B.Tech. Degree in

INSTRUMENTATION AND CONTROL ENGINEERING

Syllabus for Credit Based Curriculum

(For students admitted in 2010, 2011 & 2012)

Department of Instrumentation and Control Engineering
National Institute of Technology
Tiruchirappalli – 620015
India
### SEMESTER – III

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**TOTAL** | 18 | 0 | 9 | 27 |

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**TOTAL** | 15 | 0 | 18 | 18 |

Credits:

- **1st Year**: $23 + 22 = 45$
- **2nd Year**: $24 + 22 = 46$
- **3rd Year**: $22 + 21 = 43$
- **4th Year**: $27 + 18 = 45$
- **Total**: **179**
## ELECTIVES

### For 6th Semester (Elective – 1):

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MA 209: Mathematics III

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:
MT 211 MATERIAL SCIENCE

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

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

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


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:

Reference Books:
CE 283 THERMO DYNAMICS AND FLUID MECHANICS

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

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

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

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


Text Books:

Reference Books:
IC 201 SENSORS AND TRANSDUCERS

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

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

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

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

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

Text Books:

Reference Books:
IC 203 CIRCUIT THEORY


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


Text Books:

Reference Books:
IC 205 DIGITAL TECHNIQUES

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

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

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


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:

Reference Books:
IC 207 DEVICES AND CIRCUITS LABORATORY

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.
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.

CE 285 THERMO DYNAMICS AND FLUID MECHANICS LABORATORY

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

**Fluid Mechanics:**
1. Determination of pipe friction
2. Calibration of flow meters – Venturimeter and Orifice meter
3. Determination of discharge coefficients for notches
4. Determination of minor losses
5. Centrifugal pump
6. Submersible pump
7. Jet pump
8. Gear pump
9. Screw pump
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**TOTAL**  
18 0 6 22
MA202 NUMERICAL METHODS

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.


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 ($\int_0^{\infty} e^{-x}f(x)\,dx$).


Computer based exercise are recommended in all units.

Text Books

IC 202 SIGNALS AND SYSTEMS

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

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

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

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

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

Text Books:

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

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

Radiation measurement: Radiation thermometers, introduction, definition of terms, general form of radiation measurement system, radiation thermometer types, photo electric radiation thermometers, signal conditioning for radiation thermometers, remote reading thermometers. Temperature sensor selection and applications, sensor calibrators and simulators.

Pressure measurement basics, mechanical type instruments, electromechanical type, low pressure measurement, related accessories, pressure measuring standards, selection and application. Transmitter definition, classification, pneumatic transmitter-force balance type, torque balance type, two wire and four wire transmitters, I/P and P/I converters.

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

Text Books:

Reference Books:
IC 206 ANALOG ELECTRONIC CIRCUITS


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

Text Books:

Reference Books:
IC 208 MICROPROCESSORS AND MICROCONTROLLERS

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

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

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

Architectures of 8051 Microcontroller: Bus configuration, instruction sets, programming exercises. Embedded System software and hardware design, development and troubleshooting tools.

Text Books:

Reference Books:
4. www.intel.com
IC 210 ELECTRICAL AND ELECTRONIC MEASUREMENTS


Power and Energy Measurements: Electrodynamatic wattometers, 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.


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

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

Text Books:

Reference Books:
IC 212 SENSORS AND TRANSDUCERS LABORATORY

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

IC 214 MICROPROCESSOR AND MICROCONTROLLERS LABORATORY

1. Familiarization with 8085 microprocessor kit and its keyboard.
2. Exercises with entry and manipulation of data (Different addressing modes).
4. Programming exercises using 8086 microprocessor
5. Programming exercises to programmable peripheral interface.
7. Programming an EPROM for a specific application.
8. Programming exercises to programmable timer
9. Familiarization 8051 Microcontroller kit and its assembler
11. Basic I/O operations and ADC Interfacing using KEIL software
12. Counting Pulses using Interrupt & Serial Data Transmission
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**TOTAL** 18 0 6 22
Amplitude modulation: AM, generation of AM waves, demodulation, DSBSC, SSB, VSB, FDM, AM 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:

Reference Books:
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.


**Text Book:**

**Reference Books:**
IC 303 DATA STRUCTURES AND ALGORITHMS

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, Fibonacci heaps, Introduction NP completeness.

Text Books:

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


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

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

Text Books:

Reference Books:

Discrete-time systems, Difference equations and the Z-transform, Analysis of discrete-time LTIL systems, Stability and Jury’s test.


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:

Reference Books:
IC 309 CONTROL SYSTEMS

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


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


Design of Compensators: Proportional (Constant gain), Lead, Lag, PI, PD, and lead-lag compensator design using root loci and Bode plots.

