems	3	0	0	3
GROUP 3 (Common STREAM)					
CODE	**COURSE OF STUDY**	**L**	**T**	**P**	**C**
IC041	Electron Devices	3	0	0	3
IC042	Electrical Machines	3	0	0	3
IC043	Digital Signal Processing	3	0	0	3
IC044	Power Electronics	3	0	0	3
IC045	Embedded Systems	3	0	0	3
IC046	Engineering Optimization	3	0	0	3
IC047	Sensor Networks	3	0	0	3
IC048	Uncertainty Analysis in Engineering	3	0	0	3
IC049	Probability & Computing	3	0	0	3
IC050	Image Processing	3	0	0	3
IC051	ARM System Architecture	3	0	0	3
IC052	Introduction to Chemical Processes	3	0	0	3
IC053	Disaster Management	3	0	0	3

IC 001 VIRTUAL INSTRUMENT DESIGN

L	T	P	C
3	0	0	3

Course Objectives:

The aim of the course is to make the student capable of designing a virtual instrument on their own depending on the application.

Transducer Interfacing

Interfacing techniques for the following transducers: Potentiometers - Temperature sensors – Thermocouple, RTD, Thermistors – Load cells – High and low range tension, Low and mid range precision – Torque Sensors –Pressure sensors – Vibration Sensors – Acoustic Sensors – Automotive Sensors – Displacement sensors – Biomedical transducers.

Signal Conditioning

Filtering, Cold Junction Compensation, Amplification, Instrumentation Amplifier – Linearization – Circuit Protection - Ground loops, CMRR, Noise Reduction and Isolation, Attenuation – Multiplexing – Digital signal conditioning – IEEE1451 standards – Transducer Electronic Data Sheet (TEDS)

Data Acquisition and Hardware Selection

Overview of DAQ architecture – Analog IO & Digital IO - Finite and continuous buffered acquisition – Data acquisition with C language - Industrial Communication buses – Wireless network standards - Micro-controller selection parameters for a virtual instrument – CPU, code space (ROM), data space (RAM) requirements.

Real-Time OS for Small Devices

Small device real-time concepts – Resources - Sequential programming - Multitasking - RTOS – Kernels – Timing loops – Synchronization and scheduling – Fixed point analysis – Building embedded real-time application for small devices.

Graphical User Interface for Virtual Instrument

Building an embedded Virtual Instrument GUI – Text and Number display – GUI Windows management. – Simulation – Display drivers – Creating and distributing applications – Examples of Virtual Instrument design using GUI in any of the applications like consumer goods, robotics, machine vision, and process control automation.

Text Books:

1. Daniel H. Sheingold, *Transducer Interfacing Handbook – A Guide to Analog Signal Conditioning*, Analog Devices Inc. 1980.
2. Kevin James, *PC Interfacing and Data Acquisition - Techniques for Measurement,Instrumentationa and Control,* Newnes, 2000.
3. Timothy Wilmshurst, *Designing Embedded Systems with PIC Microcontrollers –Principles and Applications*, Elsevier, 2007.

Reference Books:

1. Jean Labrosse, *Embedded System Building Blocks,* 2nd Edition. R&D Books, 2000
2. Jean Labrosse, *MicroC/OS-II* – The Real-Time Kernel, 2nd Edition. CMP Books, 2002

Course Outcomes:

After completing this course, the student will be able to:

1. Choose the interface the target transducer to the signal conditioning board
2. Condition the acquired signal from the transducer to standard data formats
3. Select the most appropriate hardware for the virtual instrument to be built
4. Implement the real-time OS for the selected micro-controller and the GUI interface for the virtual instrument.

IC 002 MICRO SYSTEM DESIGN

L	T	P	C
3	0	0	3

Course Objectives:

This course is designed to provide an introduction to microsystem technology and MEMS fabrication technologies followed by basic sensing and actuation principles of microsensors and actuators.

Prerequisite: Basics in physics, microelectronics, mechanics

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)

Course Outcome:

Upon undergoing this course, the student will be able to

1. Knows materials and methods to process sensors, actuators, and microsystems.
2. Generate complex systems similar to microelectronics for physical, chemical, biological and optical parameters for applications in mechanical, fluidic and optical Systems.
3. Analyze and describe of the functional behaviour.
4. Solve Problem and Evaluate of the potential of Microsystems.

IC 003 SMART MATERIALS & SYSTEMS

L	T	P	C
3	0	0	3

Course objectives:

To provide the student with knowledge for analysis and design of intelligent structures for aerospace, mechanical, and civil applications using different smart materials.

Prerequisites: Foundational knowledge from Principles of mechanics, including basic statics, dynamics, and strength of materials, machine or structure design

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 and their applications: Magnetostrictive materials, Electrostrictive materials, Magnetic Shape Memory Alloy, Composites, Ionic Polymer Metal Composites. Bio inspired engineering and micro electro mechanical systems using smart materials

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.

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

4. Culshaw B., *Smart structures and Materials*, Artech house, 1996

5. Leo, D.J. *Engineering Analysis of Smart Material Systems*, Wiley, (2007).

Web Resources:

1. www.iop.org/sms
2. www.jim.sagepub.com

Course Outcomes:

Upon completion of this course, the student will:

1. Perform detailed analysis of the response of materials and systems exhibiting piezoelectricity and apply principles of dynamic elasticity for structural health monitoring and repair
2. Perform detailed analysis of the response of systems exhibiting shape memory effects
3. Demonstrate knowledge of electro-active fluidic systems
4. Design simple intelligent structural systems to meet specific performance requirements.
5. Communicate principles of mimicking biological systems for engineering solutions

IC 004 OPTO-ELECTRONICS AND LASER BASED INSTRUMENTATION

L	T	P	C
3	0	0	3

Course Objective:

To expose the students to the basics of Lasers and Laser established sensors .

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

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

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 vaporisation, calculation of power requirements.

Text Books:

1. Wilson and Hawkes, *Opto Electronics - An Introduction*, 2 nd Edition, Prentice Hall, New Delhi, 2003.
2. Bhattacharya P, *Semiconductor Optoelectronics*, 2nd Edition, Prentice Hall, New Delhi, 2002.
3. Djafar.K.Mynbaev, Lowell.L.Scheiner, *Fiber-Optic Communications Technology*, 1/e, Pearson Education Pte. Ltd., 2008.

