DEPARTMENT OF MECHANICAL ENGINEERING

COURSE STRUCTURE & SYLLABUS M.Tech ME for ROBOTICS AND ARTIFICIAL INTELLIGENCE PROGRAMME

(Applicable for batches admitted from 2025-2026)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA

I Semester

S.No	Course Code	Course Title	L	T	P	C
1		Robotics and Applications	3	1	0	4
2		Artificial Intelligence for Robotics	3	1	0	4
3		Kinematics and Dynamics of Robotics	3	1	0	4
4	RBAI 1041	Robot Sensing and Vision	3	0	0	3
	RBAI 1042	Intelligent Systems and Interfaces				
	RBAI 1043	Mathematical Foundations for Robotics and AI				
	RBAI 1044	Introduction to Quantum Technologies				
5	RBAI 1051	Machine Learning	3	0	0	3
	RBAI 1052	Smart Manufacturing				
	RBAI 1053	Mechatronics System Design				
	RBAI 1054	Drives and Control Systems for Robots				
6		Robotics Simulation LAB	0	1	2	2
7		Artificial Intelligence Programming LAB	0	1	2	2
8		Seminar I	0	0	2	1
		Total	**15**	**5**	**6**	**23**

II Semester

S. No	Course Code	Course Title	L	T	P	C
1		Sensors, Actuators and Embedded Systems for Robotics	3	1	0	4
2		Autonomous Vehicles and Drones	3	1	0	4
3		Advances in Artificial Intelligence	3	1	0	4
4	RBAI 2041	Internet of Things	3	0	0	3
	RBAI 2042	Cryptography & Network Security				
	RBAI 2043	Robotic Simulation and Localization Mapping				
	RBAI 2044	Image Processing				
5	RBAI 2051	Robotics In Manufacturing	3	0	0	3
	RBAI 2052	Intelligent Sensors and Actuators				
	RBAI 2053	Mobile and Micro-Robotics				
	RBAI 2054	Medical Robotics				
6		Control Systems LAB	0	0	4	2
7		Robotics Systems LAB	0	1	2	2
8		Seminar II	0	0	2	1
		Total	**15**	**5**	**6**	**23**

III Semester

S. No	Course Title	L	T	P	C
1	Research Methodology and IPR/Swayam 12 Week MOOC Course RM&IPR	3	0	0	3
2	Summer Internship/Industrial Training (8-10 Weeks)	-	-	-	3
3	Comprehensive Viva	-	-	-	2
4	Dissertation Part - A	-	-	20	10
	TOTAL	3	-	20	18

IV –SEMESTER

S. No	Course Code	Course Title	L	T	P	C
1		Dissertation Part - B	-	-	32	16
TOTAL			-	-	32	16

I Semester	ROBOTICS AND APPLICATIONS (Programme Core 1)	L	T	P	C
		3	1	0	4

Course Objectives: The course aims to:

1. To introduce the fundamental concepts and components of robotic systems.
2. To understand spatial descriptions and transformations for robotic motion.
3. To study forward and inverse kinematics for manipulators and mobile robots.
4. To analyze the dynamics and trajectory planning of robotic systems.
5. To explore applications of robotic systems in real-world environments.

Course Outcomes: Upon successful completion of this course,

1. Explain the essential elements, structure, and types of robotic systems.
2. Apply spatial transformations and homogeneous coordinates in robot motion analysis.
3. Perform forward and inverse kinematic analysis of manipulators and mobile robots.
4. Analyze robot dynamics and plan trajectories based on motion requirements.
5. Evaluate the performance and design of robotic systems for practical applications.

UNIT - I: Robotic Systems and Coordinate Frames

Robot Anatomy Definition, Law of Robotics, History and Terminology of Robotics, Accuracy and Repeatability of Robotics, Simple Problems, Specifications of Robot-Speed of Robot-Robot Joints And Links-Robot Classifications, Architecture of Robotic Systems, Robot Drive Systems, Hydraulic, Pneumatic and Electric System.

UNIT - II: End Effectors and Controls

Mechanical Grippers, Slider crank mechanism, Screw type, Rotary actuators, cam Type-Magnetic grippers, Vacuum grippers, Air operated Grippers, Gripper force Analysis, Gripper design, Simple problems, Robot controls, Point to point control, Continuous path control, Intelligent robot, Control system for robot joint, Control actions, Feedback devices, Encoder, Resolver, LVDT, Motion Interpolations, Adaptive control.

UNIT - III: Transformations and Sensors

Robot Kinematics, Types, 2D and 3D Transformation, Scaling, Rotation, Translation, Homogeneous coordinates, multiple Transformation. Simple problems. Sensors in robot: Touch sensors, Tactile sensor, Proximity and range sensors, Robotic vision Sensor, Force sensor, Light sensors, Pressure sensors.

UNIT - IV: Robot Dynamics and Trajectory Planning

Robot Cell Design and Micro/Nano Robotics System: Robot work cell design and Control, Sequence control, Operator interface, Safety monitoring devices in Robot, Mobile robot working principle, actuation using MATLAB, NXT Software Introductions, Robot applications, Material handling, Machine loading and unloading, assembly, Inspection, Welding, Spray painting and undersea robot. Micro/Nanorobotics system Overview, Scaling effect, Top down and bottom up approach, Actuators of Micro/Nano robotics system, Nanorobot communication Techniques, Fabrication of micro/nano Grippers, Wall climbing micro robot working Principles, Biomimetic Robot, Swarm Robot, Nano robot in targeted drug delivery system.

UNIT - V: Robot Programming and Languages

Robot Programming, Introduction, Types, Flex Pendant, Lead Through Programming, Coordinate Systems of Robot, Robot Controller, Major Components, Functions, Wrist Mechanism, Interpolation, Interlock Commands, Operating Mode of Robot, Jogging, Types, Robot Specifications, Motion Commands, End Effectors and Sensors Commands. Robot Languages, Classifications, Structures, VAL Language Commands, Motion Control, Hand Control, Program Control, Pick and Place Applications, Palletizing Applications Using VAL, Robot Welding Application Using VAL Program, Wait, Signal and Delay Command for Communications Using Simple Applications. RAPID Language Basic Commands, Motion Instructions, Pick and Place Operation Using Industrial Robot, Manual Mode, Automatic Mode, Subroutine Command-Based Programming. Move Master Command Language, Introduction, Syntax, Simple Problems. VAL-II Programming, Basic Commands, Applications, Simple Problem Using Conditional Statements, Simple Pick and Place Applications.

TEXT BOOKS:

1. Industrial Robotics: Technology, Programming and Applications, Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey and Ashish Dutta, McGraw-Hill, 2nd Edition, 2013
2. Introduction to Robotics: Mechanics and Control, John J. Craig, Pearson, 4th Edition, 2018
3. Robotics Control, Sensing, Vision, and Intelligence, KS FU., R.C Gonzalez., CSG Lee

REFERENCE BOOKS:

1. Robotic Engineering: An Integrated Approach, Richard D. Klafter, Thomas A. Chmielewski, Michael Negin, Prentice Hall (Englewood Cliffs, NJ), 1st Edition, 1989.
2. Robotics Technology and Flexible Automation, S. R. Deb and Sankha Deb, Tata McGraw-Hill Education, 1st Edition, 2009.
3. Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Peter Corke, Springer, 2nd Edition, 2022.
4. Robot Modeling and Control, Mark W. Spong and Seth Hutchinson and M. Vidyasagar, Wiley, 2nd Edition, 2023.
5. Introduction to Autonomous Robots: Mechanisms, Sensors, Actuators, and Algorithms, Nikolaus Correll and Bradley Hayes and David Coleman, CreateSpace, 2nd Edition, 2022.
6. Mobile Robotics: Mathematics, Models and Methods, Alonzo Kelly, Cambridge University Press, 2nd Edition, 2023.

I Semester	ARTIFICIAL INTELLIGENCE FOR ROBOTICS (Programme Core 2)	L	T	P	C
		3	1	0	4

Course Objectives:

1. Introduce the fundamentals and scope of artificial intelligence and its role in intelligent systems.
2. Explore problem-solving techniques such as search strategies and knowledge representation.
3. Familiarize students with machine learning methods including supervised and unsupervised learning.
4. Develop the ability to model reasoning under uncertainty using probabilistic approaches.
5. Examine applications of AI in natural language processing, robotics, and expert systems.

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

1. Understand the foundational concepts, structure, and scope of artificial intelligence.
2. Apply heuristic search and optimization algorithms to solve AI-related problems.
3. Represent knowledge using logic and ontologies for building intelligent agents.
4. Analyze machine-learning algorithms and implement basic classifiers and clustering models.
5. Demonstrate the use of AI in practical domains such as robotics, speech recognition, and intelligent decision-making systems.

UNIT - I: Concepts of Artificial Intelligence

Introduction, History, Definition of AI, Emulation of Human Cognitive Process, Intelligent Agents, The Concept of Rationality, The Nature of Environments, The Structure of Agents.

UNIT - II: Search Methods and Strategies

Search Methods, Problem-Solving Agents, Problem Definitions, Formulating Problems, Searching for Solutions, Measuring Problem-Solving Performance with Examples. Search Strategies, Uninformed Search Strategies, Breadth-First Search, Uniform-Cost Search, Depth-First Search, Depth-Limited Search, Iterative Deepening Depth-First Search, Bidirectional Search, Comparing Uninformed Search Strategies. Informed Search Strategies, Heuristic Information, Hill Climbing Methods, Best-First Search, Branch-and-Bound Search, Optimal Search and A*, and Iterative Deepening A*.

UNIT III: Machine Learning Concepts

Concepts of Machine Learning I, Supervised Learning, Unsupervised and Reinforcement Learning, Linear, Logistic, and Hierarchical Cluster Analysis, Decision Tree, Procedure and Technique of Decision Tree, Support Vector Machine, Mathematical Approach.

UNIT IV: Advanced Machine Learning Techniques

Concepts of Machine Learning - II, Clustering and Classification Analysis, Boosting and Bagging, Data Visualization, Random Forest Algorithm, K-Nearest Neighbour Algorithm, Naïve Bayes Algorithm, Solving Numerical Methods.

UNIT V: Logical Methods in Artificial Intelligence

Programming and Logics in Artificial Intelligence, LISP and Other Programming Languages, Introduction to LISP, Syntax and Numerical Function, LISP and PROLOG Distinction, Input, Output and Local Variables, Interaction and Recursion, Property List and Arrays, Alternative Languages, Formalized Symbolic Logics, Properties of WERS, Non-Deductive Inference Methods.

TEXT BOOKS:

1. Artificial Intelligence: A Modern Approach, Stuart J. Russell and Peter Norvig, Prentice Hall, 3rd Edition, 2009
2. Machine Learning, Tom M. Mitchell, McGraw-Hill, 1st Edition, 1997

REFERENCE BOOKS:

1. Introduction to Artificial Intelligence and Expert Systems, Dan W. Patterson, Prentice-Hall (PHI in India), 1st Edition, 1990.
2. A Guide to Expert Systems, Donald A. Waterman, Addison-Wesley, 1st Edition, 1986.
3. Introduction to Artificial Intelligence, Wolfgang Ertel, Springer, 2nd Edition, 2017.
4. Artificial Intelligence, Patrick Henry Winston, Pearson Education, 3rd Edition, 1992.
5. Deep Learning, Ian Goodfellow, Yoshua Bengio and Aaron Courville, MIT Press, 1st Edition, 2016.
6. Machine Learning, Tom M. Mitchell, McGraw Hill Education, 1st Edition, 1997.

