File Ref.No.Ac.A3/Faculty of Technology/2024

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

(Abstract)

Faculty of Technology - Scheme and Syllabus of various programmes offered at Department of Instrumentation - Approved by the Academic Council - Orders issued.

ACADEMIC A SECTION

No.CUSAT/AC(A).A3/3221/2025 Dated,KOCHI-22,12.08.2025

Read:-Short Minutes on Item No. I(f)(1) of the Minutes of the Meeting of the Academic Council held on 26.06.2025

ORDER

The Academic Council, vide item read above, considered along with the recommendations of its Standing Committee, the Minutes of the meeting of the Faculty of Technology held on 09.05 2025 & 20.06.2025, and resolved to approve the following:

1. List of Electives and their detailed Syllabus for B.Tech Instrumentation and Control Engineering with effect from 2024 admission **(Appendix - I)**
2. Scheme and Syllabus for B.Tech (Honours) in Instrumentation and Control Engineering with effect from 2024 admission **(Appendix - II)**
3. Scheme and Syllabus for B.Tech Minors in Robotics with effect from 2024 admission **(Appendix - III)**

Orders are, therefore, issued accordingly.

Dr. Arun A U *
Registrar

To:

1. The Dean, Faculty of Technology
2. Chairperson, Board of Studies in Instrumentation

3. The Head, Department of Instrumentation
4. All AR/DR Examination wing - with a request to forward to sections concerned
5. The Director, IQAC/ DoA
6. CIRM/Conference Sections
7. PS to VC/PVC;PA To Registrar/CE.

* This is a computer generated document. Hence no signature is required.

DEPARTMENT OF INSTRUMENTATION

Syllabus for Elective subjects offered to B.Tech Instrumentation and Control Engineering students (2024 Admission Onwards(V to VIII Semesters)

24-219-0508 VLSI DESIGN

L	T	P	C
3	1	0	3

Total hours: 64

Course Outcomes:
After completion of the course, students will be able to
CO1:MOSFET basics and various second-order MOS device effects (Understand)
CO2:Different processing steps in IC fabrication
CO3:Design different types of logic gates using CMOS inverters and analyze their transfer characteristics.
CO4:Basics of semiconductor memories and arithmetic circuits

Mapping of course outcomes with Program outcomes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	-	-	1	-	-	-	-	-	3
CO2	3	3	2	-	-	1	-	-	-	-	-	3
CO3	3	3	2	-	-	1	-	-	-	-	-	3
CO4	3	3	2	-	-	1	-	-	-	-	-	3

Module I (16 hours, End semester marks 25%)
Basic electrical properties of MOS transistor: V-I relationship, Threshold Voltage, MOS device as a resistor, MOS device as a capacitor, Transconductance, Conduction mechanisms in MOS device, Scaling of MOS Circuits, Second order MOS device effects, short channel effect, narrow width effect, sub-threshold current.

Module II (16 hours, End semester marks 25%)
Basics of VLSI Device Fabrication: Material Preparation- Purification, Crystal growth (CZ and FZ process), wafer preparation, Thermal Oxidation- Growth mechanisms, Dry and Wet oxidation, Deal Grove model. Diffusion, Ion implantation, Epitaxy, lithography, etching, and metal deposition. Methods of isolation Circuit component fabrication: transistor, diodes, resistors, capacitors, N well and P well, and Twin tub CMOS IC Fabrication process

Module III (16 hours, End semester marks 25%)
MOS Circuit Design Processes and Subsystem Layout: Layout Design rules- Diagram and layout of CMOS inverter, two input NAND and NOR gates, Latch-up in CMOS. CMOS inverters -DC characteristics, switching characteristics, power dissipation. MOSFET Logic Design -Pass transistor logic, Complementary pass transistor logic and transmission gate logic, realization of functions.

Module IV (16 hours, End semester marks 25%)
Read Only Memory-4x4 MOS ROM Cell Arrays (OR, NOR, NAND) Random Access Memory SRAM-Six transistor CMOS SRAM cell, DRAM –Three transistor and One transistor Dynamic Memory Cell Adders Static adder, Carry bypass adder, Linear Carry Select adder, Square root Carry Select adder, Multipliers-Array multiplier.

References:
1. D.S. Pucknell & K. Esharghian, Basic VLSI Design, Prentice Hall, 2000
2. Y Taur & T.H. Ning, Fundamentals of Modern VLSI Devices, Cambridge University Press, 2003
3. John P Uyemura, Introduction to VLSI Circuits and Systems, Wiley India, 2006
4. Jan M.Rabaey, Digital Integrated Circuits- A Design Perspective, Prentice Hall, Second Edition, 2005.
5. Neil H.E. Weste, Kamran Eshraghian, Principles of CMOS VLSI Design- A Systems Perspective, Second Edition. Pearson Publication, 2000.
7. Razavi - Design of Analog CMOS Integrated Circuits,1e, McGraw Hill Education India Education, New Delhi, 2003.
8. S. M. Kang, Y. Leblebici, & C. Kum, CMOS Digital Integrated Circuits, Analysis and design, Revised 4th edition, McGraw-Hill Education, 2019.

NPTEL course links that align with the syllabus:

1. **CMOS Digital VLSI Design, IIT Roorkee**
   https://nptel.ac.in/courses/108107129

2. **VLSI Technology, IIT Madras**
   https://nptel.ac.in/courses/117/106/117106093

24-219-0509 SMART MATERIALS AND SYSTEMS

L	T	P	C
3	1	0	3

Total hours: 64

Course Outcomes:
After completion of the course, students will be able to
CO1: Familiarize with the different smart materials for different applications.
CO2: Acquire knowledge about the smart materials, their characteristics and design aspects
CO3: Explain the functionalities through the mathematical models.
CO4: Outline the significant features of smart materials in sensing, actuation and control.
CO5: Design and develop smart structures using smart material-based actuators and sensors.
CO6: Design, model and control of smart systems, through simulation and experimentation.

Mapping of course outcomes with Program outcomes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	2	-	-	-	-	3
CO2	3	3	2	-	-	-	-	-	-	-	-	3
CO3	-	3	3	3	3	-	-	-	-	-	-	3
CO4	3	-	2	-	3	-	-	-	-	-	-	3
CO5	-	-		-	3	2	2	-	-	-	-	-
CO6	-	-	3	3	3	-	-	-	3	-	-	3

Module I (16 hours, End semester marks 25%)

Introduction to Smart Materials and Structures: Smart materials for sensing and actuation, the role of smart materials in developing intelligent systems and adaptive structures. Potential feasibility of smart structures, key elements of smart structures, Introduction to smart materials, classification of smart materials.

Module II (16 hours, End semester marks 25%)

Piezoelectric Materials: piezoelectric effect, direct and converse, constitutive relationship, piezoelectric constants, piezoceramics, piezopolymers, piezoelectric composites. Actuators and sensor based on piezoelectric materials: Piezoelectric sensors, Unimorph and Bimorph Actuators. Shape Memory Alloys (SMA) – Shape Memory Effect, phase transformation, Tanaka's constitutive model, basic material behavior and modelling issues, one way and two-way SME

Module III (16 hours, End semester marks 25%)

Electro-active Polymers (EAP): Electro-active Polymers for Work-Volume Generation, EAP as actuator and sensor. Electro-Rheological (ER) fluids, Magneto-Rheological (MR) fluids. Magnetostrictive Materials – Constitutive relationship, magneto-mechanical coupling coefficients, Joule Effect, Villari Effect, Matteuci Effect, Wiedemann effect, Giant magnetostriction in TerfenolD, Magnetostrictive Composites. Magnetostrictive Sensors, Magnetostrictive Mini Actuators.

Module IV (16 hours, End semester marks 25%)

Integration of Smart Sensors and Actuators to Smart Structures – Optimal placement of sensors and actuators, design of controller for smart structure, techniques of self-sensing using piezoelectric and SMA. Case Studies to Advanced Smart Materials: Piezoelectric unimorph and bimorph energy harvesters, Vibration control system using SMA, Self-healing smart materials.

References:

1. Mukesh V Gandhi, Brian S Thompson, Smart Materials and Structures, Chapman & Hall Publishers, 1st Edition, 1992.
2. Mel Schwartz, Encyclopaedia of smart materials, John Wiley and Sons, 1st Edition, 2002.
3. Srinivasan A.V., Michael McFarland D., Smart Structures Analysis and Design, Cambridge University Press, 1st Edition, 2010.
4. Culshaw B., Smart structures and Materials, Artech house, 1st Edition, 2004.
5. Leo, D.J. Engineering Analysis of Smart Material Systems, John Wiley & sons, 1st Edition 2008.
6. R.C. Smith, smart material systems: model development, frontiers in applied mathematics, SIAM, 2005. 20-211

24-219-0510 SUSTAINABLE ENGINEERING

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 64

Course Outcomes:

After completion of the course, students will be able to demonstrate the ability to:

CO1:	Understand the relevance and the concept of sustainability and the global initiatives in this direction
CO2:	Evaluate the various categories of environmental pollutants and detail corresponding sustainable solution methodologies.
CO3:	Evaluate and apply principles of sustainable resource utilization, including energy sources, life cycle analysis, and industrial ecology, to assess and mitigate environmental impacts.
CO4:	Apply sustainable principles to the design and implementation of habitats, buildings, and urban systems, focusing on energy efficiency, green engineering, and sustainable urbanization.

Mapping of course outcomes with Program outcomes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	2	3	-	-	-	-	3
CO2	-	-	-	-	-	3	3	-	-	-	-	3
CO3	-	-	-	-	-	2	3	-	-	-	-	3
CO4	-	-	-	-	-	2	3	-	-	-	-	3

Module I:
Foundations of Sustainability (16 hours, End semester marks 25%)
Sustainability: Introduction, concept, evolution. Social, environmental, economic sustainability. Sustainable development, Technology and Sustainable development nexus. MDGs and SDGs. CDM. Carbon credits (intro). Zero waste concept (intro).

Module II:
Environmental Challenges and Management (16 hours, End semester marks 25%)
Environmental Pollution: Air, Water pollution, effects, sources. Greenhouse effect, Global warming, Climate change, Ozone depletion. Carbon credits, trading, footprint. Zero waste, 3 R concepts. Legal provisions for environmental protection. ISO 14001:2015 framework, benefits.

Module III:
Sustainable Resource Utilization and Analysis (16 hours, End semester marks 25%)
Resources, Conventional and non-conventional energy. Solar energy, Fuel cells, Wind energy, Small hydro, bio-fuels, Ocean energy, Geothermal energy. LCA: Scope, goal. Circular economy. Bio-mimicking. EIA. Industrial ecology, industrial symbiosis.
Module IV:
Sustainable Practices and Habitats (16 hours, End semester marks 25%)
Sustainable habitat concept. Energy efficiency in buildings methods. Green Engineering. Sustainable Urbanisation, cities, transport. Green buildings, materials.

