Bachelor of Technology in Robotics and Artificial Intelligence (2025-2026) onwards
(160 and 180 Credits)
DETAILS SYLLABUS
THIRD SEMESTER

MEEXXXX ENGINEERING ECONOMICS [3 0 0 3]

Concept and Value Analysis, Economic Decision Making, Types of Estimates, Accounting and Control, Elements of Cost, Prime Cost, Overheads, Types of Cost, Process Cost & Cost of Production, Break Even Analysis, Inventory Control & Management, EOQ, Financial Analysis, Simple payback, Return on Investment, NPV (Net Present Value), IRR (Internal rate of Return), Life Cycle Cost Method, Sensitivity Analysis, Project Financing Options. Budget and Budgetary Control, Concept of Budgeting, Type of Budgets. Risk - Risk vs Return, System Concept and Value Analysis, System Analysis & System Engineering, Value Analysis. Replacement Analysis, Depreciation.

References:

1. R. Panneerselvam, *Engineering Economics*, 2nd ed., New Delhi, India: Prentice Hall India, 2013.
2. D. D. Riggs, S. U. Randhawa, and “Riggs, D. D. Bedworth”, *Engineering Economics*, Latest ed., New Delhi, India: McGraw Hill Education.
3. P. L. Mehta, *Managerial Economics*, 21st ed., New Delhi, India: Sultan Chand & Sons, 2016.
4. E. L. Grant, W. G. Ireson, and R. S. Leavenworth, *Principles of Engineering Economic Analysis*, Latest ed., New York, USA: John Wiley & Sons, 1990.
5. G. J. Tuesen, W. J. Fabrycky, and H. G. Tuesen, *Engineering Economy*, 8th ed., New Delhi, India: Prentice Hall India, 1992.

MCE2101 EMBEDDED CONTROLLERS [3 1 0 4]

Comparison between microprocessor and microcontroller, Introduction to embedded controllers, Architecture of microcontroller: Register Banks; Programming model, Pin diagram & details, I/O Ports & details. Assembly Language Programming: Assembler Directives, Addressing Modes, Instruction set, calculation of delay, delay programs. Timers, Counters, Serial Communication, Interrupts, Programming examples. Programming in Embedded C: Data types in embedded C, arithmetic & logic operators, control statements and loops in embedded C, functions & arrays, Hardware Interfacing: Stepper Motor, Seven Segment Display, LCD, Design of Microcontroller based systems: Introduction to other Microcontroller families (PIC, AVR and ARM).

References:

1. M. A. Mazidi, J. G. Mazidi, and R. D. McKinlay, *The 8051 Microcontroller and Embedded Systems Using Assembly and C*, 2nd ed., Upper Saddle River, NJ, USA: Pearson Education, 2010.
2. K. J. Ayala, *The 8051 Microcontroller and Embedded Systems Using Assembly and C*, 2nd ed., Boston, MA, USA: Cengage Learning, 2010.
3. A. V. Deshmukh, *Microcontrollers: Theory and Applications*, New Delhi, India: Tata McGraw-Hill, 2011.
4. K. Uma Rao and A. Pallavi, *8051 and MSP430 Microcontrollers: Architecture, Programming and Applications*, Hoboken, NJ, USA: Wiley, 2019.

RAI2102 BASICS OF AI AND ML [3 1 0 4]

Introduction: Basics of Artificial Intelligence - Definition and history of AI, Basic concepts and goals of AI, Applications and impact of AI in various fields, Problem-Solving and Search Algorithms, Problemsolving methods in AI, Search algorithms: breadth-first search, depth-first search, A* search, other models, Heuristic search techniques. Machine Learning Fundamentals: Introduction to machine Learning—Supervised learning, unsupervised learning, and reinforcement learning; Evaluation metrics in machine learning, Regression and Classification Algorithms: Regression Models: Linear regression, performance Metrics. Ensemble methods; Introduction to Neural Network.

References:

1. E. Alpaydin, *Introduction to Machine Learning*, 4th ed., Cambridge, MA, USA: MIT Press, 2020.
2. S. Marsland, *Machine Learning: An Algorithmic Perspective*, 2nd ed., Boca Raton, FL, USA: Chapman & Hall/CRC, 2015.
3. S. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach*, 4th ed., Upper Saddle River, NJ, USA: Prentice Hall, 2020.
4. E. Rich, K. Knight, and S. B. Nair, *Artificial Intelligence*, 3rd ed., New Delhi, India: Tata McGraw-Hill, 2009.
5. S. Marsland, *Machine Learning: An Algorithmic Perspective*, 2nd ed., Boca Raton, FL, USA: Chapman & Hall/CRC, 2015.

MCE2103 STRENGTH OF MATERIALS [3 0 0 3]

Stress and Strain of Solids, Deformation of simple and compound bars, Hooke's law, Stress-Strain diagrams for materials, Elongation of tapering bars of circular and rectangular cross sections, Saint Venant's principle, Thermal stress, Elastic constants, Strain energy, Analysis Biaxial state of stresses, Stresses on inclined plane, Principal planes and stresses, Mohr's circle of biaxial stresses, Theory of Failure. Shear force and Bending Moment in Cantilever, Simply supported and Overhanging beams, Theory of simple bending, Effect of shape of beam section on stress induced with different load, Expression for transverse shear stress in beams, Bending and shear stress distribution diagrams for circular, rectangular, 'I', and 'T' sections, Torsion: Analysis of torsion of circular bars, Shear stress distribution for Solid and hollow circular section, Stepped shaft, Twist and torsion stiffness, Introduction, short and long columns. Euler's theory; Assumptions, Buckling load for different end conditions, Limitations of Euler's theory. Rankine-Gordon's formula for columns.

References:

1. E. P. Popov, *Engineering Mechanics of Solids*, 2nd ed., New Delhi, India: Prentice-Hall of India, 2015.
2. S. M. A. Kazimi, *Solid Mechanics*, 2nd ed., New Delhi, India: Tata McGraw-Hill, 2017.
3. R. C. Hibbeler, *Mechanics of Materials*, 6th ed. New Delhi, India: Pearson, 2014.
4. F. P. Beer, E. R. Johnston Jr., J. T. Dewolf, and D. F. Mazurek, *Mechanics of Materials*, 6th ed., New Delhi, India: McGraw-Hill Education (India) Pvt. Ltd., 2013.
5. B. C. Punmia, A. K. Jain, and A. K. Jain, *SMTS-I Strength of Materials*, 10th ed., New Delhi, India: Laxmi Publications Pvt. Ltd., 2018.

RAI2104 MANUFACTURING TECHNOLOGY [3 1 0 4]

Metal Casting Process: Classification of metal casting, Pattern Allowances, Molding Materials, Gating system design. Casting defects: Causes and remedies, Inspection of castings. Introduction to Machine Tools: Classification of machine tool, Mechanics of Metal Cutting: Principles of metal machining, cutting tools and tool materials, tool signature, mechanics of chip removal, tool wear, tool life, economics of machining. Metal Joining Processes: Principle of welding, soldering, Brazing and adhesive bonding. Classification of welding and allied processes. Resistance welding: Spot, Projection and Seam welding process, atomic hydrogen, ultrasonic, Plasma and laser beam welding, Electron beam welding, and special welding process e.g. TIG, MIG, friction and explosive welding. Metal Shaping and Forming: Metal working, Elastic and plastic deformation, Hot and cold working, Rolling, Principle and operations, Forging, Forging operations, extrusion, Wire, and tube drawing processes. Forging: Principle of forging tool design,

References:

1. S. Kalpakjian and S. R. Schmid, *Manufacturing Engineering and Technology*, 7th ed., New Delhi, India: Pearson Education, 2013.
2. A. Ghosh and A. K. Malik, *Manufacturing Science*, 2nd ed., New Delhi, India: Affiliated East-West Press Pvt. Ltd., 2010.
3. P. C. Sharma, *A Textbook of Production Technology*, 8th ed., New Delhi, India: S. Chand and Company, 2007.

4. R. K. Jain, *Production Technology: Manufacturing Processes, Technology and Automation*, 17th ed., New Delhi, India: Khanna Publishers, 2011.
5. P. N. Rao, *Manufacturing Technology, Volume 1*, 4th ed., New Delhi, India: Tata McGraw-Hill Education, 2013

RAI2105 ROBOT KINEMATICS AND DYNAMICS [3 1 0 4]

Introduction: Laws of Robotics, Robot Classifications, Links, Joints, Degrees of Freedom (DOF), Coordinate Systems, Work Volume, Precision, Repeatability, Accuracy, Position & Orientation: Roll, Pitch, Yaw, Overview of End Effector Selection and Serial Manipulators, Kinematics: Forward & Inverse Kinematics: Geometrical and Algebraic Approaches, Transformation Matrices: Translation, Rotation, Euler Angles, Homogeneous Transformation, D-H Convention and Solutions for Kinematics Problems, Dynamics: Kinetic and Potential Energy, Lagrangian and Euler-Lagrange Equations, Newton-Euler Formulation, Jacobian Matrix in Dynamics, Inertia Matrix, Equations of Motion for Robots, Inverse Dynamics, Basic of Trajectory Planning.