I Semester	KINEMATICS AND DYNAMICS OF ROBOTICS (Programme Core 3)	L	T	P	C
		3	1	0	4

Course Objectives:

1. To understand the principles of kinematics and dynamics as applied to robotic systems.
2. To study forward and inverse kinematics for various robot configurations.
3. To analyze robot motion using velocity and acceleration equations.
4. To apply dynamic modeling for manipulator motion and control.
5. To develop mathematical models for trajectory planning and performance analysis.

Course Outcomes: After completing this course, students will be able to:

1. Derive and solve forward and inverse kinematics for robotic manipulators.
2. Analyze velocity and acceleration in robotic joints and links.
3. Develop dynamic equations of motion using Lagrangian and Newton–Euler methods.
4. Perform trajectory planning considering motion constraints.
5. Apply kinematics and dynamics principles for robotic control and simulation.

UNIT – I: Object Position and Transformations

Introduction to Position and Orientation of Objects, Objects Coordinate Frame Rotation Matrix, Euler Angles Roll, Pitch and Yaw Angles Coordinate Transformations, Joint Variables and Position of End Effector, Dot and Cross Products, Coordinate Frames, Rotations, Homogeneous Coordinates.

UNIT - II: Direct Kinematics and D-H Representation

Link Coordinates D-H Representation, The Arm Equation, Direct Kinematic Analysis for Four Axis, SCARA Robot and Three, Five and Six Axis Articulated Robots.

UNIT - III: Inverse Kinematics

The Inverse Kinematics Problem, General Properties of Solutions. Tool Configuration, Inverse Kinematics of Four Axis SCARA Robot and Three and Five Axis, Articulated Robot.

UNIT - IV: Workspace and Trajectory Planning

Workspace Analysis and Trajectory Planning: Workspace Analysis, Work Envelope of a Four Axis SCARA Robot and Five Axis Articulated Robot Workspace Fixtures, The Pick and Place Operations, Joint Space Technique - Continuous Path Motion, Interpolated Motion, Straight Line Motion and Cartesian Space Technique in Trajectory Planning.

UNIT - V: Manipulator Dynamics

Introduction, Lagrange's Equation Kinetic and Potential Energy. Link Inertia Tensor, Link Jacobian Manipulator Inertia Tensor. Gravity, Generalized Forces, Lagrange-Euler Dynamic Model, Dynamic Model of a Two-Axis Planar Robot, Newton Euler Formulation, Lagrange - Euler Formulation, Problems.

TEXT BOOKS:

1. Fundamentals of Robotics Engineering, Harry H. Poole, Cengage Learning, 1st Edition, 2012.
2. Robotics and Control, R. K. Mittal and Nagrath, Tata McGraw-Hill Education Private Limited, 3rd Edition, 2009

REFERENCE BOOKS:

1. Fundamentals of Robotics: Analysis and Control, Robert J. Schilling, PHI Learning, 1st Edition, 2009.
2. Robotics Engineering**:** An Integrated Approach, Richard D. Klafter, Thomas A. Chmielewski and Michael Negin, PHI Learning, 1st Edition, 2009.
3. Robotics and Image Processing: An Introduction, Janaki Raman P.A., Tata McGraw-Hill Publishing Company Ltd., 1st Edition, 1995.
4. Industrial Robotics, Bernard Hodges, Jaico Publishing House, 2nd Edition, 1993.
5. Foundations of Robotics: Analysis and Control, Tsuneo Yoshikawa, MIT Press, 1st Edition, 2003.
6. Introduction to Robotics: Mechanics and Control, John J. Craig, Pearson Education, 3rd Edition, 2008.

I Semester	ROBOT SENSING AND VISION (Program Elective – I)	L	T	P	C
		3	0	0	3

Course Objectives:

1. To introduce the principles and applications of sensors in robotic systems.
2. To study vision systems and image processing techniques for robots.
3. To integrate sensor data for perception, navigation, and control.
4. To explore 2D and 3D vision systems for object detection and recognition.
5. To develop algorithms for visual serving and robot guidance.

Course Outcomes: After completing this course, students will be able to:

1. Identify and select appropriate sensors for robotic applications.
2. Implement image acquisition, enhancement, and feature extraction techniques.
3. Integrate vision systems with robot control for real-time operation.
4. Develop algorithms for object detection, tracking, and scene interpretation.
5. Apply sensing and vision techniques for industrial inspection, assembly, and navigation tas

UNIT – I: Robotic Vision

Robotic Vision Sensors and their Interfacing, Fundamentals of Computer Vision, Image Accusation and Representation, Image Transformation, Filtering, Restoration, Morphing, Camera Models, Calibration, Single View Geometry, Multiple View Geometry, Epipolar Geometry, RANSAC.

UNIT – II: Robotic Machine Vision Systems

Robotic Machine Vision, Imaging Devices, Lighting Techniques, Image Processing and Analysis, Analog to Digital Signal Conversion, Object Recognition, Training the Vision System.

UNIT – III: Position and Orientation Estimation

Position and Orientation: Feature Based Alignment, Pose Estimation, Time Varying Pose and Trajectories, Structure from Motion, Dense Motion Estimation, Visual Odometry (Semi-direct VO, Direct Sparse Odometry), Bundle Assignment.

UNIT – IV: Localization and Mapping

Localization and Mapping, Initialization, Tracking, Mapping, Geometric SLAM Formulations (Indirect vs. Direct Error Formulation, Geometry Parameterization, Sparse vs. Dense Model, Optimization Approach), Relocalization and Map Optimization, Visual SLAM. Examples: Indirect (Feature Based) Methods (MonoSLAM, PTAM, ORB-SLAM), Direct Methods (DTAM, LSD- SLAM), Sensor Combinations (IMU, Mono vs. Stereo, RGB-Depth), Analysis and Parameter Studies.

UNIT –V: Recognition and Interpretation in Robotic Vision

Recognition and Interpretations, Concepts of Machine Learning and Deep Learning, Sequence Modeling, Learning for Robotic Vision: Active Learning, Incremental and Class Incremental Learning Identify Unknowns, Uncertainty Estimation and Embodiment for Robotic Vision, Active Vision, Spatial and Temporal Embodiment, Reasoning for Object, Scene and Scene Semantics.

TEXT BOOKS:

1. Sensors for Mobile Robots: Theory and Application, H. R. Everett, A K Peters / CRC Press, 2nd Edition, published July 15, 1995.
2. Robotic Tactile Sensing: Technologies and System, Ravinder S. Dahiya and Maurizio Valle, Springer, 1st Edition, 2013.

REFERENCE BOOKS:

1. Simulation Modeling and Analysis, Averill M. Law and W. David Kelton, McGraw-Hill, 2nd Edition, 1991
2. Discrete Event System Simulation, Jerry Banks and John J. S. Carson II, Prentice-Hall, 1st Edition, 1984.
3. Introduction to Autonomous Robots: Mechanisms, Sensors, Actuators, and Algorithms, Nikolaus Correll, Bradley Hayes, Patrick Beeson, and Amit Talwalkar, MIT Press, 2nd Edition, 2022.
4. Robotics, Vision and Control: Fundamental Algorithms In MATLAB, Peter Corke, Springer, 2nd Edition, 2017.
5. Computer Vision: Algorithms and Applications, Richard Szeliski, Springer, 2nd Edition, 2022.
6. Introduction to Autonomous Mobile Robots, Roland Siegwart, Illah R. Nourbakhsh and Davide Scaramuzza, MIT Press, 2nd Edition, 2011.

I Semester	INTELLIGENT SYSTEMS AND INTERFACES (Program Elective – I)	L	T	P	C
		3	0	0	3

Course Objectives: The course aims to:
1. Introduce the principles and architectures of intelligent systems and human-computer interfaces.
2. Explain the integration of artificial intelligence techniques into real-time and embedded systems.
3. Explore natural user interfaces including voice, gesture, and touch-based interactions.
4. Develop understanding of adaptive systems that learn user behavior and provide context- aware responses.
5. Expose students to design, implementation, and evaluation of intelligent interactive systems.

Course Outcomes: Upon successful completion of this course, the student will be able to:
1. Understand the design and architecture of intelligent systems with user-centered interfaces.
2. Apply AI and machine learning techniques in building adaptive and interactive systems.
3. Design multimodal interfaces using speech, gesture, and visual inputs for enhanced interaction.
4. Develop context-aware applications capable of sensing, interpreting, and responding to user environments.
5. Evaluate the performance and usability of intelligent systems and recommend improvements based on user feedback and data analytics.

UNIT – I: Language Processing and Parsing

Language Processing, Computational Phonology, Issues, Phonological Rules, Mapping Text to Phones, Prosody in TTS, Probabilistic Models of Pronunciation and Spelling, N-Grams. Syntax: Word Classes and POS Tagging, CFG for English, Lexicalized and Probabilistic Parsing.

UNIT – II: Semantics, Pragmatics, and Machine Learning

Semantic Representation, Semantic and Lexical Analysis and Word Sense Disambiguation, IR, Pragmatics, Discourse, Dialogue Agents, Natural Language Generation and Machine Translation. Machine Learning: Data Mining, Association Rules, Clustering, Decision Trees and Text Mining.

UNIT – III: Synergetic and Neural Network Techniques

Synergetic Techniques, Synergetic Learning Systems, Concept, Architecture and Algorithm, Basics of Genetic Algorithms, Artificial Neural Network Techniques for Machine Learning.

UNIT – IV: Bioinformatics and Intelligent Interfaces

Application to Bio Informatics, Intelligent Interfaces, Incorporating Intelligence, Requirements, Design Issues, Applications, Development of Intelligent Interfaces for Systems, Stand Alone Systems like OS, Databases, Physical Machines Including Robots.

UNIT – V: Web Applications and Intelligent Systems

Web Based Application, Intelligent Tutoring Systems, Design and Developmental Methods, Methods of Web Mining, E Shopping, E-Commerce Chat Box, Augmented Reality.

TEXT BOOKS:

1. Speech and Language Processing, Daniel Jurafsky and James H. Martin, Pearson Education, 1st Edition, 2000.
2. Building Natural Language Generation Systems, Ehud Reiter and Robert Dale, Cambridge University Press, 1st Edition, 2000.

REFERENCE BOOKS:

1. Machine Learning, Tom M. Mitchell, McGraw-Hill (MGH), 1st Edition, 1997.
2. Data Mining: Concepts and Techniques, Jiawei Han and Micheline Kamber, Morgan Kaufmann Publishers, 1st Edition, 2000.
3. Intelligent Systems: Architecture, Design and Control, P. S. Grover and Manisha Grover, Oxford University Press, 1st Edition, 2016.
4. Human-Computer Interaction, Alan Dix, Janet Finlay, Gregory D. Abowd and Russell Beale, Pearson, 3rd Edition, 2004.
5. Designing User Interface: Strategies for Effective Human-Computer Interaction, Ben Shneiderman and Catherine Plaisant, Pearson, 6th Edition, 2017.
6. Pattern Recognition and Machine Learning, Christopher M. Bishop, Springer, 1st Edition, 2006.

I Semester	MATHEMATICAL FOUNDAITONS FOR ROBOTICS & AI (Program Elective – I)	L	T	P	C
		3	0	0	3

Course Objectives:

1. Compute with integers, fractions, and decimals.
2. Apply the rules of order of operation to simplify numerical expressions.
3. Perform calculations and conversions using the U.S. and metric systems of measurement.
4. Demonstrate the use of ratios, proportions, and percentages.
5. Calculate the perimeter, circumference, area, and volume of geometric figures.