References:

1. Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall.
2.Bradley. A.S; Adebayo,A.O., Maria, P. Engineering applications in sustainable design and development, Cengage learning
3.Environment Impact Assessment Guidelines, Notification of Government of India, 2006
4. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998
5. Ni bin Chang, Systems Analysis for Sustainable Engineering: Theory and Applications, McGraw-Hill Professional.

NPTEL course links that align with the syllabus:

1. **Sustainable Engineering Concepts and Life Cycle Analysis**
   https://archive.nptel.ac.in/courses/105/105/105105157/
2. **Introduction to Environmental Engineering and Science - Fundamental and Sustainability Concepts**
   https://onlinecourses.nptel.ac.in/noc25_ge17/preview

24-219-0511 LINEAR ALGEBRA IN AI AND ML

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 64

Course Outcomes:

After completion of the course, students will be able to

CO1: Perform basic matrix operations, including addition, multiplication, and inversion, and analyze their properties and applications

CO2: Apply methods such as Gaussian elimination and LU decomposition to solve linear systems and interpret the solutions

CO3: Explore the concepts of vector spaces, linear independence, bases, and dimensions, and apply these to understand linear transformations and change of basis

CO4: Compute eigenvalues and eigenvectors, use them to diagonalize matrices, and apply these concepts to solve practical problems in various fields

Mapping of Course Outcomes to Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	-	-	-	-	-	-	-	-	3
CO2	3	2	2	2	-	-	-	-	-	-	-	3
CO3	3	3	2	2	-	-	-	-	-	-	-	3
CO4	3	3	2	2	2	-	-	-	-	-	-	3

Module I (16 hours, End semester marks 25%)
Linear Equations - Gaussian Elimination and Matrices, Ill-Conditioned Systems.
Rectangular Systems and Echelon Forms - Row Echelon Form and Rank, Consistency of Linear Systems, Homogeneous Systems, Non homogeneous Systems.
Matrix Algebra - Addition and Transposition, Linearity, Matrix Multiplication, Properties of Matrix Multiplication, Matrix Inversion, Inverses of Sum sand Sensitivity, Elementary Matrices and Equivalence, The LU Factorization.

Module II (16 hours, End semester marks 25%)
Vector Spaces - Spaces and Subspaces, Four Fundamental Subspaces, Linear Independence, Basis and Dimension, Classical Least Squares, Linear Transformations, Change of Basis and Similarity, Invariant Subspaces.

Module III (16 hours, End semester marks 25%)
Norms, Inner Products, and Orthogonality - Vector Norms, Matrix Norms, Inner-Product Spaces, Orthogonal Vectors, Gram–Schmidt Procedure, Unitary and Orthogonal Matrices, Orthogonal Reduction, Complementary Subspaces, Range-Null Space Decomposition, Orthogonal Decomposition, Singular Value Decomposition, Orthogonal Projection, Importance of Least Squares.
Determinants - Properties of Determinants

Module IV (16 hours, End semester marks 25%)
Eigenvalues and Eigenvectors - Elementary Properties of Eigensystems, Diagonalization by Similarity Transformations, Functions of Diagonalizable Matrices, Systems of Differential Equations, Normal Matrices, Positive Definite Matrices, Nilpotent Matrices and Jordan Structure, Jordan Form.
Perron–Frobenius Theory - Positive Matrices, Non-negative Matrices, Stochastic Matrices and Markov Chains

References:

1. Matrix Analysis and Applied Linear Algebra Carl D. Meyer, SIAM, 2nd Edn., 2023.
2. A Second Course in Linear Algebra, Stephan Ramon Garcia Roger A. Horn, Cambridge University press, 1st Edn. 2017.
3. Analysis and Linear Algebra: The Singular Value Decomposition and Applications, James Bisgard, American Mathematical Society, 1st Edn. 2021.
4. Introduction to Linear Algebra, Gilbert Strang, Wellesley-Cambridge, Press, U.S., 6th Edn., 2023.

NPTEL course links that align with the syllabus:
1. Advanced Matrix theory and Linear algebra for Engineers
https://nptel.ac.in/courses/111108066

24-219-0512 OPERATIONS RESEARCH

L	T	P	C
3	1	0	3

Total hours: 64

Course Outcomes:
After completion of the course, students will be able to
CO1: Understanding the concepts of Linear programming problems.
CO2: Evaluation of simplex method and its application.
CO3: Formulation of dual simplex and assignment problems.
CO4: Application of transportation problems and replacement theory.

Mapping of course outcomes with Program outcomes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	-	-	2	-	-	-	-	3	2
CO2	3	3	3	-	-	2	-	-	-	-	3	2
CO3	3	3	2	-	-	2	-	-	-	-	3	2
CO4	3	3	2	-	-	2	-	-	-	-	3	2

Module I (16 hours, End semester marks 25%)
Basics of operations research-features-scope-properties. General methods of deriving the solution-techniques of OR. Linear programming problems-formulation of LPP-General linear programming problems-solution of LPP-Graphical method of LPP.

Module II (16 hours, End semester marks 25%)
Simplex method-Slack and surplus variable. Canonical and standard Forms of LPP-Initial basic feasible solution. Inconsistency and redundancy, Simplex algorithm, computation, exceptional cases. Artificial variables techniques-two phase simplex method- The Big-M method. LPP with unrestricted variables. problem of degeneracy. Application of simplex method.

Module III (16 hours, End semester marks 25%)
Dual problems -concept, definition, primal problem and its duality. Standard form, properties. Duality and simplex method Assignment problems-Formulation, solving, computational procedure, maximization AP, Unbalanced AP.

Module IV (16 hours, End semester marks 25%)
Transportation problem-transportation table, loop. Initial basic feasible solution, Determining the Net evaluation, selecting the incoming and outgoing variable ,degeneracy in TP. Unbalanced TP. Maximization in TP. Replacement theory **.**

References:

1. B.S.Grewal, Higher Engineering Mathematic ,Khanna publishers, 42Edition.
2. Operations Research: Principles and Applications by G. Srinivasan, PHI Learning Private Limited.

NPTEL course links that align with the syllabus:

1. **Introduction to operation research**
   https://nptel.ac.in/courses/110106062

2. **Operations research**
   https://onlinecourses.nptel.ac.in/noc22_ma48/preview

3. **Fundamentals of operations research**
   https://archive.nptel.ac.in/courses/112/106/112106134/

24-219-0608 SOFT COMPUTING AND INTELLIGENT SYSTEMS

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 64

Course Outcomes:
After completion of the course, students will be able to
CO1: Identify and describe soft computing techniques and their roles in building intelligent Machines.
CO2: Apply fuzzy logic and reasoning to handle uncertainty and solve engineering problems
CO3: Apply neural networks to pattern classification and regression problems.
CO4: Apply genetic algorithms to combinatorial optimization problems

Mapping of Course Outcomes to Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1:	3	2	2	-	3	-	-	-	-	-	-	2
CO2:	3	3	3	2	3	-	-	-	-	-	-	2
CO3:	3	3	3	2	3	-	-	-	-	-	-	2
CO4:	3	3	3	3	3	-	-	-	-	-	-	2

Module I (16 hours, End semester marks 25%)
Soft computing: Introduction, soft computing vs hard computing, Fuzzy Computing, Neural Computing, Genetic Algorithms. applications of soft computing. Introduction to Neural Networks - Applications –Biological neuron- Typical architecture of Artificial Neural Networks - Common activation function. McCulloh Pitts Neuron – Architecture, logic implementations. Supervised and Unsupervised learning. Feed Forward Neural Networks and Feed Back Neural Networks, Boltzmann Machine. Competitive Learning Neural Networks. Linear Separability, Pattern Classification: Perceptrons-

Module II (16 hours, End semester marks 25%)
Multilayer networks - Back propagation algorithm, Back propagation network and its architecture. Associative learning, Associative memory, Hopfield memory, BAM, Simulated annealing Introduction to fuzzy sets and systems-crispness, vagueness, uncertainty and fuzziness. Basics of fuzzy sets, membership functions, Operation on fuzzy set. Fuzzy Relations – cardinality of fuzzy relations- operations on fuzzy relations – properties – fuzzy composition.

Module III (16 hours, End semester marks 25%)
Fuzzy Rule base and Approximate reasoning: Fuzzy rule-based system. Fuzzy Inference Systems. Fuzzification - Defuzzification using centroid, Centre of sums and mean of maxima methods. Fuzzy Logic Control Systems – Applications of FLC Systems - Hybrid Systems

Module IV (16 hours, End semester marks 25%)
Genetic algorithms – Genetic Algorithm Basic concepts, Initialization and selection, Survival of the Fittest - Fitness Computations. Operators - working. Swarm Intelligent Systems: Ant Colony Systems (ACO): Biological concept, artificial systems – Applications. Particle Swarm Intelligent Systems – the Basic PSO method, Engineering Applications of PSIS.

References

1. D.E. Goldberg, "Genetic Algorithms: Search, Optimization and Machine Learning", Addison Wesley,N.Y, 1989.
2. Laurene V. Fausett, (1993) “Fundamentals of Neural Networks: Architecture, Algorithms and Applications", Prentice Hall.
3. Timothy J. Ross, “Fuzzy Logic with Engineering Applications” Wiley India.
4. Ibrahim A. M., Introduction to Applied Fuzzy Electronics, PHI, 2013.
5. J. Yen and R. Langari, Fuzzy Logic, Intelligence, Control and Information, Pearson Education.
6. S. Rajsekaran & G.A. Vijayalakshmi Pai, “Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis and Applications” Prentice Hall of India.
7. S.N. Sivanandan and S.N. Deepa, Principles of Soft Computing, Wiley India, 2007. ISBN: 10: 81-265-1075-7.
8. Artificial Intelligence and Intelligent Systems, N.P Padhy, Oxford University Press, 2005.
9. Neural Networks –A Comprehensive Foundation, Simon Haykins, PHI

24-219-0609: MACHINE LEARNING

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 64

Course Outcomes:

After completion of the course, students will be able to

CO1: Explain the fundamentals of machine learning, including supervised learning, Bayesian decision theory, and model selection techniques.

CO2: Compare and apply various dimensionality reduction techniques and unsupervised learning methods, including clustering and mixture models.

CO3: Understand nonparametric methods, decision trees, and kernel-based approaches for classification and regression tasks.

CO4: Analyse advanced machine learning techniques, including graphical models, reinforcement learning, ensemble methods and neural networks.

Mapping of course outcomes with Program outcomes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	-	-	-	-	-	-	1
CO2	3	3	3	2	2	-	-	-	-	-	-	1
CO3	3	3	3	3	3	-	-	-	-	-	-	1

CO4	3	3	2	3	3	-	-	-	-	-	-	1

Module I (16 hours, End semester marks 25%)
Introduction to machine learning: importance, machine learning life cycle, comparison with traditional programming, Identification of Problems, Data sets, Types of Learning, Applications. Supervised Learning: Learning a class, Hypothesis and concept of shattering, Vapnik-Chervonenkis(VC) Dimension, Probably Approximately Correct(PAC) Learning, Learning multiple Classes, Regression, Model Selection and Generalization. Bayesian Decision Theory: Parametric Methods: Maximum Likelihood Estimation, Bias and Variance, The Bayes Estimator.