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*,1/e, John Wiley, 1998.
3. Kasap, *Optoelectronics and Photonics: Principles and practices*, 2/e ,Pearson Education, 2012.
4. R.P.Khare, *Fibre Optics and Optoelectronics, Oxford Press,* July 2004

Course Outcomes:

Upon completion of this course, the student will:

1. Know the types of lasers,
2. Laser characteristics and its applications to design the laser based instrument sensors.

IC 005 MEMS AND NANO TECHNOLOGY

L	T	P	C
3	0	0	3

Course Objectives:

1. To gain in-depth knowledge and understanding on microsystems, with emphasis on different micro-electromechanical actuator types, on their working principles, concept and design, process technology, clean-room fabrication, device characterization, and failure analysis.
2. To introducing the concepts of microelectromechanical devices.
3. To know the fabrication process of Microsystems.
4. To know the design concepts of micro sensors and micro actuators.
5. To introducing concepts of quantum mechanics and nano systems.

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.

Text Books:

1. Tai Ran Hsu, *MEMS & Microsystem Design and Manufacture*, Tata McGraw Hill, New Delhi 2002.
2. Marc Madou, *Fundamentals of Micro fabrication*, 2/e ,CRC Press, 2002.
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*, Taylor & Francis Group,2002.
5. Bharat Bhushan, *Handbook of Nanotechnology*, 3rd Edition, Springer, 2010.

Course Outcomes:

Upon successfully completing the course, the student will be able to:

1. propose, plan and develop MEMS/NEMS system devices and actuators for different application requirements
2. understand multidomain problems: thermal, fluidic, mechanical and electrical design a fabrication process of a MEMS/NEMS device
3. accurate modelling and simulating by modelling using state-of-the-art multi-physics finite-element based design tools (FEM)

IC 006 POWER PLANT INSTRUMENTATION AND CONTROL

L	T	P	C
3	0	0	3

Course objectives:

1. To provide a window of applications of instrumentation and automation in power plants.
2. Additionally students know about the various methods of power generation and its control methods.

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 CO2 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.

Course Outcomes:

1. An understanding on various power generation process, Important parameter to be monitored and controlled, Various parameters to be analyzed and monitored
2. Various instruments involved in and its controlling process
3. An ability to design and conduct experiments, as well as to analyze and interpret data

IC 007 BIOMEDICAL INSTRUMENTATION

L	T	P	C
3	0	0	3

Course Objectives:

1. This course gives a brief introduction to the instrumentation for measuring and analyzing the physiological parameters related to the human anatomy.
2. The present syllabus is organized taking into considerations the development of Instrumentation technology in the field of medicine for health care industry.

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: Measurement of blood pressure using sphygmomanometer instrument based on Korotkoff sound, indirect measurement of blood pressure, automated indirect measurement, and specific direct measurement techniques. Heart sound measurement - stethoscope, phonocardiograph. EMG - Evoked potential response, EEG, foetal monitor. ECG, phonocardiography, vector cardiograph, 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, physiotherapy, diathermy, nerve stimulator, Heart lung machine, Hemodialysis, ventilators, infant incubators, drug delivery devices, therapeutic applications of the laser.

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

Medical imaging systems: X ray machine, Computer tomography, ultrasonic imaging system, magnetic resonance imaging system, thermal imaging system, positron emission tomography.

Text Book:

1. Leslie Cromwell, Fred J. Weibell and Erich A. Pfeiffer, *Biomedical Instrumentation and Measurements*, Prentice Hall of India, New Delhi,2007.
2. Joseph J. Carr and John M. Brown, *Introduction to Biomedical Equipment Technology*, 4/e Cbs Publishers & Distributors, Prentice Hall 2000.

Reference Books:

1. L.A.Geddes and L.E.Baker, *Principles of Applied Biomedical Instrumentation,* 3rd Edition, John Wiley, New York, 2009.
2. R.S.Kandpur, *Handbook of Biomedical Instrumentation*,2/e, Tata McGraw Hill, New Delhi, 2003.

Course Outcomes:

Students are able to

1. Understand the basic knowledge of physiology.
2. Explore the occurrence of potential and operation of cardiovascular measurements.
3. Understand the basic knowledge on respiratory and pulmonary measurements.
4. Discuss the methods used for monitoring the patients.
5. Be familiar with the various imaging systems used in the hospitals.

IC 008 SMART AND WIRELESS INSTRUMENTATION

L	T	P	C
3	0	0	3

Course Objective:

1. To provide the adequate knowledge on smart instrumentation and wireless networks.
2. After successful completion of the course, the learner will be able to
    - Design self-diagnosing instrumentation system
    - Understand the issues in power efficient systems
    - Design wireless instrumentation systems for the given requirement

Prerequisites: Sensors and Transducer / Equivalent subject

Sensor Classification-Thermal sensors-Humidity sensors-Capacitive Sensors-Planar Inter digital Sensors-Planar Electromagnetic Sensors-Light Sensing Technology-Moisture Sensing Technology-Carbon Dioxide (CO_2) sensing technology-Sensors Parameters

Frequency of Wireless communication-Development of Wireless Sensor Network based Project-Wireless sensor based on Microcontroller and communication device-Zigbee Communication device.

Power sources- Energy Harvesting –Solar and Lead acid batteries-RF Energy /Harvesting-Energy Harvesting from vibration-Thermal Energy Harvesting-Energy Management Techniques-Calculation for Battery Selection

Tedes IEEE 1412- Brief description of API mode data transmission-Testing the communication between coordinator and remote XBee- Design and development of graphical user interface for receiving sensor data using C++; A brief review of signal processing techniques for structural health monitoring.

WSN based physiological parameters monitoring system- Intelligent sensing system for emotion recognition-WSN based smart power monitoring system.

Text Books:

1. Subhas Chandra Mukhopadhyay, “Smart Sensors, Measurement and Instrumentation”, Springer Heidelberg, New York, Dordrecht London, 2013.
2. Halit Eren, “Wireless Sensors and Instruments: Networks, Design and Applications”, CRC Press, Taylor and Francis Group, 2006

References:

1. Uvais Qidwai, Smart Instrumentation: A data flow approach to Interfacing“, Chapman & Hall; 1st Edn, December 2013.

IC 021 COMPUTATIONAL TECHNIQUES IN CONTROL ENGINEERING

L	T	P	C
3	0	0	3

Course Objectives:

1. To emphasize the importance of control system design in the current computer era and teach the interdisciplinary necessity of linear algebra, control theory, and computer science.
2. To describe and develop algorithms useful for practicing engineers for easy implementation on a range of computers.