Unit-I

Linear Algebra Basics: Vector spaces and subspaces, basis and dimensions, linear transformation, four fundamental subspaces.

Unit-II

Matrix Theory: Norms and spaces, Eigen values and eigenvectors, Special Matrices and their properties, least squared and minimum normed solutions.

Matrix Decomposition Algorithms-SVD: Properties and applications, low rank approximations, Gram Schmidt process, polar decomposition.

Unit-III

Dimensions Reduction Algorithms and JCF: Principal component analysis, linear discriminate analysis, minimal polynomial and Jordan canonical form.

Calculus: Basic concepts of calculus: Partial derivatives, gradient, directional derivatives, Jacobian, hessian, convex sets, convex functions and its properties.

Unit-IV

Optimization: Unconstrained and Constrained optimization, Numerical optimization techniques for constrained and unconstrained optimization: Newton's method, Steepest descent method, Penalty function method.

Unit-V

Probability: Basic concepts of probability: Conditional probability, Bayes' theorem, independence, theorem of total probability, expectation and variance, few discrete and continuous distributions, joint distributions and covariance.

Support Vector Machines: Introduction to SVM, Error minimizing LPP, concepts of duality, hard and soft margin classifiers.

Text Books:

1. W. Cheney, Analysis for Applied Mathematics. New York: Springer Science + Business Medias, 2001.
2. S. Axler, Linear Algebra Done Right (Third Edition). Springer International Publishing, 2015.

Reference Books:

1. J. Nocedal and S.J. Wright, Numerical Optimization. NewYork: Springer Science + Business Media, 2006.
2. J.S. Rosenthal, A First Look at Rigorous Probability Theory (Second Edition). Singapore: World Scientific Publishing, 2006.
3. Marc Perter Deisenroth, A. Aldo Faijal, Cheng Soon Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.
4. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley Publication, 2001

Course Outcomes:

The students will be able to

1. Understand and apply basic concepts of linear algebra and matrix theory.
2. Define various concepts in multivariable calculus and solve problems.
3. Apply various techniques of optimization.
4. Use probability theory in problem solving.
5. Understand support vector machines and error minimization.

Demonstrate capacity for mathematical reasoning through analyzing, proving and explaining concepts from the foundations of mathematics

I Semester	INTRODUCTION TO QUANTUM TECHNOLOGIES	L	T	P	C
	(Program Elective – I)	3	0	0	3

COURSE OBJECTIVES:

- To introduce fundamental concepts of quantum mechanics and its mathematical formalism.
- To explore quantum computing and communication principles and technologies.
- To understand the physical implementation and limitations of quantum systems.
- To enable students to relate quantum theory to practical applications in computing, cryptography, and sensing.
- To familiarize students with the emerging trends in quantum technologies.

COURSE OUTCOMES:

Upon successful completion of this course, the student will be able to:

	Course Outcome	*BTL (K#)*
CO1	Explain core principles of quantum mechanics and their technological implications.	K2
CO2	Analyze quantum phenomena like superposition and entanglement.	K4
CO3	Apply mathematical tools to model and solve quantum systems.	K3
CO4	Demonstrate understanding of quantum algorithms and quantum circuits.	K2 & K3
CO5	Evaluate potential applications and challenges in quantum communication and sensing.	K5

 # Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: ***Remember***	**K2:** ***Understand***	**K3:** ***Apply***
K4: ***Analyse***	**K5:** ***Evaluate***	**K6:** ***Create***

Unit Description	*Contact Hrs.*
UNIT – I: **Fundamentals of Quantum Mechanics:** Historical background: Blackbody radiation, photoelectric effect, and Compton scattering; Dual nature of light and matter; De Broglie hypothesis; Schrodinger equation; Free particle, infinite potential well, step potential; Operators and observables: position, momentum, Hamiltonian; Commutation relations and uncertainty principle; Quantum postulates and measurement theory; Eigenvalues, eigenfunctions.	**[10]**
UNIT – II: **Quantum Information Theory:** Classical vs. quantum information; Qubit representation using Bloch sphere; Quantum superposition and quantum entanglement; Dirac notation (bra-ket), tensor products, and composite systems; Bell states; Quantum gates: Pauli-X, Y, Z; Hadamard; Phase; T; CNOT; Quantum circuit models and notation; Measurement in computational basis; Quantum teleportation and no-cloning theorem; Quantum state tomography (introductory)	**[10]**

UNIT – III:

Quantum Computing: Classical computing review and limitations; Quantum parallelism and interference; Deutsch and Deutsch-Jozsa algorithms; Grover's search algorithm, Oracle and amplitude amplification; Shor's factoring algorithm (overview and significance); Quantum Fourier Transform (QFT); Quantum error correction: Bit-flip, phase-flip, Introduction to quantum programming: Qiskit(overview) **[12]**

UNIT – IV:

Quantum Communication: Introduction to quantum cryptography; Quantum key distribution (QKD): BB84 protocol; Entanglement-based QKD: Ekert protocol (E91); Eavesdropping and security of QKD; Quantum teleportation (circuit and protocol); Quantum dense coding; Quantum networks and entanglement swapping; Role of quantum repeaters; Single-photon sources and detectors; Implementation challenges (loss, decoherence, noise) **[09]**

UNIT – V:

Quantum Technologies and Applications: Quantum sensors: magnetometry, gravimetry; Quantum metrology: standard time, atomic clocks; Quantum imaging and lithography; Quantum materials: topological insulators, graphene, quantum dots; NV centers in diamonds for sensing; Hardware platforms: Superconducting qubits, Trapped ions, Photonic quantum processors; Quantum supremacy and NISQ era. **[07]**

TEXTBOOKS:

1. "Quantum Computation and Quantum Information" by Michael A. Nielsen and Isaac L. Chuang
2. "Quantum Mechanics: Concepts and Applications" by Nouredine Zettili

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,

I Semester	MACHINE LEARNING	L	T	P	C
	(Program Elective – II)	3	0	0	3

Course Objectives: The course aims to:

1. To introduce the fundamental concepts and algorithms of machine learning.
2. To study supervised, unsupervised, and reinforcement learning techniques.
3. To explore feature selection, dimensionality reduction, and model evaluation methods.
4. To apply machine learning for pattern recognition, prediction, and classification tasks.
5. To develop skills in implementing machine learning algorithms using programming tools.

Course Outcomes: After completing this course, students will be able to,

1. Explain the basic principles and types of machine learning approaches.
2. Select and apply suitable algorithms for classification, regression, and clustering.
3. Evaluate and improve machine-learning models using performance metrics.
4. Implement ML algorithms using tools such as Python, Tensor Flow, or Scikit-learn.
5. Apply machine-learning solutions to real-world engineering and industrial problems.

UNIT – I: Concepts of Machine Learning

Types of Machine Learning, Supervised, Unsupervised and Reinforcement Learning, Various Packages used for Machine Learning, Data Visualization, Splitting the Data into Training and Validation.

UNIT – II: Supervised Learning - I

Linear Regression Technique, Logistic Regression Technique and Hierarchical Cluster Analysis, Significance of using Decision Tree, Types of Decision Trees, Theory on Hyperplane and Kernels, Strategies to Implement Transformations such as Translation, Scaling, Rotation, Mirror Reflection, Shearing for Simple Geometries.

UNIT – III: Supervised Learning - II

Bayesian Classification, Perceptrons, Multi-Layer Perceptron, RBF Networks, Regression Model, Support Vector Machines, Convolutional Neural Networks, Recurrent Neural Networks, Random Forest, Mathematical Concepts, Native Bayes Theorem, Limitation of Naïve Bayes Theorem, K Nearest Neighbors Algorithm.

UNIT – IV: Unsupervised Learning

K-Means Clustering, DBSCAN, Non-Parametric Estimation, Mean Shift Clustering, Classification Performance Analysis, Ensemble Methods, Boosting and Bagging.

UNIT –V: Reinforcement and Deep Learning

Reinforcement Learning, Learning Task, Q Learning, Temporal Difference Learning, Relationship to Dynamic Programming, Generalizing from Examples. Introduction To Deep Learning, Applications: Structure Mapping, Case Studies In Robotics.

TEXT BOOKS:

1. Machine Learning, Tom Mitchell, McGraw Hill Publishers, 1st Edition, 1997.
2. Introduction to Machine Learning, Alpaydin, Prentice Hall, 3rd Edition, 2015.

REFERENCE BOOKS:

1. Neural Networks and Learning Machines, S. O. Haykin, Pearson Education (India), 3rd Edition, 2016.
2. Deep Learning, Ian Goodfellow, Yoshua Bengio and Aaron Courville, MIT Press,1st Edition, 2017.
3. Pattern Recognition and Machine Learning, Christopher M. Bishop, Springer, 1st Edition, 2006.
4. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, Aurélien Géron, O'Reilly Media, 2nd Edition, 2019.
5. The Elements of Statistical Learning, Trevor Hastie, Robert Tibshirani and Jerome Friedman, Springer, 2nd Edition, 2009.
6. Deep Learning, Ian Goodfellow, Yoshua Bengio and Aaron Courville, MIT Press, 1st Edition, 2016.
7. Machine Learning: A Probabilistic Perspective, Kevin P. Murphy, MIT Press, 1st Edition, 2012.
8. Understanding Machine Learning: From Theory to Algorithms, Shai Shalev-Shwartz and Shai Ben-David, Cambridge University Press, 1st Edition, 2014.
9. Bayesian Reasoning and Machine Learning, David Barber, Cambridge University Press, 1st Edition, 2012.

I Semester	SMART MANUFACTURING (Program Elective – II)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- This course is introduced to impart the knowledge of smart manufacturing for industry 4.0 for making student innovative.

COURSE OUTCOMES:
Upon successful completion of this course, the student will be able to:

	Course Outcome	*BTL (K#)*
CO1	Employ the concept of Industry 4.0 for Smart Manufacturing and analyse the challenges more effectively in context of Industry 4.0.	K3 & K4
CO2	Recognize the requirement for different hardware and software, as well as the IoT Layers and their relative significance, in order to construct an Industry 4.0-compliant smart machine interface.	K2 & K4
CO3	Describe the Architecture of Cyber – Physical System (CPS) and apply to make the machines more oriented towards Industry 4.0 in enhancing the productivity.	K2 & K3
CO4	Describe the cloud-computing IoT platform for smart manufacturing and apply the AI & ML techniques in analysing the predictive maintenance of manufacturing systems.	K3& K4
CO5	Demonstrate the application of hardware, communication protocol, IOT platform, machine learning etc. to implement IoT for smart manufacturing for the need of Industry 4.0.	K2

 # Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: ***Remember***	**K2:** ***Understand***	**K3:** ***Apply***
K4: ***Analyse***	**K5:** ***Evaluate***	**K6:** ***Create***

Unit Description	*Contact Hrs.*
<u>UNIT – I:</u>	
Concepts of Smart Manufacturing: Definition and key characteristics of smart manufacturing, corporate adaptation processes, manufacturing challenges, challenges vs technologies, Stages in smart manufacturing. Minimizing Six big losses in manufacturing with Industry 4.0, and their benefits.	**[10]**
<u>UNIT – II:</u>	
Smart Machines and Smart Sensors: Concept and Functions of a Smart, Machine Salient features and Critical Subsystems of a Smart Machine, Smart sensors; smart sensors ecosystem, need, benefits and applications of sensors in industry, Sensing for Manufacturing Process in IIoT, Block Diagram of aIIoT Sensing Device, Sensors in IIoT Applications, Smart Machine Interfaces.	**[10]**

UNIT – III:

Architecture of Cyber- Physical system (CPS): Functions of CPS, 5C Architecture; Smart Connection Level, Data-to- Information Level, Cyber Level, Cognition Level, Configuration Level. Design of PHM based CPS systems. Comparison of today's factory and Industry 4.0 factory by the implementation of 5C CPS architecture. **[12]**

UNIT – IV:

Digital Twin: Introduction, applications of digital twins, impact zones of digital twins in manufacturing (factories/plants and OEMs), advantages of digital twins, basic steps of digital twin technology.