References:

1. J. J. Craig, *Introduction to Robotics: Mechanics and Control*, 4th ed., Upper Saddle River, NJ, USA: Pearson Education International, 2018.
2. S. B. Niku, *Introduction to Robotics: Analysis, Control, An Indian Adaptation*, 2nd ed., New Delhi, India: Wiley, 2016.
3. S. K. Saha, *Introduction to Robotics*, 1st ed., New Delhi, India: Tata McGraw-Hill Education, 2008.
4. M. W. Spong, S. Hutchinson, and M. Vidyasagar, *Robot Modeling and Control*, 2nd ed., Hoboken, NJ, USA: John Wiley & Sons Inc., 2006.
5. K. M. Lynch and F. C. Park, *Modern Robotics: Mechanics, Planning, and Control*, 1st ed., Singapore: Cambridge University Press, 2017.
6. Ghosal, *Robotics: Fundamental Concepts and Analysis*, 1st ed., New Delhi, India: Oxford University Press, 2014.

RAI2130 EMBEDDED CONTROLLERS LAB [0 0 2 1]

Introduction to Microcontroller, arithmetic instructions, array handling and code conversions, bit manipulations and logic instructions, timer/counter programming, serial communication and interrupts, interfacing ADC, interfacing stepper motor, interfacing DAC, interfacing buzzer, interfacing seven segment display, interfacing LCD, implementing a traffic light controller using.

References:

1. M. Fisher, *ARM® Cortex® M4 Cookbook*, 1st ed., Place of publication: Publisher. 2016
2. A. N. Sloss, D. Symes, and C. Wright, *ARM System Developer's Guide: Designing and Optimizing System Software*, Amsterdam, Netherlands: Elsevier, 2004.
3. M. A. Mazidi, J. G. Mazidi, and R. D. McKinlay, *The 8051 Microcontroller and Embedded Systems Using Assembly and C*, 2nd ed., Upper Saddle River, NJ, USA: Pearson Education, 2010.
4. M. Wolf, *Computers as Components: Principles of Embedded Computing System Design*, 4th ed., Cambridge, MA, USA: Morgan Kaufmann Publishers, 2016.
5. J. Yiu, *The Definitive Guide to ARM Cortex-M3 and Cortex-M4 Processors*, 3rd ed., Amsterdam, Netherlands: Elsevier, 2013.
6. P. Marwedel, *Embedded System Design*, 2nd ed., Berlin, Germany: Springer, 2011.

RAI2131 AI AND ML LAB [0 0 2 1]

Uninformed search, Heuristic search, Machine Learning: basic concepts, Use any programming language for the applications, supervised learning: linear regression, perceptron, naive Bayes, k-nearest neighbor, support vector machine and unsupervised learning, Performance metrics.

References:

1. E. Rich, K. Knight, and S. B. Nair, *Artificial Intelligence*, 4th ed., New Delhi, India: Tata McGraw-Hill, 2024.

2. H. P. Langtangen, *Python Scripting for Computational Science*, 4th ed., Berlin, Germany: Springer Publishers, 2017.
3. N. R. Ceder, *The Quick Python Book*, 3rd ed., Shelter Island, NY, USA: Manning Publications Co., 2015.
4. G. James, D. Witten, T. Hastie, and R. Tibshirani, *An Introduction to Statistical Learning with Applications in R*, 2nd ed., New York, NY, USA: Springer, 2021.

FOURTH SEMESTER

MAS21XX STATISTICS & PROBABILITY [3 0 0 3]

Probability Theory and Random Variables: Probability (Only One Lecture), Random variables, Cumulative distribution functions, Discrete random variables, Continuous random variables, Independent random variables, Probability mass and density functions, Expectation of random variables, Chebyschev's inequality, Central limit theorem. Probability distribution: Binomial, Poisson, Uniform, Normal, Exponential Theory of Estimation: Maximum Likelihood and method moment estimation, Sufficient statistics, Bayesian estimation, Confidence intervals for means. Tests of Statistical Hypothesis: Introduction, Parameter and Statistic, Standard error, Statistical hypotheses, Critical region, Tests of hypotheses and significance, Type I and Type II errors, level of significance. level of significance, Test about one mean, Test about equality of two means, Test of variances, Chi square test, Analysis of Variance.

References:

1. A. M. Goon, M. K. Gupta, and B. Dasgupta, *An Outline of Statistical Theory*, Vol. II, 3rd ed., Kolkata, India: World Press, 2005.
2. M. G. Kendall and A. Stuart, *The Advanced Theory of Statistics*, Vol. II, London, U.K.: Charles Griffin & Co. Ltd., 1979.
3. G. Casella and R. L. Berger, *Statistical Inference*, 2nd ed., Pacific Grove, CA, USA: Thomson Duxbury, 2024.
4. R. V. Hogg and E. A. Tanis, *Probability and Statistical Inference*, 10th ed., New York, NY, USA: Macmillan Publishing Co. Inc., 2021.
5. W. Feller, *An Introduction to Probability Theory and Its Applications*, Vol. 1, 3rd ed., New York, NY, USA: John Wiley & Sons, 1968.

MBB2001 PRINCIPLE OF MANAGEMENT [3 0 0 3]

Management: Definition, Functions, Concept, Scope of Management, Nature of Management, Levels of Management, Managerial Skills, Roles of a Manager, Difference between Management and Administration Evolution of Management Thoughts: Classical Approach- scientific management, Administrative Management and Bureaucracy. Neo-Classical Approach- Human relations movement and Behavioural approach. Modern Approach- Quantitative approach, Systems approach, and Contingency approach. Forms of organization – Sole Proprietorship, Partnership, Co-operative Organization, and Company. Functions of Management: Planning: Concept, Importance, Strategies, Planning Premises; Decision making, Management by Objectives (MBO), Process of Planning. Organizing: Concept, Importance, Process of Organizing, Types of Organizational Structures, Span of Management, Line and Staff Relationship, Centralization and Decentralization. Staffing: Concept, Scope of Staffing, Manpower Planning, Selection & Training, Performance Appraisal. Directing: Concept, Importance. Motivation: Concept, Importance, Maslow's Need Hierarchy theory, Leadership: Concept, Characteristics of Leadership, and Leadership styles. Communication: Types, Process, Channels and Barriers of Communication. Coordinating: Definition, Characteristics, Principles and Techniques of Coordination, Concept of Managerial Effectiveness. Controlling: Concept, Importance, Process of Controlling, Management Control Techniques, Effective Control Systems.

References:

1. Stephen P. Robbins, Mary Coulter, David De Cenzo: *Fundamentals of Management*, 9th ed., Pearson Education India, 9th ed. 2016.
2. J.K. Mitra, *Principles of Management*, 1st ed. Oxford Publication, 2017.
3. H. Koontz, *Essentials of Management*, 1st Indian ed. Tata McGraw Hill Education, 2010.
4. Y.K. Bhushan, *Fundamentals of Business Organization and Management*, Sultan Chand & Sons,9th Edition, 2014.
5. PC Tripathi, et al., *Principles of Management*, 7th ed., Tata McGraw-Hill Education, 2021

RAI2203 SENSORS AND ACTUATORS [3 1 0 4]

Introduction to Sensors and Actuators: Role of sensors and actuators in engineering systems. Classification and performance characteristics. Static response of sensors. Sensors – Principles and Applications: Proximity sensors. Velocity and acceleration sensors. Force, torque, and pressure sensors. Temperature sensors. Signal Conditioning and Data Acquisition: Amplification, filtering, modulation. Analog-to-digital (ADC) and digital-to-analog (DAC) conversion. Actuators – Principles and Types: Electrical actuators: DC motors, stepper motors, servo motors, BLDC. Hydraulic and pneumatic actuators: principles, characteristics, applications. Piezoelectric actuators and shape memory alloys (SMA). Micro-actuators and MEMS-based actuation systems. Integration of Sensors and Actuators: Case studies in robotics, automotive systems, and industrial automation.

References:

1. Jacob Fraden, *Handbook of Modern Sensors: Physics, Designs, and Applications*, 5th ed., Cham, Switzerland: Springer, 2016.
2. Measurement, Instrumentation, and Sensors Handbook, 2nd edition (2014), is edited by Webster and Eren, published by CRC Press.
3. C. W. de Silva, *Sensors and Actuators: Engineering System Instrumentation*, 2nd ed., Boca Raton, FL, USA: CRC Press, 2015.

RAI2240 DIGITAL SYSTEM DESIGN [3 0 0 3]

Number system, Boolean algebra, Logic gates, Concept of K-Maps reduction, Design of combinational circuits: Adder, Subtractor, Encoder, Decoder, Multiplexer, Demultiplexer. Design sequential circuits by using memory elements like latches, flip-flops, Counters, Registers, Synchronous Counters, Asynchronous counters, Logic families, Analysis and Design of Finite State Machines, Sequence Generator and Sequence Detector-Lock out condition, Design examples, Basics of FPGA Architecture.

References:

1. M. M. Mano, *Digital Design*, 5th ed., Upper Saddle River, NJ, USA: Prentice Hall Publishers, 2013.
2. A. Kumar, *Switching Theory and Logic Design*, 3rd ed., New Delhi, India: PHI Learning, 2019.
3. D. J. Comer, *Digital Logic State Machine Design*, 3rd ed., New York, NY, USA: Oxford University Press, 2012.
4. S. Palnitkar, *Verilog HDL: A Guide to Digital Design and Synthesis*, 2nd ed., Upper Saddle River, NJ, USA: Prentice Hall PTR, 2003.