Module II (16 hours, End semester marks 25%)
Dimensionality reduction: Measures of error, Subset Selection, Principal Components Analysis, Factor Analysis, Multidimensional Scaling, Linear Discriminant Analysis. Unsupervised Learning: Clustering, Mixture Densities, k-Means Clustering, Expectation-Maximization Algorithm, Mixtures of Latent Variable Models, Supervised Learning after Clustering, Hierarchical Clustering, Choosing the Number of Clusters.

Module III (16 hours, End semester marks 25%)
Nonparametric Methods: Nonparametric Density Estimation, Generalization to Multivariate Data, Nonparametric Classification, K Nearest Neighbor, Condensed Nearest Neighbor, Nonparametric regression. Decision Trees: Univariate Trees, Pruning, Rule Extraction from Trees, Learning Rules from Data, Multivariate Trees. Kernel Machines: SVM, Optimal Separating Hyperplane. Soft Margin Hyperplane, -SVM, Kernel Trick, Vectorial Kernels, Defining Kernels.

Module IV (16 hours, End semester marks 25%)
Graphical models: Discrete Markov Processes and Hidden Markov models. Reinforcement Learning: model based and temporal difference learning. Combining multiple Learners: Ensembles, model combination schemes, Voting. Bagging, Boosting. Neural Networks: Perceptrons, Training, Learning boolean functions, Back Propagation, Multilayer Perceptrons. Deep Neural Networks. Competitive learning, Radial Basis Function. Design and Analysis of Machine Learning Experiments, Structural risk minimization.

References:

1. Ethem Alpaydin, Introduction to Machine Leaming, MIT Press, Fourth edition,2020.
2. C. M. Bishop, Pattern recognition and Machine Learning, Springer 2009.
3. M. Mitchell. Machine Learning. Publisher, McGraw Hill, Edition 2017.
4. P. Harrington. Machine learning in action, Manning Publications Co,2012.
5. Stephen Marsland, Machine Learning: An Algorithmic Perspective, CRC Press, Second Edition, 2014.

NPTEL course links that align with the syllabus:

1. **Introduction to Machine Learning, IIT Madras**
   https://nptel.ac.in/courses/106106139

2. **Machine Learning ML, KTH Royal Institute of Technology, Sweden**
   https://nptel.ac.in/courses/106106202

Experimental learning modules:

1. https://developers.google.com/machine-learning/managing-ml-projects/experiments
2. https://www.tensorflow.org/resources/learn-ml

24-219-0610 DISASTER MANAGEMENT

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 64

Course Outcomes:

After completion of the course, students will be able to demonstrate the ability to:

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

CO1: Explain the earth systems and fundamental concepts of disaster risk reduction and management.

CO2: Analyze hazard and vulnerability types and apply disaster risk assessment procedures.

CO3: Evaluate disaster risk management elements, risk reduction measures, and disaster response strategies.

CO4: Describe disaster management frameworks, policies, and practices at the national and international levels.

Mapping of course outcomes with Program outcomes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	2	-	-	-	-	-	3
CO2	2	3	-	2	-	-	-	-	-	-	-	3
CO3	2	-	2	-	-	3	3	-	-	-	-	3
CO4	-	-	-	-	-	3	-	3	-	-	-	3

Module I (16 hours, End semester marks 25%)

Systems of earth- Lithosphere, Atmosphere, hydrosphere, biosphere; Definition and meaning of key terms in Disaster Risk Reduction and Management- disaster, hazard, exposure, vulnerability, risk, risk assessment, risk mapping, capacity, resilience, disaster risk reduction, disaster risk management, early warning systems, disaster preparedness, disaster prevention, disaster mitigation, disaster response, damage assessment, crisis counseling, needs assessment.

Module II (16 hours, End semester marks 25%)
Hazard types and hazard mapping; Vulnerability types and their assessment- physical, social, economic and environmental vulnerability. Disaster risk assessment-approaches, procedures

Module III (16 hours, End semester marks 25%)
Disaster risk management -Core elements and phases of Disaster Risk Management. Measures for Disaster Risk Reduction - prevention, mitigation, and preparedness. Disaster response- objectives, requirements; response planning; types of responses. Relief; international relief organizations. Participatory stakeholder engagement; Disaster communication- importance, methods, barriers; Crisis counseling Capacity Building: Concept - Structural and Non-structural Measures, Capacity Assessment; Strengthening Capacity for Reducing Risk

Module IV (16 hours, End semester marks 25%)
Common disaster types in India; Legislations in India on disaster management; National disaster management policy; Institutional arrangements for disaster management in India. The Sendai Framework for Disaster Risk Reduction- targets, priorities for action, guiding principles

References:
1. R. Subramanian, Disaster Management, Vikas Publishing House
2. M. M. Sulphey, Disaster Management, PHI Learning
3. UNDP, Disaster Risk Management Training Manual
4. United Nations Office for Disaster Risk Reduction, Sendai Framework for Disaster Risk Reduction 2015-2030, 2015

NPTEL course links that align with the syllabus:

1. **Sustainable Engineering Concepts and Life Cycle Analysis**
   https://archive.nptel.ac.in/courses/105/105/105105157/

2. **Introduction to Environmental Engineering and Science - Fundamental and Sustainability Concepts**
   https://onlinecourses.nptel.ac.in/noc25_ge17/preview

24-219-0611 SAFETY INSTRUMENTED SYSTEM

Pre-requisites: Nil

L	T	P	C
2	1	0	2

Total hours: 48

Course Outcomes:
After completion of the course, students will be able to demonstrate the ability to:
CO1: Explain the importance of safety in process industries (Understand).
CO2: Explain the relevant standards governing functional safety in process industries (Understand)
CO3: Explain the importance of the lifecycle approach in achieving functional safety (Understand)
CO4: Associate the relation between risk reduction and SIL levels (Understand)
CO5: Understand the importance of product certification for SIL level (Understand)
CO6: Explain the different SIS PLCs used in the process industry (Understand)

Mapping of course outcomes with Program outcomes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	3	-	-	-	-	-
CO2	3	3	-	-	-	-	3	-	-	-	-	-
CO3	3	3	-	2	-	-	3	-	-	-	-	-
CO4	3	3	2	-	-	-	2	-	-	-	-	-
CO5	3	3	-	-	-	-	2	-	-	-	-	-
CO6	3	2	2	-	3	-	-	-	-	-	-	-

Module I (12 hours, End semester marks 25%)

Safety - Industry practises, Key Concepts - International standards and guidelines on Safety Instrumented Systems (SIS) design and follow-up in Oil & Gas industry, Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems - IEC 61508. Instrumented protective function (IPF) – Hazard- Trip-Alarm- SIS standards in Oil & gas industry

Module II (12 hours, End semester marks 25%)
Safety Instrumented Functions (SIF) Vs SIS – Risk assessment- IEC 61508 & IEC 61511, hazard and operability study (HAZOP), Shutdown levels, Safety integrity level (SIL) classification, Probability of Failure on Demand (PFD), Safe Failure Fraction (SFF), Dangerous failure and Safe Failures- Safety integrity level (SIL), Fault Tolerance, Equipment Under Control (EUC) control system & SIS, Safety Life cycle.

Module III (12 hours, End semester marks 25%)
SIS Architecture, SIS Manufacture qualification, Safety and Reliability, System Model, Common Cause Failure (CCF), Diagnostic testing and reporting, Spurious activation, and Factors influencing spurious activation.

Module IV (12 hours, End semester marks 25%)
Logic Solver- Evolution of Logic solver- SIS PLC, Functional safety life cycle approach. The need for Product Certification and Engineer certifications.

References:
1. IEC61508-1, "Functional safety of electrical/electronic/programmable electronic safety related systems - Part 1: General requirements," IEC 1998
2. IEC61511-1, "Functional safety - Safety instrumented systems for the process industry sector, Part 1: Framework, definitions, system, hardware and software requirements," International Electrotechnical Commission (IEC) 2003.
3. D. J. Smith and K. G. L. Simpson, Functional safety - A straightforward guide to applying the IEC 61508 and related standards, Second edition ed: Elsevier, 2005.
4. SINTEF, "Reliability Prediction Methods for Safety Instrumented Systems - PDS Method Handbook, 2006 Edition," SINTEF 2006
5. S. Brown, "Overview of IEC 61508. Design of electrical/electronic/programmable electronic safety-related systems," Computing and Control Engineering Journal, vol. 11, 2000
6. P. Hokstad, "Estimation of Common cause factors from systems with different channels," IEEE Transactions on Reliability, vol. 55, 2006

24-219-0612 CYBER SECURITY FOR INDUSTRIAL AUTOMATION

Pre-requisites: Nil

L	T	P	C
2	1	0	2

Total hours: 48

Course Outcomes:
After completion of the course, students will be able to demonstrate the ability to:
CO1: To introduce IACS architecture and industrial communication protocols.
CO2: Understand the various security threats and vulnerabilities of the cyber world keeping in line with the industrial trends.
CO3: Analyze and assess risks in the industrial environment.
CO4: Design and implement cybersecurity and understand emerging trends.