Pre-requisites: Control Systems Design, Data Structures & Algorithms

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, Eigen value 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

Course Outcomes:

Upon completing this course, the student acquires skills in

1. Numerical solutions of state equations and frequency response computations.
2. Numerical algorithms for controllability, observability, and stability
3. Numerical solutions for conditioning of Lyapunov and algebraic Riccati equation
4. Large-scale solutions of control problems.

IC 022 SYSTEM IDENTIFICATION

L	T	P	C
3	0	0	3

Course Objectives:

The objective of this course is to provide the student with knowledge for mathematical modelling of systems from observations of their behaviour by parametric and non parametric identification methods using online and offline data sets.

Prerequisites: Continuous and discrete signal and system analysis, Linear Systems Theory, Linear Algebra, Basic Calculus, Basic Probability and Statistics.

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 (ARX, ARMAX, Box-Jenkins, FIR, Output Error models), Input signals: commonly used signals, spectral properties, and persistent excitation, Residual analysis for determining adequacy of the estimated models

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 using MATLAB/Equivalent software System Identification toolbox: Electro mechanical systems.

Text Books:

1. jung, L. *System Identification: Theory for the User*, 2nd Edition, Prentice-Hall, 1999, ISBN 0-13-656695-2.
2. Torsten Soderstrom, Petre Stoica, *System Identification*, Prentice Hall International (UK) Ltd. 1989.
3. Karel J. Keesman, *System Identification, An introduction,* Springer, 2011.
4. Zhu, Y. *Multivariable System Identification for Process Control*, Pergamon, 2001.

Course Outcomes:

Upon completion of this course, the student will:

1. Be familiar with different model structures, parameterization, identifiability, structure determination and order estimation
2. Be able to perform parameter estimation using different identification techniques
3. Be able to identify plants online using recursive estimation methods
4. Be able to set up an experiment, identify a nominal model, assess the accuracy/precision of this model, and make appropriate design choices to arrive at a validated model.

IC 023 FAULT DETECTION AND DIAGNOSIS

L	T	P	C
3	0	0	3

Course Objectives:

- To learn basic principle of Faulty detection and diagnosis

Prerequisites: Basic knowledge of Control Systems, Process control

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.

Course Outcomes:

Upon completion of this course, the students can able to

1. Know about different type of faults occurred in a system.
2. Understand Mathematical analysis of different faults.
3. Understand Structured and directional concepts techniques for FDI design.

IC 024 COOPERATIVE CONTROL SYSTEMS

L	T	P	C
3	**0**	**0**	**3**

Course Objectives:
1. To expose the student to the significant progress in the design and analysis of high-level decision making and intelligent control schemes
2. To teach the student advances in autonomous control system design techniques that deal with greater levels of modeling uncertainty

Pre-requisites: Control Systems Design, Data Structures & Algorithms

Introduction to cooperative control, Mathematical preliminaries, Algebraic graph theory, Matrices for cooperative control, stability of formations

Introduction to Consensus algorithms, Consensus for single and double integrator dynamics, Consensus in position, direction, and attitude dynamics

Distributed multi-vehicular cooperative control, Generalized cyclic pursuit

Spacecraft formation flying, UAV applications in search, coverage, and surveillance of large areas, and in monitoring and controlling of hazards, Routing and path planning of UAVs

Role of communication, Operation in uncertain environments and uncertainty.

Text Books:

1. J. Shamma (Ed): *Cooperative Control of Distributed Multi-Agent Systems,* John Wiley, 2008.
2. Z. Qu: *Cooperative Control of Dynamical Systems,* Springer Verlag, 2009.
3. W. Ren and R. Beard: *Distributed Consensus in Multi-vehicle Cooperative Control: Theory and Applications,* Springer, 2007.
4. S. Rasmussen and T. Shima (Eds.): *UAV Cooperative Decision and Control: Challenges and Practical Approaches,* SIAM Publications, 2008.

Course Outcomes:

Upon completing this course, the student
1. Is exposed to autonomous agents like mobile robots and UAVs
2. Learns about the fascinating ideas of formation control
3. Understands high-level decision making algorithms and their computational complexity
4. Various path planning algorithms that work in uncertain environments

IC 025 DIGITAL CONTROL SYSTEMS

L	T	P	C
3	0	0	3

Course Objectives:

To learn the digital control design techniques in PTF and State space domain

Prerequisites: Basic knowledge of Control Systems, Process control

Introduction- Merits and demerits of digital control system over analog control system - Importance of digital control system- Mathematical representation of SDCS - Open loop and closed loop response of SDCS - Modified Z Transform.

Transfer function of Zero order hold and first order hold circuit analysis - Frequency response of discrete time systems- Properties of frequency response of discrete time systems-Sampling theorem Stability analysis in Z domain - Different Techniques

Digital control algorithm requirements- Design of Dead beat, Dahlin, SMPC , IMC and other important digital control algorithm - Design and implementation of above control algorithm for simple FOPDT and SOPDT process.

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.

Controllability and observability, equivalent controllability/observability conditions. Design of state feedback and output feedback control. Design of observers.

Text Books:

1. Kannan M. Moudgalya, *'Digital Control'*, Wiley Publishers, 1st illustrated edition, 2007.
2. M.Gopal, '*Digital Control engineering'*, New Age International (ltd) Publishers,1st edition reprint(2003),1998.
3. Deshpande P.B. & Ash R.H – "Computer Process Control" - ISA publication, USA 1995

Reference Books:

1. M. Sam Fadalli, "Digital Control Engineering Analysis And Design", Elsiever publication, 1st edition, 2012..
2. Katsuhiko Ogata, "Discrete Time Control Systems", Pearson Education Publications,2 nd edition, 2005.

Course Outcomes:

Upon completion of this course, the students can able to

1. Understand the fundamental differences between continuous time control and digital control.
2. Design and simulate for digital control algorithms for simple FOPDT and SOPDT models.
3. Understand the Stability analysis in Z domain.
4. Develop state space models in discrete domain and check controllability & observability conditions
5. Design and simulate the state feedback , output feedback and observer for simple applications.