MCE2241 ROBOT GRIPPER DESIGN [3 0 0 3]

Introduction to Robot Grippers: Overview of robotic gripping systems, Classification of grippers, Applications of robot grippers in industry, Gripper Kinematics and Dynamics: Grasping theory: Force closure vs. Form closure, Kinematics of different gripper types, Dynamics of gripping and object manipulation, Actuation technologies: pneumatic, hydraulic, electric, shape memory alloys (SMA), and soft actuators, Materials and Manufacturing of Grippers: Material selection, Additive manufacturing (3D printing) of grippers, Durability, flexibility, and cost considerations, Gripper Design Considerations: Design for specific tasks, Design constraints: load, object size, and environment, Integration with robotic arms.

References:

1. G. J. Monkman, *Robot Grippers*, 1st ed., Cham, Switzerland: Springer, 2016.
2. M. T. Mason, *Mechanics of Robotic Manipulation*, 1st ed., Cambridge, MA, USA: MIT Press, 2001.
3. K. S. Fu, R. C. Gonzalez, and C. S. G. Lee, *Robotics: Control, Sensing, Vision, and Intelligence*, 1st ed., New York, NY, USA: McGraw-Hill, 1987.
4. M. F. Ashby, *Materials Selection in Mechanical Design*, 4th ed., Oxford, U.K.: Butterworth-Heinemann, 2016.

5. M. T. Mason and J. K. Salisbury, *Robot Hands and the Mechanics of Manipulation*, 1st ed., Cambridge, MA, USA: MIT Press, 1985.

RAI0001 FUNDAMENTAL OF ROBOTICS [3 0 0 3]

Introduction- Basics of robotics, Laws of Robotics, Different kinds of Robots, Degrees of freedom (DOF), types of movements, vertical, radial, and rotational, roll, pitch and yaw, Wok envelope, robot configuration space. Sensors- sensor classification, applications of sensors, need of sensors, selections of sensors. Actuators- transmission and drives systems, Hydraulic, Pneumatic and Electric drive systems, classification of end effectors. Automation- Types of automation, Levels of Automation, need of automation, AI- Introduction to artificial intelligence, AI techniques, Need and application of AI. Robot programming – Deferent methods of robot programming, Robot applications, future of robots.

References:

1. J. J. Craig, *Introduction to Robotics: Mechanics and Control*, Upper Saddle River, 4th ed. NJ, USA: Pearson Education International, 2004.
2. S. R. Deb, *Robotics Technology and Flexible Automation*, 2nd ed., New Delhi, India: McGraw-Hill Education, 2012.
3. M. W. Spong and M. Vidyasagar, *Robot Dynamics and Control*, 2nd ed. New Delhi, India: Wiley India Pvt. Ltd., 2008.
4. K. S. Fu, *Robotics: Control, Sensing, Vision and Intelligence*, 1st ed., New York, NY, USA: McGraw-Hill Education, 2010.

XXX22XX TECHNICAL REPORT WRITING [2 0 0 2]

The essentials of planning and organizing technical reports; understanding report structure including title page, abstract, table of contents, introduction, methods, results, discussion, conclusions, Referencess, and appendices; principles of clear, concise, and objective technical writing; effective use of diagrams, tables, graphs, and data; proper referencing and citation practices; editing and proofreading strategies; and tailoring reports for specific technical audiences such as industry and academia, Latex – Overleaf, TeX Live / MiKTeX, References & Citation Management, Google Scholar Search, Scopus Search, Jupyter Notebook.

References:

1. Barrass, Robert. *"Scientists must write: A guide to better writing for scientists, engineers and students",* Routledge, 2005.
2. University of Wollongong, "*Report Writing: Engineering*," 2024.
3. Hering, Heike, Heike Hering, and Baumann. "*How to write technical reports*", Berlin, Germany: Springer Berlin Heidelberg, 2019.

RAI2232 SENSORS AND ACTUATORS LAB [0 0 2 1]

Study of Resistive, Capacitive, and Inductive Sensors, Temperature Measurement, Displacement & Proximity Measurement, Pressure and Force Measurement, Interfacing Sensors with Arduino/Microcontroller, Speed and Position Control of DC Motor/Stepper Motor, Servo Motor Control, Hydraulic/Pneumatic Actuator Demonstration, Demonstration of Hydraulic and Pneumatic actuators, Closed-loop Temperature Control System, Mini Mechatronic Project.

References:

1. C. W. de Silva, *Sensors and Actuators: Engineering System Instrumentation*, 2nd ed., Boca Raton, FL, USA: CRC Press, 2015.
2. D. Patranabis, *Sensors and Transducers*, 2nd ed., New Delhi, India: PHI Learning, 2021.
3. J. Fraden, *Handbook of Modern Sensors: Physics, Designs, and Applications*, 5th ed., Cham, Switzerland: Springer, 2016.

RAI2233 INTEGRATED ELECTRONICS LAB [0 0 2 1]

Analog circuit designs using 741 IC, linear applications of Op-amps: design of rectifiers, DACs and ADCs, filters, multivibrators & Schmitt trigger using 555 IC, regulators. Digital circuit designs- combinational circuit's, implementation of Boolean functions and arithmetic circuits, multiplexers, encoders, decoders, code converters, design of sequential circuits- ripple counters, shift registers and ring counters, synchronous counters, sequence detectors.

References:

1. S. Franco, *Design with Operational Amplifiers and Analog Integrated Circuits*, 4th ed., New York, NY, USA: McGraw-Hill Education, 2015.
2. M. Morris Mano and M. D. Ciletti, *Digital Design: With an Introduction to the Verilog HDL*, 6th ed., Harlow, UK: Pearson Education Limited, 2019.

RAI2271 PROJECT-BASED LEARNING-1 [0 0 0 3]

Project-based learning involves students designing, developing, and constructing hands-on solutions to a problem. The educational value of Project based learning is that it aims to build students' creative capacity to work through difficult or ill-structured problems, commonly in small teams. Typically, Project based learning takes students through the following phases or steps: Identifying a problem, agreeing on or devising a solution and potential solution path to the problem (i.e., how to achieve the solution), Designing and developing a prototype of the solution, refining the solution based on feedback from experts, instructors, and/or peers. Depending on the goals of the instructor, the size and scope of the project can vary greatly.

References:

1. S. Franco, *Design with Operational Amplifiers and Analog Integrated Circuits*, 4th ed. New York, NY, USA: McGraw-Hill Education, 2015.
2. M. M. Mano and M. D. Ciletti, *Digital Design: With an Introduction to the Verilog HDL, VHDL, and SystemVerilog*, 6th ed. Boston, MA, USA: Pearson, 2018.

FIFTH SEMESTER

RAI3102 DEEP LEARNING [3 1 0 4]

Basic concepts of perceptron, learning and recognition- supervise and unsupervised learning. Fundamentals of delta learning rules and back propagation algorithm, SVM, KNN. Machine Learning, machine learning techniques, challenges motivating deep learning. Over fitting and under fitting, bias and variance, Gradient based optimization, Maximum Likelihood Estimation. Deep Feed-forward network, backpropagation. Some Regularization and Optimization Techniques. Convolutional Neural Network, RNN, methodology and Applications of deep learning. Deep Generative Models: Boltzmann Machine, RBM, Deep Belief Nets, Deep Boltzmann Machine, Convolutional Boltzmann Machine, Generative adversarial networks (GANs), autoencoders, transformers, and explainable AI

References:

1. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, *Deep Learning*, Cambridge, MA, USA: MIT Press, 2016.
2. François Chollet, *Deep Learning with Python*, 3rd ed. (forthcoming), Manning Publications, expected late 2025.
3. Aurélien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*, 3rd ed., Sebastopol, CA, USA: O'Reilly Media, 2024.
4. Simon Haykin, *Neural Networks and Learning Machines*, Upper Saddle River, NJ, 3rd ed. USA: Pearson, 2008.

RAI3103 DESIGN OF MACHINE ELEMENTS [3 0 0 3]

Basic Concepts: Fundamentals of Mechanical Design: The Design Process, Economics of Design, Reliability, Safety and Product Liability, Codes and Standards, Types of Materials, Stress-Strain Response, Types of Loads and Stresses, Failure Modes, Factor of Safety, Strength Design. Static And Variable Stress Analysis: Static Strength, Failure Theories, Stress Concentration, Fatigue Strength, Stress-Life (S-N) Diagram, High Cycle Fatigue, Endurance Limit Modifying Factors, Effect of Mean Stress, Fluctuating Stresses, and Stresses due to Combined Loading. Design For Static and Fatigue Load, Springs: Helical Spring: Compression Springs of Round/Square/Rectangular Wires, Spring Materials, Stress and Deflection of Spring Subjected to Steady, Fluctuating and Impact Loads, Spring Surge and Buckling, Concentric Springs. Design of Spur Gears, Design of Shaft.