Predictive Maintenance: Introduction of predictive maintenance, difference between preventive and predictive maintenance, working and various components of predictive maintenance, benefits and tools of predictive maintenance. Common approaches to IoT predictive maintenance; Rule-based (condition monitoring) and AI (artificial intelligence) based predictive maintenance. **[09]**

Augmented Reality in Maintenance (Electrical & Mechanical).

UNIT – V:

IoT connectivity for Industry 4.0: Industrial communication requirement and its infrastructure, an overview of different types of networks, mesh network in industrial IoT, IoT protocols and the internet, TCP/IP (transmission control protocol/internet protocol) model, IoT connectivity standards: common protocols, application layer protocols, internet/network layer protocols, physical layer IoT protocols, choosing the right IoT connectivity protocol. **[07]**

TEXTBOOKS:

1. Industry 4.0 The Industrial Internet of Things by Alasdair Gilchrist, Apress.
2. Industrial Internet of Things, Cyber Manufacturing System by Sabina Jeschke, Christian Brecher, Houbing Song Danda B. Rawat, Springer.

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,

I Semester	MECHATRONICS SYSTEM DESIGN (Program Elective – II)	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To impart the basic knowledge and importance on Mechatronics in Engineering Fields among the students.
- To create the awareness on Mechatronics in Research and Application area.
- To impart the knowledge about the application and utility of Mechatronics used in various sectors and fields.

COURSE OUTCOMES:
Upon successful completion of this course, the student will be able to:

	Course Outcome	*BTL (K#)*
CO1	Identification and demonstration of key elements of mechatronics system and its representation in terms of block diagram.	K2
CO2	Describe the use of solid-state electronic devices, diodes, amplifiers, etc. in designing the mechatronics systems and MEMS.	K2
CO3	Illustrate the applications of various hydraulic, pneumatic, mechanical, electrical actuating systems and valves in designing the mechatronic systems.	K3
CO4	Develop the PLC ladder programming for the creation of real-time mechatronic system.	K6
CO5	Develop dynamic models using system interfacing and data acquisition methods to design mechatronics systems for future applications.	K6

 # Based on suggested Revised Blooms Taxonomy Level (BTL)

K1:	***Remember***	K2:	***Understand***	K3:	***Apply***
K4:	***Analyse***	K5:	***Evaluate***	K6:	***Create***

Unit Description — *Contact Hrs.*

UNIT – I:

Mechatronics systems, elements, levels of mechatronics system, Mechatronics design process, system, measurement systems, control systems, microprocessor-based controllers, advantages and disadvantages of mechatronics systems. Sensors and transducers, types, displacement, position, proximity, velocity, motion, force, acceleration, torque, fluid pressure, liquid flow, liquid level, temperature and light sensors. **[10]**

UNIT – II:

Solid state electronic devices, Analog signal conditioning, amplifiers, filtering. Introduction to MEMS & typical applications. System and interfacing and data acquisition, DAQS, Analogue to Digital and Digital to Analogue conversions **[10]**

UNIT – III:

Hydraulic and pneumatic actuating systems, Fluid systems, Hydraulic and pneumatic systems, components, control valves, electro-pneumatic, hydro- **[12]**

pneumatic, electro-hydraulic servo systems, Mechanical actuating systems and electrical actuating systems.

UNIT – IV:

Digital electronics and systems, digital logic control, microprocessors and micro controllers, programming, process controllers, programmable logic controllers, PLCs versus computers, application of PLCs for control. **[09]**

UNIT – V:

Dynamic models and analogies, System response. Design of mechatronics systems & future trends. Modeling and analysis of mechatronics systems (case studies) **[07]**

TEXTBOOKS:

1. MECHATRONICS Integrated Mechanical Electronics Systems/KP Ramachandran & GK VijayaRaghavan/WILEY India Edition/2008.
2. Mechatronics Electronics Control Systems in Mechanical and Electrical Engineering by W Bolton, Pearson Education Press, 3rd edition, 2005.

REFERENCE BOOKS:

1. Mechatronics Source Book by Newton C Braga, Thomson Publications, Chennai.
2. Mechatronics – N. Shanmugam / Anuradha Agencies Publishers.
3. Mechatronics System Design / Devdasshetty / Richard / Thomson.
4. Mechatronics / M.D. Singh / J.G. Joshi/PHI.
5. Mechatronics – Electronic Control Systems in Mechanical and Electrical Engg. 4th Edition, Pearson, 2012 W. Bolton.
6. Mechatronics – Principles and Application Godfrey C. Onwubolu, Wlsevier, 2006 Indian print.

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,

I Semester	DRIVES AND CONTROL SYSTEMS FOR ROBOTS	L	T	P	C
	(Program Elective – II)	3	0	0	3

Course Objective:
To impart knowledge about various drive systems and its selection for particular applications

Unit I
Robot Drive Mechanism: Objectives, motivation, open loop control, closed loop control with velocity and position feedback, Types of drive systems. Functions of drive system. Lead Screws, Ball Screws, Chain & linkage drives, Belt drives, Gear drives, Precision gear boxes, Harmonic drives, Cycle speed reducers.

Unit II
Hydraulic Drives: Introduction, Requirements, Hydraulic piston and transfer valve, hydraulic circuit incorporating control amplifier, hydraulic fluid considerations, hydraulic actuators Rotary and linear actuators. Hydraulic components in robots.

Unit III
Pneumatic Drives: Introduction, Advantages, pistons-Linear Pistons, Rotary pistons, Motors- Flapper motor, Geared motor, Components used in pneumatic control. Pneumatic proportional controller pneumatically controlled prismatic joint.

Unit IV
Electric Drives: Introduction, Types, DC electric motor, AC electric motor, stepper motors, half step mode operation, micro step mode. Types of stepper motors, Direct drive actuator.

Unit V
Servo Systems for Robot Control: General aspects of robot control. Basic control techniques, mathematical modeling of robot servos, error responses and steady state errors in robot servos, feedback and feed forward compensations, hydraulic position servo, computer-controlled servo system for robot applications, selection of robot drive systems.

Text Books:
1. R Kelly, D. Santibanez, LP Victor and Julio Antonio, “Control of Robot Manipulators in Joint Space”, Springer, 2005.
2. A Sabanovic and K Ohnishi, “Motion Control Systems”, John Wiley & Sons (Asia), 2011.

Reference Books:

1. Francis N-Nagy Andras Siegler, Engineering foundation of Robotics, Prentice Hall Inc., 1987.
2. Richard D. Klafter, Thomas. A, Chri Elewski, Michael Negin, Robotics Engineering an Integrated Approach, Phi Learning., 2009.
3. P.A. Janaki Raman, Robotics and Image Processing an Introduction, Tata Mc Graw Hill Publishing company Ltd., 1995.
4. Mikell P Groover & Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, Industrial Robotics, Technology programming and Applications, Tata McGraw-Hill Education, 2012.
5. Bernard Hodges, Industrial Robotics, Second Edition, Jaico Publishing house, 1993.
6. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, PHI Learning., 2009.
7. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, MIT Press., 2003.
8. John J. Craig, Introduction to Robotics Mechanics and Control, Third Edition, Pearson, 2008.

Course Outcomes:

The students will be able to

1. Understand various types of drive systems.
2. Select a drive system for a particular application.
3. Know the accurate positioning of the robot end effectors with error compensation by servo control.
4. To understand working principles of various types of mo tors, differences, characteristics and selection criteria.
5. To apply the knowledge in selection of motors, heating effects and braking concepts in various industrial applications.
6. Develop nonlinear observer schemes.

I Semester	ROBOTICS SIMULATION LAB	L	T	P	C
		0	1	2	2

Course Objectives: The course aims to:

1. Provide hands-on experience in modeling, simulating, and controlling robotic systems using simulation tools.
2. Enable students to understand and implement forward and inverse kinematics, path planning, and trajectory generation.
3. Familiarize students with robot programming environments and visualization platforms.
4. Integrate sensing, actuation, and control in a simulated environment.
5. Prepare students for real-world robotic applications through virtual testing and debugging.

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Model and simulate robotic manipulators using kinematic and dynamic principles.
2. Implement forward and inverse kinematics algorithms using simulation tools like MATLAB, ROS, or Gazebo.
3. Design motion planning and trajectory generation routines for various robotic applications.
4. Integrate sensors and actuators virtually to simulate closed-loop control systems.
5. Develop and test robotic algorithms in a simulated environment and analyze their performance.

List of Experiments:

1. Dynamic model development and simulation of simple mechanical systems using Matlab and Mathematica.
2. Numerical simulation of simple mechanical systems.
3. Stability analysis of simple mechanical systems using linear system theory namely root locus and Bodeplot.
4. State space model development and dynamic simulation using Simulink.
5. Model a single degree of freedom spring–mass–damper system using MATLAB Simscape Multibody to analyze natural frequency, damping, and parameter effects.
6. Simulate a crankshaft–rod–piston assembly using MATLAB Simscape Multibody to study kinematics, angular velocity distribution, and bearing reaction forces.
7. Create and validate hydraulic components using MATLAB Simscape Multibody and integrate them with multibody mechanics for performance analysis.
8. Build and control a complete hydraulic actuation system with load using MATLAB Simscape Multibody to analyze dynamic performance and stability.
9. Model and control a multi–degree of freedom robot manipulator using MATLAB Simscape Multibody to validate kinematics, dynamics, and trajectory tracking.Mobile robot control using Matlab/Simulink.
10. Acquiring Data from Sensors and Instruments Using MATLAB.
11. Developing Kinematics (Forward and Inverse of popular configurations using simulations.

Lab Manuals:

1. Dynamic Model Development and Simulation of Mechanical Systems Using MATLAB and Mathematica, Peter W. Christensen, Springer, 1st Edition, 2022.
2. Numerical Simulation of Mechanical Systems with MATLAB, William B. J. Zimmerman, Elsevier, 2nd Edition, 2020.
3. Linear System Theory and Stability Analysis with MATLAB, Chi-Tsong Chen, Oxford University Press, 4th Edition, 2019.
4. State-Space Modeling and Simulation Using Simulink, Brian D. Hahn, Elsevier, 3rd Edition, 2021.
5. Simscape Multibody Simulation with MATLAB and Simulink, Michael Tan, MathWorks Press, 1st Edition, 2022.
6. Mobile Robot Control with MATLAB and Simulink, Bruno Siciliano, Springer, 2nd Edition, 2021.
7. Data Acquisition Using MATLAB, Gary W. Johnson, CRC Press, 2nd Edition, 2020.
8. Robot Kinematics and Dynamics with MATLAB Simulation, John J. Craig, Pearson, 4th Edition, 2021.

I Semester	ARTIFICIAL INTELLIGENCE PROGRAMMING LAB	L	T	P	C
		0	1	2	2

Course Objectives:

1. Provide practical exposure to implementing AI concepts and algorithms.
2. Enable students to solve problems using uninformed and informed search strategies.
3. Teach the design of knowledge representation systems using logic and rules.
4. Develop reasoning and inference engines using forward and backward chaining.
5. Introduce AI-based applications in areas such as games, planning, and intelligent agents.

