B. Tech in Electronics and Instrumentation Engineering 2018 scheme (with all approved updates)

Yr	THIRD SEMESTER						FOURTH SEMESTER					
	Subject Code	**Subject Name**	**L**	**T**	**P**	**C**	**Subject Code**	**Subject Name**	**L**	**T**	**P**	**C**
II	MAT 2152	Engineering Mathematics – III	2	1	0	3	MAT 2258	Engineering Mathematics – IV	2	1	0	3
	ICE 2151	Analog Electronic Circuits	3	1	0	4	ICE 2251	Digital System Design	2	1	0	3
	ICE 2152	Digital Electronic Circuits	2	1	0	3	ICE 2252	Industrial Instrumentation	3	0	0	3
	ICE 2153	Electronic Measurements	3	0	0	3	ICE 2253	Linear control Theory	3	1	0	4
	ICE 2154	Network Analysis and Signals	3	1	0	4	ICE 2254	Linear Integrated Circuits	3	1	0	4
	ICE 2155	Sensors and Transducers	3	0	0	3	****	Open elective-I	3	0	0	3
	ICE 2161	Digital Circuits Lab	0	0	3	1	ICE 2261	Analog Circuits Lab	0	1	3	2
	ICE 2162	Measurement and Transducers lab	0	0	3	1	ICE 2262	Circuit Simulation and HDL Lab	0	0	3	1
	ICE 2163	Virtual Instrumentation Lab	0	1	3	2	ICE 2263	Instrumentation lab	0	0	3	1
			16	**5**	**9**	**24**			**16**	**5**	**9**	**24**
		Total contact hour (L+T+P)	**30**					Total contact hour (L+T+P) + OE	**30**			
	FIFTH SEMESTER						SIXTH SEMESTER					
III	HUM 3152	Essentials of Management	2	1	0	3	HUM 3151	Engineering Economics and Financial Management	2	1	0	3
	ICE 3151	Control System Components	3	0	0	3	ICE 3251	Digital Signal Processing	3	1	0	4
	ICE 3152	Micro-controllers	4	0	0	4	ICE 3252	Industrial Automation	4	0	0	4
	ICE 3153	Modern Control Theory	3	1	0	4	ICE ****	Program elective-1	3	0	0	3
	ICE 3154	Process Instrumentation and Control	3	0	0	3	ICE ****	Program elective-2	3	0	0	3
	****	Open elective-II	3	0	0	3	*** ****	Open elective-III	3	0	0	3
	ICE 3161	Micro-controller Lab	0	1	3	2	ICE 3261	Automation Lab	0	0	3	1
	ICE 3162	Process Control Lab	0	0	3	1	ICE 3262	Control System Lab	0	0	3	1
							ICE 3263	DSP Lab	0	1	3	2
			18	**3**	**6**	**23**			**18**	**3**	**9**	**24**
		Total contact hour (L+T+P) + OE	**27**					Total contact hour (L+T+P) + OE	**30**			
	SEVENTH SEMESTER						EIGHT SEMESTER					
IV	ICE ****	Program elective -3	3	0	0	3	ICE 4298	Industrial Training				**1**
	ICE ****	Program elective-4	3	0	0	3	ICE 4299	Project and practice school				**12**
	ICE ****	Program elective-5	3	0	0	3						
	ICE ****	Program elective-6	3	0	0	3						
	ICE ****	Program elective-7	3	0	0	3						
	***	Open elective-IV	3	0	0	3						
			18	**0**	**0**	**18**						**13**
		Total Contact Hours (L + T + P) +OE	**18**									

B. Tech in Electronics and Instrumentation Engineering 2018 scheme (with all approved updates)

Minor Specialization		Other Electives
I. Computational Intelligence	**VI. Signal Processing**	ICE 4059: Neural Network and Fuzzy Logic
ELE 4061: Artificial Intelligence	ECE 4055: Advanced Digital Signal Processing	ICE 4060: Real Time Operating System
ECE 4051: Computer Vision	ELE 4073: Digital Image Processing	ICE 4061: DSP algorithms and Architecture
ECE 4052: Machine Learning	ECE 4056: Digital Speech Processing	ICE 4062: Analytical and optical Instrumentation
ELE 4062: Soft Computing Techniques	ELE 4074: Linear Algebra for Signal Processing	ICE 4063: Automotive Electronics
II. Control Systems	**VII. VLSI Design**	ICE 4064: Biomedical Instrumentation and Equipment
ICE 4051: Digital Control Systems	ECE 4061: Analog & Mixed Signal Design	ICE 4065: Data Structures using C++
ICE 4052: Non-Linear Control Systems	ECE 4062: Digital Design Verification	ICE 4066: Cyber physical systems
ICE 4053: Robust Control	ECE 4063: Low power VLSI Design	ICE 4067: Power Electronics
ICE 4054: System Identification	ECE 4064: Semiconductor Device Theory	ICE 4068: Robotics
III. Embedded Systems	**VIII. Material Science**	ICE 4069: Reliability and safety Engineering
ECE 4053: Embedded System Design	PHY 4051 Physics of low dimensional materials	ICE 4070: Wireless Sensor Technology
ELE 4063: FPGA based system Design	PHY 4052 Physics of photonic and energy storage devices	ICE4071 Industrial Internet of Things
ECE 4054: Internet of Things	CHM 4051 Chemical bonding	ICE4072 Bio sensors and BioMEMS
ELE 4064: Real Time Systems	CHM 4052 Chemistry of carbon compound	**Open Electives**
IV. Illumination Technology	**IX. Business Management**	ICE 4301: Feedback Control Theory
ELE 4065: Integrated Lighting Design	HUM 4051: Financial Management	ICE 4302: Industrial Automation
ELE 4066: Lighting Controls: Technology & Applications	HUM 4052: Human Resource Management	ICE 4303: Industrial Instrumentation
ELE 4067: Lighting Science: Devices and Systems	HUM 4053: Marketing Management	ICE 4304: Sensor Technology
ELE 4068: Solid State Lighting	HUM 4054: Operation Management	ICE 4305: Smart Sensor
V. Sensor Technology	**X. Computational Mathematics**	ICE 4306: Virtual Instrumentation
ICE 4055: Advanced Sensor Technology	MAT 4051: Applied Statistics and Time Series Analysis	ICE 4307 Farm Automation
ICE 4056: Micro Electro Mechanical Systems	MAT 4052: Computational Linear Algebra	
ICE 4057: Multi Sensor Data Fusion		
ICE 4058: Smart Sensor		

	MAT 4053: Computational Probability and Design of Experiments MAT 4054: Graphs and Matrices **X1 Systems Engineering** ICE 4073 Introduction to Systems Engineering ICE 4074 System Architecture and Desing ICE 4075 Introduction to SysML and MBSE !CE 4076 System Verification and Validation	

MAT 2152: ENGINEERING MATHEMATICS III [2 1 0 3]

Functions of complex variable. Analytic function, C-R equations, differentiation, Integration of complex function, Cauchy's integral formula. Taylor's and Laurent Series, Singular points, Residues, Cauchy's residue theorem. Periodic function, Fourier Series expansion. even and odd functions, functions with arbitrary periods, Half range expansions Fourier transform, Parseval's identity, PDE-Solution by method of separation of variables and by indicated transformations. One dimensional wave equation, One dimensional heat equation and their solutions. Vector differtial operator, gradient divergence and curl. Line, surface and volume integrals. Green's theorem, Divergence and Stoke's theorem

References:

1. Grewal B.S., *Higher Engineering Mathematics*, Khanna Publishers.
2. Erwin Kreyszig: *Advanced Engg. Mathematics*, Wiley Eastern.
3. Murray R. Spiegel: *Vector Analysis*. 1959, Schaum Publishing Co.
4. *Advanced Engineering Mathematics*, Vol 3, by Narayanan, Ramaniah and Manicavachagom Pillay

ICE 2151: ANALOG ELECTRONIC CIRCUITS [3 1 0 4]

Course Outcomes	CO Statements
CO1	Understand the operation of field effect transistors (FET)
CO2	Analyze various biasing and amplifier topologies of FET
CO3	Realize differential amplifiers using FET.
CO4	Analyze frequency response of FET amplifiers.
CO5	Design of various feedback amplifiers and power amplifiers.

Structure and operation of MOSFET, I-V Characteristics, Channel-Length Modulation, Transconductance, Large-Signal and Small-Signal Model, Biasing, Amplifier topologies, Common-Source Amplifier, Common-Gate Amplifier, Source Follower, Cascode, Two stage CS Amplifiers, MOS Differential amplifier, Miller's Theorem, Frequency Response of CS, CG, CD, Cascode and differential amplifier Stage, Negative Feedback Amplifiers, Feedback Topologies, Power amplifiers, Push-Pull Stage, LC Oscillators, Hartley's and Colpitt's Oscillator, RC Phase Shift Oscillator, Ring Oscillator.

References:

1. Behzad Razavi, *Fundamental of Microelectronics*, Wiley, (2e), 2013.
2. A. S. Sedra, K. C. Smith, *Microelectronic circuits*, Oxford University Press, (6e), 2011.
3. R. L. Boylestad, L. Nashelsky, *Electronic Devices and Circuit Theory*, PHI, (11e), 2014.

ICE 2152: DIGITAL ELECTRONIC CIRCUITS [2 1 0 3]

Course Outcomes	CO Statements
CO1	Understand the basics of Logic Families and binary systems.
CO2	Analyze and synthesize combinational logic circuits.
CO3	Realize synchronous sequential circuits.
CO4	Design and analyze various asynchronous sequential circuits.
CO5	Apply state machine models for design of sequential circuits.

Performance metrics of logic families, Binary codes, Boolean Algebra, Karnaugh map, Quine-McCluskey method, Arithmetic circuits, Code convertors, Multiplexers, De-multiplexers, Encoders, Decoders, Comparators, Parity generators and checker. Latches, flip-flops, Synchronous and Asynchronous circuits - Counters, Shift registers, Cycles, Races and Hazards, Finite State Machines, ASM Chart, Timing issues.

References:

1. Donald D. Givone, *Digital Principles and Design*, TMH, (1e), 2002.
2. M. Morris Mano, *Digital Design*, PHI, (5e), 2002.
3. C. H. Roth, *Fundamentals of Logic Design*, Thomson, (6e), 2000.
4. A. Anand Kumar, *Switching Theory and Logic Design*, PHI, (2e), 2014.

ICE 2153: ELECTRONIC MEASUREMENTS [3 0 0 3]

Course Outcomes	CO Statements
CO1	Recall basic principles of AC bridges and understand measurement principle of L, C and Energy.
CO2	Understand the working, types and applications of Oscilloscopes.
CO3	Describe the working of different types of display devices and digital meters.
CO4	Comprehend the working and design of Q, LCR meters and different types of recorders.
CO5	Describe the working principle of wave and spectrum analyser.

Sources and detectors, Anderson Bridge, De-Sauty Bridge, Schering Bridge, Shielding, Wien's bridge, Electro dynamometer type wattmeter, energy-meters, Digital Storage Oscilloscopes. Measurement using CRO's, Sampling oscilloscope, display devices – LED, LCD, Dot matrix, Digital Voltmeters, Digital Multimeter, Digital Frequency meter, Q-meter, LCR meter, Analog and digital recorders, Wave Analyzers, Spectrum Analyzers, Power Analyzers.

References:

1. David A Bell, *Electronic Instrumentation and Measurements*, Oxford Press, (2e), 2004.
2. H S Kalsi, *Electronic Instrumentation*, MGH education, (2e), 2004.
3. Helfrick A.D, Cooper W.D, *Modern Electronic Instrumentation & Measurement Techniques*, PHI, (5e), 2002.

ICE 2154: NETWORK ANALYSIS AND SIGNALS [3 1 0 4]

Course Outcomes	CO Statements
CO1	Solve linear electrical networks using suitable methodologies.
CO2	Evaluate initial conditions, transient response and steady state response of first and second order circuits to solve computingproblems
CO3	Ability to designlinked list data structure to solvevarious problems.
CO4	Describe commonapplication of trees and demonstratedifferent methods for tree traversal
CO5	Describe theconcept of graphs,search structures, and give examples of its use and discuss various searching and sorting techniques

Analysis of circuits with dependent sources, Network theorems, Initial conditions and transient analysis of RL, RC and RLC circuits, Continuous time signals and systems, LTI systems - convolution integral, Response of Continuous time LTI systems to complex exponentials, Fourier series, Fourier transform, Properties of Fourier series and Fourier transform, Analysis of networks by Laplace transform method, Transform functions, Transform circuits, Network functions, Two port network parameters.

References:

1. Van Valkenberg, *Network Analysis*, (3e), PHI, 2010.
2. Allan Oppenheim, Allan Willsky with Ian T Young, *Signals and Systems*, PHI, 1999.
3. Hayt W. H., J. E. Kemmerly & S. M. Durbin, *Engineering Circuit Analysis*, (7e), TMH, 2010.
4. Schaum's outline series, *Electric Circuits*, MGH, (5e), 1992.

ICE2155 SENSORS & TRANSDUCERS [3 0 0 3]

Course Outcomes	CO Statements
CO1	Classify and understand the characteristics of sensors.
CO2	Categorize and describe the working of electrical transducers
CO3	Understand, identify and design physical sensors and piezoelectric sensors.
CO4	Understand, identify and design electrochemical sensors for analytical and industrial measurements.
CO5	Understand, choose and design optical sensors for analytical and industrial measurements

Functional elements of an Instrument, Types of transducers, Null and Deflection methods, Input/output configurations, characteristics, types of errors, Resistive, Capacitive, Inductive transducers, Hall Effect sensors, magneto elastic transducers, solid state sensors, eddy current transducers, Piezo Electric transducers, pH Measurement, Semiconductor sensors, photo electric transducers, CCD, shaft encoder and decoders, optical encoders, gas sensors, density, viscosity, moisture and humidity measurements.

References:

1. E.O. Doeblin, *Measurement Systems: Application and Design*, McGraw Hill, (5e), 2004.
2. DVS Murthy, *Transducers & Instrumentation*, PHI, (2e), 1999.