References:

1. J. Keith Nisbett and R. G. Budynas, *Shigley's Mechanical Engineering Design*, 2024 Release, New York, NY, USA: McGraw-Hill LLC, 2024.
2. R. L. Norton, *Machine Design: An Integrated Approach*, 6th ed., Boston, MA, USA: Pearson, 2021.
3. U. C. Jindal, *Machine Design*, 1st ed., New Delhi, India: Pearson, 2010.
4. V. B. Bhandari, *Design of Machine Elements*, 5th ed., New Delhi, India: Tata McGraw-Hill Education, 2023.

RAI3104 MODERN CONTROL THEORY [3 0 0 3]

Analysis and design of linear systems, Feedback of control systems, Physical systems, Time and frequency domain analysis, System Compensation: Using elementary lag, lead and lead- lag compensating networks, Mathematical Preliminaries and State Variable Analysis, Linear dynamical systems, Autonomous system, Controllability and Observability, feedback controllers, introduction to non-linear systems, stability analysis, Optimal and Adaptive Control.

References:

1. K. Ogata, *Modern Control Engineering*, 3rd ed. Englewood Cliffs, NJ, USA: Prentice Hall, 2025.
2. F. L. Lewis, *Applied Optimal Control and Estimation*. Englewood Cliffs, NJ, USA: Prentice Hall, 2024.
3. B. Friedland, *Control System Design*. New York, NY, USA: McGraw-Hill, 2000.

MCE3105 MOBILE ROBOTS [3 1 0 4]

Types of locomotion, hopping robots, legged robots, wheeled robots, stability, maneuverability, controllability; Mobile robot kinematics and dynamics: Forward and inverse kinematics, holonomic and nonholonomic constraints, kinematic models of simple car and legged robots, Control theory - Control design basics, Cruise-Controllers, Performance Objectives. Simple robot - State space model, Linearization, LTI system, stability. PID control, basic control algorithms,Sensors for mobile robots - Classification, performance, uncertainty in sensors, wheel sensor, heading sensor, accelerometers, inertial measurement, motion sensor, range sensors.

References:

1. R. Siegwart and I. R. Nourbakhsh, *Introduction to Autonomous Mobile Robots*, Cambridge, 2nd ed. MA, USA: MIT Press, 2011.
2. P. Corke, *Robotics, Vision and Control: Fundamental Algorithms in MATLAB*, 3rd ed. Singapore: Springer Tracts in Advanced Robotics, 2017.
3. S. M. LaValle, *Planning Algorithms*, Cambridge, U.K.: Cambridge University Press, 2006.
4. S. Thrun, W. Burgard, and D. Fox, *Probabilistic Robotics*, Cambridge, MA, USA: MIT Press, 2005.
5. E. R. Melgar and C. C. Diez, *Arduino and Kinect Projects: Design, Build, Blow Their Minds*, 1st ed., Berkeley, CA, USA: Apress, 2012.
6. H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, and S. Thrun, *Principles of Robot Motion: Theory, Algorithms and Implementations*, Upper Saddle River, NJ, USA: Prentice-Hall India, 2005.

RAI3140 SIGNALS AND SYSTEMS [3 0 0 3]

Introduction: Definitions, Overview of specific systems, Classification of signals, Basic operations on signals, Elementary signals and functions, Systems viewed as interconnections of operations, properties of systems. Time domain representations for linear time-invariant systems: Introduction, Convolution: Impulse response representation for LTI systems, properties of the impulse response representation for LTI systems, Differential and difference equation representations for LTI systems, S-domain transformation using Laplace transform, Fourier representation for signals: The discrete-time Fourier series, continuous-time periodic signals: Discrete-time non-periodic signals: The discrete-time Fourier transform, Z-Transform, The Fourier transform, properties of Fourier representations, Fast Fourier transform. Signal processing in MATLAB.

References:

1. R. P. Ramesh Babu and R. Anandanatarajan, *Signals & Systems*, 5th ed., Chennai, India: Scitech Publications (India) Pvt. Ltd., 2017
2. S. Haykin and B. V. Veen, *Signals and Systems*, 2nd ed., New Delhi, India: John Wiley & Sons, 2002.
3. J. G. Proakis, D. G. Manolakis, and D. K. Mimitris, *Introduction to Digital Signal Processing*, 4th ed., New Delhi, India: Prentice Hall of India, 2006

RAI3142 SMART MATERIALS [3 0 0 3]

Overview of smart materials, Piezoelectric ceramics, magnetostrictive materials, shape memory alloys, Modelling of smart materials, composite smart materials, Mechanics of smart composite materials, Smart sensors based on high bandwidth low strain smart materials, Low-bandwidth high strain smart actuators, Intelligent devices based on smart materials.

References:

1. B. Culshaw, *Smart Structures and Materials*, Boston, MA, USA: Artech House Publishers, 2004
2. P. Gaudenzi, *Smart Structures: Physical Behaviour, Mathematical Modelling and Applications*, Hoboken, NJ, USA: Wiley, 2009
3. W. Cady, *Piezoelectricity*, New York, NY, USA: Dover Publications, 2018.

RAI3150 CYBER PHYSICAL SYSTEM [3 0 0 3]

Cyber-Physical Systems (CPS) in the real world, basics of cyber physical system, components of cyber physical system, real time sensing and communication for CPS, basics of wireless sensor network, control of CPS: dynamical system modelling, stability, controller design, event triggered control, distributed control, control challenges; basics of networked control system, security of cyber physical systems, Attack Detection and Mitigation in CPS, case studies.

References:

1. E. A. Lee and S. A. Seshia, *Introduction to Embedded Systems: A Cyber-Physical Systems Approach*, 2nd ed. Cambridge, MA, USA: MIT Press, 2017.
2. R. Alur, *Principles of Cyber-Physical Systems*, 1st ed. Cambridge, MA, USA: MIT Press, 2015.
3. M. Wolf, *High-Performance Embedded Computing: Applications in Cyber-Physical Systems and Mobile Computing*, 2nd ed. San Francisco, CA, USA: Morgan Kaufmann, 2014.
4. H. H. Song, D. B. Rawat, S. Jeschke, and C. Brecher, Eds., *Cyber-Physical Systems: Foundations, Principles and Applications*, 1st ed. Cambridge, MA, USA: Academic Press, 2016.

RAI3151 DIGITAL SIGNAL PROCESSING [3 0 0 3]

Introduction to Signal Processing, Sampling, Aliasing, Transform domain analysis of discrete-time systems: Z Transform and application of Z transforms to discrete time systems, Computation of DFT, Fast Fourier Transform. Digital Filter Characteristics and structures, IIR Filter Design using Butterworth and Chebyshev approximations, Impulse invariant and bilinear transformation methods. FIR Filter Design using Window method and Frequency sampling method. Architectural features of Digital signal processors and Case study: Sensing, measurement and analysis of mechanical motion, fault analysis.

References:

1. D. Sundararajan, *Digital Signal Processing: An Introduction,* 2nd ed. Cham, Switzerland: Springer, 2024.
2. R. Li and J. Jiang, *Digital Signal Processing: Fundamentals, Applications, and Deep Learning*, 4th ed. New York, NY, USA: Academic Press / Elsevier, 2025.
3. S. K. Mitra, *Digital Signal Processing: A Computer-Based Approach*, 5th ed. New York, NY, USA: McGraw-Hill, 2024.
4. S. W. Smith, *The Scientist and Engineer's Guide to Digital Signal Processing*, 2nd edition. San Diego, CA, USA: California Technical Publishing, 1999.
5. R. Lyon and D. Ray, *Understanding Digital Signal Processing*, 3rd ed. Upper Saddle River, NJ, USA: Pearson, 2017.

RAI3130 MODELLING AND SIMULATION LAB [0 0 2 1]

Introduction of 2D model design and 3D CAD parametric design; CREO parametric design: Sketch, Part modelling, Surface modelling, Dimensions and annotation; Assembly; Advanced assembly; Multi-view drawing and reading; Animation; Mechanical part design; Robotic arm part design.

References:

1. I. Zeid, CAD/CAM Theory and Practice, Special Indian Edition, New Delhi, India: McGraw Hill Education India, 2012.
2. R. H. Shih, *Parametric Modeling with Creo Parametric 11.0: An Introduction to Creo Parametric 11.0*, 1st ed., SDC Publications, 2024.

RAI3131 ROBOTICS LAB [0 0 2 1]

Forward and inverse kinematics of a Robot, velocity analysis, Mobile robot, Dynamics of Robot Manipulators, Control of Robot Manipulators: PID control, Adaptive Control, Robot Path-Planning.

References:

1. S. B. Niku, *Introduction to Robotics: Analysis, Control, Applications*, 3rd ed. Hoboken, NJ, USA: Wiley, 2020.
2. S. G. Tzafestas, *Introduction to Mobile Robot Control*, 1st ed. Waltham, MA, USA: Elsevier, 2013.
3. M. W. Spong and M. Vidyasagar, *Robot Dynamics and Control*, 2nd ed. New York, NY, USA: Wiley, 2009.
4. K. Yoram, *Robotics*, New York, NY, USA: McGraw-Hill, 1992.
5. J. J. Craig, *Introduction to Robotics: Mechanics and Control*, 4th ed. Upper Saddle River, NJ, USA: Pearson, 2022.