Mapping of course outcomes with Program outcomes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	-	-	-	-	-	-	-	-	3
CO2	3	3	3	-	-	-	-	-	-	-	-	3
CO3	3	3	2	-	-	-	-	-	-	-	-	3
CO4	3	3	2	-	-	-	-	-	-	-	-	3

Module I (12 hours, End semester marks 25%)
Introduction to Industrial Automation and Protocols
Industrial Automation Fundamental Concepts: Industrial Automation and Control Systems (IACS) Architecture, The Purdue Model, Industrial automation protocol summary, The Open System Interconnection (OSI) Model,, The Transmission Control Protocol (TCP)/Internet Protocol (IP) Model, Object Linking and Embedding for Process Control (OLE for Process Control), Open

Platform Communication (OPC) Unified Architecture, Modbus/TCP Model, The Distributed Network Protocol (DNP), Controller Area Network (CAN), Ethernet/IP, Open Safety Protocol

Module II (12 hours, End semester marks 25%)
Information System Security Technology and IT/Industrial Automation Paradigms
Information System Security Technology: Types and classes of attacks, Policies, Standards, Guidelines, and Procedures, Malicious Code and Attacks, Firewalls, Cryptography, Attacks against cryptosystems.
Industrial Automation Culture versus Information Technology (IT) Paradigms: Considerations in adapting IT security methods to industrial automation, Threats, IT, and industrial automation

Module III (12 hours, End semester marks 25%)
Risk Management and Standards for Industrial Automation
Risk identification, classification and assessment, Addressing risk: Cyber security Management System (CSMS), organizational security, physical and environmental security, network segmentation, access control, risk management and implementation. Cybersecurity Standards: Overview of ISA/IEC-62443 Series standards, 62443-3-2 : Security risk assessment for system design; 62443-3-3 :System security requirements and security levels

Module IV (12 hours, End semester marks 25%)
Cybersecurity Design and Implementation
Cyber security lifecycle- conceptual design process- detailed design process- firewall design remote access design- intrusion detection design. IACS incident response.
Emerging Approaches to Industrial Automation Security
Internet of Things (IoT) and its impact, Open Platform Communications Unified Architecture (OPC UA), Security and privacy concerns, Big Data Analytics and the Industrial Internet of Things (IIoT), The National Institute of Standards and Technology (NIST) Cyber-Physical Systems (CPS) Framework, Critical Infrastructure security and cybersecurity issues, Software-defined elements in industrial automation

References:

1. Ronald L. Krutz, “Industrial Automation and Control System Security Principles: Protecting the Critical Infrastructure”, 2nd Edition, International Society of Automation, 2017.
2. David J. Teumim, “Industrial Network Security, Second Edition”, International Society of Automation, 2010.
3. Lawrence M. Thompson and Tim Shaw, “Industrial Data Communications”, Fifth Edition, International Society of Automation, 2015.
4. Dick Caro, “Automation Network Selection: A Reference Manual”, 3rd Edition, Paperback, International Society of Automation, 2016.
5. The ISA/IEC 62443 series of standards.
6. NIST SP 800-39 Integrated Enterprise Risk Management
7. Edward J.M. Colbert and Alexander Kott, Cyber-security of SCADA and other industrial control systems, Springer, 2016.
8. Eric D. Knapp, “Industrial Network Security : Securing Critical Infrastructure Networks for Smart Grid, SCADA, and Other Industrial Control Systems” Syngress, 3rd Edition - March 26, 2024

NPTEL course links that align with the syllabus:

1. **Cyber security and privacy**
   https://onlinecourses.nptel.ac.in/noc23_cs127/preview

24-219-0613 MEMS AND NEMS

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 64

Course Outcomes:

After completion of the course, students will be able to demonstrate the ability to:

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

CO1: Understand the working principles and applications of micro and nano devices and systems.

CO2: Understand the working of MEMS transducers and Microsystems.

CO3: Understand and design bio-MEMS sensors.

CO4: Distinguish between classical and quantum mechanics.

Mapping of course outcomes with Program outcomes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	-	-	-	-	-	-	-	-	1
CO2	3	1	1	-	-	-	-	-	-	-	-	1
CO3	3	3	2	-	-	-	-	-	-	-	-	1
CO4	3	1	3	-	-	-	-	-	-	-	-	1

Module I (16 hours, End semester marks 25%)

Introduction to MEMS and NEMS: Overview of MEMS, NEMS and applications; Scaling laws; Materials for MEMS and NEMS- Silicon, metals, polymers, ceramics; Micro and nanofabrication techniques- Photolithography, etching, deposition, bonding

Module II (16 hours, End semester marks 25%)

MEMS Transducers and Microsystems: MEMS sensors: mechanical -pressure, inertial, ultrasonic; thermal, optical- MOEMS, radiation, chemical and biological sensors, Design principles; MEMS actuators: electrostatic, thermal, magnetic, SMA based actuators Microfluidics, Optical MEMS, RF MEMS, Power MEMS

Module III (16 hours, End semester marks 25%)

BioMEMS and Nanosystems: BioMEMS: DNA microarrays, lab-on-a-chip, μTAS, Nanopore sensors, Design of bioMEMS Introduction to Nanosystems: Nanoelectronics and nanophotonics devices, Carbon nanotubes, nanowires, Atomic and molecular scale systems, Quantum physics of nanosystems

Module IV (16 hours, End semester marks 25%)

Packaging, Manufacturing and CAD for MEMS/NEMS: Packaging of MEMS: Hermetic and non-hermetic packaging, Wafer bonding, Adhesives, Reliability testing, Manufacturing and Process Integration of MEMS, Testing of MEMS: Optical inspection, Scanning probe microscopy, Functional testing CAD/CAE tools for MEMS/NEMS

References:

1. Sergey Edward Lyshevski, MEMS and NEMS: Systems, Devices and Structures, Nano and Micro Science Engineering, Technology and Medicine Series, CRC Press, 2018
2. Marc J. Madou, Fundamentals of Microfabrication and Nanotechnology, CRC press, 4th Edition (2019), ISBN 9781315274164
3. Mark Hong, Principles and Applications of Micro and Nanoscale Devices CRC press, (2021), ISBN 9781003220602
4. Albert Folch, Introduction to BioMEMS, CRC press, (2nd Edition) 2016, ISBN 978-1439818398
5. Wanjun Wang, Steven A Soper, BioMEMS: Technologies and Applications, CRC Press, ISBN-10: 0-8493-3532-9
6. Reza Ghodssi, Pinyin Lin, MEMS Materials and Processes Handbook, Springer, ISBN 978-0-387-47316-1
7. Jan G. Korvink, Oliver Paul, and Dietmar Petersen, MEMS: A Practical Guide to Design, Analysis, and Applications. (3rd Edition, 2022)

24-219-0709 DIGITAL IMAGE PROCESSING

L	T	P	C
3	1	0	3

Total hours: 64

Course Outcomes:
After completion of the course, students will be able to
CO1: Explain the fundamentals of digital image representation and image enhancement techniques
CO2: Explain the image restoration methods in digital image processing.
CO3: Explain the basic image segmentation methods in digital image processing.
CO4: Explain the commonly used image compression algorithms.

Mapping of course outcomes with Program outcomes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	-	-	1	-	-	-	-	-	3
CO2	3	3	2	-	-	1	-	-	-	-	-	3
CO3	3	3	2	-	-	1	-	-	-	-	-	3
CO4	3	3	2	-	-	1	-	-	-	-	-	3

Module I (16 hours, End semester marks 25%)
Digital Image fundamentals: representation, elements of visual perception, simple image formation model, image sampling and quantization.
Image Enhancement: Spatial Domain Methods - point processing, intensity transformations, histogram processing, image subtraction, image averaging. Spatial filtering - smoothing filters, and sharpening filters. Frequency Domain methods – 2D FFT, low pass filtering, high pass filtering, homomorphic filtering, and generation of spatial masks from frequency domain specifications.

Module II (16 hours, End semester marks 25%)

Image restoration: Degradation model, algebraic approach to restoration, inverse filtering, least means square filters, constrained least squares restoration, interactive restoration. Inverse filtering- removal of blur caused by uniform linear motion, Weiner filtering, Geometric transformations-spatial transformations.

Module III (16 hours, End semester marks 25%)

Image Segmentation: Detection of discontinuities - point, line, edge, and combined detection, edge linking and boundary detection, local and global processing using Hough transform, thresholding, region-oriented segmentation – basic formulation, region growing by pixel aggregation, region splitting and merging, and use of motion in segmentation.

Module IV (16 hours, End semester marks 25%)

Image Compression: Redundancies and their removal methods, fidelity criteria, image compression models, Huffman and arithmetic coding, run length coding, error-free compression, lossy compression, transform-based compression, lossy and lossless predictive coding, JPEG, MPEG.

References:

1. Gonzalez and Woods, Digital Image Processing, Pearson Education, 4th Edition, 2018.
2. S Jayaraman, S Esakkirajan, T Veerakumar, Digital Image Processing, McGraw Hill, 2nd Edition, 2020.
3. Fundamentals of Digital Image Processing by Anil K Jain, Pearson Education, 2015.
4. Kenneth R Castleman, Digital image processing, Pearson Education, 2nd Edition, 2003
5. Digital Image Processing by William K Pratt, 4th Edition, Wiley, 2007.

NPTEL course links that align with the syllabus:

1. **Digital Image Processing, IIT Kharagpur**
   https://nptel.ac.in/courses/106/105/10610503

2. **Digital Image Processing, IIT Kharagpur**
   https://onlinecourses.nptel.ac.in/noc22_ee116

24-219-0710 INTERNET OF THINGS AND APPLICATION

L	T	P	C
2	1	0	2

Total hours: 48

Course Outcomes:

After completion of the course, students will be able to

On completion of this course the student will be able to:

CO1: Familiarize IoT and its components

CO2: Learn data and knowledge management and use of devices in IoT technology

CO3: Distinguish different communication models and protocols

CO4: Design IoT applications for different domains

CO5: Implement basic IoT applications

Mapping of course outcomes with Program outcomes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	2	-	-	-	-	-	-	1
CO2	3	3	-	-	3	-	-	-	-	-	-	1
CO3	3	3	2	-	3	-	-	-	-	-	-	1
CO4	3	3	3	3	3	2	2	-	2	-	-	1
CO5	3	3	3	3	3	-	-	-	3	-	-	1

Module I (12 hours, End semester marks 25%)

Introduction to IoT- History and evolution- Architecture of an IoT ecosystem-Components for designing IoT application. Building the Internet of Things: Device Proliferation and connection, Making things work together, IoT for building Intelligent Applications. Understanding of -Smart devices, Network connections, IP addresses, RF technology, Data, Intelligent applications, Big data.

Module II (12 hours, End semester marks 25%)

IoT Communication Models and Protocols -Request-Response, Publish-Subscribe, Push-Pull,Exclusive Pair. Application Protocols: HTTP, CoAP, MQTT, AMQP. Communication APIs: REST- based, Web Socket-based. Network Layer-IPv4, IPv6, 6LoWPAN.

Module III (12 hours, End semester marks 25%)

Overview of Raspberry Pi 3-Important features of Raspberry Pi 3-Setting up Raspberry Pi-Setting of headless Raspberry Pi. Overview of Linux OS, CLI. Setting up Raspbian as an IoT gateway, Interfacing with sensors and actuators using GPIO pins, Interfacing with camera on Rpi.

Module IV (12 hours, End semester marks 25%)

Building python-based programs to communicate to cloud server using various application Protocols. Develop a complete python based IoT application, Python program to interface with Arduino using serial libraries, Rpi as a device.

References:

1. Michael Miller,The Internet of Things: How Smart TVs, Smart Cars, Smart Homes, and Smart Cities are Changing the World,First Edition.
2. Maneesh Rao, Internet of Things with Raspberry Pi 3: Leverage the power of Raspberry Pi 3 and JavaScript to build exciting IoT projects, First Edition. ISBN 978-1-78862-740-5.
3. Tim Dox, Dr.Steven Lawrence Fernandes, Barberry pi 3 cookbook for python programmers, Third Edition.

24-219-0711 DEEP LEARNING

L	T	P	C
3	1	0	3

Total hours: 64

Course Outcomes:
After completion of the course, students will be able to
CO1: Illustrate the basic concepts of neural networks.
CO2: Train CNN models and Solve real world problems.
CO3: Create solutions for real world problems using Sequence models
CO4: Understand the concepts of GAN.