IC 026 ROBOTICS

L	T	P	C
3	0	0	3

Course Objectives:

1. To introduce robotics in the fields of manufacturing, medicine, search and rescue, service, and entertainment.
2. To teach robotics as the synergistic integration of mechanics, electronics, controls, and computer science.

Pre-requisites: Control Systems Design

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, M.W., Hutchinson, H., & Vidyasagar, M., "*Robot Modeling and Control*", John Wiley (Wiley India Ed.), 2006.
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.

Course Outcome:

Upon undergoing this course, the student

1. Learns the mathematics of rigid motions, rotations, translations, velocity kinematics
2. Gets introduced to the most popular methods for motion planning and obstacle avoidance
3. Understands robot dynamics and multivariable control
4. Shall acquire familiarity with computer vision, visual servo control problems and applications in the industry.

IC 027 NEURAL NETWORKS AND FUZZY LOGIC CONTROL

L	T	P	C
3	0	0	3

Course Objective:

This course is designed to expose students to fundamentals of neural network and fuzzy logic.

Prerequisite: Fundamental knowledge of control system and its application.

Introduction to fuzzy logic and neural networks, Classification, Merits and demerits of intelligent techniques compared to conventional techniques. Need of an intelligent techniques for real world Engineering applications.

Supervised and Unsupervised Neural networks: Perceptron, Standard back propagation Neural network: Architecture, Algorithm and other issues. Discrete Hopfield's networks, Kohnen's self-organizing maps, adaptive resonance theory (ART1).

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

Fuzzy set and operations, Fuzzy relations, Fuzzifications, Fuzzy rule based systems, defuzzificaiton fuzzy learning algorithms.

Fuzzy logic for control system with case studies. Introduction to neuro-fuzzy system and genetic algorithm.

Text Books:

1. Timothy J. Ross, Fuzzy Logic with Engineering Applications, John Wiley & Sons Ltd Publications, 3rd edition, 2010.
2. Laurene Fausett, Fundamentals of Neural networks, Pearson education, Eight Impression, 2012.

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. Zdenko Kovacic, Stjepan Bogdan, Fuzzy Controller Design Theory and Applications, CRC Press, 1st edition, 2006.
4. Satish Kumar, Neural Networks–A classroom approach, Tata McGraw-Hill Publishing Company Limited, 2013

Course Outcomes:

Upon completion of the course, the student will be able to

1. Understand the basic principles of fuzzy logic and neural network.
2. Apply and analyze the neural network and Fuzzy logic for Identification and control design for simple applications.
3. Understand the importance of other intelligent techniques like neuro-fuzzy logic and genetic algorithm.

IC 028 DESIGN OF AUTOMOTIVE SYSTEMS

L	T	P	C
3	0	0	3

Course Objective:

1. To acquire knowledge on sensor and measuring systems used in automotive industry.
2. To understand the functionality of automotive systems.
3. To gain the modeling and control system design for automotive system.

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, Active suspension system Temperature control, CAN bus.

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

Course Outcomes:

Upon completion of the course, the student will be able to

1. Understand the basic knowledge of sensor and measuring system.
2. Explore the various system utility.
3. Design the basic modeling and control scheme for automotive systems.
4. Build a system for practical applications.

IC 041 ELECTRON DEVICES

L	T	P	C
3	0	0	3

Course Objectives:

1. To give the students a comprehensive introductory account of electronic devices and their operational principles.
2. To encourage students to understand the physics and mathematical formulations of important semiconductor devices

Pre-requisites: Basic Physics and Mathematics.

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. 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, Punch through and other breakdown mechanisms, Photo-voltic 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, 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*, Wiley, 2003.

Reference Books:

1. D.A.Neamen, *Semiconductor physics and devices*, Irwin, 2002.
2. B.G.Streetman, *Solid state devices*, 4th Edition, PHI, 1995.
3. D.A.Pucknell & K.Eshraghian, *Basic VLSI Design*, 3rd Edition, PHI, 1996.

Course Outcome:

Upon completing this course the student

1. Learns to appreciate the internal working principles of various electron devices
2. Understands the construction and fabrication process of BJTs, FETs etc.
3. Is equipped with techniques to design advanced sensors and transducers
4. Develops interest in working for the electronic design industry

IC 042 ELECTRICAL MACHINES

L	T	P	C
3	0	0	3

Course Objectives:

1. This course aims to equip the students with a basic understanding of DC and AC machines
2. Machine parts and help to gain the skills for operating DC and AC Machines
3. The course also equips the students with ability to understand and analyze the equivalent circuits of DC and AC machines.

REVIEW OF COLOMBS' S LAW

Electrical field intensity and potential due to a point, line and surface charge distributions, Gauss's law and its application, Biot - savart's law, field due to straight, circular and solenoid conductors carrying currents, Force between current carrying conductors; Ampere's circuital law, Farms law of electromagnetic induction, Maxwell equation; displacement current, Plane wave solutions in dielectric and conducting media, Reflective index skin effect, Field energy and pointing vector.

D.C. MACHINES

Construction and theory of operation of D.C. generator, Characteristics of D.C. generator, D.C. motors of different types, Voltage equations, Back EMF, Characteristics of series. Shunt compound motor.

SYNCHRONOUS MACHINES

Basic principle of alternator, Construction of stator and rotor , Equation of induced EMF, Armature reaction, Vector diagram, Method of starting of synchronous motor, Torque developed by the motor, V-curves.

INDUCTION MACHINES

Construction and principle of operation, Squirrel cage rotor. Phase wound rotor, relation between torque and rotor power factor, Starting torque characteristics, Speed control of induction motor.

SPECIAL MOTORS

Types of single phase motor, Double revolving field theory. Repulsion type motor Brushless motors, Capacitor start capacitor run motor, Universal motor, A.C. and D.C. servomotors, Tacho generators.

Text Books:

1. Theraja B.L., *A Text book of Electrical Technology* , S.C.Chand and Co., New Delhi,2004.
2. Cotton H, *Advanced electrical technology,* CBS Publishers and Distributors. Delhi.

Reference Books:

1. Fitzgerald A.E. Kingsly C., Umans S.D.: *Electrical Machinery*; 5/e, McGraw Hill International Edition, 2002.
2. Verinott C. C , *Fractional and Subfraction Horse-Power Electric* Motors , McGraw Hill Book Co.
3. Del Toro V, *Electrical engineering fundamentals,* 2/e.Prentice Hall India. Eastern Economy Edition. 1998

Course Outcomes:

Upon the completion of the course, The student will be able to

1. Understand the constructional details and principle of operation of DC and AC machines
2. Analyze the performance of the DC and AC Machines under various operating conditions using their various characteristics.