MCE3171 PROJECT BASED LEARNING 2 [0 0 3 3]

Project-based learning involves students designing, developing, and constructing hands-on solutions to a problem. The educational value of Project based learning is that it aims to build students' creative capacity to work through difficult or ill-structured problems, commonly in small teams. Typically, Project based learning takes students through the following phases or steps: Identifying a problem, agreeing on or devising a solution and potential solution path to the problem (i.e., how to achieve the solution), Designing and developing a prototype of the solution, refining the solution based on feedback from experts, instructors, and/or peers. Depending on the goals of the instructor, the size and scope of the project can vary greatly.

References:

1. S. Franco, *Design with Operational Amplifiers and Analog Integrated Circuits*, 4th ed. New York, NY, USA: McGraw-Hill Education, 2015.
2. M. M. Mano and M. D. Ciletti, *Digital Design: With an Introduction to the Verilog HDL, VHDL, and SystemVerilog*, 6th ed. Boston, MA, USA: Pearson, 2018.

MCE3190 ADDITIVE MANUFACTURING (MINOR SPECIALIZATION 1) [3 0 0 3]

AM importance, generic process, stereolithography/3D printing, rapid prototyping, benefits, AM vs CNC, reverse engineering. Eight steps of AM, machine variations, metal systems, equipment maintenance, material handling, design for AM, applications. AM Processes: Photopolymerization Powder Bed Fusion, Extrusion-based Systems, Printing Processes (evolution in AM), Sheet Lamination: LOM, UC, gluing, thermal bonding, applications, Beam Deposition & Direct Write. Guidelines, methods, challenges, example system, production planning/control. Support removal, surface finishing, pattern prep, property enhancement (thermal & non-thermal).

References:

1. Chua, C. K., Kah Fai Leong, and Chu Sing Lim, *Rapid Prototyping: Principles and Applications*, 3rd ed., Singapore; New Jersey, USA: World Scientific, 2010.
2. Kamrani, A. K., and Emad Abouel Nasr (eds.), *Rapid Prototyping: Theory and Practice*, Manufacturing Systems Engineering Series Vol. 6, 1st ed., New York, NY, USA: Springer, 2006.
3. Pham, D. T., and S. S. Dimov, *Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling*, London, UK: Springer, 2001.
4. Noorani, Rafiq, *Rapid Prototyping: Principles and Applications in Manufacturing*, Hoboken, NJ, USA: John Wiley & Sons, 2006.
5. Prasad, Hari, and A. V. Suresh, *Additive Manufacturing Technology*, 1st ed., Stamford, CT, USA: Cengage Learning, 2019.

MCE3180 DATA ANALYTICS AND VISUALIZATION [3 0 0 3]

Introduction to Mechatronics: Definition, scope, Evolution of mechatronics and applications in industry. Mechatronic design approach. Elements of Mechatronic Systems: Mechanical components and system modeling. Electrical and electronic elements. Integration of sensors, actuators, and signal conditioning. Sensors and Actuators in Mechatronics: Proximity sensors and Actuators, Selection criteria for sensors and actuators in system design. Control Systems for Mechatronics: Classical control (PID controllers). Digital and adaptive control approaches. Real-time control and feedback systems. Interfacing sensors and actuators. Embedded programming. System Modeling and Simulation: Mathematical modeling of mechatronic systems. Simulation tools: MATLAB/Simulink and ROS. Case Studies and Advanced Topics.

References:

1. W. Bolton, *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering*, 7th ed., Harlow, UK: Pearson, 2018.
2. D. Shetty and R. A. Kolk, *Mechatronics System Design*, 2nd ed., India: Pearson-Cengage, 2012.
3. R. H. Bishop (2nd ed.), *The Mechatronics Handbook*, 2nd ed., Boca Raton, FL, USA: CRC Press, 2002.
4. D. G. Alciatore and M. B. Histand, *Introduction to Mechatronics and Measurement Systems*, 5th ed., New York, NY, USA: McGraw Hill Education, 2020.

SIXTH SEMESTER

RAI3201 DRIVES AND AUTOMATION [3 1 0 4]

Introduction to power switches and power converters, components of electric drives, factors affecting choice of drives, fundamental torque equation, speed-torque conventions, multi-quadrant operation of electric drives, speed control of DC motors, induction motors, Servo motors, BLDC motors and Stepper motors, electric braking, Automation Hierarchy and basic component of automation system, introduction to Sequence Control, PLCs and Relay Ladder Logic, PLC integration with Pneumatic and Hydraulic systems.

References:

1. G. K. Dubey, *Fundamentals of Electrical Drives*, 2nd ed., New Delhi, India: Narosa Publishing House (reprint 2022).
2. I. J. Nagrath and D. P. Kothari, *Electric Machines*, 5th ed., New Delhi, India: Tata McGraw-Hill Education, 2017.
3. J. W. Webb and R. A. Reis, *Programmable Logic Controllers: Principles and Applications*, 5th ed., Upper Saddle River, NJ, USA: Prentice Hall.
4. K. Ogata, *Modern Control Engineering*, 5th ed., Harlow, UK: Pearson Education Limited, 2021.
5. P. A. Parr, *Hydraulics and Pneumatics: A Technician's and Engineer's Guide*, 3rd ed., Oxford, UK; Burlington, MA, USA: Elsevier Butterworth-Heinemann, 2011.

RAI3102 REINFORCEMENT LEARNING IN ROBOTICS [3 1 0 4]

Definition and scope of RL. Difference between supervised and reinforcement learning. History and applications in robotics. States, actions, rewards, transitions. Policy, value functions. Bellman equations. Policy evaluation, policy improvement. Value iteration, policy iteration. Applications to simple robotic tasks. Monte Carlo methods. Temporal-Difference (TD) learning. SARSA, Q-learning. Motivation and need for function approximation in RL. Linear function approximation. Introduction to deep RL. Policy parameterization and gradient ascent. REINFORCE algorithm. Actor-critic architectures. Deep Q-networks (DQN). Deep Deterministic Policy Gradient (DDPG), Proximal Policy Optimization (PPO). Sim-to-Real transfer. Robot navigation and motion planning. Multi-agent RL in robotics. Case studies: RL in manipulation, locomotion, and vision-driven robots. Practical frameworks (OpenAI Gym, PyBullet, ROS integration). Implementation guidelines and best practices.

References:

1. Richard S. Sutton and Andrew G. Barto, Reinforcement Learning: An Introduction, MIT Press, 2nd Edition, 2018.
2. Marco Wiering and Martijn van Otterlo (Eds.), Reinforcement Learning: State-of-the-Art, Springer, 1st Edition, 2012.
3. Abhishek Nandy, Manisha Biswas, Deeptasree Sadhukhan, Deep Reinforcement Learning with Python, PACKT, 1st Edition, 2020.

RAI3242 PNEUMATICS AND HYDRAULICS FOR ROBOTS [3 0 0 3]

Fundamentals of Fluid Power Systems: Introduction to pneumatic and hydraulic systems; Properties of fluids, compressibility, pressure-flow relationships; Energy transfer, Pascal's law, continuity equation; Advantages and limitations of pneumatics and hydraulics in robotics applications. Hydraulic Systems: Hydraulic power generation – pumps, reservoirs, filters; Hydraulic actuators – linear & rotary actuators, cylinders, motors; Valves – pressure control, directional control, flow control; Hydraulic circuits for position, speed and force control in robots. Pneumatic Systems: Air compressors, air dryers, filters, regulators, lubricators; Pneumatic actuators – cylinders, rotary actuators; Directional and flow control valves; Pneumatic circuits for robotic end-effectors, pick-and-place mechanisms, and automation modules.

References:

1. Esposito, A., *Fluid Power with Applications*, 7th ed., Upper Saddle River, NJ, USA: Pearson Prentice Hall, 2009.
2. Majumdar, S. R., *Pneumatic Systems: Principles and Maintenance*, 1st ed., New Delhi, India: Tata McGraw-Hill Publishing Company, 1995.
3. Jagadeesha, T., *Pneumatics and Hydraulics*, 1st ed., New Delhi, India: I.K. International Publishing, 2015.
4. Parr, A., *Hydraulics and Pneumatics: A Technician's and Engineer's Guide*, 3rd ed., Oxford, UK: Butterworth-Heinemann, 2011

RAI3244 COLLABORATIVE ROBOTS [3 0 0 3]

Introduction, Types of Robots, Industrial Robot, Service Robot, Cobots, Custom Robots, Flexible Robots, Industrial robots, Remote programming concept, Camera vision Systems, Different Sensors and actuators, Sensor data Integration, Sensor Data Fusion, Data Acquisitions, Simulations, Environment, Plant models, Payload, Cobot specifications - Shape, Size, Sensitivity, Sophistication, Challenges for testing with cobots, Autonomy Type, Autonomy in Cobot, Scope of cobots, Performance based applications, User based applications, Other Industrial applications, System testing, Assisted testing.