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Implement classical search algorithms such as BFS, DFS, A*, and Greedy search.
2. Design knowledge bases using propositional and predicate logic.
3. Implement reasoning systems using rule-based logic programming.
4. Develop intelligent agents for applications such as path planning, decision-making, and game strategies.
5. Utilize AI libraries and tools in Python or Prolog to develop and test simple AI systems.

List of Experiments:

1. Installing Python interpreter and working on simple programs to understand programming concepts in python.
2. Write the program to explore strings, tuples, lists, dictionaries, set and dictionary comprehensions.
3. Installing and setup the Anaconda, Spyder, Jupyter notebook environments.
4. Installing basic modules related to machine learning like numpy, pandas, json, scikit-learn, Scipy, open CV.
5. Working with machine learning programs: Linear Regression, Logistic Regression, SVM, Decision trees, KNN, Naive Bayes
6. Basic Electronics using Raspberry PI - Raspbian Installation, Connecting via SSH, Simple LED lightning programs, Motor speed control with PWM and working with basic sensors like ultrasonic, infrared and buzzers,
7. Working with camera module Open CV and Mediapipe - Basic image operations, Contours, gray scale conversion, Drawing and writing on Image, Working with video stream, Face detection, Object detection using Haar Cascade.
8. AI Based programming tools like classical AI – LISP, Prolog, Tensor Flow.
9. Exploring H20 in AI, Cortana and IBM WATSON.
10. Develop and analyze ANN models using the ANN Virtual Lab.
11. Perform pattern recognition tasks using the ANN Virtual Lab.
12. Apply ANN techniques for optimization problems using the ANN Virtual Lab.
13. Implement ANN applications in image processing using the ANN Virtual Lab.

Note: Perform any 10 out of 13 Exercises

I Semester	SEMINAR - 1	L	T	P	C
		0	0	2	1

II SEMESTER

II Semester	SENSORS ACTUATORS AND EMBEDDED SYSTEMS FOR ROBOTICS (Programme Core 1)	L	T	P	C
		3	1	0	4

Course Objective:
This course emphasizes on comprehensive treatment of embedded hardware and real time operating systems along with case studies, in tune with the requirements of Industry. The objective of this course is to enable the students to understand embedded-system programming and apply that knowledge to design and develop embedded solutions.

Unit-I

Examples of Embedded Systems: Typical Hardware, Memory, Microprocessors Busses, Direct Memory Access, Introduction to 8051 Microcontroller, Architecture-Instruction set, Programming.

Microprocessor Architecture: Interrupt Basics, The Shared-Data problem, Interrupt Latency.

Unit-II

Round–Robin Architecture: Round–Robin with Interrupts Architecture, Function- Queue, Scheduling Architecture, Real-Time Operating Systems Architecture, Selection of Architecture.

Tasks and Task States: Tasks and Data, Semaphores and Shared Data, Semaphore Problems, Semaphore variants.

Unit-III

Message Queues: Mailboxes, Pipes, Timer Functions, Events, Memory Management, Interrupt Routines in RTOS Environment.

UNIT – IV: Vision Sensors

Vision System Devices, Image Acquisition, Masking, Sampling and Quantization, Image Processing Techniques, Noise Reduction Methods, Edge Detection, Segmentation. Advanced Sensor Technology: Smart Sensors, MEMS Based Sensors, Innovations in Sensor Technology.

UNIT – V: Actuators and Its Selection While Designing a Robot System

Types of Transmission Systems, Electric Actuators: Direct Current Motor, Permanent Magnet Stepper Motor, Servo Control DC Motors, Linear and Latching Linear Actuators, Rotatory Actuators, Piezoelectric Actuators, Actuator Parameters and Characteristics, Stepper Motors, Specifications and Characteristics of Stepper Motors, Servomotors.

II Semester	AUTONOMOUS VEHICLES AND DRONES (Programme Core 2)	L	T	P	C
		3	1	0	4

Course Objectives:

1. To introduce the concepts and technologies behind autonomous vehicles.
2. To understand the sensors, perception, and decision-making systems used in autonomous driving.
3. To study control strategies and algorithms for vehicle navigation and path planning.
4. To analyze safety, security, and regulatory aspects of autonomous vehicles.
5. To explore real-world applications and challenges in autonomous vehicle development.

Course Outcomes: After completing this course, students will be able to:

1. Explain the fundamentals of autonomous vehicle systems and their components.
2. Analyze sensor technologies and data fusion techniques used for perception.
3. Develop algorithms for vehicle localization, path planning, and control.
4. Evaluate safety and ethical issues related to autonomous driving.
5. Design basic autonomous vehicle models addressing real-world driving scenarios.

UNIT – I: Mobile Robots

Introduction to Mobile Robots and Mobile Manipulators. Principle of Locomotion and Types of Locomotion. Types of Mobile Robots: Ground Robots (Wheeled and Legged Robots), Aerial Robots, Underwater Robots and Water Surface Robots.

Unit II: Introduction to drone technology

Types of Drones, Drone components (Motors, ESC, flight controllers), fundamental aerodynamics, sensors and its integration, path planning algorithms (RRT, A*), obstacle avoidance techniques (potential fields, collision cones, control barrier functions), trajectory tracking, and an introduction to simultaneous localization and mapping (SLAM)

UNIT - III: Sensors and Navigation

Sensors for Mobile Robot Navigation: Magnetic and Optical Position Sensor, Gyroscope, Accelerometer, Magnetic Compass, Inclinometer, Tactile and Proximity Sensors, Ultrasound Rangefinder, Laser Scanner, Infrared Rangefinder, Visual and Motion Sensing Systems. Robot Navigation: Localization, Error Propagation Model, Probabilistic Map Based Localisation, Autonomous Map Building, Simultaneous Localization and Mapping (SLAM).

UNIT - IV: Path Planning and Control

Motion and Path Planning: Collision Free Path Planning and Sensor-Based Obstacle Avoidance. Motion Control of Mobile Robots: Motion Controlling Methods, Kinematic Control, Dynamic Control and Cascaded Control.

UNIT - V: Advanced Mobile Robots

Introduction to Modern Mobile Robots: Swarm Robots, Cooperative and Collaborative Robots, Mobile Manipulators, Autonomous Mobile Robots.

TEXT BOOKS:

1. The Complete Guide to Drones – Adam Juniper
2. Material Handling Equipment, Michael G. Kay, Pearson Education, 2nd Edition, 2015
3. Mobile Robots: Navigation, Control and Sensing, Surface Robots and AUVs, Gerald Cook and Feitian Zhang, Wiley Publishers, 1st Edition, 2007

REFERENCE BOOKS:

1. Wheeled Mobile Robots, Kevin M. Lynch and Franck C. Park, Cambridge University Press, 1st Edition, 2011.
2. Introduction to Autonomous Mobile Robots, Roland Siegwart, Illah Reza Nourbakhsh and Davide Scaramuzza, The MIT Press, 2nd Edition, 2011.
3. Autonomous Driving: Technical, Legal and Social Aspects, Markus Maurer, J. Christian Gerdes, Barbara Lenz, Hermann Winner, Springer, 1st Edition, 2016.
4. Self-Driving Cars: The Road to Autonomy, Steven E. Shladover, Springer, 1st Edition, 2020.
5. Introduction to Autonomous Robots, Nikolaus Correll, Bradley Hayes, Patrick Beeson, and Amit Talwalkar, MIT Press, 1st Edition, 2018.
6. Vehicle Dynamics and Control, Rajesh Rajamani, Springer, 2nd Edition, 2011.
7. Robot Operating System (ROS) for Absolute Beginners: Robotics Programming Made Easy, Lentin Joseph, Apress, 2nd Edition, 2019.
8. Mobile Robotics: Mathematics, Models, and Methods, Alonzo Kelly, Cambridge University Press, 1st Edition, 2013.
9. Artificial Intelligence for Autonomous Vehicles, Amit Kumar Tyagi, Wiley, 1st Edition, 2020.

II Semester	ADVANCES IN ARTIFICIAL INTELLIGENCE (Programme Core 3)	L	T	P	C
		3	1	0	4

Course Objectives (COB):

The course aims to:

1. Provide a strong foundation in the fundamentals of neural networks and deep learning.
2. Introduce optimization methods and training strategies for deep models.
3. Familiarize students with different architectures such as CNNs, RNNs, LSTMs, and GANs.
4. Enable students to apply deep learning techniques to real-world domains like computer vision, natural language processing, and speech recognition.
5. Develop practical skills using deep learning frameworks and tools to design and evaluate intelligent systems.

Course Outcomes (CO):

At the end of the course, the student will be able to:

- **CO1:** Explain the basic concepts of artificial neural networks and deep learning architectures.
- **CO2:** Implement optimization techniques and training methods for deep neural networks.
- **CO3:** Analyze and compare different deep learning models such as CNNs, RNNs, LSTMs, and GANs.
- **CO4:** Apply deep learning algorithms to solve problems in vision, NLP, and speech domains.
- **CO5:** Use TensorFlow/PyTorch to design, train, and evaluate deep learning applications.

UNIT – I: Introduction to Neural Networks & Deep Learning

Introduction to AI, Machine Learning, and Deep Learning – similarities and differences, Biological Neural Networks vs Artificial Neural Networks, McCulloch-Pitts neuron model, Perceptron model, and limitations, Multilayer Perceptrons (MLPs) – architecture, forward propagation, Activation Functions – Sigmoid, Tanh, ReLU, Leaky ReLU, Softmax, Swish, GELU, Error Functions – MSE, Cross Entropy, KL Divergence, Gradient Descent, Stochastic Gradient Descent (SGD), Backpropagation – working, derivation, and implementation, Overfitting and Underfitting in deep models

UNIT – II: Optimization & Training of Deep Networks

Cost functions for regression and classification, Gradient-based Optimization – Batch, Stochastic, and Mini-batch approaches, Optimization Algorithms: Momentum, AdaGrad, RMSProp, Adam, AdamW, Learning Rate Scheduling and Adaptive Learning Rates, Regularization – L1, L2, Dropout, Early Stopping, Normalization

Techniques – Batch Normalization, Layer Normalization, Group Normalization, Hyperparameter Tuning – grid

search, random search, Bayesian optimization, Initialization methods: Xavier, He initialization, Vanishing and Exploding Gradient Problem – causes and solutions (e.g., residual networks)

UNIT – III: Convolutional Neural Networks (CNNs)

Convolution operation – filters, strides, padding, receptive fields, Pooling – Max, Average, Global pooling, CNN building blocks: Convolutional layers, Pooling layers, Fully Connected layers, Modern CNN architectures – LeNet-5, AlexNet, VGGNet, GoogLeNet (Inception), ResNet, DenseNet, EfficientNet, Advanced CNN Concepts – Dilated Convolutions, Depthwise Separable Convolutions (MobileNet), Applications: Image classification, object detection (R-CNN, Fast R-CNN, Faster R-CNN, YOLO, SSD), image segmentation (U-Net, Mask R-CNN), Transfer Learning and Fine-Tuning pre-trained models, Data Augmentation techniques for image datasets,

UNIT – IV: Sequence Models

Introduction to Sequential Data and Time-Series Analysis, Recurrent Neural Networks (RNNs) – structure, unfolding in time, vanishing gradient problem, LSTM Networks – gates, cell states, long-term memory, Gated Recurrent Unit (GRU) – simplified LSTM model, Encoder-Decoder architecture for sequence-to-sequence learning, Attention Mechanisms – Self-Attention, Scaled Dot-Product Attention, Transformers – architecture, BERT, GPT overview, Vision Transformers (ViT)

- **Applications:**

Natural Language Processing (NLP) – text classification, sentiment analysis, machine translation, Speech Recognition and Synthesis, Time-Series Prediction (finance, weather, IoT data)

UNIT – V: Advanced Topics & Applications

- **Generative Models:**

Autoencoders – vanilla, sparse, denoising, variational autoencoders (VAE), Generative Adversarial Networks (GANs) – architecture, training issues, variants (DCGAN, CycleGAN, StyleGAN)

- **Reinforcement Learning (RL) + Deep Learning:**

Q-learning and Deep Q Networks (DQN), Policy Gradient methods, Applications in robotics and autonomous systems

- **Graph Neural Networks (GNNs):** basics and applications in chemistry, networks, and social graphs
- **Capsule Networks** – dynamic routing
- **Practical Deep Learning:**

Model deployment, inference optimization (TensorRT, ONNX), Edge AI and mobile deep learning

- **Applications of Deep Learning:**

Healthcare (disease prediction, medical imaging), Autonomous driving (vision + sensor fusion), Finance (fraud detection, algorithmic trading), Smart assistants (speech-to-text, text-to-speech, chatbots)

- **Ethical and Societal Issues:** Bias in AI models, explainability, interpretability, AI safety

Textbooks:

1. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, *Deep Learning*, MIT Press, 2016.
2. François Chollet, *Deep Learning with Python*, Manning Publications, 2nd Edition, 2021.
3. Charu C. Aggarwal, *Neural Networks and Deep Learning: A Textbook*, Springer, 2018.