Select appropriate DC and AC motor as well as to choose an appropriate method of speed control for any industrial application

IC 043 DIGITAL SIGNAL PROCESSING

L	T	P	C
3	0	0	3

Course Objective:

1. To provide better understanding of discrete-time and digital signal in time and frequency domain
2. To provide knowledge to analyse linear systems with difference equations
3. To design and implement FIR and IIR filters with different structures.
4. To introduce DSP processor and FFT processors.

Pre-requisites: Signals and systems

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, 2007.

3. Ifeachor, E.C., & Jervis, B.W., *Digital Signal Processing: A Practical Approach*, 2/e, Pearson Education Asia, 2009.

Reference Books:

1. McClellan, J.H., Schafer, R.W., & Yoder, M.A., *DSP First: A Multimedia Approach*, 2/e Prentice Hall Upper Saddle River, NJ, 2003.
2. Mitra, S.K., *Digital Signal Processing: A Computer-Based Approach*, 4/e ,McGraw Hill, NY, 2011 (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.

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

1. To analyse the signals in both time and frequency domain
2. To design FIR and IIR filters for signal pre-processing
3. To implement and realize the filters using different structures.
4. Explain the selection of DSP processor for signal processing applications.

IC 044 POWER ELECTRONICS

L	T	P	C
3	0	0	3

Course Objectives:

1. To introduce to students the theory and applications of power electronics systems for high efficiency, renewable and energy saving conversion systems
2. To prepare students to know the characteristics of different power electronics switches, drivers and selection of components for different applications
3. To develop students with an understanding of the switching behaviour and design of power electronics circuits such as DC/DC, AC/DC, DC/AC and AC/AC converters.

Prerequisites: Circuit analysis, Electron devices and Electronic circuits, and Differential equations

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*, 4th Edition, Prentice Hall, New Delhi, 2013.
2. Dubey G. K, Doradla S.R, Joshi and Sinha R.M, *Thyristorised Power Controllers*, New Age International Publishers, New Delhi, 2010.
3. John G. Kassakian, *Principles of Power electronics*, Addison Wesley, 1991

Reference Books:

1. Vedam Subramanyam K, *Power Electronics*, 2nd Edition, New Age International Publishers, New Delhi,2012.
2. Mohan, Undeland and Robbins, *Power Electronics: Converters, Applications, and Design*", John Wiley and Sons, New York, 1995.
3. Joseph Vithyathil, *Power Electronics*, McGraw Hill, New York, 1995.

Course Outcomes:

1. This course prepares students to work professionally in the area of power and power related fields.
2. Students will have good understanding of the basic principles of switch mode power conversion
3. Students will be able to apply knowledge of mathematics and engineering, and identify formulas to solve power and power electronics engineering problems.
4. Students will be able to choose appropriate power converter topologies and design suitable power power stage and feedback controllers for various applications like microprocessor power supplies, renewable energy systems and control of motor drives.

IC 045 EMBEDDED SYSTEMS

L	T	P	C
3	0	0	3

Course Objectives:

1. To provide an understanding of hardware and software design and integration for embedded system development
2. To provide knowledge of Real-time operating systems that can be used to enhance their skills in developing real-time embedded systems.
3. To review and develop an embedded system with 8051 core and PIC controllers

Pre-requisites: Knowledge in microprocessor architecture and programming in C

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.

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.

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.

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 its 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, 2005.
3. Qing Li and Carolyn, *Real-Time Concepts for Embedded Systems,* CMP Books, 2003.
4. John G. Proakis and Dimitris K Manolakis, *Digital Signal Processing: Principles Algorithms and Applications,* PHI, 4th Edition, 2006.

Course Outcomes:

On completion of this course students will be able to:

1. Identify the specific processor and design for embedded application development
2. To demonstrate their competence and ability to develop a real-time embedded systems.
3. Explain the concepts of DSP based embedded systems design.

IC 046 ENGINEERING OPTIMIZATION

L	T	P	C
3	0	0	3

Course Objectives:

1. To introduce optimization techniques to the students
2. To teach an array of methods widely used in the industry and academia.

Pre-requisites: Mathematics courses, Control Systems Design, Data Structures & Algorithms.

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 in process industries.

Reference Books:

1. Taha, A.H., *"Operations Research,"* 8/e, Pearson Education, 2011.
2. Kanti Swarup, Gupta, P.K and Man Mohan, "*Operation Research*", Sultan Chand, 11th Edition, 2003.
3. Rao, S.S., "*Optimization: Theory and Applications*", Wiley Eastern, 1978.
4. David E. Goldberg, "*Genetic Algorithms in Search, Optimization & Machine Learning"*, Addison Wesley Publishing Company, Inc., 1989

Course Outcomes:

1. Formulate engineering problems as mathematical optimization problems
2. Have a basic understanding of numerical optimization algorithms
3. Learn unconstrained and constrained optimization methods and applications
4. Use mathematical software for the solution of optimal engineering problems

IC 047 SENSOR NETWORKS

L	T	P	C
3	0	0	3

Course Objectives:

1. To provide an understanding of wired and wireless sensor networks and challenges in its implementation
2. To provide knowledge to design a central and end point sensor nodes
3. To provide insight into the performance analysis of MAC and physical layer protocols and data security

Pre-requisites: The knowledge in Embedded systems and computer networks

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

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

Course Outcomes:

On completion of this course students will be able to:

1. Differentiate sensor network from computer networks.
2. Design and program a wireless sensor node for any application.
3. Analyse the performance measures of MAC layer and physical layer protocols
4. Explain the concepts of localization and data security

IC 048 UNCERTAINTY ANALYSIS IN ENGINEERING

L	T	P	C
3	0	0	3

Course Objective:

Student can able to understand the importance and differ techniques of uncertainty analysis for engineering application.

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.

Course outcome:

1. The student can able to analyses the different uncertainities in measurement system with simple case studies.
2. The student can able to explore the different interval based analysis techniques for uncertainity analysis.
3. The student can effectively apply the uncertainity techniques for engineering application and validation can be done using simulation environment.