References:

1. P. Matthews and S. Greenspan, *Automation and Collaborative Robotics*. Cham, Switzerland: Springer (Apress imprint), 2021.
2. H. Liu, *Intelligent Robots and Cobots: Industry 5.0 Applications*. Hoboken, NJ, USA: Wiley, 2024.
3. D. Hall and J. Llinas, *Handbook of Multisensor Data Fusion*, 2nd ed. Boca Raton, FL, USA: CRC Press, 2019.
4. R. Siegwart, I. R. Nourbakhsh, and D. Scaramuzza, *Introduction to Autonomous Mobile Robots*, 2nd ed. Cambridge, MA, USA: MIT Press, 2011.

RAI3253 ETHICS AND SOCIAL IMPLICATIONS IN AI [3 0 0 3]

Introduction to AI ethics — need for ethical frameworks in AI and robotics; Philosophical foundations of ethics (utilitarianism, deontology, virtue ethics) and their application to AI. Social implications of AI — automation and employment, decision-making, bias, discrimination, accountability, transparency, and explainability. Legal and policy perspectives — intellectual property, data privacy, surveillance, cybersecurity, national/international AI regulations, and global perspectives (EU, US, India). Ethical challenges in robotics and autonomous systems — safety, liability, human–robot interaction, military and defense applications. AI for social good — healthcare, education, sustainability and climate change, accessibility and inclusion. Emerging concerns — generative AI ethics, misinformation, deepfakes, ethical issues in LLMs and reinforcement learning agents. Case studies from healthcare robots, autonomous vehicles, drone surveillance, and decision-support systems.

References:

1. Markus D. Dubber, Frank Pasquale, and Sunit Das, *The Oxford Handbook of Ethics of AI*, Oxford, UK: Oxford University Press, 2020.
2. Patrick Lin, Keith Abney, and Ryan Jenkins, *Robot Ethics 2.0: From Autonomous Cars to Artificial Intelligence*, Oxford, UK: Oxford University Press, 2017.
3. Cathy O'Neil, *Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy*, London, UK: Penguin, 2016.
4. Virginia Dignum, *Responsible Artificial Intelligence: Developing and Using AI in a Responsible Way*, Cham, Switzerland: Springer, 2019.
5. Luciano Floridi (ed.), *The Ethics of Artificial Intelligence and Robotics*, Cham, Switzerland: Springer Nature, 2021.

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MCE3254 INTELLIGENT SYSTEMS [3 0 0 3]

Intelligent agent, structure and architecture of agents, basic elements of fuzzy systems, fuzzification, Fuzzy inference, Artificial Neural Networks (ANN) biological analogues, ANN training algorithms, supervised learning, gradient methods, reinforcement learning, unsupervised learning, deep Learning, applications: adaptive control, self-tuning PID controllers, cooperative Intelligence, characteristics of cooperative intelligence, particle swarm optimization, ant colony optimization, multi-agent systems.

References:

1. Vinod Chandra S. S. and Anand Hareendran S., *Artificial Intelligence and Machine Learning*, 2nd ed., New Delhi, India: PHI Learning, 2020.
2. Timothy J. Ross, *Fuzzy Logic with Engineering Applications*, 4th ed., Hoboken, NJ, USA: John Wiley & Sons, 2011.
3. Christopher M. Bishop, *Pattern Recognition and Machine Learning*, 1st ed., New York, NY, USA: Springer, 2006 (2016 paperback reprint).
4. Alberto Artasanchez and Prateek Joshi, *Artificial Intelligence with Python*, 2nd ed., Birmingham, UK: Packt Publishing, 2020.

RAI3260 MACHINE VISION [3 0 0 3]

Image Acquisition and Analysis: Vision system components, Image acquisition and analysis, Image digitization, Image enhancement, restoration, Segmentation, Morphological Operations, image representation and analysis, color image processing. 3D Vision: Camera and optics, Perspective Projection Geometry Rotation and translation matrix, Pinhole camera model, Calibration methods, Intrinsic and Extrinsic Camera Parameters, Stereovision, Stereo correspondence Algorithms, Epipolar Geometry, Essential and fundamental matrix, 3D Reconstruction. Motion Estimation and Tracking: Optical Flow estimation, Object tracking with Kalman filtering. Basic idea of localization employing passive markers. Case Studies/Application: Basic color detection, Face recognition, Vehicle tracking, applications using computer vision toolbox and image processing toolbox of MATLAB.

References:

1. Rafael C. Gonzalez and Richard E. Woods, *Digital Image Processing*, 4th ed., Harlow, UK: Pearson Education Limited, 2018.
2. Milan Sonka, Vaclav Hlavac, and Roger Boyle, *Image Processing, Analysis and Machine Vision*, 2nd ed., London, UK: PWS Publishing, 1999.
3. Boguslaw Cyganek and J. Paul Siebert, *An Introduction to 3D Computer Vision Techniques and Algorithms*, 1st ed., Hoboken, NJ, USA: Wiley, 2009.
4. David A. Forsyth and Jean Ponce, *Computer Vision: A Modern Approach*, 2nd ed., Upper Saddle River, NJ, USA: Prentice Hall, 2012.
5. E. R. Davies, *Machine Vision: Theory, Algorithms and Practicalities*, 3rd ed., London, UK: IET (Institution of Engineering and Technology), 2004.

RAI3263 PRODUCTION AND OPERATIONS MANAGEMENT [3 0 0 3]

Operations Strategy in a global economy, Operations Management and Productivity, Types and Characteristics of Manufacturing and Service Systems, Product Design. Introduction to Forecasting, Introduction to Time-series forecasts, Extrapolative methods Causal Methods of forecasting, Qualitative Methods of Forecasting, Introduction to Inventory Management, Various costs involved in inventory management, Models of Inventory Management, Various variations of EOQ, Inventory Models with Uncertain Demand, Inventory Models with Uncertain Demand, Miscellaneous Systems and Issues, Inventory Control and Supply Chain Management, Nature of Quality, Evolution of Quality Management, Modern Quality Management, Total Quality Management, Statistical Concepts in Quality Control, Acceptance Sampling, 7 QC Tools, Service Facility Layout, JIT Manufacturing, Lean Manufacturing, Kanban Production System, Case Discussions on JIT and Lean Philosophy. Maintenance Management, Total Productive Maintenance, Introduction to Project Management, PERT and CPM

References:

1. William J. Stevenson, *Operations Management*, 14th ed., New York, NY, USA: McGraw-Hill Education, 2021
2. E. S. Buffa and R. K. Sarin, *Modern Production/Operations Management*, 8th ed., New Delhi, India: Wiley India, 2007
3. Richard B. Chase and F. Robert Jacobs, *Operations Management for Competitive Advantage*, 11th ed., New York, NY, USA: McGraw-Hill/Irwin, circa 2001
4. Norman Gaither and Gregory Frazier, *Operations Management*, 9th ed., Noida, India: Cengage Learning India, 2025

RAI0002 AUTOMATION IN INDUSTRY [3 0 0 3]

Introduction to Industrial Automation, Intelligent Systems, Hydraulic Actuators for Industrial Applications, Pneumatic Actuators for Industrial Applications, Actuator Automation, Flow control valves, Electric Drives, Sensors and Vision used for Industrial automation, Trajectory planning, Automation Algorithm, Hydraulic and electrohydraulic system in Industries, Programming and flow control for automation.

References:

1. G. S. Hegde, *A Textbook of Industrial Robotics*, 2nd ed., New Delhi, India: Laxmi Publications, 2008.
2. Stamatios Manesis and George Nikolakopoulos, *Introduction to Industrial Automation*, Boca Raton, FL, USA: CRC Press.
3. M. P. Groover, M. Weiss, R. N. Nagel, N. Odrey, and A. Dutta, *Industrial Robotics: Technology, Programming, and Applications*, 2nd ed., New Delhi, India: McGraw Hill Education (India), 2012.

RAI3231 DRIVES AND AUTOMATION LAB [0 0 2 1]

Power converters and their operational characteristics, Control of Drives: DC motors, induction motors, BLDC motor, stepper motor, servo motor, PLC integration with pneumatic and hydraulic system and their control, implementation of PID control using PLC.

References:

1. M. H. Rashid, *Power Electronics Handbook*, 5th ed., Elsevier, 2023.
2. I.J. Nagrath and D. P. Kothari, *Electric Machines*, 5th ed., McGraw Hill Education, 2017.
3. G. K. Dubey, *Fundamentals of Electrical Drives*, 2nd ed., Alpha Science, 2020.
4. S. R. Majumdar, *Pneumatic Systems: Principles and Maintenance*, McGraw-Hill, 1996.
5. Bosch Rexroth AG, *Project Manual Industrial Hydraulics*, RE 00845/04.07, Trainer's manual, (original around 2004, later editions exist as of 2022).

RAI3232 PNEUMATICS AND HYDRAULICS LAB [0 0 4 2]

Operations of various valves like directional control valves, flow control, valves, pressure control valves and switches like pressure switches, proximity switches. Operations of timers and counters. Rigging of manual pneumatic and electro-pneumatic circuits using valves and switches. Working principles of hydraulic pumps, hydraulic motors, throttle valves, direction control valves. Manual and electrohydraulic circuits using manual and electrohydraulic components.