Text Books:
IC 311 ELECTRONIC CIRCUITS LABORATORY

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

IC 313 INSTRUMENTATION LABORATORY

1. Design of temperature transmitter using RTD.
2. Design of cold junction compensation circuit.
3. Design of IC temperature transmitter.
5. Design of pressure transmitter.
6. Performance evaluation of pressure gauges using Dead weight tester.
8. Design of alarms and annunciators.
10. PC based respiratory analyser.
11. PC based ECG, pulse analyser.
14. Characteristics of I/P and P/I.
15. Measurement of flow using orifice, electromagnetic and positive displacement flowmeters
### SEMESTER - VI

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**TOTAL**  
17 0 9 21
CS 320 COMPUTER NETWORKS


Text Books:

Reference Books:
IC 302 MODERN CONTROL THEORY

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

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

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

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

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

Text Books:
IC 304 PROCESS CONTROL


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:

Reference Books:
IC 306 PRODUCT DESIGN AND DEVELOPMENT


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

Text Books:
IC 308 MEMS AND NANO TECHNOLOGY

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.


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:
IC 310 INTERFACING LABORATORY

1. Tank level control simulation in LABVIEW.
2. Data acquisition and calibration of a given sensor using LABVIEW DAQ card
3. ON/OFF Temperature control of a water bath using LABVIEW DAQ card
4. Development of simple database application and publishing it in the web.
5. Sensor data acquisition Using VC++ tools along with MS chart to display trends of the measurements.
6. Stepper motor interfacing and control with MC8051
7. ON/OFF Temperature control of a water bath using MC8051
8. Design and simulation of a state feedback controller for a given second order system using MATLAB simulink.
9. Data acquisition and calibration of a given sensor using MCCDAQ card in MATLAB
10. Implementation of a control algorithm for a given system using MCCDAQ card in MATLAB

IC 314 CONTROL ENGINEERING LABORATORY

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
<table>
<thead>
<tr>
<th>S.No.</th>
<th>Code</th>
<th>Course of Study</th>
<th>L</th>
<th>T</th>
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<tr>
<td>1.</td>
<td>HM 401</td>
<td>Industrial Economics</td>
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<td>2.</td>
<td>IC 401</td>
<td>Logic &amp; Distributed Control Systems</td>
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<td>3.</td>
<td>IC 403</td>
<td>Analytical Instrumentation</td>
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<td>4.</td>
<td>IC 405</td>
<td>Biomedical Instrumentation</td>
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<td>IC 407</td>
<td>Product Development &amp; Design (P)</td>
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<td>Elective – 2</td>
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<td>IC 4xx</td>
<td>Elective – 3</td>
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<td>8.</td>
<td>IC 409</td>
<td>Mini Project</td>
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<td>9.</td>
<td>IC 411</td>
<td>Process Control Laboratory</td>
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<td>10.</td>
<td>IC 447</td>
<td>Comprehensive Examination</td>
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</tbody>
</table>

**TOTAL** | 18 | 0 | 9 | 27
HM 401 INDUSTRIAL ECONOMICS


Text Books:

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

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

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


Text Books:

Reference Books:
IC 403 ANALYTICAL INSTRUMENTATION

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


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


Text Books:

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

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

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

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

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

Text Book:

Reference Books:
IC 409 PROCESS CONTROL LABORATORY

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

The following experiments will be conducted on virtual DCS.

1. Three – element boiler control
2. Binary distillation column control
3. Level control in coupled tanks
4. Pressure control in different sized vessels
5. Heat exchanger control
6. Control of rotary dryer
## SEMESTER - VIII

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Code</th>
<th>Course of Study</th>
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<tbody>
<tr>
<td>1.</td>
<td>MB 790</td>
<td>Management Concepts &amp; Practices</td>
<td>3</td>
<td>0</td>
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<tr>
<td>2.</td>
<td>IC 402</td>
<td>Opto-Electronics &amp; Laser Based Instrumentation</td>
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<td>3.</td>
<td>IC 4xx</td>
<td>Elective – 4</td>
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<td>IC 488</td>
<td>Project Work</td>
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</table>

**TOTAL** 15 0 18 18
MB 790 MANAGEMENT CONCEPTS AND PRACTICES


Reference Books:
IC 402 OPTO-ELECTRONICS AND LASER BASED INSTRUMENTATION

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

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

Charge coupled devices: Opto-couplers and their application in analogue and digital devices.

Optical fibre fundamentals, modes, types of optical fibres, fibre coupling, Optrodes, Fibre optic sensors for temperature, pressure, flow and level measurement.