IC 049 PROBABILITY AND COMPUTING

L	T	P	C
3	0	0	3

Course Objectives:

1. To provide a thorough grounding in discrete probability to the students and expose them to its applications in computational, mathematical, and engineering sciences
2. To teach more advanced topics such as entropy, Markov Chain Monte Carlo methods useful for large scale control system design

Pre-requisites: Mathematics III, Mathematics IV, Data Structures & Algorithms

Events and Probability: Verifying Polynomial Identities, 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 Queues

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 Books & References:

1. Mitzenmacher M. & Upfal E., *Probability and Computing,* Cambridge Univ. Press, 2005.
2. Motwani, R. & Raghavan, P., Randomized Algorithms, Cambridge Univ. Press, 2002.

Course Outcomes:

Upon completing this course, the student

1. Learns the core material such as Chernoff bounds and Markov Chains.
2. Gets familiarized with probabilistic models using Balls & Bins and Random Graphs.
3. Is exposed to the role of randomization in modern applications ranging from combinatorial optimization, machine learning to networked control systems and cyber security.
4. Understands probabilistic techniques and paradigms used in the development of advanced algorithms for engineering applications.

IC 050 IMAGE PROCESSING

L	T	P	C
3	0	0	3

Course Objectives:

To treat the 2D systems as an extension of 1D system design and discuss techniques specific to 2D systems.

Linearity and space-invariance. PSF, Discrete images and image transforms, 2-D sampling and reconstruction, Image quantization, 2-D transforms and properties.

Image enhancement- Histogram modelling, equalization and modification. Image smoothing , Image crispening. Spatial filtering, Replication and zooming, Generalized cepstrum and homomorphic filtering.

Image restoration- image observation models. Inverse and Wiener filtering. Filtering using image transforms. Constrained least-squares restoration. Generalized inverse, SVD and interactive methods. Recursive filtering.Maximum entropy restoration. Bayesian methods.

Image data compression- sub sampling, Coarse quantization and frame repetition. Pixel coding - PCM, entropy coding, runlength coding Bit-plane coding. Predictive coding. Transform coding of images. Hybrid coding and vector DPCM. Interframe hybrid coding.

Image analysis- applications, Spatial and transform features. Edge detection, boundary extraction, AR models and region representation. Moments as features. Image structure.Morphological operations and transforms.Texture.Scene matching and detection. Segmentation and classification.

Text Books:

1. Jain A.K., *Fundamentals of Digital Image* Processing, PHI, 1995.
2. Gonzalez R.C. & Woods R.E., *Digital Image Processing*, 2nd Edition, Pearson, 2002.

Reference Books:

1. Russ J.C., *The Image Processing Handbook*, 5th Edition, CRC, 2006.
2. Gopi E.S., *Digital Image processing using Matlab*, Scitech publications, 2006.

Course Outcomes:

Students are able to

1. Analyze the need for image transforms, types and their properties.
2. Become skilled at different techniques employed for the enhancement of images both in spatial and frequency domain.
3. Explore causes for image degradation and to teach various restoration techniques.
4. Evaluate the image compression techniques in spatial and frequency domain.
5. Gain knowledge of feature extraction techniques for image analysis and recognition.

IC 051 ARM SYSTEM ARCHITECTURE

L	T	P	C
3	0	0	3

Course Objectives:
To give the students a thorough exposure to ARM architecture and make the students to learn the ARM programming & Thumb programming models.

RISC machine. ARM programmer's model. ARM Instruction Set. Assembly level language programming. Development tools.

ARM organization. ARM instruction execution. ARM implementation. ARM coprocessor interface. . Interrupt response.

Floating point architecture. Expressions. Conditional statements. Loops. Functions and procedures. Run time environment.

Thumb programmer's model. Thumb Instruction set. Thumb implementation.

Memory hierarchy. Architectural support for operating system. Memory size and speed. Cache memory management. Operating system. ARM processor chips.

Text Books:

1. Furber S., *ARM System-on-chip Architecture,2/e* Addison-Wesley, 2000.
2. Andrew Sloss, Dominic Symes & Chris Wright, *ARM system Developer's guide*, Elsevier.2005.

Reference Books:

1. Technical reference manual for ARM processor cores, including Cortex, ARM 11, ARM 9 & ARM 7 processor families.
2. User guides and reference manuals for ARM software development and modeling tools.
3. David Seal, ARM Architecture Reference Manual, Addison-Wesley.

Course Outcomes:

On completion of this course students will be able to:

Describe the programmer's model of ARM processor and create and test assembly level programming.

IC 052 INTRODUCTION TO CHEMICAL PROCESSES

L	T	P	C
3	0	0	3

Course Objectives:

This is a course that intends to expose the non-specialist student to the broad spectrum of operations in the chemical engineering field. Each topic in the syllabus will be covered only briefly.

Concept of unit operations:

Unit processes and equipment's, comminution, mixing and separations. Mechanical operations Principles and equipment. Concepts of equilibrium and rate.

Heat mass and momentum transfer:

Entropy balance. Material balance, Heat transfer concepts and equipment, Heat exchangers, furnaces and evaporators. Refrigeration process.

Mass transfer concepts of staged processes:

Process Principles for distillation, absorption. Adsorption, humidification, drying and crystallization.

Fluid Flow Equipment:

Pipe fittings: pumps, compressors and blowers. Chemical reactors; Isothermal and non-isothermal operations. Concepts of reactor stability.

Case Studies of Operations

1. Paper and pulp manufacturing
2. Thermal power plant
3. Iron and steel manufacturing
4. Petrochemical refinery.

Text Books:

1. McCabe W.L.Smith J.C., Peter Harriot: *Unit operations of chemical engineering*, 7/e. McGraw Hill International Edition.2005.
2. Austin G.T, *Shreve's chemical process industries*, McGraw Hill International Edition.1985.

References:

1. Levenspiel O., *Chemical reaction engineering*,3/e.Wiley Eastern.
2. Hummelbalu, Riggs, *Basic Principles and Calculations in Chemical Engineering* 8/e, PHI learning private Ltd., New delhi.

Course Outcome: This course will help the student to understand the operation in Process Industry.

IC 053 DISASTER MANAGEMENT

L	T	P	C
3	0	0	3

Course Objective:

1. To describe natural and manmade disasters globally and to learn disaster mitigation.
2. After successful completion of this course, the learner will be able to
    - Distinguish natural and manmade disasters
    - Identify environmental hazards and level of toxicology
    - Analyze the causes and effects of Earthquake and Tsunami
    - Explain cyclone formation and preventive measures
    - Describe about modern technological tools in disaster management.