References:

1. A. Esposito, *Fluid Power with Applications*, 7th ed., Upper Saddle River, NJ, USA: Pearson Prentice Hall, 2008.
2. S. R. Majumdar, *Pneumatic Systems: Principles and Maintenance*, 1st ed., New Delhi, India: Tata McGraw-Hill, 1996

RAI3290 SOFTWARE SKILLS FOR 3D PRINTING [3 0 0 3]

Introduction to 3D Printing and Cura Software: Basics of 3D printing technology, Overview of Cura and its significance; Setting Up Cura: Hardware requirements, Installation and user interface walkthrough; Model Preparation and Printing Basics: Importing and preparing 3D models, Customizing print settings, Optimizing support structures; Advanced Techniques: Fine-tuning print parameters, Exploring advanced Cura features; Troubleshooting and Maintenance: Resolving common issues, Maintaining printers for consistent performance

References:

1. Daniel Grosleau, *The Software Cura: A Comprehensive Guide to 3D Printing: Customizable Settings and Practical Tips for Beginners*, 1st ed., Independently published, June 2023.
2. Bob Babson, *3D Printing: The Complete Guide – Setup, Software, Ideas, Designs, Materials, Apps, Tips & More*, 1st ed., Abbott Properties, June 2019. pp. 28. ISBN-13: 978-0359753284.
3. Barrett Williams and ChatGPT, *Mastering 3D Printing Software: A Step-by-Step Guide to Creating Exceptional 3D Models*, 1st ed., independently published audiobook, April 2024.

RAI3281 ROBOT SYSTEM DESIGN [3 0 0 3]

Introduction to Robot System Design: Overview of robotic systems and their components, Design methodology for robotic systems, Mechanical Design for Robots: Robot kinematics and dynamics; Design of robotic arms: Degrees of freedom (DOF), workspace, and payload, Linkages, joints, and actuators, Material selection and structural analysis; Embedded Systems and Microcontrollers: Real-time operating systems (RTOS), Communication protocols (I2C, SPI, UART); Sensors, and actuators; Battery selection and management; Controllers fundamentals, Control system hardware: Real-time controllers; Sensor Integration and Sensor fusion techniques, Introduction to machine vision and LiDAR for robotics; Robot Programming and Simulation.

References:

1. Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, and Giuseppe Oriolo, *Robotics: Modelling, Planning and Control*, 1st ed., London, UK: Springer, 2009.
2. J. J. Craig, *Introduction to Robotics: Mechanics and Control*, 4th ed., Upper Saddle River, NJ, USA: Pearson, 2017.
3. M. W. Spong, S. Hutchinson, and M. Vidyasagar, *Robot Modeling and Control*, 2nd ed., Hoboken, NJ, USA: Wiley, 2020
4. G. C. Onwubolu, *Mechatronics: Principles and Applications*, Oxford, UK: Butterworth-Heinemann Ltd, 2005.
5. J. G. Kantor, H. Choset, K. M. Lynch, L. E. Kavraki, S. Thrun, S. Hutchinson, and W. Burgard, *Principles of Robot Motion: Theory, Algorithms, and Implementations*, Bradford , MI, USA: MIT Press (Intelligent Robotics and Autonomous Agents Series), 2005.

SEVENTH SEMESTER

RAI4143 INTERNET OF ROBOTIC THINGS [3 0 0 3]

Fundamentals of robotic systems and their sensing and actuation capabilities; IoT architecture and connectivity protocols such as Wi-Fi, Bluetooth, and MQTT; sensor integration for environmental and operational data collection; cloud computing and edge computing for data processing and storage; communication frameworks for robot-to-robot and robot-to-cloud interaction; AI and data analytics enabling intelligent decision-making and autonomous behaviors; human-machine interfaces and security/privacy challenges; and emerging trends like collaborative robotics and smart environments. Applications and case studies illustrating smart robotics deployment in industries and urban infrastructure are also discussed.

References:

1. L. Da Xu, W. He, and S. Li, "Internet of Things in Industries: A Survey," *IEEE Transactions on Industrial Informatics*, vol. 10, no. 4, pp. 2233–2243, Nov. 2014.
2. R. Alami *et al.*, "Robotic Systems Integration in the Internet of Robotic Things," *IEEE Robotics and Automation Letters*, 2019.
3. D. Evans, "The Internet of Robotic Things," *Forbes Technology Council*, 2017.
4. M. Wollschlaeger, T. Sauter, and J. Jasperneite, "The Future of Industrial Communication: Automation Networks in the Era of the Internet of Things and Industry 4.0," *IEEE Industrial Electronics Magazine*, vol. 11, no. 1, pp. 17–27, Mar. 2017.

RAI4142 ROBOT PROCESS AUTOMATION [3 0 0 3]

Fundamentals and evolution of Robotic Process Automation (RPA), difference between RPA and traditional automation. RPA architecture, ecosystems, adoption benefits, and limitations. Core RPA tools: UiPath, Automation Anywhere, Blue Prism, and open-source frameworks, various bot types and workflow design. Process identification, mapping, documentation, and re-engineering for scalable automation. Building RPA workflows, integrating with enterprise systems (ERP/CRM/SCM), web scraping, database/API connections, and exception handling. Practical case studies and current trends like hyper automation and human-bot collaboration.

References:

1. Alok Mani Tripathi, *Learning Robotic Process Automation: Create Software Robots and Automate Business Processes with the Leading RPA Tool – UiPath*, 1st ed., Birmingham, UK: Packt Publishing, Mar. 2018.
2. Tom Taulli, *The Robotic Process Automation Handbook: A Guide to Implementing RPA Systems*, 1st ed., Berkeley, CA, USA: Apress, Feb. 2020.
3. Mary C. Lacity and Leslie P. Willcocks, *Robotic Process Automation and Risk Mitigation: The Definitive Guide*, 1st ed., London, UK: SB Publishing, Apr. 2017.

RAI4154 INDUSTRIAL IOT [3 0 0 3]

Introduction to M2M communication and IoT, An emerging industrial structure for IoT, IoT system architecture, IoT References model, IoT deployment and operational view, IoT physical devices and endpoints, Communication and networking protocols-MQTT and AMQP protocols, IoT enabling technologies-RFID, WSN,SCADA etc., Analytics for the IoT, Applying the geospatial analytics to IoT data, Real world design constraint, Technical design constraint, Future internet design for various IoT use cases such as smart cities, smart environments, smart homes, smart health etc.

References:

1. Vlasios Tsiatsis, Stamatis Karnouskos, Jan Höller, David Boyle, and Catherine Mulligan, *From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence*, 1st ed., Amsterdam, Netherlands: Elsevier Science & Technology (Academic Press), 2018.
2. Arshdeep Bahga and Vijay Madisetti, *Internet of Things: A Hands-on Approach*, 1st ed. (Indian reprint), New Delhi, India: Universities Press, 2015.
3. Roderick O., Marko N., David A. Sanchez, and Arun Aryasomajula, *Internet of Things and Data Analytics Handbook*, 1st ed., Hoboken, NJ, USA: Wiley, 2017.
4. Yatish Patil, *Azure IoT Development Cookbook: Develop and Manage Robust IoT Solutions*, 1st ed., Birmingham, UK: Packt Publishing Ltd, Aug. 2017.

MCE4153 AI IN INDUSTRIAL APPLICATIONS) [3 0 0 3]

Introduction to E-Mobility: Evolution of transportation: IC engines to electric mobility. Classification of EVs: BEV, HEV, PHEV, FCEV. Global e-mobility trends and challenges. Vehicle Dynamics and Propulsion Systems: Fundamentals of vehicle dynamics (tractive effort, resistance, acceleration). Electric propulsion systems: DC motors, BLDC, induction, PMSM. Torque–speed characteristics and drive cycles. Energy Storage Systems: Battery technologies: Li-ion, solid-state, fuel cells, supercapacitors. Battery management systems (BMS. Life cycle analysis. Power Electronics and Control in EVs: DC–DC converters, inverters, and motor controllers. Regenerative braking systems. AI/ML-based control strategies for energy optimization. Charging Infrastructure and Smart Grids: EV charging standards: AC, DC fast charging, wireless charging. Grid integration and vehicle-to-grid (V2G) concepts. Smart charging and renewable energy integration. Energy Management and System Integration: Hybrid powertrain control strategies. Energy efficiency and optimization. Case studies on Tesla, BYD, Tata EV, and global industry leaders. Policies, Sustainability, and Future Trends

References:

1. Mehrdad Ehsani, Yimin Gao, Stefano Longo, and Ali Emadi, *Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design*, 3rd ed., Boca Raton, FL, USA: CRC Press, 2018.
2. James Larminie and John Lowry, *Electric Vehicle Technology Explained*, 2nd ed., Hoboken, NJ, USA: Wiley, latest edition, 2012.
3. Iqbal Husain, *Electric and Hybrid Vehicles: Design Fundamentals*, 3rd ed., Boca Raton, FL, USA: CRC Press, 2021
4. L. Chan (Ching-Chuen Chan) and coauthor, 4th ed. *Modern Electric Vehicle Technology*, 2023

RAI0003 BUILDING AUTOMATION [3 0 0 3]

Introduction to Building Automation- Overview of Building Automation, History and evolution of BAS, Importance and benefits of BAS, Components of a BAS, Fundamentals of Control Systems- open-loop and closed-loop, Sensors and actuators; Energy Management Systems (EMS)- Overview of energy management, Role of BAS in energy conservation, Monitoring and controlling energy usage; Building Automation Software; Smart Buildings and IoT Integration- Introduction to smart buildings, Internet of Things (IoT) in building automation, Future trends in building automation.