II Semester	INTERNET OF THINGS (Programme Elective III)	L	T	P	C
		3	0	0	3

Course Objectives:

1. To introduce the fundamental concepts, evolution, and enabling technologies of IoT.
2. To understand the relationship between IoT and Machine-to-Machine (M2M) communication.
3. To develop practical skills in IoT device programming using Arduino and Raspberry Pi.
4. To study various IoT architectures and data management techniques.
5. To analyze the challenges and applications of IoT across different domains like agriculture, healthcare, and smart cities.

Course Outcomes: After completing this course, students will be able to:

1. Explain the basic concepts, architecture, and characteristics of IoT.
2. Differentiate between IoT and M2M and understand their value chains.
3. Program and interface sensors and actuators using Arduino and Raspberry Pi for IoT applications.
4. Describe IoT architectures and manage IoT data effectively.
5. Design IoT systems for real-world applications in various sectors, addressing challenges and emerging technologies.

UNIT – I: Technologies of IoT

Introduction and definition of IoT, Evolution of IoT, IoT growth, Application areas of IoT, Characteristics of IoT, IoT stack, enabling technologies, IoT levels, IoT sensing and actuation, Sensing types, Actuator types.

UNIT - II: IoT and M2M Communication

M2M to IoT, A Basic Perspective, Introduction, Differences and similarities betweenM2M and IoT, SDN and NFV for IoT.M2M Value Chains, IoT Value Chains, An emerging industrial structure for IoT, The international driven global value chain and global information monopolies.

UNIT - III: IoT Practical Implementation

IoT Hands-on: Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino. Introduction to Python programming, Introduction to Raspberry Pi, Interfacing Raspberry Pi with basic peripherals, Implementation of IoT with Raspberry Pi.

UNIT - IV: IoT Architecture and Data Management

IoT Architecture components, Comparing IoT architectures, A simplified IoT architecture, The core IoT functional stack, IoT Data Management and Compute Stack.

UNIT - V: IoT System Design and Applications

IoT System design: Challenges associated with IoT, Emerging pillars of IoT, Agricultural IoT, Vehicular IoT, Healthcare IoT, Smart cities, Transportation and Logistics.

TEXT BOOKS:

1. Introduction to IoT, Sudip Misra, Anandarup Mukherjee and Arijit Roy, Cambridge University Press, 1st Edition, 2019
2. IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for IoT, David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, Cisco Press, 2nd Edition, 2020.

REFERENCE BOOKS:

1. Getting Started with the Internet of Things, Cuno Pfister, O'Reilly Media, 1st Edition, 2011.
2. Rethinking the Internet of Things: A Scalable Approach to Connecting Everything, Francis daCosta, A press Publications, 1st Edition, 2013.
3. Internet of Things: A Hands-on Approach, Arshdeep Bahga and Vijay Madisetti, Universities Press, 1st Edition, 2015.
4. Internet of Things: A Hands-On Approach, Arshdeep Bahga & Vijay Madisetti, Universities Press, 1st Edition, 2014.
5. Building Internet of Things with the Arduino, Charalampos Doukas, Apress, 1st Edition, 2012.
6. Internet of Things: Architecture and Applications, Rajkumar Buyya, Sherali Zeadally & Schahram Dustdar, Wiley, 1st Edition, 2020.
7. Designing the Internet of Things, Adrian McEwen & Hakim Cassimally, Wiley, 1st Edition, 2013.
8. IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton & Jerome Henry, Cisco Press, 1st Edition, 2017.
9. The Internet of Things: Key Applications and Protocols, Olivier Hersent, David Boswarthick & Omar Elloumi, Wiley, 2nd Edition, 2012.
10. Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems, Ovidiu Vermesan & Peter Friess, River Publishers, 1st Edition, 2014.

II Semester	CRYTOGRAPHY AND NETWORK SECURITY (Programme Elective III)	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand basics of Cryptography and Network Security.
2. To be able to secure a message over insecure channel by various means.
3. To learn about how to maintain the Confidentiality, Integrity and Availability of a data.
4. To understand various protocols for network security to protect against the threats in the networks.

Unit-I

Overview: Computer Security Concepts, Threats, Attacks, and Assets, Security Functional Requirements, Security Architecture for Open Systems, Computer Security Trends, Computer Security Strategy. Cryptographic Tools: Confidentiality with Symmetric Encryption, Message Authentication and Hash Functions, Public-Key Encryption, Digital Signatures and Key Management, Random and Pseudorandom Numbers, Practical Application: Encryption of Stored Data. User Authentication: Means of Authentication, Password-Based Authentication, Token-Based Authentication, Biometric Authentication, Remote User Authentication, Security Issues for User Authentication, Practical Application: An Iris Biometric System, Case Study: Security Problems for ATM Systems.

Unit-II

Access Control: Access Control Principles, Subjects, Objects, and Access Rights, Discretionary Access Control, Example: UNIX File Access Control, Role-Based Access Control, Case Study: RBAC System for a

Bank. Database Security: The Need for Database Security, Database Management Systems, Relational Databases, Database Access Control, Inference, Statistical Databases, Database Encryption, Cloud Security.

Unit-III

Malicious Software: Types of Malicious Software (Malware), Propagation—Infected Content—Viruses, Propagation—Vulnerability Exploit—Worms, Propagation—Social Engineering—SPAM E-mail, Trojans, Payload—System Corruption, Payload—Attack Agent—Zombie, Bots, Payload—Information Theft—Key loggers, Phishing, Spyware, Payload—Steal thing—Backdoors, Root kits, Counter measures.

Unit-IV

Denial-of-Service Attacks: Denial-of-Service Attacks, Flooding Attacks, Distributed Denial-of-Service Attacks, Application-Based Bandwidth Attacks, Reflector and Amplifier Attacks, Defenses Against Denial-of-Service Attacks, Responding to a Denial-of-Service Attack.

Intrusion Detection: Intruders, Intrusion Detection, Host-Based Intrusion Detection, Distributed Host-Based Intrusion Detection, Network-Based Intrusion Detection, Distributed Adaptive Intrusion Detection, Intrusion Detection Exchange Format, And Honeypots, Example System: Snort. Firewalls and Intrusion Prevention Systems: The Need for Firewalls, Firewall Characteristics, Types of Firewalls, Firewall Basing, Firewall Location and Configurations, Intrusion Prevention Systems, Example: Unified Threat Management Products.

Unit-V

Buffer Overflow: Stack Overflows, Defending Against Buffer Overflows, Other Forms of Overflow Attacks, Software Security: Software Security Issues, Handling Program Input, Writing Safe Program Code, Interacting with the Operating System and Other Programs, Handling Program Output. Operating System Security: Introduction to Operating System Security, System Security Planning, Operating Systems Hardening, Application Security, Security Maintenance, Linux/Unix Security, Windows Security, Virtualization Security.

Text Book:

1. Computer Security - Principles and Practices (Except the Chapters 13, 14, 15, 16, 17, 18, 19), 2ndEdition by William Stallings, Pearson Education, Inc.

Reference Books:

1. Cryptography and Network Security by William Stallings, Pearson Education Asia, New Delhi.
2. Network Security Essentials Applications and Standards, by William Stallings,Pearson Education Asia, NewDelhi.

Course Outcomes:

The students will be able to

1. Understand various Cryptographic Techniques.
2. Apply various public key cryptography techniques.
3. Implement Hashing and Digital Signature techniques.
4. Understand the various Security Applications.
5. Implement system level security applications.
6. Protect any network from the threats in the world.

II Semester	ROBOTIC SIMULATION AND LOCALIZATION MAPPING (Programme Elective III)	L	T	P	C
		3	0	0	3

Course Objectives:

1. To introduce the fundamentals of robotic systems and their simulation techniques.
2. To understand robotic movements, commands, and programming for effective simulation.
3. To study localization, mapping, and motion planning methods used in robotics.
4. To learn about various robotics simulation tools and software architecture.
5. To analyze robotic motion, design linkages, and control strategies for practical applications.

Course Outcomes: After completing this course, students will be able to:

1. Explain the basics of robotics systems and types of simulation.
2. Apply robotic commands and principles to develop simulations.
3. Analyze localization and mapping techniques for robot navigation.
4. Utilize robotics simulation software and control motion effectively.
5. Design robotic linkages and evaluate motion parameters for specific applications.

UNIT – I: Robotics and Simulation Basics

Introduction to Robotics Systems, Robot Movements, Quality of Simulation, Types of Simulation, Robot Applications, Robotics Simulation Displays. Simulation Notation, Auto Lisp Functions, Features, Command Syntax, Writing Design Functions.

UNIT - II: Robotic Principles and Commands

Robotic Principles: Straight Lines, Angles and Optimal Moves Circular Interpolation, Robotic Functions Geometrical Commands, Edit Commands. Selecting Robot Views, Standard Robot Part, Using the Parts in a Simulation.

UNIT - III: Localization, Mapping and Motion Planning

Localization and Mappings: Introduction, Robotic Perception, Localization, Mappings Planning to Move, Configuration Space, Cell Decomposition Methods, Skeletonization Methods, Planning Uncertain Movements, Robust Methods. Moring, Dynamics and Control, Potential Field Control, Reactive Control, Robotics Software Architecture, Applications.

UNIT - IV: Robotics Simulation Techniques and Control

Robotics Simulation: Simulation Packages, Loading the Simulation, Simulation Editors, Delay, Resume Commands. Slide Commands, Program Flow Control. Robot Motion Control, Analysis of Robot Elements, Robotic Linkages.

UNIT - V: Robotic Motion Analysis and Design

Robotic Motion: Solids Construction, Solid Animation. Types of Motion, Velocity and Acceleration, Types of Simulation Motion: Harmonic Motion, Parabolic Motion, Uniform Motion Velocity and Acceleration Analysis for Robots. Robot Design: Linkages, Types, Transmission Elements Flexible Connectors, Pulley and Belt Drives, Variable Speed Transmission. Design of Robot for Particular Applications – A Case Study.