Disaster- Disaster management- Disaster prevention and preparedness measures-Types of disaster-Causal factor of disaster- Natural, manmade, creeping disaster- Disaster in Indian context- Various measures- Disaster related policy goals- United Nations Development Program (UNDP) – United Nations Disaster Relief Organization (UNDRO)- Govt. of India

Environmental hazards- Typology- Assessment and response-the strategies- the scale of disaster-Vulnerability- Disaster trends- Paradigms towards a balanced view- Chemical hazards and toxicology- Biological hazards- Hazard caused by world climate change- Risk analysis- Other technological disasters.

Earthquake- Causes of earthquake- Earthquake scales- Measures of earth quake- Magnitude and intensity- Earthquake recurrence hazard assessment- Seismic zoning- Earthquake disaster mitigation- Component research focus-Forecasting techniques and risk analysis-Tsunami- Causes of Tsunami-Effects of Tsunami-Tsunami warning system-Tsunami warning system in India-International status of Tsunami warning and communication system- Tsunami warning centers-Pacific Tsunami Warning Centre (PTWC), Pacific Tsunami warning system (PTWS) components-Institutional arrangements and design criteria for Tsunami mitigation.

Tropical cyclone- Warning system- Protection of buildings from cyclones- Precaution before and during cyclones- Tropical cyclone warning strategy in India- Cyclone related problems- Aerial survey- Management strategy- Risk reduction by public awareness and education.

Hazard map- Multi hazard mapping- Application of satellites in disaster management- Application of remote sensing in forecasting and disaster relief- Use of digital image processing in disaster management- GIS in disaster management- Spatial data- GIS database design- Convention mapping concepts and coordinate system- Methods of spatial interpolation in GIS.

Text Books:

1. Pardeep Sahni, Madhavimalalgoda and Ariyabandu, Disaster risk reduction in South Asia, PHI.
2. Amita Sinhal, Understanding earthquake disasters, TMH, 2010.

Course Outcomes:

1. Analyze the environmental disaster.
2. Study about the causes and measure of Tsunami.
3. Determine the application of technology in disaster management.

LIST OF ADVANCED LEVEL COURSES FOR B.Tech. HONOURS					
CODE	**COURSE OF STUDY**	**L**	**T**	**P**	**C**
IC 090	Instrumentation System Design	3	0	0	3
IC 091	Additional Topics in Control Engineering	3	0	0	3
IC 092	Advanced Process Control	3	0	0	3
IC 093	Nonlinear Control Systems	3	0	0	3
IC 094	Physiological Control Systems	3	0	0	3

IC 090 INSTRUMENTATION SYSTEM DESIGN

L	T	P	C
3	0	0	3

Objective

To obtain adequate knowledge in design of various signal conditioning circuits, instrumentation systems, controller and control valve.

FLOW AND TEMPERATURE

Orifice meter - design of orifice for given flow condition - design of rotameter -design of RTD measuring circuit - design of cold junction compensation circuit for thermocouple using RTD - Transmitters – zero and span adjustment in D/P transmitters and temperature transmitters.

PRESSURE AND LEVEL

Bourdon gauges - factors affecting sensitivity - design of Bourdon tube -design of Air purge system for level measurement.

VALVES

Control valves - design of actuators and positioners - types of valve bodies -valve characteristics - materials for body and trim - sizing of control valves - selection of body materials and characteristics of control valves for typical applications.

PUMPS

Types of pumps - pump performance - pipe work calculation - characteristics of different pumps - pump operation - maintenance - instruments used in pumping practice - pump noise and vibration - selection of pumps. Electronic P+I+D controllers - design - adjustment of setpoint, bias and controller settings.

MICROCONTROLLER BASED DESIGN

Design of logic circuits for alarm and annunciator circuits, interlocks - design of microcontroller based system for data acquisition - design of microprocessor based P+I+D controller.

Text Books

1. Anderson N.A., *Instrumentation for Process Measurment and Control*, 3/e,Routledge, 1997.
2. Considine D.M., *Process Instruments and Controls Handbook*, 5/e McGraw-Hill., 2009.

Reference Books

1. Johnson C.D., *Process Control Instrumentation Technology*, 8/e Prentice Hall of India, 2009.

Course Outcomes:

Ability to understand and analyze Instrumentation systems and their applications to various industries.

IC 091 ADDITIONAL TOPICS IN CONTROL ENGINEERING

L	T	P	C
4	0	0	4

Course Objectives:

To introduce technically advanced topics in control systems theory and practice.

To teach the student how earlier courses in mathematics and control systems can be blended to develop advanced topics in control engineering.

Pre-requisites: Circuit Theory, Signals & Systems, Control Systems Design

Computational Techniques – Reviews of Matrix Computations, Computing eAt, State Feedback Control Design for general (non-canonical) MIMO systems, Solution of the Lyapunov's equation for LTIL systems, NP hard problems, Randomized Algorithms.

Optimal Control – Introduction to Quadratic Objective Functions, Dynamic Programming, Calculus of Variations, Pontryagin's Principle, H∞ control, Game Theory and Applications.

Nonlinear Control – Introduction, Phase-Plane Methods, Describing Function Analysis, State-space Nonlinear Systems, Feedback Linearization, Lyapunov's Stability Theory.

Stochastic Control – Linear Stochastic Differential Equations and Stochastic State Models, Optimal Prediction of Discrete-Time Stationery Processes, Minimal Variance Control Strategies, Complete State Information, Incomplete State Information.

Trends in Control Engineering – Networked Control Systems, Cyber Physical Systems (CPS), Formation Control for Mobile Robotics (UGVs and UAVs), Fault Detection & Isolation, Intelligent Data Analysis & Probabilistic Inference.

Text & Reference Books:

1. Hespanha, J.P., *Linear Systems Theory*, Princeton Univ. Press, 2009.
2. Brogan, W.L., *Modern Control Theory*, 3/e, Prentice Hall, 1990.
3. Datta, B.N., *Numerical Methods for Linear Control Systems*, Elsevier, 2005.
4. Kirk, D.E., *Optimal Control Theory,* Dover Publications, 2004.
5. Slotine, J-J.E., and Li, *Applied Nonlinear Control*, Prentice Hall, 1991.
6. Astrom, K.J. *Intro. Stochastic Control Theory,* Dover Publications, 2006.
7. Ren W., and Beard, R., "*Distributed Consensus in Multi-vehicle Cooperative Control: Theory and Applications,"* Springer, 2007.
8. Hinrichsen, D., and Pritchard, A.J., *"Mathematical System Theory – I,"* Springer, 2010.