Mapping of course outcomes with Program outcomes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	-	3	-	-	-	-	-	-	3
CO2	3	3	3	2	3	-	-	-	-	-	-	3
CO3	3	3	3	2	3	-	-	-	-	-	-	3
CO4	3	3	3	2	3	-	-	-	-	-	-	3

Module I (16 hours, End semester marks 25%)
Introduction to ANN and CNN Overview of biological neuron, concept of Perceptrons, Multi-Layer Perceptrons (MLPs) Activation functions-Sigmoid, Relu and Softmax. Loss functions-Mean Error, Cross Entropy Convolutional Neural Networks - Convolution operation. CNN Architecture - convolutional layers, kernels, padding, pooling layers, fully connected layers.

Module II (16 hours, End semester marks 25%)
Training CNNs - Back-propagation and initialization Optimization algorithms - SGD, Adam Hyper parameter optimization-Learning rate Regularization methods - L1,L2 regularization, dropout, Data Augmentation, Early stopping, batch normalization Introduction to Transfer learning.

Module III (16 hours, End semester marks 25%)

Sequence Models Recurrent Neural Networks (RNN) - cell structure and architecture. Training RNN - back propagation through time, vanishing and exploding gradients. Architecture of Long Short-Term Memory (LSTM). Architecture of Gated Recurrent Units (GRU)

Module IV (16 hours, End semester marks 25%)
(Detailed mathematical treatment not required for this module)
Introduction to Generative Models GANs - adversarial training. Discriminator, Generator. Introduction to Transformer models – architecture, word embedding, position encoding, attention, basics of training transformer models. Basics of Large language model – GPT

References:

1. Learning Deep Learning, Magnus Ekman,Addison -Wesley,2022.
2. Hands – on Machine learning with Sc-kit Learn Keras and Tensorflow, Aurelien GeronOreilly, 2nd Edition 2019.
3. Dive Deep into Machine Learning, Astan Zhang and Zachary and Alexander Semola,Cambridge University Press, 2019.
4. Deep Learning, Ian Goodfellow, Yoshua Bengio and Aaron Courville, MIT Press, 2016.
5. Neural Networks and Deep Learning: A Textbook., Charu C. Aggarwal, Springer, 2019.
6. Generative Deep Learning, David Foster, OReilly, 2022.

NPTEL course links that align with the syllabus

1. **Deep Learning**
   https://www.cse.iitm.ac.in/~miteshk/CS6910.html

2. **Convolutional neural networks for visual recognition**
   https://cs231n.github.io/

3. **A Beginner's Guide to LSTMs and Recurrent Neural Networks**
   https://wiki.pathmind.com/lstm

4. **The Illustrated Transformer**
   https://jalammar.github.io/illustrated-transformer/

24-219-0712 ASIC DESIGN

L	T	P	C
3	1	0	3

Total hours: 64

Course Outcomes:
After completion of the course, students will be able to
CO1: Understand basics of ASIC design flow and libraries.
CO2: Design combinational and sequential ASIC circuits using HDL.
CO3: Analyze tradeoffs in using full-custom versus programmable ASIC design styles.
CO4: Evaluate floor planning, placement and routing algorithm and assess recent trends in ASIC technologies, tools and design methodologies.

Mapping of course outcomes with Program outcomes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	1	1	-	-	-	-	-	-	1
CO2	3	3	3	1	3	-	-	-	-	-	-	1
CO3	3	2	3	1	1	-	-	-	-	-	-	1
CO4	3	3	3	1	1	-	-	-	-	-	-	1

Module I (16 hours, End semester marks 25%)
Introduction to ASICs, Full custom, Semi-custom and Programmable ASICs, ASIC Design flow, ASIC cell libraries. CMOS Logic: Data path Logic Cells: Data Path Elements, Adders: Carry skip, Carry bypass, Carry save, Carry select, Conditional sum, Multiplier (Booth encoding), Data path Operators, I/O cells.

Module II (16 hours, End semester marks 25%) Programmable ASICs, Anti-fuse, Static RAM, EPROM and technology, Programmable ASIC logic cell: Altera flex1 I/O cells: DC output, AC output, Clock input, Interconnects: Actel ACT & amp; Xilinx LCA, Low level design entry: Hierarchical design entry.

Module III (16 hours, End semester marks 25%)
Simulation, Synthesis and Testing Basics of HDL, simulation, types of simulation, Synthesis of combinational circuit, FSM synthesis, Memory synthesis, static timing analysis, Fault simulation and ATPG algorithm.

Module IV (16 hours, End semester marks 25%)
Floor planning, Placement and Routing, Floor planning: Goals and objectives, Floor planning tools, Channel definition, I/O and Power planning and Clock planning. Placement: Goals and Objectives, Min-cut Placement algorithm, Iterative Placement Improvement, Physical Design Flow. Routing: Global Routing: Goals and objectives, Global Routing Methods, Back- annotation. Detailed Routing: Goals and objectives, Measurement of Channel Density, Left- Edge and Area-Routing Algorithms. Special Routing, Circuit extraction and DRC.

References:

1. Michael John Sebastian Smith, "Application - Specific Integrated Circuits" Addison- Wesley Professional, 2005.
2. Neil H.E. Weste, David Harris, and Ayan Banerjee, "CMOS VLSI Design: A Circuits and Systems Perspective", Addison Wesley/ Pearson education, 3/e, (2011).
3. Design manuals of Altera, Xilinx and Actel.
4. Vikram Arkalgud Chandrasetty, "VLSI Design: A Practical Guide for FPGA and ASIC Implementations",Springer, (2011), ISBN: 978-1-4614-1119-2.
5. Rakesh Chadha, Bhasker J., "An ASIC Low Power Primer", Springer, (2015) ISBN: 978-1489991508

24-219-0713 ELECTRIC VEHICLE ENGINEERING

L	T	P	C
3	1	0	3

Total hours: 64

Course Outcomes:

After completion of the course, students will be able to

CO1: Familiarise the performance of conventional vehicles and electric vehicles.

CO2: Analyse the various drive train topologies for electric vehicles and discuss the propulsion unit for electric vehicles and selection of drive systems.

CO3: Analyse the various energy storage systems and energy management strategies.

CO4: Illustrate the different renewable energy sources.

Mapping of course outcomes with Program outcomes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	2	-	-	-	-	-	-	-	-	3
CO2	3	-	2	-	-	-	-	-	-	-	-	3
CO3	3	-	2	-	2	-	-	-	-	-	-	3
CO4	3	-	2	-	2	-	-	-	-	-	-	3

Module I (16 hours, End semester marks 25%)

Conventional Vehicles - Basics of vehicle performance, Vehicle power source characterization, Transmission characteristics. Introduction to Electric Vehicles - History of electric vehicles, Classification of electric vehicles. Overview of EV challenges. Overview of EV technologies-motor drive technology, energy source technology, battery charging technology, vehicle-to-grid technology. Vehicle Dynamics & Load Forces - Mathematical models to describe vehicle performance, vehicle load forces: aerodynamic drag, rolling resistance, grading resistance, vehicle acceleration, Calculation of motor power from traction torque, Simple Numerical problems

Module II (16 hours, End semester marks 25%)

Electric Drive-trains - Basic concept of electric traction, electric drive-train topologies (Basics only), Power flow control in electric drive-train topologies, Fuel efficiency analysis.(Derivations not required). DC Drives - Motoring using a PM DC Machine - DC motor electric drive using DC-DC converter - Generating/Braking using a PM DC Machine. PMSM Drives - Review of PMSM motor basics – Independent control of orthogonal flux and torque(concept only)- Field Oriented Control (FOC) – Sensor based and sensorless control (block diagram only).

Module III (16 hours, End semester marks 25%)
Sizing the drive system - Matching the electric machine and the Internal Combustion Engine (ICE), Sizing the propulsion motor, Sizing the power electronics-Switch technology selection, Ripple capacitor design, Switching frequency and PWM. Battery based energy storage systems - Types of battery-battery parameters-units of battery energy storage - capacity rate, - cell voltage - specific energy - cycle life - self-discharge. Battery management system. Other storage topologies - Fuel Cell based energy storage systems- Supercapacitors - Hybridization of different energy storage devices.

Module IV (16 hours, End semester marks 25%)
Overview of Electric Vehicle Battery Chargers –Types of chargers-On- board chargers, Off- board chargers, Wireless charger (Concept only). Electric Vehicle Supply Equipment (EVSE) - Grid to EVSE to On-board chargers to battery pack power flow block schematic diagrams – V2G concept.
Introduction to AC and DC charging stations (Basics and Block diagram only). Types of Connectors -CHAdeMO, CCS Type1 and 2, GB/T.

Reference:

1. Electric Vehicle Technology Explained, James Larminie and John Lowry, Wiley 2nd Edition, 2012.
2. Electric and Hybrid Vehicles: Design Fundamentals, Iqbal Husain, CRC Press, 2nd Edition, 2010.
3. Renewable Energy Sources and Emerging Technologies, D. P. Kothari, K. C. Singal and Rakesh Ranjan, PHI, 3rd Edition, 2021.
4. Elementary Concepts of Power Electronic Drives, K Sundareswaran, CRC Press, 1st Edition, 2019.
5. Sensored Field Oriented Control of 3-Phase Permanent Magnet Synchronous Motors (Application Notes), Ramesh T Ramamoorthy, Brett Larimore, Manish Bhardwaj, TI.

NPTEL course links that align with the syllabus

1. **Deep Learning**

   https://www.cse.iitm.ac.in/~miteshk/CS6910.html

2. **Convolutional neural networks for visual recognition**

   https://cs231n.github.io/

3. **A Beginner's Guide to LSTMs and Recurrent Neural Networks**

   https://wiki.pathmind.com/lstm

4. **The Illustrated Transformer**

https://jalammar.github.io/illustrated-transformer/

24-219-0714 WAVELETS AND MULTI RATE ANALYSIS

L	T	P	C
3	1	0	3

Total hours: 64

Course Outcomes:
After completion of the course, students will be able to
CO1: Understand the concepts and interconnection of multirate systems to identify the efficient realization of filter banks using polyphase decomposition and multirate identities.
CO2: Explain the principles of Short Time Fourier Transform and Wavelet Transform, taking into consideration the time frequency analysis of signals.
CO3: Illustrate filter bank implementation of wavelet transform to be used in multi resolution analysis for signal processing applications
CO4: Examine the use of wavelet transforms for applications involving image and audio processing.