TEXT BOOKS:

1. Simultaneous Localization and Mapping: Exactly Sparse Information Filters, Gamini Dissanayake, Shoudong Huang and Zhan Wang, World Scientific Publishers, 1st Edition, 2011
2. Robotics: Designing the Mechanisms for Automated Machinery, Ben-Zion Sandler, Academic Press, 2nd Edition, 2003

REFERENCE BOOK:

1. Hello, Robot: Design Between Human and Machine, Mateo Kries, Vitra Design Museum Publisher, 1st Edition, 2017
1. Introduction to Autonomous Mobile Robots, Roland Siegwart, Illah R. Nourbakhsh and Davide Scaramuzza, The MIT Press, 2nd Edition, 2011.
2. Probabilistic Robotics, Sebastian Thrun, Wolfram Burgard and Dieter Fox, MIT Press, 1st Edition, 2005.
3. Robot Modeling and Control, Mark W. Spong, Seth Hutchinson and M. Vidyasagar, Wiley, 1st Edition, 2005.
4. Mobile Robotics: Mathematics, Models, and Methods, Alonzo Kelly, Cambridge University Press, 1st Edition, 2013.
5. Simultaneous Localization and Mapping: Exactly Sparse Information Filters, Timothy D. Barfoot, Cambridge University Press, 1st Edition, 2017.
6. Planning Algorithms, Steven M. LaValle, Cambridge University Press, 1st Edition, 2006.
7. Robot Operating System (ROS) for Absolute Beginners: Robotics Programming Made Easy, Lentin Joseph, Apress, 2nd Edition, 2019

II Semester	IMAGE PROCESSING (Programme Elective III)	L	T	P	C
		3	0	0	3

Course Objective:
To treat the 2D systems as an extension of 1D system design and discuss techniques specific to 2D systems.

Unit-I

Fundamentals of Image Processing: Image Acquisition, Image Model, Sampling, Quantization, Relationship between Pixels, Distance Measures, Connectivity, Image Geometry, Photographic Film. Histogram: Definition, Decision of Contrast Basing on Histogram, Operations Basing on Histograms Like Image Stretching, Image Sliding, Image Classification. Definition and Algorithm of Histogram Equalization.

Image Transforms: A Detail Discussion on Fourier Transform, DFT, FFT, Properties WALSH Transform, WFT, HADAMARD Transform, DCT

Unit-II

Image Enhancement:

a) Arithmetic and Logical Operations, Pixel or Point Operations, Size Operations,
b) Smoothing Filters-Mean, Median, Mode Filters – Comparative Study
c) Edge Enhancement Filters – Directorial Filters, Sobel, Laplacian, Robert,
KIRSCH Homogeneity
d) DIFF Filters, Prewitt Filter, Contrast Based Edge Enhancement Techniques– Comparative Study
e) Low Pass Filters, High Pass Filters, Sharpening Filters. – Comparative Study
f) Color Fundamentals and Color Models
g) Color Image Processing.

Unit-III

Image Enhancement: Design of Low Pass, High Pass, EDGE Enhancement, Smoothening Filters in Frequency Domain. Butter Worth Filter, Homomorphic Filters in Frequency Domain Advantages of Filters in Frequency Domain, Comparative Study of Filters in Frequency, Domain and Spatial Domain.

Image Compression: Run Length Encoding, Contour Coding, Huffman Code, Compression Due to Change in Domain, Compression Due to Quantization Compression at the Time of Image Transmission. Brief Discussion on: -Image Compression Standards.

Unit-IV

Image Segmentation: Characteristics of Segmentation, Detection of Discontinuities, Thresholding Pixel Based Segmentation Method. Region Based Segmentation Methods, Segmentation by Pixel Aggregation, Segmentation by Sub Region Aggregation, Histogram Based Segmentation, Spilt and Merge Technique, Motion in Segmentation

Unit-V

Morphology: Dilation, Erosion, Opening, Closing, Hit-And-Miss Transform, Boundary Extraction, Region Filling, Connected Components, Thinning, Thickening, Skeletons, Pruning Extensions to Gray– Scale Images Application of Morphology in I.P

Image, Video& Multimedia Communications: Multi-scale and multi-orientation representation; Geometry and texture representation; Object based representation; Hierarchical representation; Sparse representation, Multimedia with image and video content; Multimedia event synchronization.

Text Book:

1. Digital Image Processing, Rafael C. Gonzalez and Richard E. Woods, Addision Wesley

Reference Books:

1. Fundamentals Of Electronic Image Processing By Arthyr– R – Weeks,Jr.(PHI)
2. Image Processing, Analysis, And Machine Vision by Milan Sonka Vaclan Halavac Roger Boyle, Vikas Publishing House.
3. Digital Image Processing, S. Jayaraman, S. Esakkirajan & T. VeeraKumar, TMH.

Course Outcomes:

The students will be able to

1. Understand the need for image transforms different types of images transforms and their properties and develop any image processing application.
2. Understand the rapid advances in Machine vision.
3. Learn different techniques employed for the enhancement of images.
4. Learn different causes for image degradation and overview of image restoration techniques.
5. Understand the need for image compression and to learn the spatial and frequency domain techniques of image compression
6. Learn different feature extraction techniques for image analysis and recognition.

II Semester	ROBOTICS IN MANUFACTURING (Programme Elective IV)	L	T	P	C
		3	0	0	3

Course Objectives:

1. To understand the fundamentals of manufacturing systems and automation principles.
2. To analyse different manufacturing systems including automated production lines and assembly systems.
3. To explore material handling equipment, storage systems, and identification technologies.
4. To introduce digital twin technology and its role in modern manufacturing.
5. To study the implementation of virtual twin experience and its impact on innovation and manufacturing efficiency.

Course Outcomes: After completing this course, students will be able to:

1. After completing this course, the student will be able to explain the concepts of automation and manufacturing systems in industrial environments.
2. Evaluate various automated production lines and assembly systems for effective manufacturing.
3. Assess material handling and identification technologies to improve manufacturing processes.
4. Understand the challenges and advantages of digital twin technology in manufacturing.
5. Demonstrate knowledge of virtual twin experiences and apply them to real-world manufacturing scenarios.

UNIT – I: Manufacturing and Automation

Production Systems, Automation in Production Systems, Automation Principles and Strategies, Manufacturing Operations, Production Facilities, Basic Elements of an Automated System, Levels of Automation, Hardware Components for Automation and Process Control, Programmable Logic Controllers and Personal Computers.

UNIT – II: Manufacturing and Automated Production Lines

Components of a Manufacturing System, Single Station Manufacturing Cells, Manual Assembly Lines, Line Balancing Algorithms, Mixed Model Assembly Lines, Alternative Assembly Systems, Automated Production Lines: Applications and Analysis of Transfer Lines, Automated Assembly Systems: Fundamentals and Analysis, Cellular Manufacturing, Part Families, Coding, Production Flow Analysis, Group Technology and Flexible Manufacturing Systems, Quantitative Analysis.

UNIT – III: Material Handling and Technologies

Material Handling Equipment and Analysis, Storage Systems: Performance and Location Strategies, Automated Storage Systems, AS/RS Types, Automatic Identification Methods:

Barcode Technology, RFID, Quality Control and Support Systems, Quality in Design and Manufacturing, Inspection Principles and Strategies, Automated Inspection: Contact vs Non-Contact Inspection, Coordinate Measuring Machines (CMM).

Unit-IV

Robot Applications in Manufacturing: Material Transfer and Machine Loading/ Unloading, an Approach for Implementing Robotics, Machining, Welding, Surface Operations (Painting, Coating etc..) and Non Destructive Inspections (NDI).

Unit-V

Future Applications: Characteristics of Future Robot Tasks, Future manufacturing Applications, Hazardous and Inaccessible Non- Manufacturing Environments, Human -Robot Interactions**,** Smart Factories.

TEXT BOOKS:

1. Automation, Production Systems and CIM, M. P. Groover, PHI, 3rd Edition, 2007
2. Computer Aided Manufacturing, T. C. Chang, R. A. Wysk and H.-P. Wang, Pearson, 1st Edition, 2002
3. Digital Twin Technology: Fundamentals and Applications, Manisha Vohra, Scrivener Publishing, 1st Edition, 2020

REFERENCE BOOKS:

1. System Approach to Computer Integrated Design and Manufacturing, Singh, John Wiley, 1st Edition, 1991
2. Manufacturing and Automation Technology, R. T. Wright and M. Berkeihiser, Goodheart- Willcox Publishers, 2nd Edition, 2013
3. Automation, Production Systems and Computer-Integrated Manufacturing, Mikell P. Groover, Pearson, 4th Edition, 2015.
4. Robotics and Automation Handbook, Thomas R. Kurfess, CRC Press, 2nd Edition, 2013.
5. Flexible Manufacturing Systems: Strategies and Simulations, S. Kant Vajpayee, Wiley, 2001.
6. Material Handling Handbook, Raymond A. Kulwiec, McGraw Hill, 2nd Edition, 2005.
7. Manufacturing Automation: Metal Cutting Mechanics, Machine Tool Vibrations, and CNC Design, Yusuf Altintas, Cambridge University Press, 1st Edition, 2012.

II Semester	INTELLIGENT SENSORS AND ACTUATORS (Programme Elective IV)	L	T	P	C
		3	0	0	3

Course Objectives:

1. To introduce the concepts and types of intelligent sensors and actuators.
2. To study sensing principles, signal conditioning, and data acquisition.
3. To explore integration of sensors and actuators in intelligent systems.
4. To understand communication protocols and networking for smart devices.
5. To apply intelligent sensing and actuation in automation, robotics, and IoT applications.

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

1. Explain the working principles and characteristics of various intelligent sensors and actuators.
2. Select and integrate appropriate sensors and actuators for specific applications.
3. Design signal conditioning and data acquisition systems for smart devices.
4. Implement communication protocols for intelligent sensing networks.
5. Apply intelligent sensor–actuator systems in industrial automation and smart manufacturing.

UNIT – I: Types of Sensors:

Pressure/contact, Resistive Position, Infrared, Light, Position Sensors, Optical Encoders, Proximity Sensors, Range Sensors, Ultrasonic Sensors, Touch and Slip Sensors, Sensors for Motion and Position, Force, Torque and Tactile Sensors, Flow Sensors, Temperature Sensing Devices.

UNIT – II: Vision Sensors

Vision System Devices, Image Acquisition, Masking, Sampling and Quantization, Image Processing Techniques, Noise Reduction Methods, Edge Detection, Segmentation. Advanced Sensor Technology: Smart Sensors, MEMS Based Sensors, Innovations in Sensor Technology.

UNIT – III: Electro Mechanical Actuators

Types of Transmission Systems, Electric Actuators: Direct Current Motor, Permanent Magnet Stepper Motor, Servo Control DC Motors, Linear and Latching Linear Actuators, Rotatory Actuators, Piezoelectric Actuators, Actuator Parameters and Characteristics, Stepper Motors, Specifications and Characteristics of Stepper Motors, Servomotors, Hybrid Electro Mechanical Actuators.

UNIT – IV: Pneumatic and Hydraulic Actuators

Hydraulic and Pneumatic Power Actuation Devices, Hydraulic Actuators, Selection of Linear Actuating Cylinders, Hydraulic Motors, Pneumatic Actuators, Design

Considerations and Selection, Pneumatic Cylinders, Pneumatic Drive System, Linear and Rotary Actuators, Hybrid Pneumatic and hydraulic Actuators.