3. B.G. Liptak, *Process Measurement & Analysis,* Chilton Book Company, (4e), 2003.

ICE 2161: DIGITAL CIRCUITS LAB [0 0 3 1]

Course Outcomes	CO Statements
CO1	Implement Boolean functions and code converters using logic gates.
CO2	Design and verify adder/subtractor, comparator and parity checker using gates.
CO3	Implement multiplexers, de-multiplexers, encoders and decoders.
CO4	Design and implement flip-flop based counters and shift registers.
CO5	Design and implement synchronous and asynchronous circuits.

Boolean functions using logic gates, Code Conversion Circuits, Adders, Subtractors, Magnitude comparator, Parity checker / generator, Multiplexers, Demultiplexers, Encoders, Decoders, Flip flops, Counters, Shift Registers, Sequential circuits.

References:

1. M. Morris Mano, *Digital Design*, PHI, (5e), 2002.
2. Ronald J. Tocci, *Digital Systems*, Pearson Education, (11e), 2003.

ICE 2162: MEASUREMENTS AND TRANSDUCERS LABORATORY [0 0 3 1]

Course Outcomes	CO Statements
CO1	Prove resonance properties and network theorems.
CO2	Determine the circuit parameters using comparison methods.
CO3	Verify the characteristics of photo devices, energy meter and temperature transducers
CO4	Characterize displacement, force and torque transducers
CO5	Design a measurement system using commercial sensors

AC bridges, network theorems, measurement of energy, measurement of self and mutual inductance, series and parallel resonance, characteristics of sensors and transducers – temperature, pressure, flow, torque, force, displacement and intensity of light.

References:

1. A.K Sawhney, *A course in Electrical and Electronic Instrumentation Measurements*, (7e), Dhanpat Rai & Co, 2002.
2. E.O. Doeblin, *Measurement Systems: Application and Design*, McGraw Hill, (5e), 2004.

ICE 2163: VIRTUAL INSTRUMENTATION LAB [0 1 3 2]

Course Outcomes	CO Statements
CO1	Understand LabVIEW basics and perform arithmetical and logical operations.
CO2	Develop modular programs with loops and shift registers.
CO3	Create iterative logics for array handling and feedback nodes.
CO4	Program for multi data types handling and plotting.
CO5	Perform string operations, structure programming and file management.

Introduction to Lab VIEW, Arithmetic and logical operations, Arrays, Clusters, and Loops. Structures, Graphs, timing pallets, Strings and file I/O, Measurement and automation explorer, Simulation of DAQ, DIAdem, ULTIboard.

References:

1. Gary Johnson, *LabVIEW Graphical Programming*, McGraw Hill, (2e), 1997.
2. Jovitha Jerome, *Virtual Instrumentation using LabVIEW*, PHI learning, 2010.

FOURTH SEMESTER

MAT 2258: ENGINEERING MATHEMATICS IV [2 1 0 3]

Statistics: Mean, Median, Mode measures of dispersion. Finite sample spaces, Conditional probability and independence, Bayes' theorem, One dimensional random variable, Mean, Variance, Chebyshev's inequality, Two and higher dimensional random variables, Covariance, Correlation coefficient, curve fitting. Binomial, Poisson, uniform, normal, gamma, Chi-square and exponential distributions, Moment generating function, Functions of one and two dimensional random variables, Sampling theory, Central limit theorem. Difference equations with constant coefficients, solutions. Z-transforms and Inverse Z-transforms, Solutions of difference equations using Z-transforms. Solution of boundary value problems, Numerical solutions of Laplace and Poisson equations, Heat and wave equations by explicit methods.

References:

1. P.L.Meyer., *Introduction to probability and Statistical Applications* , (2e), American Publishing Co., 1979
2. Erwin Kreyszig, *Advanced Engineering Mathematics*, (5e), Wiley Eastern, 1985.
3. A.V.Openheim & R.W.Schafer , *Digital Signal Processing* 1975, Prentice Hall
4. Hogg & Craig, *Introduction to Mathematical Statistics*, (4e), MacMillan, 1975
5. Narayanan, Ramaniah and Manicavachagom Pillay, *Advanced Engineering Mathematics,* Vol.3

ICE 2251: DIGITAL SYSTEM DESIGN [2 1 0 3]

Course Outcomes	CO Statements
CO1	Understand digital system design flow with programmable logic devices.
CO2	Comprehend concepts of Verilog programming.
CO3	Model and design combinational and sequential systems using Verilog programming
CO4	Analyze the design of systems with ASICs and FPGAs.
CO5	Evaluate the performance of combinational and sequential systems by testing and verification.

Digital System implementation using PLDs, PLAs and PALs, Programmable ASICs (PLDs & FPGAs), levels and domains of abstraction, Design flow, Introduction to CAD Tools, Introduction to Verilog, Verilog for Combinational Circuits – Conditional operator, Verilog Operators, Verilog for Sequential Circuits – Verilog Constructs of Storage Elements, Blocking and Non-Blocking Assignments, Module, Language Elements, Data Types, Register Types, Expressions, types of modeling, Verification, Architecture of CPLDs and FPGAs, Antifuse, SRAM, EEPROM based technologies, logic cells, I/O cells, programmable interconnect, Design flow, placement and routing, Testing combinational and sequential circuits, Functional and Timing simulation, boundary scan, faults, fault simulation, BIST, DFT, Verification.

References:

1. Samir Palnitkar, *Verilog HDL: A guide to digital design and synthesis*, Prentice Hall Professional, (2e), 2003.
2. J. Bhasker, *A Verilog HDL Primer*, BSP, (1e), 2001.
3. Stephen Brown, *Fundamentals of Digital Logic with Verilog Design,* TMH, (3e), 2013.

ICE 2252: INDUSTRIAL INSTRUMENTATION [3 0 0 3]

Course Outcomes	CO Statements
CO1	Apply and analyze different temperature measuring sensors.
CO2	Understand and apply various pressure measurement techniques.
CO3	Remember and apply various flow measurement techniques.
CO4	Recognize and analyze different speed measurement.
CO5	Recall and analyze different level measurement sensors.

Temperature measurement using RTD, Thermistors and thermocouple. Solid-state temperature sensors, radiation methods, Pressure Measurement - Manometers, Elastic types, Bell gauges, Electrical types, Differential Pressure transmitters, Dead weight Pressure gauges. Low Pressure Measurement, Flow Measurement, head type flow meters, variable area flowmeters, anemometers, velocity based flowmeters, Measurement of mass flowrate - Radiation, angular momentum, impeller, turbine, constant torque hysteresis clutch, twin turbine, Coriolis, gyroscopic. Target flowmeters, V-cone flowmeters, Multiphase flow measurement, Measurement of Speed, velocity and Acceleration, Level Measurement.

References:

1. Patranabis D, *Principles of Industrial Instrumentation,* TMH, (3e), 2005.
2. Liptak B. G, *Handbook of Process Measurement and Analysis,* Chilton Book Company, (3e), 1995.
3. Gioia Falcone, Geoffrey Hewitt, C Alimonti, *Multiphase Flow Metering- Principles and Applications*, Elsevier Publication, 2009.

ICE 2253: LINEAR CONTROL THEORY [3 1 0 4]

Course Outcomes	CO Statements
CO1	Understand the concept of mathematical modelling and transfer function
CO2	Perform stability and performance analysis in time domain
CO3	Apply rool locus techniques for analysis and design of systems
CO4	Analyze systems using Bode and Nyquist plot
CO5	Illustrate design of compensators using Bode plot

Mathematical modeling, transfer functions, Block diagram representation and reduction, signal flow graph, Masons gain formula, time domain specifications. Stability, Steady state errors, generalized error coefficients, Routh- Hurwitz criterion, Root-Locus plots, compensator design using root-locus, frequency domain specifications. Correlation between frequency domain and time domain specifications, Bode diagrams, Polar plots, Nyquist stability criterion, compensator design by frequency response approach.

References:

1. Norman S. Nise, *Control Systems Engineering*, Wiley India, (5e), 2009.
2. K. Ogata, *Modern control engineering*, PHI, (5e), 2011.
3. R.C Dorf and R.H Bishop, *Modern Control Systems*, Pearson, (11e), 2013.

ICE 2254: LINEAR INTEGRATED CIRCUITS [3 1 0 4]

Course Outcomes	CO Statements
CO1	Understand the basics of ideal Operational Amplifier and analyze its linear applications.
CO2	Understand the limitations of Operational Amplifiers and design of active filters
CO3	Design and analyze operational Amplifiers for Non-linear applications.
CO4	Design and analyze data converters using Operational Amplifiers.
CO5	Design using regulator and PLL IC's for various applications.

Op Amp fundamentals, Current to Voltage, Voltage to current Converters, Current amplifiers, Difference Amplifiers, Instrumentation Amplifiers, Active Filters, Static and Dynamic Op Amp Limitations, Voltage comparators, Comparator applications, Schmitt trigger, Precision rectifiers, Peak detector, Sample and hold circuit. Sine wave generators, Multi vibrators, Monolithic Timers, Triangular wave generators, Voltage to frequency and Frequency to voltage converters, Voltage regulators, Digital to Analog and Analog to Digital Converters, Phase locked loops, VCO.

References:

1. Franco Sergio, *Design with Op amps & Analog Integrated Circuits,* McGraw Hill, (3e), 2017.
2. Ramakant A. Gayakwad, *Op-Amps and Linear Integrated Circuits*, PHI, (4e), 2015.
3. Robert F. Coughlin and Frederick S. Driscoll, *Operational Amplifiers and Linear Integrated Circuits.* Pearson education Pvt ltd., 2002.
4. Sedra and Smith, *Micro Electronic Circuits*, Oxford university press, (6e), 2000.

ICE 2261: ANALOG CIRCUITS LABORATORY [0 1 3 2]

Course Outcomes	CO Statements
CO1	Implement and verify clipping, clamping, rectifier and voltage regulator circuits.
CO2	Design and verify transistor-based circuits.
CO3	Execute linear applications of operational amplifier.
CO4	Design and test non-linear applications of operational amplifier.
CO5	Validate the applications of 555 timer.

Rectifier circuits, Voltage regulators, Frequency Response of RC coupled Amplifier, OPAMP applications - Inverting amplifier, Non-inverting amplifier, Summing Amplifier, Difference amplifier, Integrator, Differentiator, Comparator, Schmitt trigger, Astable and Monostable multivibrator, Wein Bridge Oscillator using OPAMP, Active filter, 555 Timer circuits.

References:

1. Albert Malvino, *Electronic Principles,* McGraw Hill, (7e), 1999.
2. Ramakant A. Gayakwad, *Op-Amps and Linear Integrated Circuits*, PHI, (4e), 2015.
3. Sedra and Smith- *Micro Electronic Circuits*, Oxford university press, (6e), 2000.

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ICE 2262: CIRCUIT SIMULATION AND HDL LAB [0 0 3 1]

Course Outcomes	CO Statements
CO1	Implement and verify electrical circuits in relation to network theorems, resonance and transient analysis
CO2	Implement and verify electronic circuits dealing with clippers, clampers and amplifiers
CO3	Understand HDL design flow and verify circuits illustrating basic operators and data types
CO4	Design and verify combinational and sequential logic
CO5	Validate interfacing capabilities of FPGA with various peripheral modules.

Analysis of electrical circuits, Transient analysis of RL and RC and RLC circuits, Series and parallel resonance, Analysis of diode and transistor circuits. Design of combinational and sequential systems using Verilog, Design of finite state machines using Verilog.

References:

1 Van Valkenberg, *Network Analysis*, (3e), PHI, 2010.

2 Samir Palnitkar, *Verilog HDL: A guide to digital design and synthesis,* Prentice Hall Professional, (2e), 2003.

ICE 2263: INSTRUMENTATION LAB [0 0 3 1]

Course Outcomes	CO Statements
CO1	Apply and analyze different temperature measuring sensors.
CO2	Understand and apply various pressure measurement techniques
CO3	Apply and analyse various flow measurement techniques.
CO4	Recognize and analyze different speed measurement.
CO5	Recall and analyze different level measurement sensors.

Design of measurement circuits for liquid level, viscosity, force, displacement, flow, humidity, temperature, pressure and calibration. Object detection using image, posture estimation.

References:

1. C S Rangan, G R Sharma and V S V Mani, *Instrumentation Devices & Systems*, TMH, (2e), 2004.
2. E.O.Doeblin, *Measurement Systems – Application and Design*, McGraw Hill, (4e), 1992.
3. J. Bhasker, *A Verilog HDL Primer*, BSP, (1e), 2001.

FIFTH SEMESTER

HUM 3052: ESSENTIALS OF MANAGEMENT [3 0 0 3]

Definition of management and systems approach, Nature & scope, The functions of managers, Corporate social responsibility. Planning: Types of plans, Steps in planning, Process of MBO, How to set objectives, Strategies, Policies & planning premises, Strategic planning process and tools. Nature & purpose of organising, Span of management, factors determining the span, Basic departmentalization, Line & staff concepts, Functional authority, Art of delegation, Decentralisation of authority. HR planning, Recruitment, Development and training. Theories of motivation, Special motivational techniques. Leadership - leadership behaviour & styles, Managerial grid. Basic Control Process, Critical Control Points & Standards, Budgets, Non-budgetary control devices. Profit & loss control, Control through ROI, Direct, Preventive control. Managerial practices in Japan & USA & application of Theory Z. The nature & purpose of international business & multinational corporations, unified global theory of management. Entrepreneurial traits, Creativity, Innovation management, Market analysis, Business plan concepts, Development of financial projections

References:

1. Koontz D. *Essentials of Management*, Mc Graw Hill, New York, 2004
2. Peter Drucker. *Management*, *Task and Responsibility*, Allied Publishers, 2006
3. Peter Drucker. *The practice of management*, Butterworth Hein Mann, 2003

ICE 3151: CONTROL SYSTEM COMPONENTS [3 0 0 3]

Course Outcomes	CO Statements
CO1	Recall the fundamental principles of control system components.
CO2	Describe the construction and working of various control system components
CO3	Design different types of control devices.
CO4	Explain the various applications of control system components

Power Electronic Components/Converters for control of electrical machines: power MOSFET, IGBT, SCR, Rectifiers, Inverters, Choppers, Cycloconverters. Load –torque characteristics, DC and AC motor characteristics, drives. Servo Motors, Stepper motors and drives, BLDC motor and drives, Applications of gear in motor control. Final Control Element and Control Valves: I/P converter, Pressure Booster, Issues in Control Valves, Valve positioner, Valve Selection, Cavitation and Flashing, Applications. Pneumatic & hydraulic actuated valves, Quick exhaust valve, Time delay valve, Shuttle valve, Twin pressure valve, Solenoid operated valve. Control Valve sizing: Definition of Cv, Equations for Calculation of Cv, Pressure Drop Calculation. (08 hrs) Electro-pneumatics: Spring Diaphragm Actuator, Piston Actuators, Rotary Valve Actuator. Pneumatic Hydraulic Actuator, Rotary Pneumatic, Electro Pneumatic Actuators. Force Balance and Motion Balance Positioners, Pneumatic Relays.Fluid and Pneumatic control: Principle of operation of fluid control devices, fluidic logic gate, relays and actuators, Principle of operation of pneumatic control devices, pneumatic gates, relays, and actuators. Types of Hydraulic Control System, Pump Controlled & Valve Controlled Hydraulic Systems and its application. Gear Pump, Vane Pump, Ball Pump, Spool Type Pilot Valve, Centrifugal Pump and Displacement Pump.

References:

1. M.D.Desai, Control system components, PHI publications, 2010
2. J.E Gibson & F.B Teuter, Control System Components, Mc Graw Hill, NY

ICE 3152: MICROCONTROLLERS [4 0 0 4]

Course Outcomes	CO Statements
CO1	Understand the difference between various computer architectures, Architecture and pin details of 8051 microcontrollers, and Interfacing of 8051 to external memory.
CO2	Understand the addressing modes and write ALPs using 8051 instruction set.
CO3	Explain the operation of Timers/Counters, Serial port, and Interrupt system of 8051 with programming.
CO4	Understand the architecture of ARM and GPIO, Timer programming of LPC 2148 with its architecture.
CO5	Interface simple switches, LEDs, ADC, DAC, LCD, keyboard, stepper motor, and DC motor to 8051/LPC 2148 using I/O ports.

Processor architecture, Architecture of 8051, 8051 Addressing Modes, 8051 Instruction Set, Programming 8051 using Assembly Language and C, 8051 Timer, Serial Port and Interrupt Programming using Assembly Language and C. Introduction to ARM, ARM Architecture, Introduction to LPC2148, Architecture of LPC2148 and Programming, Interfacing of I/O ports, ADC, DAC, LCD, Keyboard, Stepper motor, DC motor using 8051 and LPC2148.

References:

1) Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin McKinlay**,** *The 8051 Microcontroller and Embedded Systems Using Assembly and C*, Pearson Education, (2e), 2007.
2) Kenneth J. Ayala, *The 8051 Microcontroller*, Cengage Learning, (3e), 2004.
3) Steve Furber, *ARM System-on-Chip Architecture*, Addison Wesley, (2e), 2000.
4) LPC21XX User Manual, 2007.

ICE 3153: MODERN CONTROL THEORY [3 1 0 4]

Course Outcomes	CO Statements
CO1	Understand the basic concept of state space analysis and apply to obtain the stae model in different forms.
CO2	Analyze the stability, performance and apply state transformation technique.
CO3	Design observer and state variable feedback control law.
CO4	Understand different types of nonlinearities and analyse non linear system behaviour
CO5	Analyse the stability of system using Lyaponuv Theory.

State Space Analysis, Phase variable and canonical form representation, Derivation of state models, Stability analysis, Eigen values, Eigen vectors, Solution of state equations, Cayley Hamilton theorem, Controllability and observability, Pole placement, Observer design, Non Linear Systems, Phase plane analysis, Construction of the phase trajectory, Describing function**,** Lyapunov's stability analysis, Sylvester's criterion, Lyapunov theorems of stability, Lyapunov function for continuous time state equations.

References:

1. K. Ogata, *Modern Control Engineering*, Prentice Hall India, (5e), 2011.
2. Nagrath and Gopal, *Control System Engineering*, New age international Limited, (2e), 1984.
3. M Gopal, *Control Systems Engineering: Principles and Design*, McGraw Hill, (4e), 2012.

ICE 3154: PROCESS INSTRUMENTATION AND CONTROL [3 0 0 3]

Course Outcomes	CO Statements
CO1	Understand the basic of process modelling and control
CO2	Analyse the philosophy of different controller modes
CO3	Design of analog and pneumatic controllers
CO4	Analyse the performance and tuning of controllers
CO5	Describe the principles of advanced control strategies

Mathematical modelling of level, pressure and thermal processes, Self-regulation, Servo and regulatory operation, On-off, proportional, single-speed, floating, integral and derivative control modes, PI, PD and PID control modes, Pneumatic and Electronic controller realization, Anti-Reset windup, Controller evaluation criteria's, Controller tuning - Process reaction curve method, Ziegler Nichols method , Damped oscillation method, Two-point method, Multi loop Control-Feed forward, Ratio, Cascade, Inferential, Split range control, Internal Model Controller, Dead time Compensator.

References:

1. Stephanopoulis, G, *Chemical Process Control*, PHI, 2008.
2. Donald R Coughanower, *Process Systems Analysis and Control*, MGH, (3e), 2017.
3. Curtis D. Johnson, *Process Control Instrumentation Technology*, PHI, (8e), 2009.

ICE 3161: MICROCONTROLLERS LAB [0 1 3 2]

Course Outcomes	CO Statements
CO1	Understand the basics of various microcontrollers and its applications.
CO2	Have the knowledge of 8051 ALP and C programming.
CO3	Have the knowledge of LPC 2148 programming.
CO4	Understand controlling concepts of various devices using LPC 2148.
CO5	Develop real-time embedded systems.

8051 Programming - Timer, Serial Port and Interrupt Programming, ARM programming, Peripherals Interfacing to 8051 and LPC2148.

References:

1) Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin McKinlay, *The 8051 Microcontroller and Embedded Systems Using Assembly and C*, Pearson Education,(2e), 2007.

2) Kenneth J. Ayala, *The 8051 Microcontroller*, Cengage Learning (3e), 2004.
3) Steve Furber, *ARM System-on-Chip Architecture*, Addison Wesley, (2e), 2000.
4) LPC21XX User Manual, 2007.

ICE 3162: PROCESS CONTROL LAB [0 0 3 1]

Course Outcomes	CO Statements
CO1	Explore the different benchmark stations of the process industry.
CO2	Comprehend the different types of PID tuning methods.
CO3	Design the PID controllers for different benchmark stations of the process industry.
CO4	Identify the mathematical model of non - linear and interacting processes.
CO5	Interface different benchmark stations of the process industry with DCS.

Study the characteristics of P, PI, PID Controller modes of Level Control System, Flow Control System, Temperature Control System, Pressure Loop, Tuning of P, PI, PID Controllers by using Z-N method, study the characteristics of different types of control valves, Study of Cascade System, PID Controller modes in Ratio control, Feed forward control for various Feed forward factor, FOPTD model estimation of a process using process reaction curve method and two point method, Real time data acquisition using Matlab.

References:

1. Curtis D. Johnson, *Process Control Instrumentation Technology*, PHI, (8e), 2009.
2. Donald R Coughanower, *Process Systems Analysis and Control*, MGH, (3e), 2017.
3. Wayne Bequette, *Process control, Modelling, simulation & Control*, PHI, (1e), 2004.

SIXTH SEMESTER

HUM 3051: ENGINEERING ECONOMICS AND FINANCIAL MANAGEMENT [3 0 0 3]

Nature and significance, Micro & macro differences, Law of demand and supply, Elasticity & equilibrium of demand & supply. Time value of money, Interest factors for discrete compounding, Nominal & effective interest rates, Present and future worth of single, Uniform gradient cash flow. Bases for comparison of alternatives, Present worth amount, Capitalized equivalent amount, Annual equivalent amount, Future worth amount, Capital recovery with return, Rate of return method, Incremental approach for economic analysis of alternatives, Replacement analysis. Break even analysis for single product and multi-product firms, Break even analysis for evaluation of investment alternatives. Physical & functional depreciation, Straight line depreciation, Declining balance method of depreciation, Sum-of-the-years digits method of depreciation, Sinking fund and service output methods, Costing and its types – Job costing and Process costing, Introduction to balance sheet and profit & loss statement. Ratio analysis - Financial ratios such as liquidity ratios, Leverage ratios, Turn over ratios, and profitability ratios.

References:

1. Blank Leland T, Tarquin Anthony J. *Engineering Economy*, McGraw Hill, 2002
2. Chan S. Park. *Contemporary Engineering Economics*, Pearson Education, Inc. 2010
3. Raman B.S. *Advanced accountancy*, United publications, 1993
4. T. Ramachandran. *Accounting and Financial Management*, Scitech Publications Pvt. Ltd., 2001
5. Thuesen G.J & Thuesen H.G. *Engineering Economics*, Prentice Hall of India, 2005

ICE 3251: DIGITAL SIGNAL PROCESSING [3 1 0 4]

Course Outcomes	CO Statements
CO1	Evaluate Z-transform for analysis of LTI systems.
CO2	Evaluate discrete fourier tranaform and fast fourier transforms for discrete signals.
CO3	Understand the design of digital filters.
CO4	Understand the structures and implementation of digital filters
CO5	Apply the principles of digital signal processing to real world problems

LTI discrete time systems, Linear convolution, Cross correlation and autocorrelation, Analysis of discrete time systems, DFT, Inverse DFT, FFT Algorithms, Radix 2 DITFFT and DIFFFT, IIR Filters - Butterworth, Chebyshev and elliptic filters, Impulse invariance, Bilinear transformation, FIR Filters, Structures for FIR systems, Structures for IIR systems, Applications.

References:

1. Proakis John G, Manolakis Dimitris G., *Digital Signal Processing*, PHI,(4e), 2003.
2. Rabiner L.R and Gold Bernard, *Theory and Applications of Digital Signal Processing*, PHI, 2002.
3. Sanjit Mitra K, *Digital Signal Processing: A Computer Based Approach*, TMH, (3e), 2008.

ICE 3252: INDUSTRIAL AUTOMATION [4 0 0 4]

Course Outcomes	CO Statements
CO1	Understand the role of computer in process control, PLC architecture and its modules.
CO2	Understand PLC architecture and basics of PLC ladder logic programming.
CO3	Develop PLC programming for process applications using different programming methods
CO4	Comprehend the structure and working of various types of communication protocols used in automation domain.
CO5	Understand the architecture of DCS and its application.

Data loggers, Data Acquisition Systems, Direct Digital Control, SCADA, Programmable Logic Controller, Ladder logic Programming, PID functions, analog PLC operation, Alternate Programming Languages, PLC Maintenance, Interface and Backplane Bus Standards, Field bus, HART protocol, Smart transmitters, Valves and Smart actuators, MODBUS, Profibus, IEC 1158-2 Transmission Technology, Distributed Control Systems, Local Control Unit, Communications for DCS, Displays – Engineering interfaces.Stepper and servo motor control using PLC and HMI. Understanding features of CENTUM DCS, interfacing process stations with DCS

References:

1. John. W. Webb Ronald A Reis, *Programmable Logic Controllers - Principles and Applications*, PHI, (4e). 1998.
2. Lukcas M.P, *Distributed Control Systems*, Van Nostrand Reinhold Co., 1986.
3. Frank D. Petruzella, *Programmable Logic Controllers*, MGH, (2e), 1997.

ICE 3261: AUTOMATION LAB [0 0 3 1]

Course Outcomes	CO Statements
CO1	Recall the digital logics and implement in ladder format
CO2	Develop simple logic using timers and counters
CO3	Implement programs in different languages
CO4	Solve the automation related case studies using simulator
CO5	Configure and communicate between PLC and SCADA

Implementation of logic gates, flip flops, multiplexers and de multiplexers in PLC, Timers operations in PLC, Counter operations in PLC, Compare and arithmetic instructions in PLC, Control of Traffic signal using PLC, Control of bottle filling station using PLC, Modbus communication using SCADA, Design of SCADA panels for level, flow, pressure and temperature, Control of pressure station using DCS.

References:

1. John. W. Webb Ronald A Reis, *Programmable Logic Controllers - Principles and Applications*, PHI, (4e), 1998.
2. Lukcas M.P, *Distributed Control Systems*, Van Nostrand Reinhold Co., New York, 1986.

ICE 3262: CONTROL SYSTEMS LAB [0 0 3 1]

Course Outcomes	CO Statements
CO1	Understand MATLAB commands for control system and write program for time domain and frequency domain analysis.
CO2	Write a MATLAB program for stability analysis and state space analysis.
CO3	Write MATLAB program for Lag and Lead compensation design.
CO4	Identify the transfer function of a DC motor and control its position and speed.
CO5	Understand working of PID controller and apply on control of oven temperature.

Block diagram reduction, Time domain analysis, Steady state errors, State space analysis, Stability analysis, Lag, Lead, Lag-Lead compensator design using Bode plot and root locus, Study of P, PI, PID controller, Modeling practice with SIMULINK.

References:

1. K. Ogata, *Modern Control Engineering*, PHI, (5e), 2011.
2. R.C. Dorf and R. H. Bishop, *Modern Control systems*, Wesley Longman, 1998.
3. Norman S. Nise, *Control Systems,* Wiley, (7e), 2000.

ICE 3263: DSP LAB [0 1 3 2]

Course Outcomes	CO Statements
CO1	Understand the use of MATLAB software and write a program to generate and compute discrete signals
CO2	Write a MATLAB program to demonstrate the concept of convolution, correlation, and sampling
CO3	Write a MATLAB program to evaluate Z-transform and DFT computation of a given sequence
CO4	Design and implement IIR and FIR filters for a given specification
CO5	Design and demonstration of various DSP applications using DSP kit

Generation of basic signals and discrete sequences, Analysis of discrete time systems, DTFT, DFT computation, Analog filter design, IIR and FIR filter design.

References:

1. Proakis John G, Manolakis Dimitris G, *Digital Signal Processing*, PHI,(4e), 2003.
2. Rabiner L.R and Gold Bernard, *Theory and applications of Digital Signal Processing*, PHI, 2002.
3. Sanjit Mitra K, *Digital Signal Processing: A computer based approach*, TMH, (4e), 2008.

SEVENTH SEMESTER

There are five program electives and one open elective with total of 18 credits to be taught in this semester.

EIGHTH SEMESTER

ICE 4298: INDUSTRIAL TRAINING

Course Outcomes	CO Statements
CO1	Interpret the functioning of the industry
CO2	Realize ethical and safe industrial practices.
CO3	Use modern engineering tools, software and equipment to analyze problems.
CO4	Demonstrate capabilities to undertake interdisciplinary and multidisciplinary tasks.
CO5	Gain experience in writing Technical reports/projects and presentation

Each student has to undergo industrial training for a minimum period of 4 weeks. This may be taken in a phased manner during the vacation starting from the end of third semester. Student has to submit to the department a training report in the prescribed format and also make a presentation of the same. The report should include the certificates issued by the industry.

ICE 4299: PROJECT WORK/PRACTICE SCHOOL

Course Outcomes	CO Statements
CO1	Demonstrate a sound technical knowledge of the selected project topic.
CO2	Design Engg Solutions to Complex problems utilizing system's approach.
CO3	Apply industry standard tools for multidisciplinary applications.
CO4	Realize safe, ethical and sustainable practices.
CO5	Demonstrate effective communication skills.

The project work may be carried out in the institution/industry/ research laboratory or any other competent institutions. The duration of the project work shall be a minimum of 16 weeks which may be extended up to 24 weeks. A mid-semester evaluation of the project work shall be done after about 8 weeks. An interim project report on the progress of the work shall be submitted to the department during the mid-semester evaluation. The final evaluation and viva-voice will be conducted after submission of the final project report in the prescribed form. Student has to make a presentation on the work carried out, before the department committee as part of project evaluation.

MINOR SPECIALIZATION

1. COMPUTATIONAL INTELLIGENCE

ELE 4061: ARTIFICIAL INTELLIGENCE [2 1 0 3]

Foundation and History of AI, State of the art, Fields of application, Performance measures, Rationality, Specification and properties of task environment, Structure of Agents, Problem solving by searching, Searching for solutions, uninformed search strategies, Informed search strategies, Heuristic functions, Local search algorithms, Online search agents, Knowledge based agents, The Wumpus World, Propositional logic – reasoning patterns, effective inference, First order logic - Syntax and semantics, Knowledge engineering, Inference rule, forward and backward chaining, Ontological engineering, categories and objects, Processes and intervals, reasoning systems, Truth maintenance systems, Uncertainty, Basic probability notation, Axioms, Baye's rule, Bayesian networks, Inference in Bayesian networks.

References:

1 Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach* (3e), Pearson, 2012
2 Elaine Rich, Kevin Knight and Shivashankar B. Nair, *Artificial Intelligence (3e)*, Tata McGraw Hill, 2012
3 David Poole and Alan Mackworth, *Artificial Intelligence: Foundations of Computational Agents* (2e), Cambridge University Press, 2017
4 http://nptel.ac.in/courses/106105077/, IIT, Kharagpur

ECE 4051: COMPUTER VISION [2 1 0 3]

Image formation model using pinhole camera, Linear filters and convolution, Image derivatives, Features: corners, SIFT, HOG, textures. Segmentation using clustering (K-means, Mean-Shift, Watershed) and fitting model, Segmentation and fitting using probabilistic methods (EM algorithm), Geometry of two view and Camera calibration including radial distortion, Bayes Classifier: using class histograms, using class conditional density, Support Vector machine

References:

1. David A. Forsyth and Jean Ponce, *Computer Vision: A Modern Approach, Pearson Education*, 2003
2. Richard Szeliski, *Computer Vision: Algorithms and Applications*, Springer, 2010
3. Richard Hartleyand and Andrew Zisserman, *Multiple View Geometry in Computer Vision*, (2e), Cambridge University Press, 2004
4. Linda Shapiro and George Stockman, *Computer Vision*, Pearson Education, 2001

ECE 4052: MACHINE LEARNING [2 1 0 3]

Machine learning basics, Naïve Bayesian Model. Non-Parametric Techniques: Density Estimation, Parzen Windows, k- Nearest-Neighbor Estimation, K- nearest neighbor classification, Radial Basis Function Network, Learning Vector Quantization, Clustering, K-Means clustering, Competitive learning, Self-Organizing Maps, Recurrent Neural Network, Hopfield Neural Network, Adaptive Resonance Theory, Support vector machines, Statistical Hypothesis testing- t-test, ANOVA, feature selection methods – Filter based techniques and wrapper methods, Principal Component Analysis, Applications of PCA, PCA ,Independent component analysis, Voting, Error correcting output codes, Bagging, Boosting

References:

1. Ethem Alpaydin, *Introduction to Machine Learning*, (2e), MIT Press. 2010.
2. Richard O. Duda, Peter E. Hart, David G. Stork, *Pattern Classification*, (2e), Wiley, 2001
3. Peter Harrington, *Machine Learning in Action*, Manning Publications, 2012.
4. Christopher M.Bishop, *Pattern Recognition and Machine Learning*, Springer, 2007.
5. Richard Jensen, Qiang, Shen *Computational Intelligence and Feature Selection*: Rough and Fuzzy Approaches, Vol. 8, IEEE Press Series on *Computational Intelligence*, John Wiley & Sons, 2008
6. Marshall, E. (2016). *The Statistics Tutor's Quick Guide to Commonly Used Statistical 210 Tests*. http://www.statstutor.ac.uk/resources/uploaded/tutorsquickguidetostatistics.pdf

ELE 4062: SOFT COMPUTING TECHNIQUES [2 1 0 3]

Introduction to Soft computing, soft computing techniques, Artificial Neural Networks, Multilayer Perceptron, Gradient descent, Logistic discrimination, Single layer Perceptron, Training a perceptron, Multilayer perceptron, Back-Propagation Algorithm, Fuzzy Systems, Fuzzy Logic, Membership Functions, Fuzzy Controllers, Evolutionary Algorithms, Genetic Algorithms, Other Optimization Techniques, Metaheuristic Search, Traveling Salesman Problem, Introduction to hybrid systems, , Adaptive Neuro-Fuzzy Inference Systems, Evolutionary Neural Networks, Evolving Fuzzy Logic, Fuzzy Artificial Neural Networks

References:

1 Jacek M Zurada, "*Introduction to Artificial Neural Systems*", Jaico publication. 2016

2 Timothy J Ross, "*Fuzzy Logic with Engineering Applications*", Intl. edition, McGraw Hill publication, 2012.

3. Anupam Shukla, Ritu Tiwari, Rahul Kala, *Real Life Applications of Soft Computing*, CRC Press, Taylor and Francis Group, London 2010
4. Shivanandam & Deepa , "*Principles of Soft Computing*" , Wiley India edition, 2009
5. Rajasekaran and G.A.Vijayalakshmi Pai "*Neural Networks, Fuzzy Logic and Genetic Algorithms*" PHI Learning, 2003

II. CONTROL SYSTEMS:

ICE 4051: DIGITAL CONTROL SYSTEMS [3 0 0 3]

Course Outcomes	CO Statements
CO1	Recall and review of sampling process, difference equations, Z and inverse Z transforms as applied to linear discrete systems.
CO2	Describe and apply block diagram reduction technique for different digital systems
CO3	Analyse steady state error of different types of digital systems
CO4	Apply different stability analysis techniques and also design compensators for digital systems.
CO5	Apply state-space analysis and pole-placement technique for digital systems.

Sampling, Data acquisition, Quantization, sample and hold, zero order hold, frequency domain consideration in sampling and reconstruction, Difference equations, pulse transfer function, Block diagram analysis of sample data systems, time response of discrete time control systems, Steady State error analysis, Stability, Jury's stability test, bilinear transformation, Root locus technique, W transformation, Bode Plot. Nyquist Stability analysis, Design of Lag, Lead, Lag-lead compensator using root locus and Bode plot, Design of PID controller, Lyapunov Stability Analysis, State Space Analysis, Diagonalization, Solution of state equations, Controllability, Observability, Representation of the system in different canonical forms, Pole Placement- Ackermann's Formula, Dead beat Algorithm.

References:

1. K. Ogata, *Discrete time control systems*, PHI, (7e), 2011.
2. M. Gopal, *Digital control and state variable methods*, TMH, 2001.
3. C.H Houpis and G.B Lamont, *Digital Control Systems – Theory and Hardware*, MGH, 1992.
4. G.F.Franklin, J.David Powell, M. L.Workman, *Digital Control of Dynamic Systems*, A-Wesley Publishing Company, (2e), 1990.
5. V. I. George and C.P. Kurian, Digital Control Systems, Cengage publishers, 2012.

ICE 4052: NONLINEAR CONTROL SYSTEMS [3 0 0 3]

Course Outcomes	CO Statements
CO1	Understand nonlinear system behavior and analyse system stability.
CO2	Understand the concept of passivity and perform frequency domain analysis.
CO3	Design feedback control law using various methods
CO4	Perform linearization of nonlinear systems.
CO5	Understand the design procedure of different nolinear controllers.

Lyapunov stability using Krasovskii's method, Variable Gradient method, L_2 stability of state models**,** L_2 gain, small gain theorem, Passivity, Memory less functions, L_2 gain and Lyapunov stability, passivity theorems, passivity based control, Review of describing function method, Absolute Stability Circle criterions, Popov Criterion, stabilization via linearization and Integral control, Gain scheduling, Graphical Linearization Methods, Analytical Linearization Method, Evaluation of Linearization Coefficients by Least-Squares Method, Local linearization, Feedback linearization, Input-state linearization, Input-output linearization, Internal dynamics, Zero dynamics, Model Reference Adaptive Control (MRAC). Sliding mode Control, sliding surfaces, continuous approximations of switching control laws, modeling performance trade off, Tracking regulation via Integral control, Lyapunov redesign, non-linear damping, back stepping, high gain observers.

References:

1. H.K. Khalil, *Nonlinear Systems***,** (3e), PHI, 2002
2. R. Marino and P. Tomei *Nonlinear Control Design - Geometric, Adaptive and Robust*, Prentice Hall, 1995.
3. J.J.E. Slotine and W.Li, *Applied Nonlinear control*, Prentice Hall, 1998.
4. Alberto Isidori, *Non-linear Control Systems*, Springer Verlag, 1999.

ICE 4053: ROBUST CONTROL [3 0 03]

Course Outcomes	**CO Statements**
CO1	Understanding the norms and signals
CO2	Able to analyze the uncertainty and model parameter variations w.r.t stability
CO3	Robust controller design via controller parameterization
CO4	Robust Stability and Robust Performance analysis
CO5	Case studies with Solution for modified cases

Issues in Control System Design**,** Norms for signals and systems, Input- Output Relationships, Computing the Norm by State-Space Methods, Condition for Internal stability, sensitivity and complementary sensitivity function, Asymptotic tracking, Performance, Sources of Model Uncertainties, Plant Uncertainty Model, Small Gain Theorem, Robust Stability, Robust Performance, Existence of Stabilizing Controllers, Parameterization of All Stabilizing Controllers, Coprime Factorization. Loop shaping with C, Shaping S, T, or Q, P^{-1} Stable, P^{-1} Unstable, The Modified Problem, Spectral Factorization, Case Studies-Robust Control for Mass Damper Spring Systems, Spacecraft and Inverted Pendulum.

References:

1. Doyle, J.C., B.A. Francis and A. Tannenbaum, *Feedback Control Theory*, Macmillan publishing co., 1990.
2. Kemin Zhou, Doyle J.C and Glover K., *Robust and Optimal Control*, Prentice Hall Inc, 1995.
3. Willian A. Wolovich, *Automatic Control Systems*, Saunders college publishing, 1994.
4. Kemin Zhou and Doyle J.C, *Essential of Robust Control*", Prentice Hall Inc, 1998.

ICE 4054: SYSTEM IDENTIFICATION [3 0 0 3]

Course Outcomes	CO Statements
CO1	Recall the purpose of system identification in industries
CO2	Comprehend the structure and working of various types of system identification techniques.
CO3	Understanding the data driven models
CO4	Analyze and implementing the data driven models

Introduction to system modeling, Types of system models, Importance of system models, Model development techniques – first principle based and data driven based, Introduction to System Identification, Procedure for identification, Concept of Identifiability, Signal to Noise Ratio, Overfitting, LTI System Modeling using time and frequency, Direct impulse response identification, Direct step response identification, Impulse response Identification using step response, Empirical Transfer function Identification, Correlation Methods, Linear Regression, Least Square Estimation, Equation Error Models – ARX Models, ARMAX Models, ARIMAX Models, OE Models, Box Jenkins Model,Model Validation Techniques.

Reference books:

1. Arun. K. Tangirala, Principles of System Identification Theory and Practice, CRC Press, 2016.
2. Karel. J. Keesman, System Identification – An Introduction, Springer, 2011.

III. EMBEDDED SYSTEM

ECE 4053: EMBEDDED SYSTEM DESIGN [2 1 0 3]

Typical embedded system: Core of the embedded system, memory, sensors & actuators, communication interface, Serial/Parallel Communication protocols, Hardware and software co-design: Data-path and controller design, Architecture design; Development Environment: OS and non-OS based firmware embedding techniques; Firmware Design and Development; operating system basics; Embedded development life cycle.

References:

1. Frank Vahid & Tony Givargis, *Embedded System Design*, Wiley Publication, 2002.
2. Shibu K. V, *Introduction to Embedded Systems*, McGraw Hill Publication, 2013.
3. Paul S R Chisholm, David Hanley, Michael Jones, Michael Lindner, and Lloyd work, *C Programming: Just the FAQs*, SAMs publishing, 1995.
4. Wayne Wolf, *Modern VLSI Design-IP based Design*, Prentice Hall, 4th Edition, 2008.

ELE 4063: FPGA BASED SYSTEM DESIGN [2 1 0 3]

Overview of Digital Systems – Implementation options , FPGA – Architecture, Programming technologies, Altera & Actel logic cells, I/O Blocks, Programmable interconnects, Logic implementation , Design verification- Test bench codes, Hardware testing, FPGA Architectural options; granularity of function and wiring resources, reconfigurable architectures- Fine grained, Coarse grained, Medium grained, Embedded multipliers, adders, MACs, processor cores, Configuring an FPGA ; Vendor specific issues, Logic block architecture, timing models-static and dynamic timing analysis, Input and Output cell characteristics , Power dissipation, Partitioning and placement, Routing resources ,Embedded system design using FPGAs, DSP using FPGAs, Multi FPGA systems, Reconfigurable systems, Application case studies

References:

1. M.J.S. Smith, *Application Specific Integrated Circuits*, Pearson, 2000
2. Peter Ashenden, *Digital Design using Verilog*, Elsevier, 2007
3. W. Wolf, *FPGA Based System Design*, Pearson, 2004
4. Clive Maxfield, *The Design Warriors Guide to FPGAs*, Elsevier, 2004
5. Paul S. Graham and Maya Gokhale *Reconfigurable Computing Accelerating Computation with Field-Programmable Gate Arrays*, Springer, 2005.

ECE 4054: INTERNET OF THINGS [2 1 0 3]

Introduction to Internet of Things, Sensing, actuation, Basics of Networking, Sensor networks, Machine to Machine communication (M2M), IOT technologies and Architectures: Infrastructure and service discovery protocols for the IoT ecosystems; Realization of IoT ecosystem using wireless technologies; Interoperability in IoT , Data handling and analytics, cloud computing, Real world design constraints; IoT use Cases

References:

1. Pethuru Raj & Anupama C Raman, *The Internet of Things: Enabling Technologies, Platforms & Use Cases*, CRC Press, 2017
2. Arshdeep Bagha & Vijay Medisetti, *Internet of Things: A Hands on Approach*, University Press
3. Jan Holler, Vlasios T Siatsis, Catherine Mulligan, Stamatics Karnouskos, Stefan Avesand, David Boyle, *From Machine to Machine to the Internet of Things: Introduction to a New Age of Intelligence*, Academic Press, 2014
4. Frank Vahid, Givargis *Embedded Systems Design: A Unified Hardware/Software Introduction*, Wiley Publications, 2000
5. Jan Axelson, *Parallel Port Complete*, Penram publications

ELE 4064: REAL TIME SYSTEMS [2 1 0 3]

Introduction to real time embedded system, terminology, Real time design issues, characteristics. Types of real time systems, timing constraints, precedence constraints, dependencies, functional and resource parameters. Real time operating systems, kernels, queues, semaphores, Multi processing and multitasking, priority inversion, dead-lock. Real time services, Real time standards, System resources, Processing, scheduling policies, Performance measures for real time systems. Scheduling algorithms, periodic and aperiodic, priority driven, frame size constraints, real time communication.

References:

1. Jane W.S.Liu , Real Time Systems, Pearson Education, 2006
2. Sam Siewert, Real Time Embedded Systems and Components, Cengage Learning, 2007
3. Qing Li, Real Time Concepts for Embedded Systems, CMP Books, Elsevier, 2003
4. Santanu Chattopadhyay, Embedded System Design, PHI, 2011
5. C.M.Krishna, Kang.G.Shin, Real Time Systems, McGraw Hill, 1997

IV. ILLUMINATION TECHNOLOGY

ELE 4065: INTEGRATED LIGHTING DESIGN [2 1 0 3]

Interior lighting design: Artificial illumination design techniques: quality and quantity aspects, Energy efficiency in illumination systems, lamp and luminaire selection, Energy conservation, visual comfort and thermal comfort. Design calculations. Exterior lighting design: Road Lighting, Sports lighting and flood lighting, Daylight -artificial light integration, Simulation assisted design of interior and exterior, lighting design standards – Subjective analysis in lighting design, daylight- artificial light integration and energy performance.

References:

1. National Lighting Code 2010 (SP 72: 2010), Bureau of Indian Standards.
2. I.E.S.N.A., New York, *Lighting Hand Book*, (10e), 2011.

ELE 4066: LIGHTING CONTROLS: TECHNOLOGY & APPLICATIONS [2 1 0 3]

Strategies and technologies: occupancy sensing, switching controls, daylight adaptation and photo sensors, Commissioning and energy codes, Controller and control algorithms: Integral reset, open-loop and closed loop control, adaptive control, predictive control , inverse control with online adaptive learning, Camera based measurement, virtual scenario based intelligent lighting control, Protocols and Networking: architecture, standard lighting protocols, wired and wireless , centralized and distributed, WSAN lighting control application, connected lighting system, SoC solutions for lighting control system, Power-over-Ethernet, Commissioning of smart lighting system.

References:

1. Simpson, Robert S. *Lighting control: technology and applications*. Taylor & Francis, 2003.
2. DiLouie, Craig. *Lighting controls handbook*. The Fairmont Press, Inc., 2008.
3. Cai, H. "Luminance gradient for evaluating lighting." *Lighting Research & Technology* 48.2, 2016: 155-175.
4. Serpanos, Dimitrios, and Marilyn Wolf. *Internet-of-things (iot) Systems: Architectures, Algorithms, Methodologies*. Springer, 2017.
5. Yang, Kun. "Wireless sensor networks." *Principles, Design and Applications*, 2014.

ELE 4067: LIGHTING SCIENCE: DEVICES AND SYSTEMS [2 1 0 3]

Light & Vision: Human visual system, photoreceptors, colour perception -spectral, spatial, and temporal characteristics, chromatic adaptation and contrast sensitivity. Lighting technologies: Light sources and Luminaires, Generation, distribution and control, emerging sources and luminaires, optical, electrical and thermal characteristics. Photometry & Colorimetry: measurements and calculations, characterization of colors of lights and objects - experimental and simulation analysis, measuring instruments, testing, reliability and lifetime of luminaires, evaluation of lighting products.

References:

1. *Lighting Handbook*, (10e), IESNA, 2011.
2. Patrick Mottier, *LED for Lighting Applications*, (1e), Wiley, 2009.
3. Spiros Kitsinelis, Light Sources: Technologies & Applications, CRC press, 2010.
4. M.a. Cayless & A.M. Marsdon, *Lamps & Lighting,* 4th ed., Oxford & IBH publishing company, 1996
5. Jack L. Lindsey, *Applied Illumination Engineering,* (2e), Fairmont Press, INC 1997
3. *Code of practice for interior illumination* - IS 3646 (Part 1) 1992, IS 3646 (Part 2).
4. 1966, IS 3646 (Part 3) 1968.
5. *Code of practice for road lighting* - IS 1944 (Part 1 to 6)
6. Karlen, Mark, Christina Spangler, and James R. Benya, *Lighting design basics*. John Wiley & Sons, 2017.

ELE 4068: SOLID STATE LIGHTING [2 1 0 3]

General Characteristics of LEDs, Electrical and optical characteristics of high brightness LEDs, CIE Chromaticity coordinates, viewing angle, Binning, Mac dam ellipse, spectral tuning and optimization algorithms, Case study: Circadian rhythm, Daylight matching spectrum and its applications in healthcare - skin and Brain related therapies, Vitamin D synthesis, LED-on-the-Tip Endoscope, LEDs in Horticulture and Automotive lighting, LED drivers: power supply, dimming and controller, Thermal management and Heat sink design , lifetime and reliability.

References:

1. E Fred Schubert, *Light emitting Diodes*,Cambridge ,(2e), University press, 2006
2. Vinod Kumar Khanna, "*Fundamentals of Solid state Lighting*" CRC press,2014
3. Arturas Zukauskus, Michael S. Shur and Remis Gaska, "*Introduction to solid state lighting*", wiley interscience 2002.
4. Gilbert Held, "*Introduction to Light Emitting Diode Technology and Applications*", CRC press, 2009
5. Mohan Underland and Robbins, " *Power Electronic converters, Applications and Design*", John Wiley and sons, 1989

V. SENSOR TECHNOLOGY:

ICE 4055: ADVANCED SENSOR TECHNOLOGY [3 0 0 3]

Course Outcomes	CO Statements
CO1	Apply fundamental concepts of measurement for sensing systems
CO2	Application specific analysis of sensors for measurement of displacement, velocity, acceleration and orientation.
CO3	Analyse the use of sensors for measurement of temperature, pressure and flow for Industrial applications
CO4	Design of chemical and electrochemical measurement systems.
CO5	Design of optical sensing systems for biosensing

Sensor classifications, Advanced sensing materials, Properties of materials, Design and modeling issues, Fiber optic light propagation, Graded index fibers, Fiber optic communication driver circuits, Laser classifications, Driver circuits for solid state laser diodes, Radiation sensors and Optical combinations, Accelerometers, Thermal, Humidity and moisture sensor, Proximity detectors using polarized light, Semiconductor gas sensor, Fluidic and Micro-fluidic sensors, Gyroscope laser, Chemical sensor characteristics, Classification of Chemical sensing mechanism, Sensors based on direct and indirect sensing techniques.

References:

1. Jacob Fraden, *Handbook of Modern Sensors: Physics, Designs, and Applications*, Springer, 2010.
2. P Ripka, A Tipek, *Modern Sensors Handbook*, Wiley Publication, 2007.
3. Sabaree Soloman, *Sensors Hand Book*, MGH, 1998.

ICE 4056: MICRO ELECTROMECHANICAL SYSTEMS [3 0 0 3]

Course Outcomes	CO Statements
CO1	Understand the basics of micro electronics, micro systems and its fabrication techniques
CO2	Understand the working and design of electrostatic and micro sensors and actuators
CO3	Understand the working and design of thermal micro sensors and actuators
CO4	Understand the working and design of piezo electric sensors and actuators
CO5	Case studies on applications of MEMS sensors

Overview of MEMS and NEMS, scaling laws, Rigid-body dynamics, Electrostatic and electro-magnetic forces, Materials, Photolithography, Ion implantation, Diffusion, Oxidation, Chemical Vapor Deposition, Physical vapor Deposition-Sputtering, Deposition by epitaxy, Etching, Bulk Micro manufacturing, Surface Micromachining, LIGA process, Microsystem Design- Process design, Mechanical design, Introduction to computer aided design using COMSOL Multiphysics, Electrostatic sensors and actuation, Thermal sensing and actuation, Piezoelectric sensing and actuation, Microsystem Packaging- Types, Interfaces, Technologies, Selection, Design and packaging case study.

References:
1. Tai-Ran-Hsu, *MEMS & Microsystems Design and Manufacture*, TMH, 2002.
2. Chang Liu, *Foundations of MEMS*, Pearson International Edition, 2006.
3. Sergey Edward Lyshevski, *MEMS and NEMS systems*, Devices and Structures, CRC Press, 2002.
4. Stephen D. Senturia, *Microsystem Design*, Kluwer Academic Publishers, Springer, 2000.

ICE 4057: MULTI SENSOR DATA FUSION [3 0 0 3]

Course Outcomes	CO Statements
CO1	Recall the concept of sensor and data fusion
CO2	Realize various common representation formats
CO3	Comprehend concept of data association and decision making
CO4	Describe data fusion frameworks
CO5	Understand data filtering techniques

Concept and role of fusion, Fusion types, Sensor configuration, Architecture of fusion nodes, Fusion topologies, Benefits of fusion, data refinement, Classification of data refinement, Spatial alignment, Temporal alignment, Semantic and radiometric alignment, Concept and need for data association and decision making, data registration, data association techniques, Decision making techniques, Information requirement for decision making. JDL framework, Revised JDL, Dasarathy's model, Thompolus framework, Luo-Key framework, Pau's framework, Waterfall and omnibus framework, distributed black box, Esteban framework, Kalman filter, Baysien filter, extended information filter, Estimation, Approximate agreement, Optimization filter, Distributed dynamic fusion, Dynamic data flow analysis.

References:
1. David L. Hall, *Mathematical Techniques in Multisensor Data Fusion*, Artech House, 2004.
2. H B Mitchell, *Data Fusion: Concepts and Ideas*, Springer Publishers, 2012.

ICE 4058: SMART SENSOR [3 0 0 3]

Course Outcomes	CO Statements
CO1	Understand the architecture of smart sensors
CO2	Understand and compare various smart sensor standards
CO3	Analyse sensor signal processing and feature extraction techniques
CO4	Analyze sensor signal processing and feature extraction techniques
CO5	Incorporate smart sensors for applications

Introduction, Signal conditioning, Separate versus integrated signal conditioning, Digital conversion, MCU control, MCUs for sensor interface, Techniques and Systems Considerations for MCUs, DSP control, Sensor integration, IEEE standards, Plug and play, Automated/ Remote sensing, Process control over the Internet, Other communication standards with case studies, Wireless zone sensing, Surface acoustical wave devices, Intelligent transportation system, RF-ID, RF MEMS basics, Varactors, Micro optics, Micro grippers, Microprobes, Micro mirrors, FEDs, Data processing, Pattern recognition and classification, Centralized and decentralized system of the measurement chains.

References:

1. Gerard Merjer, *Smart Sensor Systems*, Wiley Publisher, 2008.
2. Randy Frank, *Understanding Smart Sen**sors***, Artech House Publications, 92e), 2000.
3. Paul W. Chapman, *Smart Sensors*, ISA Press, 1996.
4. Krzystof Iniewski, *Smart Sensors for Industrial Applications*, CRC Press, 2013.

VI. SIGNAL PROCESSING

ECE 4055: ADVANCED DIGITAL SIGNAL PROCESSING [2 1 0 3]

Multi-rate systems, decimation and interpolation, interpolated FIR approach, poly phase filter structure, filter banks, perfect reconstruction, Principles and applications of adaptive filters, Weiner filters, steepest descent algorithm, LMS and RLS algorithms. Homomorphic system, cepstrum, homomorphic systems for convolution and de-convolution, applications of homomorphic signal processing. Stochastic models, Maximum likelihood, expected maximization, Bayesian estimation, random signal detection. Sparse representation, regularization, Total Variation, Compressed Sensing.

References:

1. P. P Vaidyanathan, *Multirate Systems and Filter Banks*, Prentice Hall, India, 1993.
2. Vikram M Gadre, Aditya S Abhyankar, *Multiresolution and Multirate Signal Processing: Introduction, Principles and Applications*, McGraw Hill, 2017.
3. S. J Orfanidis, *Optimum Signal Processing*, Mc Graw Hill, NJ, 2007.
4. A.V Oppenheim and R.W. Schafer, *Digital Signal Processing*, PHI Learning, 2008.
5. Russell B. Millar, *Maximum Likelihood Estimation and Inference*, John Wiley & Sons, Inc. 2011.

ELE 4073: DIGITAL IMAGE PROCESSING [2 1 0 3]

Image representation, relationship between pixels, Convolution and corrélation. Unitary 2D transforms, DFT, DCT, subband coding, multiresolution analysis, DWT, contourlet transform, SVD. Intensity transformations, histogram processing, spatial and frequency domain filters, noise types, Wiener filter, local and nonlocal filtering, Boundary detection, canny edge detector, segmentation, Otsu’s thresholding, image compression standards, Morphological operations and algorithms, Hit or Miss transform, colour image representation. Applications.

References:
1. S. Jayaraman, S. Esakkirajan, T. Veerakumar, *Digital Image Processing*, TMH, 2012.
2. Rafael C Gonzalez, Richard E Woods, *Digital Image Processing*, Pearson Education, 2nd Edition, 2003.
3. William K Pratt, *Digital Image Processing*, John Willey, 2001.
4. Milan Sonka, Vaclav Hlavac, Roger Boyle, *Image Processing, Analysis, and Machine Vision*, (4e) Cengage Learning.
5. A.K. Jain, *Fundamentals of Digital Image Processing*, PHI, New Delhi, 1995.

ECE 4056: DIGITAL SPEECH PROCESSING [2 1 0 3]

Anatomy, physiology and modeling of speech production system. Time and frequency domain analysis of speech. Cepstral analysis of speech and its applications. Linear predictive modeling of speech and its applications. Speech coding and synthesis, automatic speech recognition. Speech enhancement in the presence of noise.

References:
1. Rabiner L.R and Schaffer R.W, Digital Processing of Speech Signals, Prentice Hall, NJ, 2007.
2. Thomas F. Quatieri, Discrete.Time Speech Signal Processing—Principles and Practice, Pearson Education, Inc., 2004.
3. Douglas O' Shaughnessy, Speech Communications: Human and Machine Reading, Addison Wesley, 1987.
4. Shaila D. Apte, Speech and Audio Processing, Wiley India, 2012.
5. Lawrence Rabiner, Biing-Hwang Juang, B. Yegnanarayana, Fundamentals of Speech Recognition, Pearson, 2011.

ELE 4074: LINEAR ALGEBRA FOR SIGNAL PROCESSING [2 1 0 3]

Vectors, matrices, norms of vector and matrices, L_p norms, Holder, Cauchy - Schwarz, and triangular inequalities, inner product spaces and their applications. System of linear equations and its solution sets, Gaussian elimination and back-substitution, echelon forms, matrix operations, LU - factorization, inverse matrices, Gauss-Jordan technique, transpose, elimination, and permutation matrices. Row space, column space, and null space of a matrix, bases and dimension, rank and nullity of a matrix, matrices as linear transformations, pseudo-inverse and applications, change of basis, affine transformations. Orthogonal subspaces, projections, Gram-Schmidt process, generalized Fourier series, QR factorization, least squares and their applications. Characteristic equation, diagonalization, Jordan canonical form, special matrices, positive definite matrices and applications. Symmetric, Orthogonal, Hermitian, Unitary, Jacobian, and Hessian matrices, singular value decomposition and related applications.

References:

1. Gilbert Strang, *Linear Algebra and its Applications*, (3e), Thomson Learning Asia, 2003.
2. David C. Lay, *Linear Algebra and its Applications,* (3e), Pearson Education (Asia) Pvt. Ltd, 2005.
3. Kenneth Hoffman and Ray Kunze, *Linear Algebra*, (2e), PHI, 2004.
4. Sohail A Dianat and Eli Saber, *Advanced Linear Algebra for Engineers with MATLAB*, (1e), CRC Press.

VII. VLSI DESIGN

ECE 4061: ANALOG AND MIXED SIGNAL DESIGN [2 1 0 3]

Analog circuit design issues, second order effects, current mirror circuits: Wilson, cascode and wide swing, voltage references, cascode and differential amplifier, Gilbert cell, operational transconductance amplifier, current conveyor, current feedback op-amp; Mixed signal circuit design: fully differential circuits, current mode signal processing , OTA-C continuous-time filters, ladder filters, DAC architectures: current-mode R-2R, current steering and charge scaling. ADC, flash, successive approximation and noise shaping, Layouts, analog and mixed signal circuits.

References:

1. David A. Johns, Ken Martin, *Analog Integrated Circuit Design*, John Wiley & Sons, 2002.
2. R. Jacob Baker, Harry W. Li, David E. Boyce, *CMOS Circuit Design, Layout, and Simulation*, IEEE Press, PHI, 1998.
3. Behzad Razavi, *Design of Analog CMOS Integrated Circuits*, Tata McGraw Hill, 2002.
4. R. Jacob Baker, *CMOS Mixed Signal Circuit Design*, Volume II, Wiley Inter-science, 2002.
5. P. V. Anand Mohan, *Current mode VLSI Analog Filters Design and Applications*, Birkhauser, 2003.

ECE 4063: LOW POWER VLSI DESIGN [2 1 0 3]

Power dissipation in digital ICs, low power methodologies and their design, Impact of device technology and scaling on power, dynamic power reduction techniques, Sources of leakage current and techniques for leakage power reduction, power analysis and power estimation methods, switching activity reduction in CMOS circuits, Low power clock distribution techniques with zero or tolerable clock skew, Power and performance management, Circuit and system level architectures for low power, low power architectures for arithmetic and memory circuits.

References:

1. Gary K. Yeap, *Practical Low Power Digital VLSI Design*, KAP, 2002.
2. Christian Piguet, *Low Power CMOS Circuits – Technology, Logic Design and CAD Tools*, CRC Press, 2006.
3. Jan M. Rabaey, Massoud Pedram, *Low Power Design Methodologies*, Kluwer Academic, 1997.
4. Kaushik Roy, Sharat Prasad, *Low Power CMOS VLSI Circuit Design*, Wiley, 2000.
5. Kiat Seng Yeo, Samir S. Rofail, Wang-Ling Goh, *CMOS/BiCMOS ULSI: Low Voltage, Low Power*, Pearson, 2002.

ECE 4064: SEMICONDUCTOR DEVICE THEORY [2 1 0 3]

Energy Bands in Solids, Electron and Hole Densities in Equilibrium, Excess carriers—Non-equilibrium Situation, Junctions and Interfaces, Charge Transport in Semiconductors, P-N Junctions and its applications. Junction Field Effect Transistor and Metal-Semiconductor, MIS Junction/capacitor - ideal C-V characteristics and deviations due to interface states/charges and work function differences, threshold voltage. Field Effect Transistor, MOSFETs.- operation and characteristics.

References:

1. M. K. Achuthan and K. N. Bhat, *Fundamentals of Semiconductor Devices*, Tata Mc Graw Hill, New Delhi, 2011.
2. B. G. Streetman and S. Banerjee, *Solid State Electronic Devices*, PHI, New Delhi, 2011.
3. Nandita Das Gupta and Amitava Das Gupta, *Semiconductor Devices. Modelling and Technology*, PHI, New Delhi, 2004.

ECE 4062: DIGITAL DESIGN VERIFICATION [3 0 0 3]

System Verilog: Introduction to System Verilog, Data types, scheduling semantics and assignment statements, Connecting test bench and DUT. Verification: Introduction, Verification Methodologies, Types of Verifications and approaches, Coverage-Driven functional verification, Assertion based verification (ABV), Verification Planning and Test Bench Architecture, System-Level Verification, Processor Integration Verification, Assertions for Formal tools.

References:

1. Padmanabhan T.R. and Sundari B.B.T., *Design Through Verilog HDL*, John Wiley & Sons, 2004.
2. Palnitkar S., *Verilog® HDL. A Guide to Digital Design and Synthesis IEEE 1361-2001 Compliant (2e)*, Prentice Hall, 2003.
3. Bhaskar J., A *Verilog HDL Primer*, BS Publications, 2005.
4. Brown S. and Vranesic Z., *Fundamentals of Digital Logic with Verilog Design (5e)*, Tata McGraw Hill, 2005.
5. Ciletti M.D., *Advanced Digital Design with the Verilog HDL*, PHI, 2005.

VIII SYSTEMS ENGINEERING

ICE 4073 INTRODUCTION TO SYSTEMS ENGINEERING [3 0 0 3]

Course Outcomes	CO statements
CO1	To introduce systems science and systems engineering theory pertaining to create multidisciplinary solutions for complex systems
CO2	To appreciate and provide insights into key system engineering practices
CO3	To provide an overview of various development life cycle activities pertaining to systems engineering of complex systems
CO4	To analyze the system under development for safety
CO5	To design systems in an end to end manner

Definitions and concepts of system-system science and systems engineering, life cycle stages, definitions of requirement, architecture, design. System analysis, interface management, system integration, system verification, system transition, system validation, system operation, system maintenance, system disposal. Project planning, project management and control, decision management, risk management, configuration management, quality assurance, acquisition/supply, tailoring processes and application. Introduction to system modeling and simulation, lean and agile systems engineering, specialty areas (interoperability/logistics/safety /reliability/maintainability/security/usability)

References:

1. Kossiakof, Alexander and William N. Sweet; Systems Engineering: Principles and Practice, Wiley, 2011.
2. INCOSE Systems Engineering handbook, (4e), Wiley, 2015.
3. System Engineering Book of Knowledge, V 2.6, www.sebokwiki.org, 2022.
4. National Aeronautics and Space Administration, NASA Systems Engineering Handbook, (Rev 1), 2007.
5. Faulconbridge, R. I. and Ryan, M. J, Systems Engineering Practice, Canberra: Argos Press, Revised Edition, 2018.
6. ISO/IEC/IEEE 1528-Systems and Software engineering- System life cycle processes, https://www.iso.org/standard/63711.html
7. Blanchard, Benjamin S., Wolter J Fabrycky Systems Engineering and Analysis, Pearson (5e), 2010.

ICE 4074: SYSTEM ARCHITECTURE AND DESIGN [2 1 0 3]

Course Outcomes	CO statements
CO1	To understand System architecture and Design Processes
CO2	To understand and appreciate various frameworks, methodologies and approaches for system architecture
CO3	To apply principles and arrive at the architecture of systems, critique them and learn from them
CO4	To design and create architectures for new or improved systems
CO5	To apply and execute the role of a system architect

Architecture definition, architecture view points, concept analysis, models and views of architecture (functional/behavioral/data/performance etc.) – Structure and behavior- Evaluating candidate architectures-System/subsystem analysis- tradeoff analysis- Architecture frameworks and standards-design progression-architecture domains (software/IT/ Manufacturing/social etc)-architecture heuristics- acquisition management-tailoring processes-industrial design-design for manufacturability-robustness design-patents and intellectual property.

References:

1. Rechtin, E., and M.W.Maier, The art of Systems Architecting, Boca Raton, FL: CRC Press, 2000.
2. Oliver, D. W., T. P. Kelliher, and J. G. Keegan, Jr., Engineering Complex Systems with Models and Objects, McGraw Hill, 1997.
3. Ulrich K. T and S D Eppinger Product Design and Development, 2ed, NY, McGraw Hill Inc, 2000.
4. ISO/IEC/IEEE 42010:2011-Systems and software engineering- Architecture and description, https://www.iso.org/standard/50508.html.
5. 1220-2005-IEEE standard for application and Management of the systems engineering process, https://standards.ieee.org/ieee/1220/3372/

ICE 4075 INTRODUCTION TO SYSML AND MBSE [2 0 2 3]

Course Outcomes	**CO statements**
CO1	To understand and appreciate the need and advantages of model based approaches
CO2	To understand SysML notation
CO3	To apply various modeling approaches and methodologies
CO4	To design and develop various types of models pertaining to requirements, architecture and design of complex systems
CO5	To design and produce deliverables of the architect needed to define the architecture of a system

Introduction to MBSE-MBSE concepts- MBSE Ontology-Introduction to Object Process modelling OPM- Object process language-Overview of SysML-Block definition diagrams-Internal block diagrams-Use case diagrams-Activity diagrams-Sequence diagrams-State machine diagrams-Parametric diagrams-Requirements diagram-package diagrams-Operational analysis modeling-functional analysis modeling-logical architecture modeling-Physical architecture modeling-architecture frameworks-Case studies of MBSE-MBSE deployment-Introduction to Digital Twins.

References:

1. SysML distilled: A brief guide to the Systems modeling language. Lenny Deligatti-Addison Wesley Professional, (1e), 2013.
2. Jon Holt and Simon Perry, SysML for Systems Engineering- A model based approach. IET 2013.
3. Jean-Luc Voirin, Model based System and Architecture Engineering with the Arcadia Method (Implementation of Model Based System Engineering) ISTE Press, Elsevier, 2017.
4. Dov Dori, Model-Based Systems Engineering with OPM and SysML. Springer, 2016.

ICE 4076 SYSTEM VERIFICATION AND VALIDATION [3 0 0 3]

Course Outcomes	CO statements
CO1	To understand and apply importance and key aspects of verification /validation in Systems Engineering and Project Management as applied to System design and capability acquisition lifecycles
CO2	To apply validation methods, verification methods and categories, configuration baselines and functional and physical configuration
CO3	To analyze and compare the types of verification/validation and their contemporary issues
CO4	To design and develop hierarchical and traceable verification/validation measures for systems-measures of effectiveness/performance(MOEs/MOPs)
CO5	To understand and formal methods of verification

System verification-System validation-various approaches to system validation and verification-inspection/testing/analysis/demonstration-Generation of Test cases using the Markov Chain model-Writing verification/validation plans-introduction to formal methods-formal approaches to system validation/verification-focus on specialty areas(eg.. EMI/EMC)-test automation models (computation/timed automation)-simulation-model checking verification-verification validation activities prescribed in standards for safety critical systems (DO-178C/DO-254/APR4754)

References:

1. Engel, Avner, Verification, Validation and Testing of Engineered Systems, John Wiley & Sons, 2010.
2. Jean Francois Monin, Understanding Formal Methods, Springer, 2003.
3. Jean-Louis Boulanger (Editor), Industrial use of Formal Methods: Formal Verification, Wiley, 2012.
4. Eds. Alex Gorod, Leonie Hallo Vernon Ireland, Indra Gunawan, Evolving Toolbox for Complex Project Management, CRC press, Taylor and Francis Group, Auerbach, 2019.
5. McShea, R. E. Test and Evaluation of Aircraft Avionics and Weapon Systems, (2e), IET, 2010.

OTHER PROGRAM ELECTIVES

ICE 4059: NEURAL NETWORK AND FUZZY LOGIC [3 0 0 3]

Course Outcomes	CO Statements
CO1	Recall the fundamental principles related to neural network, terminologies of NN, MP neuron, Hebb Network,Perceptron, Adaline and Madaline
CO2	Explain Back propagation algorithm, Comprehend the different unsupervised learning algorithm in ANN like Maxnet, Mexican hat, Kohonen self organizing map, LVQ
CO3	Explain Fuzzy theory, Relations and composition in Fuzzy, Fuzzification and defuzzification, fuzzy rule based system
CO4	Describe the fuzzy Inference system, Fuzzy logic control system, Applications of FLC
CO5	Apply the knowledge to develop fuzzy logic controller

McCulloch–Pitts model, Activation functions, Feedforward and feedback networks, Learning rules, Supervised Learning network, Multi-layer Feedforward Networks, Back propagation network, Unsupervised Learning network, Maxnet, Mexican Hat net, Kohonen self-organizing feature map, Vector quantization, Fuzzy sets, Membership functions, Fuzzification, Defuzzification methods, Fuzzy rule base and approximate reasoning, Fuzzy inference systems, Fuzzy logic control system, Applications.

References:

1. Laurence Fausett, *Fundamentals of Neural networks, Architecture, Algorithm and Applications*, Pearson Education India, 1st ed., 2004.
2. Timothy J. Ross, *Fuzzy logic with engineering applications*, John Wiley & Sons,4th ed., 2016.
3. S. N. Sivanandan, S. N. Deepa, *Principles of soft computing*, Wiley India, 2010
4. B. Yegnanarayana, *Artificial Neural Networks*, PHI, 2004.

ICE 4060: REAL TIME OPERATING SYSTEM [3 0 0 3]

Course Outcomes	CO Statements
CO1	Comprehend the basic knowledge of programming and system control to perform a specific task.
CO2	Describe the differences between the general computing system and the embedded system, also recognize the classification of embedded systems.
CO3	Understand interrupts, hyper threading and software optimization.
CO4	Explain Life cycle of embedded design and its testing
CO5	Apply and analyse the applications in various processors and domains of embedded system.

Real Time Concept, Real time tasks, Timing constraints, Threads and tasks, Scheduling, Rate monotonic algorithm, Memory management, Interrupt routines and handling of interrupt, Interrupt latency, OS security Issues, UNIX based RTOS, Windows as RTOS, POSIX, PSOS, VRTX, VxWorks, QNX, RT Linux, Windows CE, Real time communication: LAN, IEEE 802.5 protocol, Routing, Resource reservation, Traffic shaping and policing, Scheduling Mechanisms, QoS Models.

References:

1. Rajib Mall, *Real-Time Systems: Theory and Practice*, Pearson Education, 2006.
2. Jane W. S. Liu, Real *Time Systems*, Pearson Education, 2006.
3. Raj Kamal, Embedded *Systems: Architecture, Programming and Design,* TMH, (3e), 2014.

ICE 4061: DSP ALGORITHM AND ARCHITECUTURE [3 0 0 3]

Basic architectural features of DSP processors, Data addressing modes of TMS320C54XX, Memory space of TMS320C54XX, Program control, On-chip peripherals, Interrupts of TMS320C54XX Processors, Pipeline operation, Implementation of DSP Algorithms, Signal spectrum, Interfacing peripherals to DSP Devices, Memory interface, Parallel I/O interface, Programmed I/O, Direct memory access, Synchronous serial interface, Multichannel buffered serial port, Applications.

References:
1. Avatar Singh, S. Srinivasan, *Digital Signal Processing Implementations: Using DSP Microprocessors with Examples from TMS320C54XX*, Thomson/Brooks/Cole, 2004.
2. B. Venkataramani, M. Bhaskar, *Digital Signal Processors: Architecture, Programming and Applications*, TMH, 2002.
3. Sen-Maw Kuo, Woon-Seng Gan, *Digital Signal Processors: Architectures, Implementations, and Applications*, Pearson Prentice Hall, 2005.

ICE 4062: ANALYTICAL AND OPTICAL INSTRUMENTATION [3 0 0 3]

Spectroscopy, Radiation Sources, Monochromator, Optical Gratings, Optical Filters. Detectors, Sample Holders, UV/Visible/IR Spectrophotometers, Mass Spectrometers, X-Ray Spectrometers, Lasers, Interferometry, Interference effect, Radiometry, Interferometers- Michelson's, Fabry-perot, Sagnac, Refractometer, Rayleigh's interferometers, Holography, Fiber optics.

References:
1. R S Kandpur, *Handbook of Analytical Instruments*, TMH,92e),2003.
2. Willard, Merritt, Dean and Settle, *Instrumental Methods of Analysis*, CBS Publishers, (7e), 1988.
3. J.Wilson & J F B Hawkes, *Opto Electronics: An Introduction*, PHI, (2e),1993.

ICE 4063: AUTOMOTIVE ELECTRONICS [3 0 0 3]

Spark and Compression Ignition Engine, Engine control functions, Fuel control, Automotive transmissions, Vehicle braking, Steering Control, Passenger Safety and Convenience occupant protection systems, Tire pressure monitoring system, Hybrid Vehicles, Sensors in airbag system, Chassis control systems, Electronic engine control system, Automotive communication protocols, Telematics, GPS and GPRS, Safety Systems, Electronic transmission checks and diagnosis.

References:
1. Ronald K Jurgen: "*Automotive Electronics Handbook*, MGH, (2e), 1999.
2. James D Halderman: -*Automotive electricity and Electronics*", PHI Publication (5e),2016.
3. Terence Rybak. Mark Stefika: *Automotive Electromagnetic Compatibility (EMC)*, Springer, 2004.

ICE 4064: BIO-MEDICAL INSTRUMENTATION & EQUIPMENT'S [3 0 0 3]

Course Outcomes	CO Statements
CO1	Analyse the concept of bio-potentials, electrodes and biomedical transducers
CO2	Elucidate cardiovascular system and related measurements
CO3	Discuss measurement techniques involved in central nervous and muscular system
CO4	Explain the working principle of therapeutic equipment's and life saving devices
CO5	Comprehend and compare the working of modern imaging systems

Biomedical transducers, Cardiovascular system, Electrocardiography, Central Nervous System and muscular system, Electroencephalography, Electromyography, Therapeutic equipment's and life saving devices**,** Blood flow meter, Oximeter, Plethysmography, Ultrasound therapy unit, Nerve stimulators, Pacemakers and defibrillators, Heart lung machine, Diathermy, Ventilator's, Spirometer, Oxygenators, Artificial kidney, Modern Imaging systems.

References:

1. R.S. Khandpur, *"Handbook of Biomedical Instrumentation"*, MGH,(2e), 2008.
2. Leslie Cromwell, Fred J. Weibell and Erich A. Pfeiffer, *"Biomedical Instrumentations and Measurements"*, PHI, (2e), 2012.
3. J.G. Webster, *"Medical instrumentation application & design"*, John Wiley and sons,2003

ICE 4065: DATA STRUCTURES USING C++

Course Outcomes	CO Statements
CO1	Recall the basic structure of C++ program.
CO2	Demonstrate the use of classes.
CO3	Apply the concepts of linked lists and recursion.
CO4	Apply the concepts of trees and queues.
CO5	Demonstrate the sorting and searching algorithms.

Data Types, Operators, Manipulators, Decision statements, Programming control statements, Functions, Pointers, Classes, Constructors and Destructors, Operator overloading, Friend classes and functions. Inheritance, Templates, Linked List, Recursion, Trees, Queues, Sorting and searching algorithms.

References:

1 Nell Dale, "C++ Plus Data Structures", Jones and Bartlett Publishers, (4e), 2010.
2 Maria Litvin, Gary Litvin, *Programming with C++ and Data Structures*, Vikas Publishing House Pvt. Ltd., 2001.
3 E Balagurusamy, "Object-oriented Programming with C++", TMH, (2e), 2001.
4 Yashavant P Kanetkar, "Let us C++", BPB Publications, 2003.

ICE 4066: CYBER PHYSICAL SYSTEM [3 0 0 3]

Synchronization in complex systems, Graph theory, Leader and leaderless cases, Motion invariants for first-order consensus, Lyapunov techniques for control, Potential fields and Motion control, Pinning control, Cooperative optimal control, Stability and optimality, Adaptive tuning laws, Impulsive systems, Safety of execution of CPS, Scheduling, Hybrid dynamical models, Hybrid automata, Deployment, Task mapping and partitioning, State estimation for attack detection, Automotive case study.

References:

1. Rajeev Alur, *Principles of Cyber-Physical Systems,* MIT Press, 2015.
2. E. A. Lee, Sanjit Seshia, *Introduction to Embedded Systems – A Cyber–Physical Systems Approach*, MIT Press, (2e), 2017.
3. Andre Platzer, Logical *Foundations of Cyber-Physical Systems,*(2e), Springer Publishing, 2018

ICE 4067: POWER ELECTRONICS [3 0 0 3]

Course Outcomes	CO Statements
CO1	Understand the working and characteristics of thyristors
CO2	Contrasting the various power electronic devices
CO3	Comprehend the working of AC-DC converters
CO4	Understand the principle of operation of DC-DC converters
CO5	Comprehend the working of DC-AC converters

Power Diodes, SCR, Gate Trigger Circuits of SCR, Traic, GTO, BJT, Power MOSFET, IGBT, DC Motor Drives, Battery chargers, HVDC transmission, Single phase fully controlled AC to DC converter, Snubber Single phase half controlled converter, Three phase half wave AC to DC converter, Three phase fully controlled ac to dc converter, Inverter mode of operation, Constraints of commutation in inverter mode, Effect of source inductance, Single phase unity power factor converter, DC- DC Power Converters, Switched Power supplies, DC-AC Power Converters, Three phase inverters, Line commuted inverters.

References:

1. Ned Mohan, Undeland, Robbins, *Power Electronics*, John Wiley, (3e), 2002.
2. M. H. Rashid, *Power Electronics,* PHI, (3e), 2004.
3. Bimbhra P.S, *Power Electronics*, Khanna Publication, (3e), 1999.
4. M. Ramamurthy, *Thyristors and their Application*, East-West Press, 1977.

ICE 4068: ROBOTICS [3 0 0 3]

Course Outcomes	CO Statements
CO1	Understand the various spatial transformations of robot links
CO2	Comprehend forward and inverse kinematic techniques of robot manipulators
CO3	Comprehend the dynamical modeling of robot manipulators
CO4	Understand the various trajectory planning schemes for robot
CO5	Understand the various trajectory control schemes for robot

Degrees of Freedom, Kinematics of Manipulators, Differential motions, Linear and angular velocity of a rigid body, Dynamics of Manipulators, Trajectory planning, Joint Space and Cartesian Space, Control schemes for robot manipulators: PID, State Feedback, Force control, Hybrid force control, Position controller.

References:
1. Mark. W. Spong, *Robotics Dynamics and Control*, Wiley, (1e),1989.
2. John. J. Craig, *Introduction to robotics – Mechanics and Control*, Pearson Education, (4e), 2017.

ICE 4069: RELIABILITY AND SAFETY ENGINEERING [3 0 0 3]

Course Outcomes	CO Statements
CO1	Understand the basic concepts of reliability engineering.
CO2	Analyze the different redundancy and maintenance techniques
CO3	Comprehend the different continuous and discrete probability distributions.
CO4	Understand and apply different reliability tests
CO5	Understand and apply basic concepts of safety engineering

Sampling distributions, Testing of hypotheses, Failure data, Failure modes, Hazard rates and failure density function, Hazard models and bath-tub curve, Reliability of systems, Redundancy, fault tree analysis, Reliability improvement methods, Reliability Tests, Component reliability and MIL standards, Safety policy, Safety Organization, Measurement and prediction of human reliability and operator training, Safety margins in critical devices, Incident Recall Technique, Disaster control, Job Safety Analysis, Safety Audit.

References:
1. Govil, A.K., *Reliability Engineering*, TMH, 1983.
2. Sinha and Kale, *Introduction to Life-Testing*, Wiley Eastern, New Delhi, 1992.
3. Wisley, *Human Engineering - Guide for Equipment Designers*, University of California Press,1973.
4. Hoang Pham, *Hand book of Reliability Engineering*, Springer, 2003.
5. Krishnan N.V, *Safety Management in Industry,* Jaico Publishing House, Bombay, 1997.
6. *Swapan Kumar Hazra, Samar Biswas, Fundamentals of Process Safety Engineering, CRC Press, 2021.*

ICE 4070: WIRELESS SENSOR TECHNOLOGY [3 0 0 3]

Course Outcomes	CO Statements
CO1	Understand the concept sensor communication channel architecture
CO2	Differentiate the sensor network
CO3	Design the sensor network using WSN protocols
CO4	Discuss various routing and localization techniques
CO5	Apply the concept of implementation of sensor communication technology

Single-Node Architecture, Energy Consumption, Operating Systems and Execution, Optimization Goals and figures of merit, Gateway Concepts, Networking sensors, WSN protocols, Wakeup Radio Concepts, Address and Name Management, Routing Protocols, Time Synchronization, Localization and Positioning, Sensor Tasking and Control, Sensor Node Hardware, Programming Challenges, Node-level software platforms, Node-level Simulators, State-centric programming. Wired Equivalent Privacy (WEP) and Wi-Fi Protected Access (WPA)

References:

1. Holger Karl & Andreas Willig, *Protocols and Architectures for Wireless Sensor Networks*, John Wiley, 2012.
2. Feng Zhao & Leonidas J. Guibas, *Wireless Sensor Networks- An Information Processing Approach*, Elsevier, 2007.
3. Kazem Sohraby, Daniel Minoli, & Taieb Znati, *Wireless Sensor Networks- Technology, Protocols, And Applications*, John Wiley, 2007.

ICE 4071 INDUSTRIAL INTERNET OF THINGS[3 0 0 3]

Course Outcomes	CO Statements
CO1	Understand the components of IIOT and network services
CO2	Understand the architecture of IIoT
CO3	Understand the role of sensors and actuators in IIoT and their associated protocols
CO4	Understand the cloud platform and their features
CO5	Understand data exchange file formats, front end and back end programming methods, real time applications

IOT Vs. IIOT, Components of IIOT -Sensors, Interface, Networks, People &Process, Real life examples, IOT Platform, Interfaces, API, clouds, Data Management, Analytics, Mining &Manipulation; Challenges & Benefits in implementing IIOT. Various Architectures of IOT and IIOT, Industrial Internet - Reference Architecture; IIOT System components: Sensors, Gateways, Routers, Modem, Cloud brokers, servers and its integration, WSN, WSN network design for IOT. Roles of sensors in IIOT, sensor architecture, special requirements for IIOT sensors, types of actuators. Hardwire the sensors with different protocols such as HART, MODBUS-Serial & Parallel, Ethernet, BACNet, Current, M2M etc**.,** Wi-Fi, Wi-Fi direct, Zigbee, Z wave, Bacnet, BLE, Modbus, SPI, I2C, IIOT protocols –COAP, MQTT,6lowpan, lwm2m, AMPQ, IIOT cloud platforms : Overview of cots cloud platforms, predix, thingworks, azure. Data analytics, cloud services, Business models: Saas, Paas, Iaas. Introduction to web security, Conventional web technology and relationship with IIOT, Vulnerabilities of IoT, Privacy, Security requirements, Threat analysis, Trust, IoT security tomography and layered attacker model, Identity establishment, Access control, Message integrity, Non-repudiation and availability, Security model for IoT, Network security techniques, Management aspects of cyber security. Role of Analytics in IOT, Data visualization Techniques, Introduction to R Programming, Statistical Methods. Internet of Things Applications.

References

1. Daniel Minoli, “Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications”, ISBN: 978-1-118-47347-4, Willy Publications.
2. Bernd Scholz-Reiter, Florian, Michahelles, “Architecting the Internet of Things”, ISBN 978-3- 642-19156-5 e-ISBN 978-3-642-19157-2, Springer.
3. Pethuru Raj and Anupama C. Raman, “The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press, 2018
4. Qusay F. Hassan, “Internet of Things A to Z: Technologies and Applications”, Wiley, 2018

ICE 4072 BIOSENSORS and BioMEMS [3 0 0 3]

Course Outcomes	CO Statements
CO1	Analyze the use of bio recognition elements in biosensors design
CO2	Analyze the various bioconjigation chemistries in biosensors design
CO3	Analyze the use of various transduction platforms in biosensing application
CO4	Understand microfabrication processes in biosensor and lab on chip design
CO5	Design the layout of novel biosensing systems

Bio-recognition elements: Whole cells, Enzymes, Antibodies, Nucleic Acids, Aptamers and Molecularly Imprinted Polymers. Nanostructured substrates for biosensing and integration of the bio-recognition elements on the substrates. Transduction Platforms: Electrochemical, Optical, Mass, Thermal, Hybrid and Lateral Flow Assays. Fundamentals of microfabrication, Lab on chip for biosensing applications and case studies.

References:

1. Mohamed Gad-el-Hak (R), MEMS handbook, CRC Press, 2002.
2. Anthony P.F.Turner, Isao Karube and George S. Wilson, Biosensors: fundamentals and applications, Oxford University Press, 1987.
3. A Sadana, Engineering biosensors: kinetics and design applications, Academic Press, 2002.
4. D Voet & JG Voet, Biochemistry, J Wiley & Sons, 1990.

ICE 4073 Machine learning for Control Systems[3 0 0 3]

Machine learning fundamentals: supervised learning – artificial neural networks, support vector machines, kernel methods, statistical techniques, recurrent (or feedback) neural networks; unsupervised learning – clustering, self-organizing map, competitive learning, pre-processing techniques; semisupervised learning – reinforcement learning Applications to Control Problems: State estimation using neuro observer kalman filter and reinforcement learning;Identification of non-linear dynamical systems using neural networks, support vector machines and reinforcement learning Modelling and Optimal control problems using support vector machines, regression methods, monte-carlo method, model predictive control and adaptive reinforcement learning . Robust control using differential neural networks, support vector machines and reinforcement learning, Path planning using dynamic neural networks, density based machine learning techinques, support vector machines Adaptive control using self organizing map or RBF networks, Trajectory tracking using dynamic (recurrent) neural networks

References:

1. Patrick Henry Winston, “Artificial Intelligence”, Addison Wesley, 2000.
2. Luger George F and Stubblefield William A, “Artificial Intelligence: Structures and Strategies for Complex Problem Solving”, Pearson Education, 2002.
3. Christopher Bishop, “Pattern Recognition and Machine Learning” Springer, 2007.
4. Kevin P. Murphy, “Machine Learning: A Probabilistic Perspective”, MIT Press, 2012.
5. Ethem Alpaydin, “Introduction to Machine Learning”, MIT Press, 3rd Edition, 2014
6. Sayed, A.H., 2014. Adaptation, learning, and optimization over networks. Foundations and Trends” in Machine Learning, 7(4-5), pp.311-801.
7. https://www.sciencedirect.com/book/9780128210925/applications-of-artificial-intelligence-in-process-systems-engineering

OPEN ELECTIVES

ICE 4301: FEEDBACK CONTROL THEORY [3 0 0 3]

Feedback control systems, Mathematical modeling, Derivation of transfer functions for electrical networks, Mechanical systems, Signal flow graph, Masons gain formula, State variable representation of linear systems, Solution of state equations, Time domain specifications for second order systems, Steady state errors of unity feedback systems, Definitions of stability, Routh Hurwitz criterion, Frequency response - gain margin, phase margin.

References:

1. Nagrath and Gopal, *Control Systems Engineering,* New age international Limited, (2e), 1984.
2. Norman S. Nise, *Control Systems Engineering,* (5e), Wiley India, 2009.
3. R.C Dorf and R.H Bishop, *Modern Control Systems,* (11e), Addison- Wesley Longman Inc., 2013.

ICE 4302: INDUSTRIAL AUTOMATION [3 0 0 3]

Course Outcomes	CO Statements
CO1	Review the role of computer in data acquisition and process control.
CO2	Understand PLC architecture, wiring and basics of PLC programming.
CO3	Develop PLC programming for process applications
CO4	Comprehend the structure and working of various types of communication protocols used in automation domain
CO5	Understand the architecture of DCS and its application

Evolution of PLC, PLC Vs PC, Architecture of PLC - I/O Modules, CPU, Program Memory, Process Image Tables, Bus System and Power Supply, Sequential Flow Chart technique for programming style, Programming a PLC, Timers & Counters, Special Instructions, Levels of Industrial control, Networking, Buts Networks, Protocols., SCADA & DCS, Profibus, Modbus, SMART devices.

References:

1. John W.Webb and Ronald A.Reis, Programmable Logic Controllers – Principles and Applications, (5e), PHI, 2003.
2. W. Bolton, Programmable Logic Controllers, 94e), Newnes Publications, 2006.
3. Frank D. Petruzella, Programmable Logic Controllers, MGH, 1989.

ICE 4303: INDUSTRIAL INSTRUMENTATION [3 0 0 3]

Course Outcomes	CO Statements
CO1	Apply and analyze different temperature measuring sensors.
CO2	Understand and apply various pressure measurement techniques.
CO3	Remember and apply various flow measurement techniques.
CO4	Recognize and analyze different speed measurement.
CO5	Recall and analyze different level measurement sensors.

Measurement System, Classification of transducers, Temperature and Pressure measurement, Level and Thickness measurement, Flow measurement-Variable head type, variable area type, Mass flowmeters, Measurement of Thermal conductivity, velocity, acceleration, pH and Force, Semiconductor sensors, Optical sensors.

References:

1. E.O. Doeblin, *Measurement Systems: Application and Design*, McGraw Hill, (5e), 2004.
2. Patranabis D, *Principles of Industrial Instrumentation*, TMH, (3e), 2005.
3. A. K. Sawhney, *A course in Mechanical Measurement and Instrumentation*, (7e), Dhanpat Rai and Co, 2002.

ICE 4304: SENSOR TECHNOLOGY [3 0 0 3]

Course Outcomes	CO Statements
CO1	Understand basic concepts and characteristics of sensors
CO2	Comprehend sensors working on electromagnetic principles
CO3	Analyze sensing principles for measuring various physical parameters
CO4	Describe working principle of sensors used for radiations and optical parameters
CO5	Understand basic concepts of advanced sensor technology

Basic sensor technology, characteristics, Capacitive and Inductive Sensors**,** Displacement Sensors, Temperature Sensors, Force/Torque Sensors, Humidity and Moisture Sensors, Acoustic Sensors, Flow Sensors, Occupancy-Motion Detectors, Acceleration and Vibration Sensors, Chemical and Biosensors, Optical and radiations Sensors, Introduction to Wireless Sensor Networks (WSN) and Applications.

References:

1. Jon S Wilson, *Sensor Technology Handbook*, Newnes Elsevier Publication, 2005.
2. Jacob Fraden, *Handbook of Modern Sensors: Physical, Designs, and Applications*, Springer, 2004.

ICE 4305: SMART SENSOR [3 0 0 3]

Course Outcomes	CO Statements
CO1	Understand the architecture of smart sensors
CO2	Understand and compare various smart sensor standards
CO3	Analyze different sensor communication interfaces
CO4	Analyze sensor signal processing and feature extraction techniques
CO5	Incorporate smart sensors for applications

MCUs and DSPs, integrated signal conditioning, IEEE1451 standards, Plug and play, Sensor Communication, Wireless zone sensing, Surface acoustical wave devices, Intelligent transportation system, RF-ID, RF MEMS basics, Micro optics, Micro grippers, Microprobes, Micro mirrors, FEDs, Centralized and decentralized measurement chains, Intelligent sensors, Nano sensors, Biosensors

References:

1. Randy Frank, *Understanding Smart Sen**sors***, (2e), Artech House Publications, 2000.
2. Paul W. Chapman, *Smart Sensors*, ISA Press, 1996.
3. Krzystof Iniewski, *Smart Sensors for Industrial Applications*, CRC Press, 2013.

ICE 4306: VIRTUAL INSTRUMENTATION [3 0 0 3]

Course Outcomes	**CO Statements**
CO1	Comprehend the concept of virtual instrumentation and how it is different from the classical instrumentation
CO2	Create VI, sub-VI, arrays, clusters, case structures, loops etc. using LabVIEW
CO3	Analyse the simulation problems on LabVIEW.
CO4	Understand the basics of instrument control interfaces.
CO5	Recognize the real time signal acquisition and processing.

Architecture of a virtual instrument, Virtual instruments V/s Traditional instruments, Advantages of VI, Graphical programming, Creating Virtual Instruments using LabVIEW-Loops, Arrays, Clusters, String and file I/O, Graphs, Data Acquisition, Common Instrument Interfaces, Current loop, System buses, Interface buses, VISA, Image acquisition and processing, Design of ON/OFF controller for a mathematically described processes using VI software

References:

1. Gary Johnson, *LabVIEW Graphical Programming, (2e), MGH, 1997.*
2. Lisa K. wells & Jeffrey Travis, *LabVIEW for everyone, National Instruments, 1997.*
3. S. Sumathi, P Surekha, *LabVIEW based Advanced Instrumentation systems, Springer, 2007.*
4. Rick Bitter, Taqi Mohiuddin, Matt Nawrocki, *LabVIEW Advanced Programming Techniques, CRC Press, 2007.*
5. Jovitha Jerome, *Virtual Instrumentation using LabVIEW, PHI, 2010.*

ICE 4307: FARM AUTOMATION [3 0 0 3]

Course Outcomes	**CO Statements**
CO1	Understand the various farm operations and their mechanization.
CO2	Comprehend the agricultural water management system.
CO3	Design post-harvest processing machines.
CO4	Design and analyse automated farm management systems.
CO5	Analyze various parameters affecting farming/farm produce through modeling and simulation.

Farm mechanization, sources of farm power, renewable energy sources, IC engines, tillage, sowing, plant protection, intercultural operations, harvesting, threshing, biomass management techniques. Watershed concept and theory, soil erosion, measures, hydrological cycle, irrigation methods, devices, Water conveyance systems, Water harvesting, aquifer and its types, interaction of water resources with the changing environment. Engineering properties of biological materials, heat and mass transfer, devices for cleaning, grading, milling and storage of farm produce. Drying and dehydration, function and features of green house. Resource conservation management, precision farming, automated irrigation scheduling, variable rate seed and chemical applicators, robotics, Rainfall-runoff prediction models, watershed modeling, climate change impact analysis on bio-resources, drying characteristics, storage or process kinetics, simulation and modeling in tillage implements.

References :

1. Jagdshwar Sahay, Elements of Agricultural Engineering, (4e), Standard Publishers Distributors, 2006

2. A. M. Michael & T. P. Ojha, Principles of Agricultural Engineering, Vol I & II., (10e), Jain Brothers, 2018

3. K M Sahay, K. K. Singh, Unit operations of Agricultural Processing, (2e),Vikas Publishing House Pvt Ltd, 2004.

4. Qin Zhang, Francis J. Pierce, Agricultural Automation Fundamental and Practices, CRS Press, Taylor and Francis group, 2013.

5. Darwin Caldwell, Robotics & Automation in the food Industries (Current & Future Technologies), Wood Head Publishing Ltd, Oxford, 2012.

5. A. M. Chandra, S. K. Ghosh, Remote Sensing and Geographical Information System, Alpha Science, 2006