Mapping of course outcomes with Program outcomes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	2	2	-	-	-	-	-	3
CO2	3	3	3	2	2	2	-	-	-	-	-	3
CO3	3	3	3	2	2	2	-	-	-	-	-	3
CO4	3	3	3	2	2	2	-	-	-	-	-	3

Module I (16 hours, End semester marks 25%)
Multirate Systems and Filter banks
Introduction to multirate signal processing and its applications. Multirate system fundamentals - Basic multi-rate operations - up sampling and down sampling, Time domain and Frequency domain analysis, Need for anti-aliasing and anti-imaging filters. Noble identities. Fractional sampling rate alteration. Type 1 and Type 2 Polyphase decomposition, Efficient structures for decimation and

interpolation filters. Introduction to Digital Filter Banks, Efficient implementation, Two Channel Quadrature Mirror Filter bank (QMF), Perfect Reconstruction.

Module II (16 hours, End semester marks 25%)

Time - Frequency analysis of signals and Wavelet Transform Time - frequency analysis of signals - Spectral analysis of signals, Spectral leakage by windowing effect, Time and frequency localization of signals, the Uncertainty Principle and its implications. Short Time Fourier transform – Continuous time and discrete time STFT, Filter bank implementation of STFT. Continuous wavelet transforms – Concept of wavelets, CWT for signal analysis, Condition of admissibility and its implications, Inverse Continuous Wavelet Transform, Properties of CWT.

Module III (16 hours, End semester marks 25%)

Discrete Wavelet Transform and filter bank implementation, Discrete Wavelet Transform – Concept of DWT, Time frequency tiling of DWT and comparison to STFT. Haar Scaling and Wavelet functions, Function Spaces, Refinement relation, Wavelet decomposition of signals. Designing orthogonal wavelet systems- Relation of DWT to filter banks for signal decomposition and reconstruction Multi resolution Analysis (MRA) - Concept of MRA and relating it to filter banks. Computation of DWT using Mallat Algorithm and Lifting Scheme.

Module IV (16 hours, End semester marks 25%)

Wavelet Transform applications in image processing – Wavelet Transform of images, Wavelet Transform based Image compression, EZW Coding. Applications of Wavelet Transform in image denoising, edge detection and object detection. Wavelet Transform applications in audio processing - Application of wavelets in audio compression, Wavelet based audio coding.

Reference

1. Multirate Systems and Filter Banks, P. Vaidyanathan, Pearson Education, 1/e 2006.
2. Insight Into Wavelets: From Theory to Practice K.P. Soman, K.I. Ramachandran, N.G. Resmi, Prentice Hall, 3/e 2010.
3. Digital Signal Processing: A Computer Based Approach, Sanjith K Mitra, Tata-McGraw Hill, 4/e 2013.
4. Digital Signal Processing. Principles, Algorithms and Applications, John G. Proakis, Dimitris G. Manolakis, Pearson Education, 4/e 2007.
5. Wavelets and Filter banks, Gilbert Strang and Truong Q. Nguyen, Wellesley- Cambridge Press, 2/e 1996.
6. Wavelet Transforms: Introduction to Theory and Applications, Raghuveer M. Rao, Ajit S. Bopardikar, Prentice Hall, 1/e 1998. Wavelets and sub band coding, M. Vetterli & J Kovacevic Prentice Hall 1/e 1995.

24-219-0715 INDUSTRIAL MANAGEMENT

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 64

Course Outcomes:

After completion of the course, students will be able to demonstrate the ability to:

CO1: Explain the fundamental concepts of project management, including project life cycle, scope, time, cost, and risk management.

CO2: Apply advanced project scheduling, resource management, and cost control techniques for effective project execution and closure.

CO3: Demonstrate understanding of production systems, facility layout, inventory control models, and planning techniques in operations management.

CO4: Analyze quality management principles, tools, and standards such as TQM, Six Sigma, and ISO for continuous improvement in engineering processes.

Mapping of course outcomes with Program outcomes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	1	-	-	-	-	-	-	1
CO2	3	3	2	2	2	-	-	-	1	1	-	1
CO3	3	2	2	2	2	1	-	-	1	1	-	1
CO4	3	3	2	3	2	2	2	2	2	2	1	2

Module 1: Introduction to Project Management

Introduction to Project Management, Definition, Objectives, and Scope of Projects, Project Life Cycle: Initiation, Planning, Execution, and Closure, Characteristics of a Successful Project, Project Integration Management, Project Charter, Project Management Plan, Project Stakeholder

Management, Project Scope Management, Defining and Managing Project Scope, Work Breakdown Structure (WBS), Scope Creep and Control, Project Time and Cost Management, Time Estimation and Scheduling, Cost Estimation, Budgeting, and Control, Earned Value Management (EVM), Risk Identification, Assessment, Mitigation, and Response, Quality Assurance and Control in Projects

Module 2: Project Planning, Control, and Advanced Project Management Techniques
Advanced Project Scheduling Techniques, Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), Resource Leveling and Allocation, Project Resource Management, Human Resource Management in Projects, Resource Allocation and Utilization, Conflict Management and Leadership in Projects, Project Cost Control, Cost-Benefit Analysis and Financial Metrics, Budgeting and Financial Control Tools, Cost Tracking and Reporting Systems, Project Closure and Evaluation, Deliverables Acceptance and Handover, Project Evaluation and Lessons Learned, Post-Project Review and Feedback

Module 3: Introduction to Production Management
Definition and Importance of Production and Operations Management (POM), Types of Production Systems: Job Shop, Batch, Assembly Line, Continuous Production, Key Performance Indicators in Production Systems, Product Life Cycle and its Stages, Design for Manufacturing (DFM) and Design for Assembly (DFA), Concurrent Engineering in Product Development, Facility Layout: Fixed-position, Process, Product, and Cellular Layout, Factors Affecting Facility Location Decisions, Layout Planning and Optimization Techniques, Types of Inventory: Raw Materials, Work-in-Progress, Finished Goods, Inventory Control Models: EOQ, JIT, and ABC Analysis, Reorder Point and Safety Stock Calculation, Master Production Scheduling (MPS), Material Requirements Planning (MRP), Capacity Planning and Resource Allocation

Module 4: Principles and Practices of Quality Management in Engineering
Introduction to Quality and Quality Management Systems (QMS): – Definitions, evolution of quality, key concepts (customer focus, continuous improvement) Total Quality Management (TQM): – Principles, tools, and implementation in engineering contexts ISO Standards and Certification: – Focus on ISO 9001, process-based approach, documentation, audits Statistical Quality Control (SQC): – Control charts, process capability, sampling methods Six Sigma and Lean Principles: – DMAIC process, waste elimination, value stream mapping Quality Tools and Techniques: – Fishbone diagrams, Pareto analysis, 5 Whys, FMEA Quality in Design and Manufacturing: – Design for Quality, Quality Function Deployment (QFD), robust design Case Studies and Applications: – Real-world applications in manufacturing, IT, and service sectors

References:

1. Project Management Institute, A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 7th ed., Project Management Institute, 2021.
2. A. K. Gupta and V. S. Ramaswamy, Project Management: Strategic Design and Implementation, 1st ed., Tata McGraw-Hill, 2015.
3. H. Kerzner, Project Management: A Systems Approach to Planning, Scheduling, and Controlling, 12th ed., John Wiley & Sons, 2017.

4. R. K. Wysocki, Effective Project Management: Traditional, Agile, Extreme, 8th ed., Wiley, 2019.
5. J. R. Meredith and S. J. Mantel, Project Management: A Managerial Approach, 10th ed., John Wiley & Sons, 2017.
6. A. K. Jain, Production and Operations Management, 4th ed., Pearson Education, 2015.
7. W. J. Stevenson, *Operations Management*, 13th ed., McGraw-Hill Education, 2018.
8. J. S. Martinich, *Production and Operations Management: An Applied Modern Approach*, 10th ed., John Wiley & Sons, 2007.
9. C. B. Bozarth and R. B. Handfield, *Introduction to Operations and Supply Chain Management*, 5th ed., Pearson, 2021.
10. F. R. Jacobs, W. L. Berry, D. C. Whybark, and T. E. Vollmann, *Manufacturing Planning and Control for Supply Chain Management*, 7th ed., McGraw-Hill Education, 2010.
11. D. H. Besterfield, C. Besterfield-Michna, and G. H. Besterfield, *Total Quality Management*, 4th ed., Pearson Education, 2011.
12. J. P. Womack and D. T. Jones, *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*, 2nd ed., Simon & Schuster, 2003.
13. S. Nahmias, *Production and Operations Analysis*, 7th ed., Waveland Press, 2013.
14. J. Heizer, B. Render, and C. Munson, *Operations Management: Sustainability and Supply Chain Management*, 13th ed., Pearson, 2016.
15. D. C. S. Summers, Quality Management: Creating and Sustaining Organizational Effectiveness, 2nd ed., Pearson Prentice Hall, 2009.
16. D. H. Besterfield, C. Besterfield-Michna, G. H. Besterfield, and M. Besterfield-Sacre, Total Quality Management, 3rd ed., Pearson Education, 2011.
17. D. C. Montgomery, Introduction to Statistical Quality Control, 6th ed., Wiley, 2009.
18. J. M. Juran and J. A. DeFeo, Juran's Quality Handbook: The Complete Guide to Performance Excellence, 6th ed., McGraw-Hill Professional, 2010.
19. L. Suganthi and A. A. Samuel, Total Quality Management, Prentice-Hall of India Pvt. Ltd., 2004.
20. M. J. Franchetti, Lean Six Sigma for Engineers and Managers: With Applied Case Studies, CRC Press, 2015.

DEPARTMENT OF INSTRUMENTATION

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

2024 Admission onwards(IV-VII Semester)

B.Tech (Honours) in Instrumentation and Control Engineering

Subject Code	Offering Semester	Subject	L H/W	T H/W	P/D H/W	C	Marks		Total Marks	Mode of Learning
							CA	SE		
24-219-0411	**4**	MOOC-H1	0	0	0	3	0	0	100	Online
24-219-0515	**5**	INDUSTRY 4.0	3	1	0	3	50	50	100	Online
24-219-0516	**5**	MOOC-H2	0	0	0	3	0	0	100	Online
24-219-0615	**6**	INSTRUMENTATION SYSTEM DESIGN	3	1	0	3	50	50	100	Class Room
24-219-0616	**6**	MOOC-H3	0	0	0	3	0	0	100	Online
24-219-0716	**7**	LOW POWER VLSI	3	1	0	3	50	50	100	Class Room

SYLLABUS

24-219-0515 INDUSTRY 4.0

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 64

Course Outcomes (COs): At the end of the course, students should be able to

CO1 Illustrate the fundamentals of Industrial IoT and Industry 4.0

CO2 Understand the enabling technologies for Industry 4.0

CO3 Apply machine learning and big data for Industry 4.0

CO4 Explain the cloud computing and security issues.

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	2	3		3							3
CO 2	3	2	3		3							3
CO 3	3	2	3		3							3
CO 4	3	2	3		3							3

Module I
Introduction to Industry 4.0

Overview and evolution of Industry 4.0, Key aspects and components of Industry 4.0.- Industrial IoT (IIoT) – Introduction, IIoT reference architecture, overview of three tier topology of IIoT (edge tier, platform tier and enterprise tier) - Basics of cyber physical systems (CPS), CPS and IIoT, Applications of IIoT- Industrial Internet Systems (IIS) – Fundamentals, elements of IIS (analytics, intelligent machines and connected people).- Applications of Industry 4.0.