Course Outcomes:

1. The student realizes the importance of efficient computer algorithms in modern and large-scale control systems.
2. The student gets exposed to designing controllers under resource constraints.
3. The student learns the existence of nonlinear theories beyond the over-emphasized linear systems in traditional engineering practice.
4. The student is exposed to the system theory in a stochastic framework.
5. The student is given an opportunity to appreciate graduate level courses and current research topics.

IC 092 ADVANCED PROCESS CONTROL

L	T	P	C
3	0	0	3

Course Objectives:

The aim of this course is to familiarize the student with the analysis and design of

1. System identification and parameter estimation
2. Auto tuning and adaptive control
3. State estimation
4. Model predictive control (MPC) and
5. optimal and robust control

Prerequisites: First-level course on process control; Linear Algebra, Basic Calculus.

Least square - Recursive Least Square - Closed loop system identification - Relay based system identification.

Gain scheduling- self tuning regulator - model reference adaptive control- auto tuning.

Design of Kalman Filter- Extended Kalman Filter (EKF)- Issues and Challenges.

Introduction to Model Predictive Control (MPC) - Concepts; Theory and implementation; Relation with LQ-control) and its variants with insightful case studies. Implementation of MPC; Receding Horizon implementation; Issues and Challenges.

Dynamic programming- Kharitonov theorem- Robust stability – Robust control

Text Books:

1. Bequette B W, *Process control modeling-design and simulation*, Prentice Hall of India, 2004.
2. Donald Kirk, *Optimal Control*, 1/e, Dover, 2004.
3. K.J.Astrom, *Adaptive Control*, Addison-Wesley, 1995.

Reference Books:

1. Ljung L, *System Identification*, Prentice Hall, Englewood Cliffs, 1987.
2. Branco Ristic, Sanjeev Arulampalam, Neil Goodon, *Beyond the kalman filter*, Artech House Publishers, Boston, 2004.
3. S.P.Bhattacharyya, *Robust control*, Prentice Hall, New Jersy, 1995.

Course outcomes:

On completion of this course, the student will understand

(i) LS & RLS method ii) MRAC, Gain scheduling, STR and auto tuning iii) kalman filter design iv) MPC design and v) dynamic programming and pontryagin minimum principle kharitonov theorem.

IC 093 NONLINEAR CONTROL SYSTEMS

L	T	P	C
3	0	0	3

Course Objectives:

1. To investigate how nonlinear systems can be analyzed as well as controlled.
2. To discuss new control methods applied to a number of example domains, including robotics.

Pre-requisites: Circuit Theory, Signals & Systems, Control Systems Design

Nonlinear system analysis: Concepts of phase plane analysis: phase portraits, construction of phase portrait, singular points, phase plane analysis of linear system and nonlinear 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 nonlinear 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. Nonlinear control system design, feedback linearization. Passivity, Nonlinear Control, and Geometric Methods.

Text Book:

1. Jean-Jacques E. Slotine, "*Applied Nonlinear Control*", Prentice Hall Englewood Cliffs, New Jersey, 1991
2. Khalil, H.K., "Nonlinear Systems," 3/e, Prentice Hall Englewood Cliffs, New Jersey, 2002.

Reference Book:

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

Course Outcomes:

Upon completing this course, the students

1. Have a different view to the behavior of a general system.
2. Are introduced to various methods of describing nonlinear systems and analyzing some of their Intrinsic properties in a qualitative manner.
3. Are exposed to the general stability theory of Lyapunov.
4. Learn various control system design techniques particularly applicable to nonlinear systems.

IC 094 PHYSIOLOGICAL CONTROL SYSTEMS

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Course Objectives:
The main objective of this course is to provide background knowledge on specific physiological systems (nervous system, sensory systems, muscle control systems, cardiovascular systems, respiratory system, and hormonal control mechanisms) and to apply control theory, system analysis, and model identification techniques to better understand the processes involved in physiological regulation.

Pre-requisites: Signals & Systems, Control Systems and Biomedical Instrumentation.

Static And Domain System Analysis: Introduction, system analysis: fundamental concepts, physiological control system analysis: an example, difference between physiological control system and engineering system, linear models of physiological systems

Time Domain Analysis Of Control Systems: linearized respiratory mechanics, transient response (first order and second order), descriptors of impulse and step responses, open loop versus closed loop dynamics.

Frequency Domain Analysis: Linear control systems: steay state resonse to sinusoidal input, graphical representation of frequency response, frequency response of a model of a circulatory control, Frequncy Response of Glucose-Insulin Regulation

System Stability And System Identification: Stability and Transient response, Routh-Hurwitz stability Criterion, Root Locus Plots, Nyquist Criterion for Stability analysis on pupillary light reflex, Model of Cheyne-Stokes Breathing.
Nonparametric and parametric identification methods, problems in parameter estimation, identification of closed loop systems, case studies

Optimization Methods: Optimization in system with negative feedback, single parameter optimization, constrained optimization - airflow pattern regulation, control of Aortic wave pulse, Adaptive control of physiological variables.
Nonlinear Analysis: Nonlinear versus linear closed loop systems, Phase-plane analysis, non-linear oscillators, models of neuronal dynamics – spike train analysis

Reference Books:

1. Michael C.K.Khoo, Physiological Control Systems (Analysis, Simulation, and Estimation), IEEE Press Series on Biomedical Engineering, 2004.
2. Blessser, W.B. A Systems Approach to Biomedicine. McGraw-Hill, New York, 1969.
3. Akay, M. Biomedical Signal Processing. Academic Press, New York, 1994.

Course Outcomes:
Upon completing the course, the student should have understood
1. Mathematical Modeling of Physiological Systems.
2. Static Analysis of Physiological Systems.
3. Time-Domain Analysis of Linear Physiological Control Systems.
4. Frequency-Domain Analysis of Linear Physiological Control Systems.
5. Stability Analysis: Linear Approaches.
6. System Identification of Physiological Control Systems.
7. Optimization methods of physiological variables.
8. Nonlinear analysis of Physiological Control Systems.