References:

1. K. Skrivankova, M. Handley, and S. Hailes, “20 Years in Life of a Smart Building: A retrospective,” arXiv preprint, Sep. 7, 2025.
2. Cătălina Mărcuță & MoldStud Research Team, “Implementing Smart Building Automation with IoT – A Comprehensive Guide,” MoldStud, May 29, 2024.
3. Richard Gargan, “Smart Building Automation: Features, Benefits, and Use Cases,” Netmaker Resources, Dec. 26, 2024.
4. P. Srividya, “Smart Building Automation System,” in Smart Building Automation, Taylor & Francis e-Book chapter, 2022.
5. “Building Automation Guide,” J2 Innovations, Published 2024.

RAI0004 SENSOR TECHNOLOGIES [3 0 0 3]

Introduction to sensor technology, classification, and operating principles of various sensors such as temperature, pressure, optical, and chemical sensors, signal processing techniques, including amplification, filtering, and analog-to-digital conversion, alongside calibration methods and error analysis, MEMS (Micro-Electro-Mechanical Systems) sensors, smart sensors, and their integration with IoT (Internet of Things) systems, emerging technologies in nanotechnology based sensor, bio-sensors, sensor for automotive, healthcare, and environmental monitoring, sensor calibration, system design, and data acquisition and industry applications in sensor technology.

References:

1. Jon S. Wilson (Ed.), *Sensor Technology Handbook*, 1st ed., Amsterdam, Netherlands: Elsevier (Newnes), 2005.

2. Zeynep Altintas and Ahmed Barhoum (Eds.), *Advanced Sensor Technology: Biomedical, Environmental, and Construction Applications*, 1st ed., Amsterdam, Netherlands: Elsevier, 2022.
3. Ahmed Barhoum and Zeynep Altintas (Eds.), *Fundamentals of Sensor Technology: Principles and Novel Designs*, 1st ed., Cambridge, UK: Woodhead Publishing (Elsevier), 2023. ISBN-13: 978-0323884310.
4. S. Nihtianov and A. Luque (Eds.), *Smart Sensors and MEMS: Intelligent Sensing Devices and Microsystems for Industrial Applications*, 2nd ed., Cambridge, UK: Woodhead Publishing (Elsevier), 2018. ISBN-13: 978-0857095022.

RAI0005 SMART AGRICULTURE [3 0 0 3]

Sensors: Classification and characteristics, Smart sensors, Dielectric Soil Moisture Sensors, ISFET, Weather sensors. Actuators for tool automation: Motors, Solenoid actuators, Electric drives, Hydraulic and Pneumatic actuator. Plant health monitoring: Measurement of leaf health, Crop mapping, Fertilizing, Drone technology for soil field analysis and assistive operations. Technologies for farming: Water quality monitoring, micro-irrigation system, solar pump and lighting system, Fencing, Android based automation, Agricultural Robots, Standards for agriculture. Telemetry: Wireless communication modules and topology, Zig-bee, Bluetooth, LORA, Energy Harvesting technology.

References:

1. N. C. Brady and R. R. Weil, *The Nature and Properties of Soils*, 16th ed., Upper Saddle River, NJ, USA: Prentice Hall, 2020.
2. E. O. Doebelin, *Measurement Systems: Application and Design*, 5th ed., New York, NY, USA: McGraw-Hill Science/Engineering/Math, 2010.

RAI4170 INTERNSHIP (INDUSTRY/ RESEARCH / INDUSTRIAL CERTIFICATION) [0 0 2 1]

Each student has to undergo industrial training for a minimum period of 45 days/ 6 weeks. This may be taken in a phased manner during the vacation starting from the end of six semester. Student has to submit to the department a training report in the prescribed format and also make a presentation of the same. The report should include the certificates issued by the industry.

RAI4192 PRODUCT DESIGN AND DEVELOPMENT [3 0 0 3]

Principles of product design and innovation; Design thinking methodology, user-centered design, and requirement analysis; Product development process models — waterfall, agile, spiral, Stage-Gate; Functional decomposition and concept generation techniques (morphological charts, brainstorming, TRIZ); Concept screening and selection methods; Product architecture, modular design, and platform-based product development. Engineering considerations — ergonomics, industrial design, form and aesthetics, reliability, safety, and sustainability. Rapid prototyping, CAD/CAE tools, and digital twins for product evaluation; Materials selection and manufacturability analysis. Costing, value engineering, and Design for X (DFM, DFA, DFS). Intellectual property rights, patenting process, and product certification. Case studies and applications in robotics and consumer technology products, highlighting innovation, interdisciplinary collaboration, and lifecycle management.

References:

1. Karl T. Ulrich, Steven D. Eppinger, and Maria C. Yang, *Product Design and Development*, 7th ed., New York, NY, USA: McGraw-Hill Education, 2020.
2. Kevin N. Otto and Kristin L. Wood, *Product Design: Techniques in Reverse Engineering and New Product Development*, 1st ed., Addison-Wesley Professional, 2001.
3. A. C. Rao, *Design Principles and Methodologies*, 1st ed., New Delhi, India: New Age International, 2011.
4. Nigel Cross, *Engineering Design Methods: Strategies for Product Design*, 4th ed., Chichester, UK: Wiley, 2008

5. A. K. Chitale and R. C. Gupta, *Product Design and Manufacturing*, 5th ed., New Delhi, India: PHI Learning, 2017.

RAI4182 ROBOT SAFETY AND MAINTENANCE [3 0 0 3]

Introduction to Robot Safety and Reliability; Fundamental Mathematical Concepts for Analysis; Basics of Reliability and Safety in Robotics; Methods for Reliability and Safety Analysis of Robot Systems; Robot Reliability and Safety Frameworks; Analysis of Robot-Related Accidents; Maintenance Strategies and Robotics Applications in Maintenance; Human Factors and Safety in Robotics Workplaces; Robot Testing, Cost Analysis, and Failure Data; Mathematical Modelling for Reliability and Safety Analysis

References:

1. B. S. Dhillon, *Robot System Reliability and Safety: A Modern Approach*, 1st ed., Boca Raton, FL, USA: CRC Press, Apr. 2021.
2. J. Starr and C. Quick, *Robotic Safety Systems: An Applied Approach*, 1st ed., Boca Raton, FL, USA: CRC Press, Nov. 2024.
3. B. B. Gupta and N. Nedjah (Eds.), *Safety, Security, and Reliability of Robotic Systems: Algorithms, Applications, and Technologies*, 1st ed., Boca Raton, FL, USA: CRC Press, 2021.

RAI4183 BIOMEDICAL ROBOTS [3 0 0 3]

Introduction to Biomedical Robots: Definition, classification, and scope of medical robotics; Historical development and current trends in biomedical robots; Ethical and regulatory considerations. Robot Mechanics and Kinematics in Biomedicine: Basics of robot manipulators: degrees of freedom, accuracy, repeatability; Mathematical modeling of robots – forward and inverse kinematics; Kinematic arrangements relevant to medical devices. Biomedical Robot Design and Control: Design considerations for medical robots – safety, sterility, miniaturization; Control systems for medical robots – position control, force control, impedance control; Human-robot interaction in medical settings. Applications of Biomedical Robots: Robots for navigation and imaging – robotic surgery, image-guided interventions; Rehabilitation robots – prosthetics, exoskeletons, assistive devices; Robots for movement replication and spatial orientation.

References:

1. John J. Craig, Introduction to Robotics: Mechanics and Control, Pearson, 4th Edition (2017).
2. P. Corke, Robotics, Vision and Control: Fundamental Algorithms in MATLAB, 1st ed., Springer Tracts in Advanced Robotics, 2017.
3. Various authors, Medical Robotics: Current Applications and Future Directions, review articles and case studies.

RAI4171 PROJECT BASED LEARNING-3 [3 0 0 3]

Project-based learning involves students designing, developing, and constructing hands-on solutions to a problem. The educational value of Project based learning is that it aims to build students' creative capacity to work through difficult or ill-structured problems, commonly in small teams. Typically, Project based learning takes students through the following phases or steps: Identifying a problem, agreeing on or devising a solution and potential solution path to the problem (i.e., how to achieve the solution), Designing and developing a prototype of the solution, refining the solution based on feedback from experts, instructors, and/or peers. Depending on the goals of the instructor, the size and scope of the project can vary greatly.

References:

1. S. Franco, *Design with Operational Amplifiers and Analog Integrated Circuits*, 4th ed. New York, NY, USA: McGraw-Hill Education, 2015.
2. M. M. Mano and M. D. Ciletti, *Digital Design: With an Introduction to the Verilog HDL, VHDL, and SystemVerilog*, 6th ed. Boston, MA, USA: Pearson, 2018.

EIGHTH SEMESTER

RAI4270 MAJOR PROJECT [0 0 0 12]

RAI4271 **MINOR SPECIALIZATION PROJECT [0 0 0 6]
RAI4272 * HONORS (RESEARCH PROJECT) [0 0 0 6]