Module II
Enabling Technologies in Industry 4.0.

Smart factories – Introduction, characteristics of smart factories, benefits, smart factories versus traditional factories. - Industrial sensing – Smart sensors, enhanced sensors (virtual sensors, self-calibration, self-testing, self-learning), introduction to tool condition monitoring. - Introduction to customized and modular robotic systems (basics only), Additive Manufacturing (AM) - Introduction, The general AM process chain, advantages and limitations of AM. Advantages of 3D printing technology for Industry 4.0

Module III
Big Data and AI in Industry 4.0

Big Data – Introduction, characteristics of big data, big data sources, big data acquisition and storage, necessity of big data analytics (basics only). - Machine learning and artificial intelligence for industry 4.0 (overview only), applications of ML in industries. -Blockchain for Industry 4.0 – Introduction, challenges for blockchain implementation.

Module IV
Recent Trends

Data Security (basics only) – types of cyber security threats, Need for security in IIoT (software security, network security, mobile device security) Introduction to Cloud Computing for Industry 4.0 (Overview and advantages only). - Introduction to Smart supply chain management - Advantages of IIoT in inventory management. -Introduction to Industry 5.0. -Case study (application and benefits of IIoT only) – Manufacturing industry and Automotive industry.

References:

1. Industry 4.0: Concepts, Processes and Systems Ravi Kant and Hema Gurung CRC Press 1st Edition, 2024.
2. Introduction to Industrial Internet of Things and Industry 4.0, Sudip Misra, Chandana Roy, Anadarup Mukherjee, CRC Press, 1st Edition, 2021.
3. Industry 4.0: The Industrial Internet of Things, Alasdair Gilchrist, APress, 1st Edition, 2016.
4. Industrial IoT Application Architecture and Use Cases Suresh, Malarvizhi Nandagopal, Pethuru Raj, E. A. Neeba, Jenn Wei Lin, CRC Press, 1st Edition, 2020.
5. Hands On Industrial Internet of Things, Giacomo Veneri and Antonio Capasso Packt, 1st Edition, 2018.
6. Industrial Internet of Things: Technologies and Research Directions, Anand Sharma, Sunil Kumar Jangir, Manish Kumar, Dilip Kumar Choubey, Tarun Shrivastava, S. Balamurugan, CRC Press, 1st Edition, 2022.
7. 5G-Enabled Industrial IoT Networks, Amitava Ghosh, Rapeepat Ratasuk, Peter Rost, Simone Redana, Artech House, 1st Edition, 2022.
8. IoT Product Design and Development: Best Practices for Industrial, Consumer and Business Applications, Ahmad Fattahi, Wiley, 1st Edition, 2023.
9. Industrial Internet of Things (IIoT): Intelligent Analytics for Predictive Maintenance R. Anandan, S. Gopalakrishnan, Souvik Pal and Noor Zaman Wiley, 1st Edition, 2022.
10. Technology for People: Industry 5.0 = Industry 4.0 + Society 5.0, Mune Moğol Sever, Literaturk Academia, 1st Edition, 2024.

NPTEL course links that align with the syllabus:

1. https://nptel.ac.in/courses/106105195

Experiential learning modules:

Any relevant Experiential learning module from Virtual Lab and courses from NPTEL may be included as and when it is made available by the Ministry of Education.

24-219-0615 INSTRUMENTATION SYSTEM DESIGN

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 64

Course Outcomes (COs): At the end of the course, students should be able to

CO1 Design signal conditioning circuits for temperature sensors, V/I and I/V converters

CO2 Design of transmitters, data logger, PID controller and alarm circuits

CO3 Carry out orifice and control valve sizing for different services

CO4 Design control panels and automation systems with PLCs

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	3									3
CO 2	3	3	3									3
CO 3	3	3	3									3
CO 4	3	3	3		3							3

Module I

Introduction and Standards: Concepts of instrument design, functional requirements and specifications. Standards – Military, Industrial, and Commercial standards. BIS standards, ANSI standards, NEMA standards, DIN standards.

Piping and Instrumentation Diagram: P & I D Symbols, line numbering, line schedule, overview of various stages in P&I D development, P&I D for pumps, compressors process vessels, absorber and evaporator.

Design of signal conditioning circuits: Design of V/I Converter and I/V Converter, Signal conditioning circuit for pH electrodes, Design of Air-purge Level Measurement, Signal conditioning circuit for Thermocouple, RTD and Thermistor, Overview of Cold Junction Compensation and Linearization – software and Hardware approaches.

Module II

Design of Transmitters : Overview of 2 wire and 4 wire transmitters, Design of RTD based Temperature Transmitter, Thermocouple based Temperature Transmitter and Smart Transmitters.

Control Valves : Characteristics, valve equation, types of valves- Globe valve, ball valve, gate valve, butterfly valve, needle valve, valve positioner, valve selection criteria.

Module III

Orifice and Control valve sizing - Orifice, Venturi and flow nozzle sizing - Liquid, Gas and steam services.

Control valve sizing – Liquid, Gas and steam services. Overview of Rotameter Design

Design of Data logger and PID controller: Design of ON/OFF Controller using Linear Integrated Circuits, Electronic PID Controller, Basics of Microcontroller based digital two-degree of freedom PID Controller, Microcontroller based Data Logger, Basic architecture of PC based Data Acquisition Cards.

Module IV

Control Panel Design

Basics of operating console and control room panel design. Control room environment for electronic equipment - heat dissipation, forced air circulation and humidity considerations. Grounding and shielding- protection against electrostatic discharge.

Design of Alarm and Annunciation circuit : Alarm and Annunciation Circuits using Analog and Digital Circuits – Design of Programmable Logic Controller for any two simple applications

Reference:

1. Instrument Engineers Handbook - Process Control and Optimization, Bela G. Liptak, CRC Press, 4th Edition, Vol.2, 2008.
2. Introduction to Process Engineering and Design, Thakore and Bhatt, McGraw Hill, 2nd Edition, 2007.
3. Process Control Instrumentation Technology, C. D. Johnson, Prentice Hall, 8th Edition, 2015.
4. Electronic Instrument Design , Kim Fowler, Oxford, Reprint 2015.
5. Principles of Measurement Systems, Bentley, Pearson Education, 4th Edition, 2015.
6. Flow Measurement Engineering Handbook, R.W. Miller, McGraw Hill, 1996.
7. Measurement Systems Application and Design E.O. Dobelin, McGraw Hill, 4th Edition, 1989.
8. Process/Industrial Instruments and Controls Handbook Gregory K. McMillan, Douglas M. Considine, Mc Graw Hill, 5th Edition, 1999.
9. Hand Book of transducer, Harry N Nortan, PHI, 1st Edition, 1989.
10. A Course in Electronic Measurements and Instrumentation, A K Sawhney, Dhanpath Rai & Co., 2021.
11. Piping and Instrumentation Diagram Development, Moe Toghraei, Wiley, 1st Edition, 2019.

NPTEL course links that align with the syllabus:

1. https://archive.nptel.ac.in/courses/108/105/108105064/
2. https://nptel.ac.in/courses/108105088

Experimental learning modules:

Any relevant Experiential learning module from Virtual Lab and courses from NPTEL may be included as and when it is made available by Ministry of Education.

24-219-0715 LOW POWER VLSI

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 64

Course Outcomes (COs)

At the end of the course, students should be able to:

CO1 Model the capacitive, short circuit and leakage power dissipation in CMOS circuits

CO2 Design lower power CMOS circuits by applying various techniques for power reduction

CO3 Implement logic circuits using clocked and non-clocked design styles

CO4 Implement the logic functions using adiabatic and reversible logic structures

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3									3
CO2	3	3	3									3
CO3	3	3	3		2							3
CO4	3	3	3		2							3

Module I

Sources of power dissipation in CMOS circuits

Dynamic Power Dissipation - Charging and Discharging capacitance power dissipation.
Short Circuit Power dissipation - Short Circuit Current of Inverter, Short circuit current dependency with input and output load, Glitching Power. Static Power Dissipation - Leakage Power Dissipation.
Gate level power analysis - Capacitive, internal, and Static power dissipation of gate level circuit.

Module II

Power Reduction Techniques

Supply voltage Scaling Approaches - Multi VDD and Dynamic VDD Leakage power reduction Techniques - Transistor stacking, VTCMOS, MTCMOS, DTCMOS,
Dynamic power dissipation - Power gating, Clock gating, Transistor and Gate Sizing for Dynamic and Leakage Power Reduction.

Module III

Circuit design styles

Clocked design style - Basic concept, Domino logic (domino NAND gate), Differential Current Switch Logic.
Non-clocked circuit design style - fully complementary logic, NMOS and pseudo–NMOS logic, differential cascade voltage switch logic (DCVS)

Module IV

Adiabatic switching

Adiabatic charging, adiabatic amplification, One stage and two stage adiabatic buffer, Adiabatic logic gates, pulsed power supplies, Reversible logic basic concepts

References:

1. Practical Low-Power Digital VLSI Design, Gray K. Yeap, Springer India, 2008.
2. Low-power CMOS VLSI Circuit Design, Kaushik Roy and Sharat C. Prasad, Wiley, 2009.
3. Low Power Digital CMOS Design, Anantha P. Chandrakasan, Robert W. Brodersen, Kluwer Academic, 2012.
4. Low power CMOS Circuits, Christian Piguet, Taylor and Francis, 2018.
5. Low Voltage, Low Power VLSI Subsystem, Kiat -Seng Yeo, Kaushik, Roy, McGraw Hill Education, 2017.

Video Links (NPTEL, SWAYAM…)

1 https://archive.nptel.ac.in/courses/106/105/106105034/

Experiential learning modules:

Any relevant Experiential learning module from Virtual Lab and courses from NPTEL may be included as and when it is made available by the Ministry of Education.

DEPARTMENT OF INSTRUMENTATION

List of Courses for B.Tech Minor in Robotics, offered at Department of Instrumentation for B.Tech Instrumentation and Control Engineering 2024 Admission Onwards

Subject Code	Offering Semester	Subject	L H/W	T H/W	P/D H/W	C	Marks		Total Marks	Mode of Learning
							CA	SE		
24-219-0309	**3**	INTRODUCTION TO ROBOTICS	3	1	0	3	50	50	100	Class Room
24-219-0409	**4**	MOOC-M1	0	0	0	3	0	0	100	Online
24-219-0410	**4**	MOOC-M2	0	0	0	3	0	0	100	Online
24-219-0513	**5**	INTRODUCTION TO INDUSTRIAL AUTOMATION	3	1	0	3	50	50	100	Class Room
24-219-0514	**5**	MOOC-M3	0	0	0	3	0	0	100	Online
24-219-0614	**6**	MINI PROJECT	0	0	6	3	50	50	100	Class Room

SYLLABUS

24-219-0309 INTRODUCTION TO ROBOTICS

Pre-requisites: Nil

L	T	P	C
3	1	0	3

Total hours: 64

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

- CO1 Explain the subsystems, types, applications and history of robots.
- CO2 Identify and explain the working of various sensors and actuators, and select suitable ones for different robotic systems.
- CO3 Apply kinematic principles and Jacobian matrices to analyze robot motion and static forces in manipulators.
- CO4 Understand robot dynamics, generate collision-free trajectories, and apply robot programming and control techniques.

Mapping of course outcomes with Program outcomes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	-	-	-	-	-	-	-	-	3
CO2	3	3	3	-	-	-	-	-	-	-	-	3
CO3	3	3	2	-	-	-	-	-	-	-	-	3
CO4	3	3	2	-	-	-	-	-	-	-	-	3

Module I:

Introduction to Robotics

Introduction to robotics: brief history, types and applications of robots, present status and future trends in robotics, overview of robot subsystems challenges in robotics, characteristics of robots, Robot Applications- medical, mining, space, defence, security, domestic, entertainment, Industrial Applications-Material handling, welding, Spray painting, Machining; robot configurations and concept of work space, types of actuators and sensors in robotics, types of grippers; wheeled, legged and tracked robots.

Module II:

Sensor classification- touch, force, proximity, vision sensors.

Internal sensors-Position sensors, velocity sensors, acceleration sensors, Force sensors; External sensors-contact type, non contact type; Vision - Elements of vision sensor, image acquisition, image processing; Selection of sensors.

Actuators for robots- classification-Electric, Hydraulic, Pneumatic actuators; their advantages and disadvantages; Electric actuators- Stepper motors, DC motors, DC servo motors and their drivers, AC motors, Linear actuators, selection of motors; Hydraulic actuators- Components and typical circuit, advantages, and disadvantages; Pneumatic Actuators- Components and typical circuit, advantages, and disadvantages.

Module III:

Robot Kinematics and Statics

Introduction to manipulator kinematics: position and orientation of rigid bodies, planar and spatial mechanism description, homogenous transformations, Denavit-Hartenberg (DH) notation, forward and inverse kinematic analysis, examples, case studies of modeling on real robot mechanism; linear and rotational velocity of rigid bodies: velocity propagation from link to link, jacobian, singularities; static forces in manipulators: jacobians in force domain.

Module IV:

Robot Dynamics, Trajectory Planning and Programming

Dynamic modeling: Lagrangian formulation, examples, trajectory generation: general consideration in path description and generation, joint space schemes, collision free path planning; robot control; overview of robot motion planning; robot programming methods.

Text Books

1. Introduction to Robotics by S K Saha, Mc Graw Hill Education, 2014.
2. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, PHI Learning., 2009.
3. R K Mittal and I J Nagrath, "Robotics and Control", Tata McGraw Hill, New Delhi,2003.
4. Introduction to Robotics (Mechanics and control), John. J. Craig, Pearson Education Asia 2002.
5. Robotics Technology and Flexible Automation, Second Edition, S. R. Deb, 2017.

NPTEL course links that align with the syllabus:

1. Introduction to robotics
   https://onlinecourses.nptel.ac.in/noc22_cs54/preview
2. Introduction to robotics
   https://onlinecourses.nptel.ac.in/noc20_de11/preview

24-219-0513 INTRODUCTION TO INDUSTRIAL AUTOMATION

L	T	P	C
3	1	0	3

Total hours: 64

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

CO1 Understand the types and trends in automation and flexible manufacturing systems.

CO2 Identify and describe the sensors and actuators used in automation systems.

CO3 Explain the principles of material handling systems and CNC components

CO4 Apply PLC programming techniques and describe inspection automation methods.

Mapping of course outcomes with Program outcomes.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	-	-	-	-	-	-	-	-	3
CO2	3	3	3	-	-	-	-	-	-	-	-	3
CO3	3	3	2	-	-	-	-	-	-	-	-	3
CO4	3	3	2	-	-	-	-	-	-	-	-	3

Module 1

Automation methodologies: Concept of Mechanization and Automation – Types of Automation Detroit type Automation, Automated flow lines, Fundamentals of Transfer Lines.

Trends in manufacturing – GT and Cellular Manufacturing, Flexible manufacturing systems – features of FMS, computer integrated manufacturing – need for AI and expert systems in CIM, Automated assembly system – flexible assembly automation.

Module 2

Sensors and actuators for automation: Classification of position and motion sensors, inductive type, electromechanical switches, rotary position sensors – resolver, encoders, LVDT, RVDT, photo electric, thermo electric, capacitive, magnetic detectors, impedance type gauging transducers, linear potentiometer, strain gauges. Practical examples on design, selection and implementation of sensor systems, calibration of sensors.

Electrical, Hydraulic and pneumatic actuators and their comparison, Examples - use of Electrical, Hydraulic and pneumatic actuators in industrial automation.

Module 3

Material Handling and Identification Technologies: Overview of Material Handling Systems, Principles and Design Consideration, Material Transport Systems, Storage Systems, Overview of Automatic Identification Methods.

Elements of CNC systems: servomotor and servo system design trends, stepper motors and controls. Drive systems. Accessories, and selection of drives for CNC machines.

Pneumatic/Hydraulic Automation: control valves – direction, pressure and flow. cascade and Karnaugh Veitch map methods

Module 4

Automation Control: Sequence control and programmable controllers – logic control and sequencing elements, ladder diagram, PLC, programming the PLC. Practical Examples on PLC ladder programming.

Inspection automation: Inspection automation, off-line and on-line inspections, computerized coordinate measuring machine – CMM construction. non-contact inspection methods. machine vision systems.

Text Books:

1. Automation, Production Systems and Computer Integrated Manufacturing, Groover M.P, Prentice – Hall Ltd., 2016.

2. Computer Control of Manufacturing Systems‖ YoramKoren, Tata McGraw-Hill Edition 2017.

3. CNC Machines, Radhakrishnan P., New Central Book Agency, 2013.

4. Pneumatic Control for Industrial Automation, Peter Rohner, Gordon Smith, 2005.

5. Mechatronics: A Multidisciplinary Approach, 4/E‖, W. Bolton. Pearson Education India, 2014.

NPTEL course links that align with the syllabus:

1. Industrial Automation and Control
   https://onlinecourses.nptel.ac.in/noc21_me67/preview

24-219-0614 MINI PROJECT

L	T	P	C
0	0	3	3

Preamble

This Minor Mini Project in Robotics aims to introduce students to research and development within the field of Robotics. Conducted in a group of three or four students under faculty supervision, the project encourages students to explore current research or propose innovative ideas, blending theoretical concepts with practical implementation. Focusing on areas such as mechanical design, electronics, control systems, and intelligent decision-making, the project fosters hands-on learning and teamwork. It serves as a foundation for future academic or industrial R&D by developing problem-solving skills and exposing students to real-world robotic applications.

The assignment to normally include:

- Conducting a comprehensive survey and review of published literature relevant to the assigned topic.
- Formulating an action plan for the investigation, outlining the workflow and distribution of tasks within the team.
- Developing a preliminary approach or strategy to address the identified problem.
- Preparing detailed block-level system design documentation to illustrate the proposed solution architecture.
- Performing initial analysis, modelling, simulation, experimental setup, design, or feasibility studies to validate the chosen approach.
- Compiling the findings into a structured written report to be presented before the department for evaluation and feedback.

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

CO1	Analyze real-world problems in the domain and propose effective, innovative solutions (Analyze).
CO2	Develop a structured work plan and coordinate efficiently within a team to meet project deadlines (Apply)
CO3	Validate proposed solutions through theoretical analysis and practical experimentation (Evaluate).

CO4	Document technical findings effectively and enhance written and verbal communication skills (Apply).
CO5	Present project outcomes confidently and defend design choices and methodologies with clarity (Evaluate).

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	-	-	-	-	3	3	-	2
CO2	3	-	-	3	-	-	-	3	3	3	3	-
CO3	3	3	3	3	3	-	-	-	-	3	-	-
CO4	-	-	-	-	3	-	-	3	3	3	-	1
CO5	3	3	3	3	-	-	-	3	-	3	3	1

Assessment Pattern

The End Semester Evaluation (ESE) will be conducted internally and will assess the project based on the developed product, the submitted report, and a viva-voce examination. The evaluation will be carried out by a three-member committee appointed by the Head of the Department. This committee will include the HoD or a senior faculty member, the academic coordinator of the program, and the project guide or coordinator. The assessment will focus on the extent of project completion, demonstration of functionality as per specifications, quality of the presentation, performance in the oral examination, depth of technical understanding, and the level of individual involvement throughout the project.

The Continuous Internal Evaluation (CIE) is carried out through a minimum of two formal project reviews to assess the progress of the mini project. During the first review, students are expected to present a novel concept, system, or design, backed by a comprehensive literature review of existing solutions within their chosen domain. In the second review, the focus shifts to the implementation phase, where students must detail how their proposed solution has been realized. The review committee will evaluate how effectively the implementation aligns with the proposed design. At this stage, a well-developed, fully functional, and integrated product is expected as the outcome. The final CIE score is calculated as the average of the marks awarded in both reviews.

A zeroth review may be conducted prior to the official start of the project, providing students an opportunity to present their area of interest, problem domain, or engage in open brainstorming sessions to explore innovative ideas. This review is intended to guide project direction and encourage creativity but will not be considered in the CIE evaluation.

Marks Distribution

Total Marks	CIE	ESE
100	50	50

Continuous Internal Evaluation Pattern:

Attendance : 5 Marks

Marks awarded by Guide : 10 Marks

Project Report : 10 Marks

Evaluation by the Committee : 25 Marks

End Semester Examination Pattern:

Demonstration : 30 Marks

Project report : 10 Marks

Viva voce : 10 Marks

Course Plan

In this course, each student group comprising three to four members is expected to design and develop a moderately complex software or hardware system with practical applications. The final output should be a functional working model, incorporating the fundamentals of product design. Students must identify a project topic of interest in consultation with the Faculty-in-Charge or Project Advisor. A thorough literature review should be conducted to gather relevant information. Based on this, the group must define clear objectives and develop a suitable methodology to achieve them. The project should involve design, fabrication, coding, or system development, depending on the nature of the work. Throughout the semester, the novelty and innovation of the project must be demonstrated through tangible results. The project's progress will be evaluated through at least two formal reviews, overseen by a review committee appointed by the Head of the Department. At the end of the semester, students are required to submit a comprehensive project report and demonstrate the final product, ensuring it meets all functional and design specifications. Additional credit will be given for projects that incorporate innovative design principles, address reliability, and consider aesthetics and ergonomic aspects.