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

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

Text Books:

Reference Books:
## ELECTIVES

### For 6th Semester (Elective – 1):

<table>
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<tr>
<th>S.No.</th>
<th>Code</th>
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<tr>
<td>1.</td>
<td>IC 362</td>
<td>Power Electronics</td>
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<td>2.</td>
<td>IC 364</td>
<td>Electron Devices</td>
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<td>3.</td>
<td>IC 366</td>
<td>Neural Networks, Fuzzy Logic, and Control</td>
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<td>4.</td>
<td>IC 368</td>
<td>Embedded Systems</td>
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### For 7th Semester (Electives – 2 & 3):

<table>
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<tr>
<td>1.</td>
<td>IC 451</td>
<td>Design of Automotive Systems</td>
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<td>2.</td>
<td>IC 453</td>
<td>Virtual Instrument Design</td>
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<td>IC 455</td>
<td>Engineering Optimization</td>
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<td>4.</td>
<td>IC 457</td>
<td>Digital Control Systems</td>
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<td>IC 459</td>
<td>Robotics</td>
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<td>6.</td>
<td>IC 461</td>
<td>Sensor Networks</td>
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<td>IC 463</td>
<td>Micro System Design</td>
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<td>IC 465</td>
<td>Advanced Process Control</td>
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<td>IC 467</td>
<td>Smart Materials &amp; Systems</td>
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<td>IC 469</td>
<td>Nonlinear Control Systems</td>
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<td>Cooperative Control Systems</td>
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<td>12.</td>
<td>EC 456</td>
<td>Digital Image Processing</td>
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<td>13.</td>
<td>EC 453</td>
<td>ARM System Architecture</td>
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<td>14.</td>
<td>CS 451</td>
<td>Principles of Cryptography</td>
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### For 8th Semester (Electives – 4 & 5):

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<tr>
<td>1.</td>
<td>IC 452</td>
<td>Power Plant Instrumentation &amp; Control</td>
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<td>2.</td>
<td>IC 454</td>
<td>System Identification</td>
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<td>IC 456</td>
<td>Fault Detection &amp; Diagnosis</td>
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<td>IC 458</td>
<td>Computational Techniques in Control Engineering</td>
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<td>IC 460</td>
<td>Uncertainty Analysis in Engineering</td>
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<td>IC 462</td>
<td>Probability &amp; Computing</td>
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<td>EC 308</td>
<td>VLSI Systems (core course for 6th sem ECE Students)</td>
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<td>EC 454</td>
<td>Display Systems</td>
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</table>
IC 362 POWER ELECTRONICS

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

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

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

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

AC to AC converters: Single phase and three phase AC voltage controllers, integral cycle control, single phase cyclo-converters - effect of harmonics and Electro Magnetic Interference (EMI).

Applications in power electronics: UPS, SMPS and Drives.

Text Books:

Reference Books:
IC 364 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 $\alpha$, Current amplification $\beta$. Bipolar transistor switch, SPICE BJT model, 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, SPICE MOSFET model, CMOS structure, operation, BiCMOS operation, CCDs.

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

Text Books:

Reference Books:
IC 366 NEURAL NETWORKS AND FUZZY LOGIC CONTROL

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

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

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

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


Text Books:
1. Bose and Liang, “Artificial Neural Networks”, Tata Mcgraw Hill, New Delhi, 1996

Reference Books:
IC 368 EMBEDDED SYSTEMS

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


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:

IC 451 DESIGN OF AUTOMOTIVE SYSTEMS


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

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

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

Text Books:

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

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

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

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

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

Text Books:

Reference Books:

Web Resources:
1. www.ni.com
2. www.iltrpub.com
IC 455 ENGINEERING OPTIMIZATION

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.


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

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

Reference Books:
IC 457 DIGITAL CONTROL SYSTEMS

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

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

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

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

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

Text Books:

Reference Books:
IC 459 ROBOTICS

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

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

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

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

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

Text Books:

Reference Books:
IC 461 SENSOR NETWORKS


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


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


Reference Books:
IC 463 MICRO SYSTEM DESIGN

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

Energy conserving transducer, Mechanics of membranes and beams

Electrostatic Actuation and Sensing, Effects of electrical excitation

Design of Micro pressure sensor and Micro accelerometer

Electronic Integration and Packaging

Text Book:

Reference Books:
IC 465 ADVANCED PROCESS CONTROL


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


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

Reference Books:
IC 467 SMART MATERIALS & SYSTEMS

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

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

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

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

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

Reference Books:

Web Resources:
1. www.iop.org/sms
2. www.jim.sagepub.com
IC 469 NONLINEAR CONTROL SYSTEMS

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 non linear systems-stability analysis.


Lyapunov analysis of Non –Autonomous system. Nonlinear control system design: feedback linearization.

Text Book:

Reference Book:
IC 471 COOPERATIVE CONTROL SYSTEMS

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

Textbooks:
5. Current Literature

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:

Reference Books:
IC454 SYSTEM IDENTIFICATION

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

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

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

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

Case studies: Electro mechanical systems.

Text Books:
IC 456 FAULT DETECTION AND DIAGNOSIS

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


Text Books:

Reference Books:
IC 458 COMPUTATIONAL TECHNIQUES IN CONTROL ENGINEERING

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

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


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

Text Books/References/Resources:

4. www.scilab.org
IC 460 UNCERTAINTY ANALYSIS IN ENGINEERING

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

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

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

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

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

Reference Books:
IC 462 PROBABILITY AND COMPUTING

Events and Probability: Verifying Polynomial Identities, Verifying Matrix Multiplication, A Randomized mini-cut Algorithm

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

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


Text Book: