MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

Department of Instrumentation and Control Engineering

B. Tech in Cyber Physical Systems

Program Structure and curriculum-2022 scheme

Year	THIRD SEMESTER						FOURTH SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
II	MAT 2122	Engineering Mathematics - III	2	1	0	3	MAT 2234	Engineering Mathematics - IV	2	1	0	3
	ICE 2121	Analog Electronic Circuits	3	1	0	4	ICE 2222	Microcontroller	3	1	0	4
	ICE 2126	Digital Logic Design	3	0	0	3	ICE 2226	Digital Transmission	3	0	0	3
	ICE 2127	Computer Architecture and Organization	3	0	0	3	ICE 2227	Introduction of Cyber Physical Systems	3	0	0	3
	ICE 2128	Data Structures and Algorithms	3	1	0	4	ICE 2228	Introduction to Control Theory	2	1	0	3
	ICE 2129	Sensor Technology	3	0	0	3	ICE 2225	Communication systems	3	0	0	3
	ICE 2142	Sensors and Circuits Lab	0	0	3	1	ICE 2243	Communication Systems lab	0	0	3	1
	ICE 2144	Data Structures Lab	0	0	3	1	ICE 2242	Microcontroller Lab	0	0	3	1
			17	**3**	**6**	**22**			**16**	**3**	**6**	**21**
	Total Contact Hours (L + T + P)		**26**				**Total Contact Hours (L + T + P)**		**25**			

Year	FIFTH SEMESTER						SIXTH SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
III	HUM3022	Essentials of Management	3	0	0	3	HUM 3021	Engineering Economics and Financial Management	3	0	0	3
	ICE 3126	Cyber Physical system design	3	1	0	4	ICE ****	Flexible Core – 2 (A2/B2/C2)*	3	0	0	3
	ICE 3127	Data Communication and networks	3	1	0	4	ICE ****	Flexible Core – 3 (A3/B3/C3)*	3	0	0	3
	ICE 3128	Embedded systems design and programming	3	0	0	3	ICE ****	PE – 1 / Minor Specialization	3	0	0	3
	ICE ****	Flexible Core – 1 A1/ B1/C1)*	3	0	0	3	ICE ****	PE – 2 / Minor Specialization	3	0	0	3
	IPE 4302	OE 1 – Creativity, Problem Solving and Innovation** (MLC) - mandatory	3	0	0	3	*** ****	OE – 2** (MLC)	3	0	0	3
	ICE 3143	Cyber physical systems design Lab	0	0	3	1	ICE 3244	CPS Interface Lab	0	0	3	1
	ICE 3144	Embedded system programming Lab	0	0	3	1	ICE 3245	Networking lab	0	0	3	1
			18	**2**	**6**	**22**			**18**	**0**	**6**	**20**
	Total Contact Hours (L + T + P)		**26**				**Total Contact Hours (L + T + P)**		**24**			

*Courses of three independent tracks A, B, C
** Performance of students to be recorded in Eighth semester grade sheet

Year	SEVENTH SEMESTER						EIGHTH SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
IV	ICE ****	PE – 3 / Minor Specialization	3	0	0	3	ICE 4291	Industrial Training (MLC)				1
	ICE ****	PE – 4 / Minor Specialization	3	0	0	3	ICE 4292	Project Work				12
	ICE ****	PE – 5	3	0	0	3	ICE 4293	Project Work (B Tech – honours)* (V - VIII sem)				20
	ICE ****	PE – 6	3	0	0	3	ICE ****	B Tech – honours Theory – 1* (V semester)				4
	ICE ****	PE - 7	3	0	0	3	ICE ****	B Tech – honours Theory – 2* (VI semester)				4
	XXX****	OE – 3** (MLC)	3	0	0	3	ICE ****	B Tech – honours Theory – 3* (VII semester)				4
	ICE 4191	Mini Project (Minor specialization)***				8						
			18	**0**	**0**	**18/26*** **						**13/33***
	Total Contact Hours (L + T + P)		**18**				**Total Contact Hours (L + T + P)**					

*Applicable to eligible students who opted for and successfully completed the B Tech – honours requirements
** Performance of students to be recorded in Eighth semester grade sheet
***Applicable to students who opted for minor specialization

Flexible Core:

I Automation (A)

ICE 3129 Industry 4.0 (A1)
ICE 3225 Industrial Automation (A2)
ICE 3227 Design of Safe systems (A3)

II System Intelligence(B)

ICE 3130 Introduction to Augmented and Virtual Reality(B1)
ICE 3226 Unsupervised intelligence in CPS (B2)
ICE 3228 CPS Interface (B3)

III L&TEdutech

Foundations of EV & Hybrid Vehicles (C1)
Automotive Mechanics for Electric Vehicles (C2)

Minor Specialization

I. Control Systems

ICE 4401: Modern Control Theory
ICE 4402: Nonlinear control theory
ICE 4403: Digital Control Systems
ICE 4404: System Identification

II. Sensor Technology

ICE 4405: Sensor Design
ICE 4406: Biosensors and BioMEMS
ICE 4407: Multi Sensor Data Fusion
ICE 4408: Automotive Sensors

III. Systems Engineering

ICE 4409: Introduction to Systems Engineering
ICE 4410: System architecture and Design
ICE 4411: SysML and MBSE
ICE 4412: System Verification and validation

IV. Smart Transportation Systems

ICE 4413: Automotive Electronics
ICE 4414: In-vehicle Networking
ICE 4415: Intelligent Transportation Systems
ICE 4416: Advanced Driver Assistance Systems

V E-Mobility (L&T Edutech)

EV Battery Technology and Power Train Development
EV Charging Infrastructure, Vehicle Testing & Homologation
EV Vehicle Design & Analysis
EV Data Analytics & Cyber Security

Other Program Electives

ICE 4461: Big Data Analytics
ICE 4462: Blockchain Technology
ICE 4464: CPS Assurance
ICE 4465: CPS for internal and external security
ICE 4466: Cyber Security
ICE 4467: Design of Safe Systems
ICE 4468: E-Vehicles
ICE 4469: Intelligent Manufacturing Automation
ICE 4470: Metaverse
ICE 4471: Next Generation Networks
ICE 4472: Smart Farming and Agriculture
ICE 4473: Smart Grid
ICE 4474: Smart Infrastructure
ICE 4475: Virtual and Augmented Reality
ICE 4476: Wireless Sensor Technology
ICE : Smart Sensors

Open Electives

ICE 4311 Feedback Control Theory
ICE 4312 Industrial Automation
ICE 4313 Industrial Instrumentation
ICE 4314 Sensor Technology
ICE 4315 Smart Sensor
ICE 4316 Virtual Instrumentation
ICE 4317 Farm Automation

Semester: III

MAT 2122: ENGINEERING MATHEMATICS – III [2 1 0 3]

	CO Statements
CO1	Analyse signals using Fourier series and transform
CO2	Apply suitable matrix decomposition methods for dimension reduction process
CO3	Apply the concept of Linear algebra to linear system of equations
CO4	Analyse matrices as linear transformation
CO5	Apply the concept of inner product for geometrical interpretation of vectors

Linear Algebra: Systems of Linear Equations, Matrices, Solving Systems of Linear Equations, Vector Spaces, Linear Independence, Basis and Rank, Linear Mappings, Affine Spaces. Analytic Geometry: Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Orthonormal Basis, Orthogonal Complement, Inner Product of Functions, Orthogonal Projections, Rotations. Matrix Decompositions: Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky Decomposition, Eigen decomposition and Diagonalization, Singular Value Decomposition, Matrix Approximation. Fourier Series and Transforms: Periodic function, Fourier Series expansion. even and odd functions, functions with arbitrary periods, Half range expansionsFourier transform, basic properties, Parseval's identity and applications.

References:

1. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, *Mathematics for Machine Learning*, Cambridge University Press, 2020.
2. Grewal B.S. - *Higher Engineering Mathematics*, Khanna Publishers, 43rd edition, 2015
3. Stephen H. Friedberg Lawrence E Spence, *Arnold J Insel, Elementary Linear Algebra: A Matrix Approach Introduction to Linear Algebra*, Second Edition, 2019.
4. David Lay, Steven Lay, Judi McDonald, *Linear Algebra and Its Applications*, Pearson, 2019.
5. Gilbert Strang, *Introduction to Linear Algebra*, Wellesley-Cambridge Press, Fifth Edition 2016.
6. Mordechai Ben-Ari, *Mathematical Logic for Computer Science*, Third Edition, Springer,2012.
7. Narayanan, Ramaniah and Manicavachagom Pillay , *Advanced Engineering Mathematics, Vol 2 and 3, Vishwanthan Publishers Pvt Ltd. 1998*
8. Erwin Kreyszig, Advanced Engineering Mathematics, 5th edn., Wiley Eastern, 1985

ICE 2121: Analog Electronic Circuits [3 1 0 4]

	CO Statements
CO1	Analyze the characteristics of various transistor technologies.
CO2	Realize amplifier topologies using field effect transistors.
CO3	Perform small signal analysis of field effect transistors.
CO4	Analyze frequency response of amplifiers.
CO5	Design feedback and power amplifiers using transistors.

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, Fundamentals 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 2126: Digital Logic Design [3 0 0 3]

	CO Statements
CO1	Use binary system for digital design
CO2	Analyze combinational logic circuits
CO3	Analyze sequential logic circuits
CO4	Apply state machine models for design of sequential circuits
CO5	Analyze various system-level design 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, MGH, (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 2127: Computer Architecture and Organization [3 0 0 3]

	CO Statements
CO1	Analyze various computer architectures.
CO2	Apply instruction sets for efficient programming.
CO3	Implement algorithms for arithmetic operations with basic hardware building blocks
CO4	Analyze the memory system in computers for efficient computation.
CO5	Apply computer architecture and organization for embedded systems.

Number Representation and Arithmetic Operations, Character Representation, Memory locations and addresses, Memory operations, Addressing modes, CISC and RISC. Hardware for addition and subtraction, Multiplication, Hardware implementation, Booth's algorithm, Division, Floating point representation, IEEE standard floating-point representation. Bus organization, comparison of hardwired and micro-programmed approach, hardwired control design, Booths multiplier design, Micro-programmed multiplier control unit. Internal organization of memory chips, Structure of Larger Memories, Cache mapping functions, Replacement algorithms, and Virtual memories. Accessing I/O devices, Interrupts, Enabling and disabling Interrupts, DMA. Pipeline Organization, Data dependencies, Handling data dependencies, Hardware multithreading, SIMD Processing, Graphics processing units, Shared memory multiprocessors, Interconnection Networks, Cache Coherence, Write-Through Protocol, Write-Back protocol, Directory-Based Cache Coherence.

References:

1. Carl Hamacher, ZvonkoVranesic and SafwatZaky, Computer Organization and Embedded Systems, (6e), McGraw Hill Publication, 2012.
2. William Stallings, Computer Organization and Architecture – Designing for Performance, (9e), PHI, 2015.
3. Mohammed Rafiquzzaman and Rajan Chandra, Modern Computer Architecture, Galgotia Publications Pvt. Ltd., 2010.

ICE 2128: Data Structures and Algorithm [3 1 0 4]

	CO Statements
CO1	Validate the application of classes using basic C++ programs.
CO2	Apply the concepts of linked lists and recursion.
CO3	Illustrate the concepts of trees and queues.
CO4	Apply data structure algorithms with python.
CO5	Implement sorting and searching algorithms using C++ or python

Structure of C++ Program: Data Types. Basic, user-defined and derived, operators: assignment, arithmetic, relational, logical, increment/decrement, conditional, precedence of operators, manipulators, decision statements, programming control statements, Functions. Main Function, Function Prototyping, Call and return by reference, Inline functions, Default and constant arguments, Pointers, Classes, Inheritance, Linked List Data structure, Linked list traversal, insert function, remove function, Linked list with tail and doubly linked lists, Recursion, Trees, Stacks, Queues, Sorting and searching algorithms: Sorting, Searching, hashing, Radix sort.

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.

ICE 2129: Sensor Technology [3 0 0 3]

	CO Statements
CO1	Analyse static and dynamic characteristics of sensors for design of measurement systems.
CO2	Analyse the working of resistive, capacitive and inductive transducers and wired transmitters
CO3	Interpret the use of temperature, flow, pressure and displacement sensors for industrial sensing.
CO4	Evaluate the use of piezo-electric transducers and electrochemical sensors for analytical and industrial sensing.
CO5	Investigate optical sensors for analytical and industrial measurements

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 2142: Sensors and Circuits Lab [0 0 3 1]

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

Characteristics of sensors and transducers, measurements of temperature, pressure, flow, torque, force, displacement and intensity of light.

Reference:

1. E.O. Doeblin, Measurement Systems: Application and Design, McGraw Hill, (5e), 2004.

ICE 2144: Data Structures lab [0 0 3 1]

	CO Statements
CO1	Demonstrate the basic concepts of classes.
CO2	Formulate programs for operator overloading.
CO3	Implement linked list and recursion.
CO4	Develop various data structure operations using trees, stacks, queues and graphs.
CO5	Apply different data structures algorithms using python.

Linked list implementation, Implementation of Binary Trees, Implementation of Binary search trees, Application of Stacks, Implementation of Queues, Breadth first search, depth first search, Application of graphs, Bubble sort, insertion sort, Hashing

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.

Semester IV

MAT 2234: ENGINEERING MATHEMATICS – IV [2 1 0 3]

	CO Statements
CO1	Apply the concept of probability and use them in engineering models.
CO2	Analyse the concept of random variables and their applications.
CO3	Quantify the uncertainty in the data using the aspects of probability.
CO4	Apply the concept of vector gradient in physical phenomenon.
CO5	Apply and analyse the optimistic solution for linear and non-linear programming problems.

Probability and Distributions: Construction of a Probability Space, Discrete and Continuous Probabilities, Sum Rule, Product Rule, and Bayes' Theorem, Summary Statistics and Independence, Distributions: Binomial, Poisson, uniform, normal, Chi-square and exponential distributions. Multivariate Random variables and Stochastic Process: Two and higher dimensional random variables, covariance, correlation coefficient. Moment generating function, functions of one dimensional and two dimensional random variables. Static probabilities: review and prerequisites generating functions, difference equations. Dynamic probability: definition and description with examples. Markov chains, transition probabilities. Vector Calculus: Differentiation of Univariate Functions, Partial Differentiation and Gradients, Gradients of Vector-Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients, Backpropagation and Automatic Differentiation, Higher-Order Derivatives, Linearization and Multivariate Taylor Series. Optimization: Basic solution, Convex sets and function, Simplex Method, Optimization Using Gradient Descent, Constrained Optimization and Lagrange Multipliers.

References:

1. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, *Mathematics for Machine Learning*, Cambridge University Press, 2020.
2. P L Meyer, Introductory Probability and Statistical Applications, Addison Wiley, 2 Ed, 2017.
3. Medhi. J. Stochastic Processes, New Age International 1994.
4. Murray R. Spiegel, Vector Analysis Theory and Problems, Schaum's Outline Series, 2019.
5. Hamdy A. Taha, "Operations Research: An Introduction", 8^{th} Edn., Pearson Education (2008).
6. Sheldon M. Ross, Introduction to Probability Models Eleventh Edition Elsevier, 2007.
7. E. S. Page, L. B. Wilson, An Introduction to Computational Combinatorics, Cambridge University Press.
8. Bhat U R, Elements of Applied Stochastic Processes, John Wiley.

ICE 2222: Microcontroller [3 1 0 4]

	CO Statements
CO1	Analyze the architectures and features of 8051 microcontroller.
CO2	Apply the instruction set of 8051 microcontroller to develop assembly language.
CO3	Illustrate timers/counters, serial communication and interrupts using 8051.
CO4	Analyze the architecture and features of ARM LPC 2148 microcontroller.
CO5	Interface I/O devices with 8051/LPC 2148 microcontrollers.

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 2226: Digital Transmission Systems [3 0 0 3]

	CO Statements
CO1	Analyse linear time-invariant (LTI) system.
CO2	Evaluate the various line coding techniques used for baseband transmission.
CO3	Analyse digital and analog synchronization circuits used in communication system.
CO4	Evaluate the various digital modulation techniques used in passband transmission.
CO5	Apply error correcting codes and channel equalization techniques to improve the performance of digital communication system.

Introduction to Digital Transmission, Signals and systems, Baseband Pulse Transmission, Carrier Transmission, Synchronization, Communication channels, baseband digital transmission, passband digital transmission, wideband transmission techniques, error-correcting codes, advanced topics.

References:

1. Anderson, John B. Digital transmission engineering. Vol. 12. John Wiley & Sons, 2006.
2. Guimaraes, Dayan Adionel. Digital transmission: a simulation-aided introduction with VisSim/Comm. Springer Science & Business Media, 2010.

ICE 2227: Introduction to Cyber Physical System [3 0 0 3]

	CO Statements
CO1	Analyse the building blocks of cyber physical systems.
CO2	Design of synchronous and asynchronous CPS models.
CO3	Analyse the system performance under dynamic conditions.
CO4	Interpret hybrid CPS models with real time scheduling.
CO5	Evaluate secure deployment of CPS.

Principles behind CPS, Concept of Synchronization in Complex Systems, Known Networks II, Graph Theory and CPS Communication Structure, Graph Theory, Eigen structure of Graph Laplacian Matrix, Single Integrator Dynamics and Average Consensus, Leader and Leaderless Cases, Motion Invariants for First-Order Consensus, Comparison of Discrete and Continuous Time Systems, Double Integrator Dynamics, Bipartite Consensus, Time Varying Graphs, Matrix Analysis of Graphs, Control Loops and Importance of Control and Actuation in CPS, Control and Estimation over Lossy and Attacked Networks, Timed Model and Real-Time Scheduling, Hybrid systems, Secure Deployment of CPS.

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 2228: Introduction to Control Theory [2 1 0 3]

	CO Statements
CO1	Derive the mathematical model of LTI systems
CO2	Perform time domain analysis to determine the system stability.
CO3	Apply root locus techniques for stability and performance analysis of systems
CO4	Analyze systems' stability using Bode plot and Nyquist plot.
CO5	Analyze the state space models.

Mathematical modelling, transfer functions, signal flow graph, Masons gain formula, time domain specifications. Stability, Steady state errors, Routh-Hurwitz criterion, Root-Locus plots, frequency domain specifications. Correlation between frequency domain and time domain specifications, Bode diagrams, Polar plots, Nyquist stability criterion, Concepts of Lag, Lead and Lag-Lead compensator in reshaping Root Locus and Bode plot (Qualitative analysis). State Space Analysis, Phase variable and canonical form representation, Derivation of state models, state transition matrix, solution of state equations. (Note: Theoretical concepts be demonstrated in class. Additional examples be solved using MATLAB on every topic during tutorials.)

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 2225: Communication Systems [3 0 0 3]

	CO Statements
CO1	Analyse the working of modulators and demodulators used in analog communication.
CO2	Interpret the different pulse modulation techniques.
CO3	Analyse the generation and detection process in digital communication.
CO4	Analyse the working of various protocols and underlying devices used for IoT and computer networks.
CO5	Analyse the working of different transmission techniques used in cellular and optical fiber communication.

Elements of communication systems; Analog Communication techniques : Amplitude modulation Schemes, Angle (Non-Linear) Modulation; Pulse Modulation schemes ; Data transmission using analog carriers- Shift Keying techniques ; Channel Encoding & decoding technologies; Conceptual idea of encryption & decryption; Communication Protocols& Networking; Internet of Things; Wireless sensor actuator networks, Applications: Spread Spectrum & Mobile Communications - Optical fiber communication- Digital telephony , Basic principles of Digital TV Broadcasting.

References:
1. Haykin, Simon, and Michael Moher, Introduction to analog & digital communications, John Wiley & Sons. 2007.
2. Haykin, Simon, Communication systems, John Wiley & Sons, (4e), 2008.
3. Stallings, William, Cryptography and network security: principles and practices, Pearson Education India, (4e), 2006.

ICE 2242: Microcontroller Lab [0 0 3 1]

	CO Statements
CO1	Analyze data transfer and arithmetic instructions using 8051 Microcontroller.
CO2	Develop code conversion and array handling programs using 8051 Microcontroller.
CO3	Create programs for I/O configuration and waveform generation using 8051 Microcontroller
CO4	Develop programs for controlling display devices using ARM LPC2148.
CO5	Interface ARM LPC2148 for controlling motors .

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 2243: Communication Systems Lab [0 0 3 1]

	CO Statements
CO1	Evaluate the performance of AM and FM modulation techniques.
CO2	Evaluate the effect of sampling rates on the fidelity and accuracy of signals.
CO3	Realize PCM modulator and demodulator circuits.
CO4	Analyze digital modulation techniques.
CO5	Implement PAM,PWM and PPM modulation and demodulation techniques.

Error detection and correction mechanisms, Flow control mechanisms, IP addressing Classless addressing, Observing Packets across the network and Performance Analysis of Routing protocols Socket programming (TCP and UDP) Multi client chatting, Simulation of unicast routing protocols Simulation of Transport layer Protocols and analysis of congestion control techniques in network Develop a DNS client server to resolve the given host name or IP address

References:
1. Computer Networks: A Systems Approach, Larry Peterson and Bruce Davie, (5e), The Morgan Kaufmann Series, Elsevier, 2011.
2. Computer Networking: A Top-Down Approach Featuring the Internet, J.F. Kurose and K. W. Ross, (6e), Pearson Education, 2012.

Semester: V

HUM 3022: ESSENTIALS OF MANAGEMENT [3 0 0 3]

	CO Statements
CO1	Understand the roles of managers, principles of management, managerial skills, and strategies required to run a business successfully with social and ethical responsibilities
CO2	Develop an organizational structure and plan for manpower in a given business organization
CO3	Apply leadership and motivational theories in the organizational contexts
CO4	Acquire budgetary skills through process and techniques of controlling
CO5	Differentiate the managerial practices internationally; Prepare a business plan by identifying business opportunities, conducting market analysis and preparing feasibility reports; Business Ethics, Ethical and Social Responsibilities

Definition of management and systems approach, Nature & scope. The Functions of managers, Principles of Management. Planning: Types of plans, steps in planning, Process of MBO, how to set objectives, strategies, policies and planning premises, Strategic planning process and tools. Nature and purpose of organizing, Span of management, factors determining the span, Basic departmentation, Line and staff concepts, Functional authority, Art of delegation, Decentralization of authority. HR theories of planning, Recruitment, Development and training. Theories of motivation, Special motivational techniques. Leadership – leadership behavior & styles, Managerial grid. Basic Control Process, Critical Control Points & Standards, Budgets, Non-budgetary control devices. Profit and Loss control, Control through ROI, Direct, Preventive control. PROFESSIONAL ETHICS - Senses of Engineering Ethics, Variety of moral issues, Types of inquiry, Moral dilemmas, Moral Autonomy, Kohlberg's theory, Gilligan's theory, Consensus and Controversy, Models of professional roles, Theories about right action, Self-interest, Customs and Religion, Uses of Ethical Theories. GLOBAL ISSUES - Managerial practices in Japan and USA & application of Theory Z. The nature and purpose of international business & multinational corporations, unified global theory of management, Entrepreneurship and writing business plans. Multinational Corporations, Environmental Ethics, Computer Ethics, Weapons Development, Engineers as Managers, Consulting Engineers, Engineers as Expert Witnesses and Advisers, Moral Leadership, Code of Conduct, Corporate Social Responsibility.

References:

1. Harold Koontz & Heinz Weihrich, "Essentials of Management", McGraw Hill, New Delhi. (2020)
2. Peter Drucker, "The practice of management", Harper and Row, New York. (2004)
3. Vasant Desai, "Dynamics of entrepreneurial development & management", Himalaya Publishing House. (2007)
4. Poornima M Charantimath (2006), "Entrepreneurship Development", Pearson Education.
5. Mike W. Martin & Ronald Schinzinger, "Ethics in engineering", Tata McGraw Hill, New Delhi. (2003)
6. Govindarajan M, Natarajan S, & Senthil Kumar V S, "Engineering Ethics", Prentice Hall of India, New Delhi. (2004)

7. R. S. Nagarazan., "A text book on professional ethics and human values", New age international publishers, New Delhi. (2004)

ICE 3126: Cyber Physical System Design [3 1 0 4]

	CO Statements
CO1	Analyze the complexity of Cyber Physical Systems (CPS).
CO2	Illustrate the difference between information and data in the context of WSNs and CPS
CO3	Analyze the challenges involved in integration of WSNs and CPS.
CO4	Analyze different modelling techniques for WSNs and CPS.
CO5	Design user interfaces and communication systems considering the constraints of WSNs and CPS integration.

Introduction, Understanding and complexity, information vs data, modelling, Multi-level hierarchies, Communication systems, interface and design, Wireless sensor networks: basics and fundamentals, Cyber-physical systems: basics and fundamentals, Integrating wireless sensor networks and cyber-physical systems: challenges and opportunities, Mobile sensors in wireless sensor network cyber-physical systems, Medical cyber-physical systems.

References:

1. Kopetz, H., and Simplicity Is Complex, Foundations of Cyber-physical System Design, 2019.
2. Zeadally, Sherali, and Nafaa Jabeur, Cyber-physical system design with sensor networking technologies. Institution of Engineering and Technology, 2016.

ICE 3127: Data Communication and Networks [3 1 0 4]

	CO Statements
CO1	Interpret the different communication models for computer network.
CO2	Apply error detection and correction techniques at the data link layer.
CO3	Evaluate the suitability of different routing protocols for various network topologies.
CO4	Analyze the different transmission protocols used in transport layer.
CO5	Analyze a case study to identify network security vulnerabilities and propose solutions based on recent trends in network security.

Communications Model, Circuit and Packet switching. Switched Communications Networks. Data Link Layer. Error Detection and Correction. Network Layer IPV4 Address Space. Routing Protocols. Transport Layer. TCP and UDP, Application Layer, Case Study, Recent Trends in Network Security.

References:

1. Computer Networks: A Systems Approach, Larry Peterson and Bruce Davie, (5e), The Morgan Kaufmann Series, Elsevier, 2011.
2. Computer Networking: A Top-Down Approach Featuring the Internet, J.F. Kurose and K.W.Ross, (6e), Pearson Education, 2012.

ICE 3128: Embedded Systems Design and Programming [3 0 0 3]

	CO Statements

CO1	Analyze the architecture of embedded systems.
CO2	Analyze the instruction set of embedded systems.
CO3	Evaluate the suitability of OS-based and non-OS-based firmware embedding techniques for different embedded system projects.
CO4	Analyze the computing platforms of embedded systems.
CO5	Analyze RTOS based on task scheduling algorithms and project requirements.

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, Programming concepts, and embedded programming, Real-Time Operating systems and Task Scheduling algorithms, Hardware Software Co-simulation: Co-simulation approaches, Embedded System Development Life Cycle (EDLC).

References:

1. Vahid F and Givargis T, Embedded System Design, Wiley Publication, 2002.
2. Shibu K. V, Introduction to Embedded Systems, McGraw Hill Publication, 2013.
3. Frank Vahid and Tony Givargis, "Embedded system Design – A Unified Hardware/Software Introduction", Wiley India Pvt. Ltd, 2014.

Flexible core A1 ICE 3129: Industry 4.0 [3 0 0 3]

CO1	Understand the background for industrial IOT
CO2	Apprehend the different cases/applications of industrial IOT
CO3	Identify the different phases of I 4.0
CO4	Analyze the architecture of I4.0
CO5	Explore the design and implement of I4.0

Introduction, Theoretical background, The concept Industry 4.0, Technologies and functions of the concept Industry 4.0, Technology potential and recommendations for action, Introduction to the Industrial Internet, The Technical and Business Innovators of the Industrial Internet, IIoT, Examining the Access Network Technology and Protocols, Middleware Industrial Internet of Things Platforms, Traditional Simulation Applications in Industry 4.0, Distributed Simulation of Supply Chains in the Industry 4.0 Era: A State of the Art Field Overview, Product Delivery and Simulation for Industry 4.0, IoT Integration in Manufacturing Processes, Smart Combat Simulations in Terms of Industry 4.0, Simulation for the Better: The Future in Industry 4.0.

References:

1. Jan, Bartodziej Christoph, The Concept Industry 4.0: An Empirical Analysis of Technologies and Applications in Production Logistics, 2016.
2. Gilchrist, Alasdair. Industry 4.0: the industrial internet of things. Apress, 2016.
3. Gunal, Murat M, Simulation for Industry 4.0 Past, Present, and Future, Springer 2019.

Flexible core B1: ICE **** Introduction to Augmented and Virtual Reality[3 0 0 3]

	CO Statements

CO1	Interpret the basic features of augmented reality and virtual reality.
CO2	Analyze features and architecture of Virtual Reality (VR) systems.
CO3	Investigate stereoscopic vision & haptic rendering.
CO4	Evaluate Augmented Reality (AR) environments and systems.
CO5	Analyze industrial applications of AR/VR technology.

Introduction to Augmented-Virtual and Mixed Reality, Taxonomy, Challenges with AR, AR systems and functionality, visualization techniques for augmented reality. VR as a discipline, Architecture of VR systems, VR input hardware, visual displays. Fundamentals of the human visual system, Depth cues, Stereopsis, Retinal disparity, Haptic sense, Haptic devices, Algorithms for haptic rendering and parallax, AR Taxonomy, AR systems and functionality, Augmented reality methods, visualization techniques for augmented reality, enhancing interactivity in AR environments, evaluating AR systems. VR Technology in Film & TV Production. VR Technology in Physical Exercises and Games.

References:

1. Coiffet, P., Burdea, G. C., (2003), "Virtual Reality Technology," Wiley-IEEE Press, ISBN: 9780471360896
2. Schmalstieg, D., Höllerer, T., (2016), "Augmented Reality: Principles & Practice," Pearson, ISBN: 9789332578494
3. Jerald, J., (2015), The VR Book: Human-Centered Design for Virtual Reality, Morgan & Claypool
4. Mather, G., (2009), Foundations of Sensation and Perception, 2nd Edition, Psychology Press
5. Bowman, D.A., Kruijff, E., LaViola, J. J. and Poupyrev, I., (2014), 3D User Interfaces: Theory and Practice, 2nd Edition, Addison Wesley Professional

Flexicore C1: Fundamentals of EV and HV

ICE 3143: Cyber Physical Systems design Lab [0 0 3 1]

	CO Statements
CO1	Analyze different interfaces for communication network.
CO2	Design wireless sensor network module for CPS.
CO3	Design an optimized local area network for CPS.
CO4	Design an interface system for smart transport.
CO5	Design a control and communication mechanism for ITS.

Communication systems: interface and design, Wireless sensor networks, Cyber-physical systems, integrating wireless sensor networks and cyber-physical systems, Mobile sensors in wireless sensor network cyber-physical systems, Medical cyber-physical systems.

References:

1. Kopetz, H., and Simplicity Is Complex, Foundations of Cyber-physical System Design, 2019.
2. Zeadally, Sherali, and Nafaa Jabeur. Cyber-physical system design with sensor networking technologies, Institution of Engineering and Technology, 2016.

ICE 3144: Embedded system programming lab [0 0 3 1]

	CO Statements
CO1	Develop programming concepts for embedded systems.
CO2	Develop program for RTOS.

CO3	Develop the program for task scheduling using co-simulations.
CO4	Develop program for I/O functionalities in embedded systems.
CO5	Analyze the concept of EDLC.

Programming concepts, and embedded programming, Real-Time Operating systems and Task Scheduling algorithms, Hardware Software Co-simulation: Co-simulation approaches, Embedded System Development Life Cycle (EDLC).

References:

1. Frank Vahid and Tony Givargis, Embedded system Design – A Unified Hardware/Software Introduction, Wiley India Pvt. Ltd, 2014.
2. Shibu K.V, Introduction to Embedded Systems, TMH, New Delhi, 2010.

Semester: VI

HUM 3021: ENGINEERING ECONOMICS AND FINANCIAL MANAGEMENT [3 0 0 3]

	CO Statements
CO1	Compute the worth of money at various points of time
CO2	Apply various depreciation methods in determining the value of an asset
CO3	Describe and apply the basic techniques of financial statement analysis.
CO4	Evaluate the replacement of an existing asset based on standard replacement analysis techniques.
CO5	Evaluate the best alternative in Engineering Economics problems considering risk and safety

Time value of money, Interest factors for discrete compounding, Nominal & effective interest rates, Present and future worth of Single, Uniform, and Gradient cash flow. Related problems and case studies. 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 and double declining balance method of depreciation, Sum-of-the-Years Digits, Sinking Fund and Service Output Methods, Case Study. Balance sheet and profit & loss statement. Meaning & Contents. Ratio analysis, financial ratios such as liquidity ratios, Leverage ratios, Turn over ratios, and profitability ratios, Drawbacks. Safety and Risk, Assessment of Risk and safety, Case study, Risk Benefit Analysis and Reducing Risk.

References:

1. Chan S. Park, "Contemporary Engineering Economics", 4th Edition, Pearson Prentice Hall, 2007.
2. Thuesen G. J, "Engineering Economics", Prentice Hall of India, New Delhi, 2005.
3. Blank Leland T. and Tarquin Anthony J., "Engineering Economy", McGraw Hill, Delhi, 2002.
4. Prasanna Chandra, "Fundamentals of Financial Management", Tata McGraw Hill, Delhi, 2006.
5. Mike W. Martin and Roland Schinzinger, "Ethics in Engineering", Tata McGraw Hill, New Delhi, 2003.
6. Govindarajan M, Natarajan S, Senthil Kumar V. S, "Engineering Ethics", Prentice Hall of India, New Delhi, 2004

Flexible core A2 ICE 3225: INDUSTRIAL AUTOMATION [3 0 0 3]

	CO Statements
CO1	Analyse the architecture of industrial computers.
CO2	Program industrial computers for diverse applications.
CO3	Analyse various industrial communication protocols.
CO4	Develop the drive logics for the motor control using PLC.
CO5	Interpret the architecture of DCS, communication in 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.

Flexible core B2 ICE 3226: Unsupervised Intelligence in CPS [3 0 0 3]

	CO Statements
CO1	Analyze the core concepts of reinforcement learning (RL).
CO2	Scrutinize different modules of unsupervised intelligence in CPS.
CO3	Formulate CPS problems as RL problems.
CO4	Apply dynamic programming principles to solve simple RL problems.
CO5	Apply the concept of CPS on smart grid and defense sector.

Overview of Reinforcement Learning, Comparison of Different Reinforcement Learning Methods, Reinforcement Learning Problems, and Model Based Reinforcement Learning Introduction, Dynamic Programming Principles & Applications, Deep Reinforcement Learning Introduction, Reinforcement Learning for Cyber Security. CASE STUDY, Unsupervised Learning Using Scikit-Learn, Dimensionality Reduction.

References:

1. Chong Li, Meikang Qiu, Reinforcement Learning for Cyber-Physical Systems and Cybersecurity Case Studies, 1st Edition, CRC Press.(2019)

2. Ankur A. Patel, Hands-On Unsupervised Learning Using Python, 1st Edition, O'Reilly Media, Inc., March 2019.

Flexicore C2: Automotive Mechanics for Electric Vehicles

Flexible core A3 ICE 3227: Design of Safe Systems [3 0 0 3]

Composition and Compositionality in CPS, Evolving Security, Cybersecurity for Commercial Advantage, Reasoning about Safety and Security: The Logic of Assurance, From Risk Management to Risk Engineering: Challenges In Future Ict Systems, A Design Methodology for Developing Resilient Cloud Services, Cloud and Mobile Cloud Architecture, Security And Safety, Smart Grid Safety And Security, The Algebra Of Systems And System Interactions With An Application To Smart Grid.

References:

1. Griffor, Edward, ed. Handbook of system safety and security: cyber risk and risk management, cyber security, threat analysis, functional safety, software systems, and cyber physical systems. Syngress, 2016.
2. Gullo, Louis J., and Jack Dixon. Design for safety. John Wiley & Sons, 2017.

Flexible core B3 ICE 3228: CPS Interface [3 0 0 3]

	CO Statements
CO1	Illustrate the concept of systems of systems (SoS).
CO2	Analyze the interfaces for evolving Cyber-Physical Systems-of-Systems (CPSoS).
CO3	Scrutinize the emergence of CPSoS.
CO4	Apply the AMADEOS SysML profile to create a conceptual model for a complex SoS.
CO5	Apply concept of AMADEOS in building of CPSoS.

Basic Concepts on Systems of Systems, Interfaces in Evolving Cyber-Physical Systems-of-Systems, Emergence in Cyber-Physical Systems-of-Systems (CPSoSs), AMADEOS SysML Profile for SoS Conceptual Modeling, AMADEOS Framework and Supporting Tools, Time and Resilient Master Clocks in Cyber-Physical Systems, Managing Dynamicity in SoS.

References:

1. Andrea Bondavalli, Sara Bouchenak and Hermann Kopetz. Cyber-Physical Systems of Systems, Foundations – A Conceptual Model and Some Derivations: The AMADEOS Legacy, Springer, 2016.
2. Vikram Bali, Vishal Batnagar, Cyber-Physical, IoT, and Autonomous Systems in Industry 4.0, CRC Press, 2021

ICE 3244: CPS Interface Lab [0 0 3 1]

	CO Statements
CO1	Implement the ADC in CPS environment.
CO2	Implement FSM and Digital communication.
CO3	Design the CPSoS.
CO4	Evaluate the network parameters.

CO5	Apply concept of AMADEOS on process loops.

CPS Model of an Analog to Digital Converter, Digital to Analog Converter, Implementation Finite state Machine, implantation of Digital Communication Network, Cyber-Physical System Model for Estimation Over a Network, CPS implantation on process loops.

References:

1. Andrea Bondavalli, Sara Bouchenak and Hermann Kopetz. Cyber-Physical Systems of Systems, Foundations – A Conceptual Model and Some Derivations: The AMADEOS Legacy, Springer, 2016.
2. Vikram Bali, Vishal Batnagar, Cyber-Physical, IoT, and Autonomous Systems in Industry 4.0, CRC Press, 2021

ICE 3245: Networking lab [0 0 3 1]

	CO Statements
CO1	Develop the algorithm for socket programming.
CO2	Analyze file transfer and remote command execution
CO3	Simulate ARP and web page downloading.
CO4	Implement TCP/IP and RMI module.
CO5	Implement Client sever using Java programming.

Networking commands, Socket Program for Echo/Ping/Talk commands, File transfer, Remote Command Execution, Create a socket (UDP), Simulation of ARP, Web page downloading, TCP Module Implementation, Implementation of RMI, Implementation of Client in C Server in Java, Case study of routing algorithms.

References:

1. Computer Networks: A Systems Approach, Larry Peterson and Bruce Davie, (5e), The Morgan Kaufmann Series, Elsevier, 2011.
2. Computer Networking: A Top-Down Approach Featuring the Internet, J.F. Kurose and K. W. Ross, (6), Pearson Education, 2012.

MINOR SPECIALIZATION

Minor: I Control Systems

ICE 4401: MODERN CONTROL THEORY [3 0 0 3]

	CO Statements
CO1	Model systems in State variable representation and transform into canonical forms
CO2	Analyse time domain response and stability of LTI systems using State space techniques
CO3	Design LTI systems in State variable forms using Pole placement technique
CO4	Analyse nonlinear systems using Phase plane and Describing function methods

CO5	Apply Lyapunov stability criteria for systems represented in state variable techniques

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.
4. Thomas Kailath, Linear Systems, Prentice-Hall, 1980

ICE 4402: NONLINEAR CONTROL THEORY [3 0 0 3]

	CO Statements
CO1	Apply Lyapunov stability criteria for nonlinear systems
CO2	Analyse the concept of passivity and perform frequency domain analysis.
CO3	Design feedback control law using various methods
CO4	Perform linearization of nonlinear systems.
CO5	Classify various advanced control design procedure for nonlinear systems.

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, and high gain observers. Back stepping algorithm.

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.
5. Zoran Vukic, Ljubomir Kuljaca, Nonlinear Control Systems, Marcel Dekker Inc., 2003.

ICE 4403: DIGITAL CONTROL SYSTEMS [3 0 0 3]

	CO Statements
CO1	Develop Pulse transfer functions of systems involving sampler and zero order hold, Apply block diagram reduction technique for different configuration of discrete time systems
CO2	Anayse time domain response, steady state error and stability of discrete time systems
CO3	Interpret stability of discrete time systems using Root locus and frequency domain plots and design compensators and PID controllers

CO4	Represent systems in discrete time state variable models, transform to various canonical forms, obtain response and analyse stability.
CO5	Design pole placement controller design for discrete time systems in state variable form.

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 4404: SYSTEM IDENTIFICATION [3 0 0 3]

	CO Statements
CO1	Explore the concept of the identifiability and identification procedure.
CO2	Model LTI systems using Time and Frequency domain Techniques.
CO3	Estimate transfer function and correlation models
CO4	Realize structures of autoregressive analysis and its types
CO5	Implement and validate output error 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.

References:

1. L. Ljung, System Identification: Theory for the User, Prentice Hall, 1992.
2. Arun. K. Tangirala, Principles of System Identification Theory and Practice, CRC Press, 2016.
3. Karel. J. Keesman, System Identification – An Introduction, Springer, 2011.
4. Philip D. Cha, Fundamentals of Modeling and Analyzing Engineering Systems, Cambridge, 2000.

Minor:II SENSOR TECHNOLOGY

ICE 4405: SENSOR DESIGN [3 0 0 3]

	CO Statements

CO1	Review the basic sensor characteristics
CO2	Interpret the concept of multi spectral sensors
CO3	Design the dedicated sensor system
CO4	Develop the CONOPS system for targeted techniques.
CO5	Analyze and design sensor packaging

Review of basic performance characteristics of sensors, Fractional order elements and electrochemical sensor design, Design and development of a dedicated sensor system: Requirement analysis; Definition of technical and functional requirements; Cost analysis; Development of a measurement system prototype using necessary tools, Practical realization of a sensor system; Planning and documenting. Factors Influencing Sensor-based System Design. Limited field trials and sensor calibrations. Case studies of novel sensor design. Multi-spectral sensor Concept of Operation (CONOPS) development, sensor requirements allocation and derived requirement development, Sensor Architecture development, hardware and software partitioning, functional and physical interface requirements and design, signal processing requirement definition, subcomponent performance modeling and testing, observable measurement definition, Key sensor design trade parameters, Multi-spectral sensor systems design methodology, Modern target tracking techniques. Design of sensor packaging, installation and wiring considerations based on hazard classifications. Safety considerations in sensor design and commissioning.

Reference:

1. Jacob Fraden - Handbook of Modern Sensors, Physics, Designs, and Applications, Springer, 2010.
2. T. Grandke, W. H. Ko, Sensors: Fundamentals, Volume 1, Wiley publisher, 1990.

ICE 4406: BIOSENSORS AND BioMEMS [3 0 0 3]

	CO Statements
CO1	Analyze use of bio recognition elements in biosensors design
CO2	Analyze various bioconjigation chemistries in biosensors design
CO3	Analyze use of various transduction platforms in biosensing application
CO4	Illustrate 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 4407: MULTI SENSOR DATA FUSION [3 0 0 3]

	CO Statements
CO1	Recall the concept of sensor and data fusion

CO2	Interpret and evaluate the role of agents and how it is related to various environments
CO3	Comprehend concept of data association and decision making
CO4	Describe data fusion frameworks
CO5	Understand data filtering techniques

Concept of fusion, Role of fusion, comparison between sensor and data fusion, fusion types, I/O types, Sensor configuration, Architecture of fusion nodes, fusion topologies, Benefits of fusion. Fusion Architectures - Centralized Fusion, Distributed Fusion, Hybrid Fusion, Introduction to process of data fusion: Need for 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 - Biological and puzzle solving types, Command and control, Evidence combination, Information requirement for decision making. Bayesian and Dempster–Shafer Fusion Methods - Bayesian Method, Bayesian Method for Fusion of Data from Two Sensors, Dempster–Shafer Method, Comparison of the Bayesian Inference Method and the Dempster–Shafer Method. JDL framework, Revised JDL, Dasarathy's model, Boyd model, Thompolus framework, Luo-Key framework, Pau's framework, Waterfall and omnibus framework, Distributed black box, Esteban framework. Introduction to data filters, 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.
3. Multi Sensor Data Fusion with MATLAB, Jitendra R. Raol, CRC Press, 2009.
4. Sensor and Data Fusion, Lawrence A. Klein, (2e), SPIE Press, 2012.

ICE 4408: AUTOMOTIVE SENSORS [3 0 0 3]

	CO Statements
CO1	Demonstrate the application of electronics and sensing in automobiles
CO2	Interpret and evaluate the role of sensors in power train and chassis management
CO3	Apply different measurement principle in vehicle body management
CO4	Acquire the knowledge of sensors in passenger safety systems.
CO5	Analyze and design a real-world vehicle communication

Automotive Management systems, Application areas of electronics in the automobiles, Possibilities and challenges in the automotive industry, Power train sensors, sensors for chassis management, Sensors for vehicle body management, Sensors for automotive vehicle convenience and security systems, Two wheeler and Four wheeler security systems, parking guide systems, anti-lock braking system, future safety technologies, Vehicle diagnostics and health monitoring, Safety and Reliability, Traction Control, Vehicle dynamics control, Air Bag and Seat Belt Pre tensioner Systems, Principal Sensor Functions, Passenger Convenience Systems, Electromechanical Seat, Seat Belt Height, Steering Wheel, and Mirror Adjustments, Central Locking Systems, Electromechanical Window Drives. Enabling Connectivity by Networking:-In vehicle communication standards (CAN & LIN), Telematic solutions, Portable or embedded connectivity- Endorsing Dependability in Drive-bywire systems - Terminology and concepts, Why by-wire, FLEXRAY, Requirements on cost and dependability, Drive-by-wire case studies- prototype development-future of In vehicle communication.

References:

1. Automotive Electrics, Automotive Electronics: Systems & Components, (5e), BOSCH, 2014.
2. Automotive Sensors Handbook, (8e), BOSCH, 2011.
3. Jiri Marek, Hans-Peter Trah, Yasutoshi Suzuki, Iwao Yokomori, Sensors for Automotive Technology, (4e), Wiley, New York, 2010.
4. John Turner, Automotive Sensors (1e), Momentum Press, New York, 2010.

Minor: III SYSTEMS ENGINEERING

ICE 4409 INTRODUCTION TO SYSTEMS ENGINEERING [3 0 0 3]

	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 4410: SYSTEM ARCHITECTURE AND DESIGN [2 1 0 3]

	CO Statements
CO1	understand System architecture and Design Processes
CO2	Appreciate various frameworks, methodologies and approaches for system architecture
CO3	Able to identify 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 4411 SYSML AND MBSE [2 0 2 3]

	CO Statements
CO1	understand and appreciate the need and advantages of model based approache
CO2	understand SysML notation
CO3	apply various modeling approaches and methodologies
CO4	design and develop various types of models pertaining to requirements, architecture and design of complex systems
CO5	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 4412 SYSTEM VERIFICATION AND VALIDATION [3 0 0 3]

	CO Statements

CO1	Articulate importance and key aspects of verification /validation in Systems Engineering and Project Management as applied to System design and capability acquisition lifecycles
CO2	Appreciate validation methods, verification methods and categories, configuration baselines and functional and physical configuration
CO3	Compare the types of verification/validation and their contemporary issues
CO4	Develop hierarchical and traceable verification/validation measures for systems-measures of effectiveness/performance(MOEs/MOPs)
CO5	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.

Minor IV SMART TRANSPORTATION SYSTEM

ICE 4413: Automotive Electronics [3 0 0 3]

	CO Statements
CO1	Grasp the Integration of Electronics in Automotive Systems
CO2	Apply knowledge of sensors and actuators for various automotive applications
CO3	Explain Electronic Fuel Injection and Ignition System Principles
CO4	Perform Basic Battery Maintenance and Understand Battery Types
CO5	Analyze and differentiate between open-loop and closed-loop control systems in automotive applications

	CO Statements
CO1	Analyze the working of electrical and electronic systems in e-vehicle.
CO2	Interpret different control strategies in e-vehicle.
CO3	Evaluate the different lighting technologies in e-vehicle.
CO4	Analyze different stability programs in e-vehicle.
CO5	Analyze the adaptive cruise control in e-vehicle.

Introduction to Electronic systems in Automotives, Sensors and Actuators for body electronics, power train and chassis systems, Power train and chassis control domain, Engine management, Transmission control Battery- types and maintenance, Automotive Electronics, Sensors and Actuators, Basic sensor arrangement, Types of sensors, Electronic Fuel Injection and Ignition Systems, Digital engine control systems, Open loop and closed loop control systems.

References:

1. Bosch, Automotive Electrics and Automotive Electronics. System and components, Networking and Hybrid drive, (5e), Springer view 2014
2. Najamuz Zaman, Automotive Electronics Design Fundamental (1e), Springer 2015.
3. Hillier's, Fundamentals of Motor Vehicle Technology on Chassis and Body Electronics, (5e), Nelson Thrones, 2007.

ICE 4414: In-vehicle Networking [3 0 0 3]

	CO Statements
CO1	Illustrate data communication networks and automotive communication protocols.
CO2	Recognize the fundamentals of vehicular communication networks and standards
CO3	Evaluate the different network topologies in vehiclular communication
CO4	Analyze the concept of automotive network and coupling of network
CO5	Analyze the process of automotive vehicle system and diagnostics protocol

	CO Statements
CO1	Interpret the smart vehicle communication protocol.
CO2	Analyze the fundamentals of vehicular communication.
CO3	Evaluate the different network topologies in vehicle.
CO4	Analyze the different fault diagnostic methods for automotive network
CO5	Evaluate different traffic management systems for automotive network.

Basics of Data Communication Networks and Automotive Communication Protocols, Need for networks, Types of networks, Need for standards, TCP/IP model, Topologies, Controller Area Network (CAN) Protocol, CAN Higher Layer Protocols and LIN, FlexRay and MOST Protocol, Process of Automotive Fault Diagnostics, Fault Codes, Vehicle Systems (open-loop and closed-loop) On- and Off- Board Diagnostics, OBD-I, OBD-II, Engine Analyzers, Steps taken to diagnose a fault, Diagnostics Protocol-KWP2000, SAE-J1587, SAE-J1708 and Case Study.

References:

1. Gilbert Held. Inter- and Intra-Vehicle Communications, CRC Press, (2007)
2. Behrouz Forouzan. Data Communications and Networking, McGraw-Hill. 2003
3. Ronald k. Jurgen. Automotive Electronics Handbook, McGraw-Hill. 1999

ICE 4415: Intelligent Transportation Systems [3 0 0 3]

	CO Statements
CO1	Analyze different traffic flow and control mechanisms in Intelligent transport systems (ITS).
CO2	Interpret various ITS user services and their functionalities.
CO3	Evaluate traffic and incident management systems.
CO4	Analyze the challenges of ITS planning.
CO5	Apply ITS principles to traffic/incident management, sustainable mobility (TDM, ETC), and road pricing strategies.

Fundamentals of ITS, Definition of ITS, the historical context of ITS from both public policy and market economic perspectives, Types of ITS; Historical Background, Benefits of ITS, Sensor technologies and Data requirements of ITS, ITS User Needs and Services and Functional areas, ITS Architecture, Regional and Project ITS architecture; Concept of operations; ITS Models and Evaluation Methods, ITS applications, Traffic and incident management systems; ITS and sustainable mobility, travel demand management, electronic toll collection, ITS and road-pricing.

References:

1. Mashrur A. Chowdhury, Adel Wadid Sadek, Fundamentals of intelligent transportation systems planning, ARTECH House, 2013.
2. Lawrence A. Klein, Sensor technologies and Data requirements of ITS, Artech House, 2011.

ICE 4416: Advanced Driver Assistance Systems [3 0 0 3]

	CO Statements
CO1	Analyze core principles of Advance driver Assistance system (ADAS).
CO2	Evaluate various techniques employed for object tracking in ADAS systems.
CO3	Evaluate the human factors of vehicle automation.
CO4	Analyze the legal issues and challenges of automated driving technologies.
CO5	Examine the implications of different ADAS technologies for autonomous vehicle.

Advanced driver assistance system, human factors of automated driving systems, human factor of vehicle automation, legal issue surrounding cyber security and privacy on automated vehicle, user perspective on autonomous driving systems, ADAS technology A review on challenges, legal risk mitigation and solutions, localization and mapping for autonomous driving, open pit mine autonomous bot.

References:

1. Chapmann and Hall, Autonomous driving and advanced driver assistance system (ADAS), CRC Press, 2021

2. Dietmar P.F. Möller, Roland E. Haas, Guide to Automotive Connectivity and Cybersecurity: Trends, Technologies, 2017

Other Program Electives

ICE 4461: Big Data Analytics [3 0 0 3]

Introduction to big data-Characteristic features, Big Data Applications, web data, Modern Data Analytic Tools, Hadoop framework, Data analysis- statistical methods, classification, Mining data streams-Stream data model and architecture, Mining data streams, Real Time Analytics Platform (RTAP) Applications, Big data frameworks.

References:

1. Michael Berthold, David J. Hand, Intelligent Data Analysis, Springer, 2007.
2. Bill Franks, ―Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics‖, Wiley and SAS Business Series, 2012.
3. David Loshin, Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph, 2013.

ICE 4462: Blockchain Technology [3 0 0 3]

Introduction to cryptographic hash functions and cryptocurrencies, Mechanics, Storage and Use of Bitcoins, Bitcoin Mining and Anonymity, Blockchain contracts-Crowd funding, bitcoin prediction markets, smart contracts, blockchain 2.0 protocol projects, wallet development projects, Blockchain Development Platforms and APIs, Blockchain Ecosystem, Ethereum: Turing-Complete Virtual Machine, Blockchain markets and applications, Blockchain economy and variants, Blockchain Challenges, Recent Trends.

References:

1. Melanie Swan, Blockchain: Blueprint for a New Economy, O'Reilly, 2015.
2. Josh Thompsons, Blockchain: The Blockchain for Beginners-Guide to Blockchain Technology and Leveraging Blockchain Programming, 2017

ICE 4464: CPS Assurance [3 0 0 3]

	CO Statements
CO1	Analyze Risks in cyber physical systems.
CO2	Evaluating cryptographic components in CPS.
CO3	Design security mechanisms for CPS.
CO4	Analyze trust models and algorithms to establish trust relationships among CPS components.
CO5	Evaluate security of CPS deployment strategies.

Cyber Physical Systems - Risk analysis, Cryptographic Components-Cryptographic components – Hash functions – Asymmetric key cryptography – Digital signatures – Security to state machines – Certified security by design for IOT applications, CPS Assurance-CPS Quality Assurance - Co-Verification Interface Design for High-Assurance CPS - High Assurance Aerospace CPS - Safety Assurance for Machine Learning in CPS , Trust Management in CPS, CPS Secured Implementation, Secure Deployment of CPS, Intelligent CPS.

References:

1. Cyber Physical Systems: Architecture, Protocol and Applications, Edited by Chi (Harold) Liu and Yan Zhang, CRC Press, 2016.
2. Cyber Physical Systems: Foundations, Principles and Applications, Edited by Houbing Song, and others, Elsevier, 2017.
3. Raj Rajkumar, Dionisio De Niz, and Mark Klein, Cyber-Physical Systems, Addison-Wesley Professional, 2016.
4. Rajeev Alur, Principles of Cyber-Physical Systems, MIT Press, 2015.

ICE 4465: CPS for internal and external security [3 0 0 3]

	CO Statements
CO1	Analyze various design recommendations for cyber physical systems.
CO2	Analyze real-world cyber attacks on CPS systems.
CO3	Examine physical security measures employed to protect CPS systems.
CO4	Analyze cloud computing security related to CPS systems.
CO5	Examine Policy Issues in security management for CPS.

Introduction to Cyber Physical Systems- Cyber Physical Systems Design Recommendations - CPS system requirements and its Applications. Security and Vulnerabilities-Cyber Security Vulnerabilities, Cyber Security Safeguards, Attacks. Physical Security, Cloud Computing Security, Interconnection- Hardware platforms for Cyber Physical Systems, Policy Issues-Policy issues in security management.

References:

1. John R.Vacca, Computer and Information Security Handbook, (2e), Elsevier 2013.
2. Richard E.Smith, Elementary Information Security, Second Edition, Jones and Bartlett Learning, 2016.

ICE 4466: Cyber Security [3 0 0 3]

	CO Statements
CO1	Analyze various types of cyber attacks and their implications on digital security.
CO2	Evaluate privacy laws and regulations relevant to digital communication.
CO3	Evaluate cryptographic techniques for ensuring secure communication.
CO4	Investigate cybercrime issues ,and digital fraud through a forensic lens.
CO5	Analyze the implications of recent trends and contemporary issues in NGN.

Digital securities-Types Of Cyber Attacks- Privacy Laws-Phishing - Definition And Working Principle, online anonymity-Anonymous Networks-VPN Design And Architecture, cryptography and secure communication-Cryptographic Functions-Disk Encryption Using Open Source Tools, cybercrime issues and investigation-Internet Hacking And Cracking-Digital Laws And Legislation, Law Enforcement Roles And Responses, digital forensics.

References:

1. Nihad Hassan and Rami Hijazi, Digital Privacy and Security Using Windows: A Practical Guide, Apress Publications, 2017
2. Digital Forensics, DSCI - Nasscom, 2012.
3. Cyber Crime Investigation, DSCI - Nasscom, 2013.

ICE 4467 Design of Safe Systems

Composition and Compositionality in Cps, Evolving Security, Cybersecurity for Commercial Advantage, Reasoning about Safety and Security: The Logic of Assurance, From Risk Management to Risk Engineering: Challenges In Future Ict Systems, A Design Methodology for Developing Resilient Cloud Services, Cloud and Mobile Cloud Architecture, Security And Safety, Smart Grid Safety And Security, The Algebra Of Systems And System Interactions With An Application To Smart Grid.

References:

1. Griffor, Edward, ed. Handbook of system safety and security: cyber risk and risk management, cyber security, threat analysis, functional safety, software systems, and cyber physical systems. Syngress, 2016.
2. Gullo, Louis J., and Jack Dixon. Design for safety. John Wiley & Sons, 2017.

ICE 4468: E-Vehicles [3 0 0 3]

Introduction to Electric Vehicles, Electric Drive trains, Power Converters, Electric Motor Drives, Energy storage technologies and Auxiliary systems, Automotive networking and Communication, In-vehicle networks, CAN, ADAS, V2X- Internet of things technologies, M2M communication. Cyber–Physical systems Design for Electric vehicles, Contemporary issues.

References:

1. Iqbal Hussain, "Electric and Hybrid Vehicles-Design Fundamentals", CRC Press, (2e), 2021.
2. Mehrdad Ehsani, Yimin Gao, and Ali Emadi, "Modern Electric, Hybrid and Fuel Cell Vehicles: Fundamentals", CRC Press, (2e), 2018.

ICE 4469: Intelligent Manufacturing Automation [3 0 0 3]

Introduction to Automation and Digital Manufacturing-Automation principles and strategies-- Basic Elements of an Automated System, Levels of Automations, Concepts of Industry 4.0 and Connected Machines, Digital Design and Fabrication, Intelligent Manufacturing Support Systems-Online Predictive Modeling - Monitoring and Intelligent Control of production and Logistics/Supply Chain Processes, Automated Inventory and Production, Automated Inspection and Testing, Intelligent Manufacturing Systems-Artificial Intelligence based systems.

References:

1. Andrew Kusiak, Smart Manufacturing, Publisher, Taylor & Francis, 2018.
2. Mikell P. Grover, Automation, Production Systems and Computer Integrated Manufacturing (2016), Fourth Edition, Pearson Education.
3. William MacDougall, Industrie 4.0: Smart Manufacturing for the Future, Germany Trade & Invest, 2014.
4. Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things, Apress, 2016.

ICE 4470: Metaverse [3 0 0 3]

	CO Statements
CO1	Analyze the conceptual foundations of the metaverse.
CO2	Evaluate the notions of digital virtual self and identity in the metaverse.
CO3	Interpret interaction and interactivity in the metaverse.
CO4	Analyze the nature of autopoietic and allopoietic machines in the metaverse.
CO5	Evaluate the cognitive mechanisms and awareness in the metaverse.

Teaching and learning in the networked society, network learning culture and the emerging paradigm, reflections about reality, systemic thinking and complexity, epistemological conceptions, metaverse: 3D digital virtual worlds, metaverse technology and the nature of 3d digital virtual worlds, second life metaverse, open source metaverses, avatar: building a “digital virtual self”, the construction of a digital virtual identity, representation/action of the “digital virtual self” through the technologicized body, immersion, telepresence, and digital virtual presence in metaverses, presence and proximity, relational presence and social presence, telepresence and digital virtual presence, interaction and interactivity in metaverse, languages and interaction/interactivity forms in metaverse, autopoietic machines: human beings, alopoietic machines: the nature of the metaverse, structural coupling, cognition and socio-cognition in metaverse, doing, understanding, and awareness in metaverse

References:

1. Eliane Schlemmer and Luciana Backes, Learning in Metaverses: Co-Existing in Real Virtuality, IGI Global, 2014.
2. Nelson Zagalo, Leonel Morgado and Ana Boa-Ventura. Virtual Worlds and Metaverse Platforms: New Communication and Identity Paradigms, IGI Global, 2011.

ICE 4471: Next Generation Networks [3 0 0 3]

	CO Statements
CO1	Analyze the functional architecture of next generation networks (NGN).
CO2	Evaluate key development areas in next generation networks.
CO3	Interpret corporate responsibility in next generation networks.
CO4	Evaluate the architecture and technologies for 5G mobile networks.
CO5	Analyze recent trends and contemporary issues in NGN.

Introduction to Next Generation Networks, NGN Functional Architecture, NGN Key Development Areas, Corporate Responsibility. 5G Mobile Network, Software Defined Networks, Network Function Virtualization, Recent Trends / Contemporary Issues related to 5G mobile networks / Software Defined Networks/ Network Function Virtualization.

References:

1. Next Generation Networks: Perspectives and Potentials, Dr Jingming Li Salina Pascal Salina, John Wiley & Sons, Ltd, 2007.
2. Fundamentals of 5G Mobile Networks, Jonathan Rodriguez, Wiley, (1e), 2015.
3. Foundations of Modern Networking, William Stallings, Addison-Wesley Professional, (1e), 2015.

ICE 4472: Smart Farming and Agriculture [3 0 0 3]

Information communication technologies for Agriculture, Automation in Smart agricultural monitoring, Internet of Things practices for Agriculture, Smart Irrigation models, Wireless Sensor Networks Technologies and Applications for Smart Farming, Sustainable Smart-Farming Framework: Smart Farming, Soil monitoring, Pest and weed control.

References:

1. Ramesh C. Poonia, Xiao-Zhi Gao, Linesh Raja, Sugam Sharma, Sonali Vyas, Smart Farming Technologies for Sustainable Agricultural Development, IGI Global, 2018.
2. Internet of Things and Analytics for Agriculture, edited by Pattnaik, Prasant Kumar, Kumar, Raghvendra, Pal, Souvik (Eds), Springer, 2020.

ICE 4473: Smart Grid [3 0 0 3]

Smart Grid Basics-main features and challenges of smart grid, Energy resources - centralized vs. distributed generation- renewable energy- solar, wind, hydropower, biomass, geothermal, ocean wave; Plug-in Electric Vehicle (PEV)-history of EV- PEV challenges and potential solutions- EV and electric power grid, Demand-side management: -load profile of the power grid;-market pricing-peak shaving and valley filling-load forecasting- regulations and policies, Monitoring and Protection.

References:

1. J. Duncan Glover, Mulukutla S. Sarma, and Thomas J. Overbye, Power System Analysis and Design, 4th Ed.,Stamford, CT: Cengage Learning, 2008.

2. Jan Machowski, JanuszBialek, and James R. Bumby, Power Systems Dynamics, Stability and Control, 2nd Ed.New York, New York: John Wiley, 2008.
3. B. Droste-Franke, et al., Balancing Renewable Electricity – energy storage, demand side management, and network extension from an interdisciplinary perspective. Heidelberg, Germany: Springer, 2012.
4. T. Ackermann, Wind Power in Power Systems. New York, New York: Wiley, 2005.

ICE 4474: Smart Infrastructure [3 0 0 3]

	CO Statements
CO1	Analyze the Interplay between CPS and IoT in smart infrastructure.
CO2	Evaluate the physical infrastructures of cyber physical systems.
CO3	Evaluate the energy efficiency, sustainability and reliability issues in CPS.
CO4	Analyze the role of robotics and smart systems in cyber context.
CO5	Evaluate security issues in cyber physical systems.

CPS and IoT, Physical Infrastructures of Cyber Physical Systems, Energy and Reliability Issues in Cyber Physical Systems, Robotics and Smart Systems in Cyber Context, Ubiquitous and Cloud Computing for Monitoring Cyber Physical Systems, Security Issues in Cyber Physical Systems, Role of Cyber-Physical Systems in Big Data Analytics, Social Network Analysis, and Healthcare.

References:

1. Gaddadevara Matt Siddesh, Ganesh Chandra Deka, Krishnarajanagar GopalaIyengar Srinivasa, Lalit Mohan Patnaik, “Cyber-Physical Systems A Computational Perspective”, (1e), 2016, CRC Press, Taylor and Francis.

ICE 4475: Virtual and Augmented Reality [3 0 0 3]

	CO Statements
CO1	Interpret the basic features of augmented reality and virtual reality.
CO2	Analyze features and architecture of Virtual Reality (VR) systems.
CO3	Investigate stereoscopic vision & haptic rendering.
CO4	Evaluate Augmented Reality (AR) environments and systems.
CO5	Analyze industrial applications of AR/VR technology.

Introduction of Virtual Reality, Multiple Models of Input and Output Interface in Virtual Reality, Visual Computation in Virtual Reality, Interactive Techniques in Virtual Reality, Development Tools and Frameworks in Virtual Reality, Application of VR in Digital Entertainment, Augmented and Mixed Reality, Taxonomy, technology and features of augmented reality, difference between AR and VR, Augmented reality methods.

References:

1. Burdea, G. C. and P. Coffet. Virtual Reality Technology, Second Edition. Wiley-IEEE Press, 2006.
2. Alan B. Craig, Understanding Augmented Reality, Concepts and Applications, Morgan Kaufmann, 2013.

ICE 4476: Wireless Sensor Technology [3 0 0 3]

	CO Statements
CO1	Interpret the architecture of wireless sensor network
CO2	Analyse sensor networks
CO3	Design sensor networks using WSN protocols
CO4	Apply the concept of sensor communication technology
CO5	Analyse sensor network platforms

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.

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 **** Smart Sensor [3 0 0 3]

	CO Statements
CO1	Interpret the architecture of smart sensors
CO2	Analyse communication techniques for smart sensing
CO3	Interpret various smart sensor standards
CO4	Analyse smart measurement chains
CO5	Incorporate smart sensors for industrial 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, lEEE 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, RFID, 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 Sensors, Artech House Publications, 2e, 2000.
3. Paul W. Chapman, Smart Sensors, ISA Press, 1996.
4. Krzystof Iniewski, Smart Sensors for Industrial Applications, CRC Press, 2013.

OPEN ELECTIVES

ICE 4311: FEEDBACK CONTROL THEORY [3 0 0 3]

	CO Statements
CO1	Apply mathematical modelling techniques to derive transfer functions for electrical and mechanical systems
CO2	Analyze feedback control systems using signal flow graphs and Mason's gain formula
CO3	Interpret and utilize state variable representations of linear systems
CO4	Evaluate control system performance in both time and frequency domains
CO5	Assesss the stability of linear feedback control systems

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 4312: INDUSTRIAL AUTOMATION [3 0 0 3]

	CO Statements
CO1	Illustrate role of computer in data acquisition and process control
CO2	Grasp PLC architecture and perofrm basic PLC programming
CO3	Develop PLC programming for process applications
CO4	Analyse structure and working of various communication protocols used in automation
CO5	Illustrate the architecture of DCS, SCADA 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 4313: INDUSTRIAL INSTRUMENTATION [3 0 0 3]

	CO Statements
CO1	Illustrate the fundamental concepts of industrial Instrumentation
CO2	Describe the working principles of various transducers
CO3	Elaborate the working of instruments used of measurement of temperature, pressure
CO4	Elucidate the instruments used to measure level, thickness and flow
CO5	Illustrate working of instruments used to measure velocity, PH, Force and optical based devices.

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 4314: SENSOR TECHNOLOGY [3 0 0 3]

	CO Statements
CO1	Illustrate the basic concepts and fundamentals of sensor technology
CO2	Describe the working principles of sensors for displacement, temperature, force/torque
CO3	Describe the working principles of sensors for Humidity, moisture, flow, acceleration, vibration etc
CO4	Illustrate working of chemical and biosensors, optical and radiation sensors
CO5	Describe wirelelss sensor networks and its application.

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 4315: SMART SENSOR [3 0 0 3]

	CO Statements
CO1	Illustrate requirements and architecture of smart sensors
CO2	Grasp and compare various smart sensor standards
CO3	Analyse different sensor communication interfaces
CO4	Analyse sensor signal processing and feature extraction techniques
CO5	Demonstrate smart sensor application cases.

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 Sensors, (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 4316: VIRTUAL INSTRUMENTATION [3 0 0 3]

	CO Statements

CO1	Illustrate the concept of Virtual instrumentation and compare it with classical instrumentation
CO2	Develop VI, Sub-VI, arrays, clusters, case structures, loops etc using LabVIEW
CO3	Analyse simulation problems on LabVIEW
CO4	Illustrate 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 4317: FARM AUTOMATION [3 0 0 3]

	CO Statements
CO1	Grasp various farm operations and their mechanization
CO2	Illustrate agricultural water management system
CO3	Design post harvest processing machines
CO4	Design and analyse automated farm management systems
CO5	Analyse 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