UNIT – V: Advanced Actuators

Piezoelectric Actuators, Elastomer Actuators, Soft Actuators, Shape Memory Alloy Based Actuators, under actuated Robotic Hand.

TEXT BOOKS:

1. Sensor Technology Handbook, Jon S. Wilson, Elsevier, 1st Edition, 2005
2. Industrial Robotics: Technology, Programming and Applications, Mikell P. Groover, Nicholas Godfrey, Mitchel Weiss, Roger N. Nagel, and Ashish Dutta, McGraw-Hill Publishers, 2nd Edition, 2012.

REFERENCE BOOKS:

1. Embedded Robotics: Mobile Robot Design and Applications with Embedded Systems, T. Braünl, Springer, 3rd Edition, 2008
2. Robot Sensors and Transducers, S.R. Ruocco, Springer, 1st Edition, 2013.
3. Smart Sensor Systems, Gerard C. M. Meijer, Wiley, 1st Edition, 2008.
4. Introduction to Robotics: Mechanics and Control, John J. Craig, Pearson, 4th Edition, 2019.
5. Sensors and Actuators: Engineering System Instrumentation, Clarence W. de Silva, CRC Press, 2nd Edition, 2007.
6. Robotics: Control, Sensing, Vision, and Intelligence, K. S. Fu, R. C. Gonzalez, C. S. G. Lee, McGraw Hill, 1987.
7. Mechatronics: Principles and Applications, Godfrey C. Onwubolu, Elsevier, 1st Edition, 2005.
8. Microelectromechanical Systems (MEMS) and Their Applications, Chang Liu, CRC Press, 2011.
9. Smart Sensors and MEMS: Intelligent Devices and Microsystems for Industrial Applications, Sabrie Soloman, CRC Press, 2013.
10. Sensors and Actuators in Mechatronics, Andrzej M. Pawlak, Taylor and Francis Group, 1st Edition, 2007.

II Semester	MOBILE AND MICRO-ROBOTICS (Programme Elective IV)	L	T	P	C
		3	0	0	3

Course Objectives:

1. Provide brief introduction to micromachining and the principles of microsystems
2. Understand the various flexures, actuators and sensor systems.
3. Discuss the methods of implementation of micro robots.

Unit-I

Introduction to Mobile Robots: Tasks of mobile robots, robots manufacturers, type of obstacles and challenges, tele-robotics, philosophy of robotics, service robotics, types of environment representation.

Unit-II

Ground Robots: Wheeled and Legged Robots, Aerial Robots, Underwater Robots and Surface Robots. Kinematics and Dynamics of Wheeled Mobile Robots (two, three, four - wheeled robots, Omni-directional and macanum wheeled robots).

Unit-III

Motion Control of Mobile Robots (Model and Motion based Controllers): Lyapunov-based Motion Control Designs and Case Studies. Understand the current application and limitations of Mobile Robots. Introduction to Mobile Manipulators and Cooperative Mobile Robots.

Sensors for localization and Navigation Mobile Robotics: magnetic and optic position sensor, gyroscope, accelerometer, magnetic compass, inclinometer, tactile and proximity sensors, ultrasound rangefinder, laser scanner, infrared rangefinder and visual systems.

Unit-IV

Micro Robotics: Introduction, Task specific definition of micro-robots - Size and Fabrication Technology based definition of micro robots - Mobility and Functional-based definition of micro-robots - Applications for MEMS based micro-robots.

Unit-V

Implementation of Micro Robots: Arrayed actuator principles for micro- robotic applications – Micro-robotic actuators - Design of locomotive micro- robot devices based on arrayed actuators. Micro-robotics devices: Micro- grippers and other micro-tools - Micro-conveyors - Walking MEMS Micro- robots – multi-robot system: Micro-robot powering, Micro-robot communication.

Micro Fabrication and Micro Assembly: Micro-fabrication principles - Design selection criteria for micromachining - Packaging and Integration aspects – Micro-assembly platforms and manipulators.

Text Books:

1. Mohamed Gad-el-Hak, "The MEMS Handbook", CRC Press, New York, 2002.
2. Yves Bellouard, "Micro robotics Methods and Applications", CRC Press, Massachusetts, 2011.

Reference Books:

1. R Siegwart, IR Nourbakhsh, D Scaramuzza,Introduction to Autonomous Mobile Robots, The MIT Press, USA, 2011,
2. SG Tzafestas, Introduction to Mobile Robot Control, Elsevier, USA, 2014,
3. A Kelly, Mobile Robotics, Mathematics, Models, and Methods, Cambridge University Press, USA, 2013,
4. G Dudek, M Jenkin, Computational Principles of Mobile Robotics, Cambridge University Press, USA,
5. Mohamed Gad-el-Hak, ―The MEMS Handbook‖, CRC Press, New York, 2002.
6. Yves Bellouard, ―Micro robotics Methods and Applications, CRC Press, Massachusetts, 2011.
7. Patnaik, Srikanta, "Robot Cognition and Navigation An Experiment with Mobile Robots", Springer-Verlag Berlin and Heidelberg, 2007.
8. Howie Choset, Kevin LynchSeth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, ―Principles of Robot Motion-Theory, Algorithms, and Implementation, MIT Press, Cambridge, 2005.
9. Margaret E. Jefferies and Wai-Kiang Yeap, "Robotics and Cognitive Approaches to Spatial Mapping", Springer-Verlag Berlin Heidelberg 2008.

II Semester	MEDICAL ROBOTICS (Programme Elective IV)	L	T	P	C
		3	0	0	3

Course Outcomes:
The students will be able to

1. Identify and design a suitable manufacturing process for micro robots.
2. Understand the importance of visual perception and recognition for cybernetic view.
3. Program a robot for wandering and teleportation.
4. Outline the various methods of implementation of micro robots.
5. Discuss about the principle of micro fabrication and micro assembly.
6. Specify the characteristics of various flexures, actuators and sensor systems

Unit 1:
Introduction to robots – Robots as mechanical devices – Classification of robotic manipulators – Robotic systems – Accuracy and repeatability – Wrists and end-effectors –

Unit 2:
Mathematical modelling of robots – Symbolic representation of robots – The configuration space – The state space – The workspace common kinematic arrangements of manipulators – Forward kinematics – Inverse kinematics – Velocity kinematics.

Unit 3:
Medical robots – Robots for navigation – Movement replication – Robots for imaging – Rehabilitation and prosthetics – Describing spatial positioned orientation –

Unit 4:
Standardizing kinematic analysis – Computing joint angles – Quaternions – Robot kinematics -Three-joint robot – Six-joint robot.

Unit 5:
Application of medical robots – The learning curve of robot – Assisted laparoscopic surgery – Haptic feedback in robotic heart surgery – Robotic applications in neurosurgery – Miniature robotic guidance for spine surgery.

Textbooks

1. Achim Schweikard and Floris Ernst, Medical Robotics, Springer, 2015.
2. VanjaBozovic, Medical Robotics, Springer, 2008.

II Semester	CONTROL SYSTEMS LAB	L	T	P	C
		0	0	4	2

List of Experiments:

1. Study of Rectilinear Motion
2. Study and operation of Magnetic Levitation
3. Determination of the incremental transfer function of an AC Servomotor
4. Temperature Control System
5. Two Tank Water Level Control
6. Study and operation of Inverted Pendulum System
7. Study of DC Motor
8. Study and operation of the Process Simulator setup
9. Study and operation of the Process Trainer setup
10. Study and operation of the DC speed and position control setup
11. Transient and frequency response of D' Arsonval Galvanometer
12. Simulation of Control Systems

II Semester	ROBOTICS SYSTEMS LAB	L	T	P	C
		0	1	2	2

Course Objectives:

1. Provide hands-on experience in programming and controlling various robotic systems.
2. Familiarize students with kinematic modeling, sensor integration, and path planning in physical robots.
3. Enable students to use robotic simulation and programming platforms effectively.
4. Develop the ability to implement basic robotic tasks such as pick-and-place, obstacle avoidance, and line following.

Course Outcomes: The students will be able to

1. Design a gripper for different applications using design considerations
2. Learn working of touch sensors and their interfacing and feedback
3. Perform kinematic analysis
4. Perform trajectory planning
5. Detect the object and path tracing using vision sensor

List of Experiments:

1. Study of Robot Gripper design using a manipulator.
2. Demonstrating Touch Sensors interfacing and feedback system.
3. Performing Manipulator kinematics analysis using R-R-R Robot manipulator.
4. Performing object detection and Image processing using Vision sensors in Robot System.
5. Performing Trajectory planning and analysis using simulation software.
6. Demonstrating Pick and place tracking using robot.
7. Demonstrating path tracking using robot
8. Designing collision avoidance robots incorporating sensors.
9. Virtual lab experiments on Robot kinematics for Move PUMA 560 and KGP 50.

II Semester	SEMINAR - II	L	T	P	C
		0	0	2	1

SEMESTER – III

III Semester	RESEARCH METHODOLOGY AND IPR	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the knowledge on basics of research and its types.
- To impart the concept of Literature Review, Technical Reading, Attributions and Citations.
- To know the Ethics in Engineering Research.
- To know the concepts of Intellectual Property Rights in Engineering.

COURSE OUTCOMES:
Upon successful completion of this course, the student will be able to:

	Course Outcome	*BTL (K#)*
CO1	Explain the meaning of engineering research and apply to develop an appropriate framework for research studies.	K2& K3
CO2	Identify the procedure of Literature Review, Technical Reading, etc. and apply to develop a research design during their project work.	K2 & K3
CO3	Explain and apply the fundamentals of patent laws and drafting procedure in their research works.	K2& K3
CO4	Demonstrate the copyright laws, subject matters of copyrights, designs etc. to apply in patent filing.	K2 & K3
CO5	Identify the new developments in IPR and employ the applications of computer software in writing/filing patents in future.	K2 & K3

 # Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: ***Remember***	**K2:** ***Understand***	**K3:** ***Apply***
K4: ***Analyse***	**K5:** ***Evaluate***	**K6:** ***Create***

Unit Description *Contact Hrs.*

UNIT – I: **[10]**

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

UNIT – II: **[10]**

Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

UNIT – III: **[10]**

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT – IV: **[10]**

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

UNIT – V: **[09]**

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR.

TEXTBOOKS:

1. C.R. Kothari , 2nd Edition, “Research Methodology: Methods and Techniques”.
2. Ranjit Kumar, 2nd Edition, “Research Methodology: A Step-by-Step Guide for beginners”

REFERENCE BOOKS:

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students.
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”.
3. Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd ,2007.
4. Mayall, “Industrial Design”, McGraw Hill, 1992.
5. Niebel, “Product Design”, McGraw Hill, 1974.
6. Asimov, “Introduction to Design”, Prentice Hall, 1962.
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
8. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

WEB REFERENCES:

- Please include hyperlinks related to NPTEL/VLabs etc.,

III Semester	SUMMER INTERNSHIP	L	T	P	C
		0	0	0	3

COURSE OBJECTIVES:

- Internships provide students with an opportunity to put into practice skills they have learned while in college.
- In addition, students should have an opportunity to enhance those skills, obtain the perspective of a work environment and benefit from a mentor or supervisor's experience and advice.

COURSE OUTCOMES:

Upon successful completion of this course, the student will be able to:

	Course Outcome	***BTL (K#)***
CO1	Integrate theory and practice to assess interests and abilities in their field of study.	K3 & K4
CO2	Develop work habits, attitudes necessary to appreciate work and its function in the economy.	K3
CO3	Develop communication, interpersonal and other critical skills to build a record of work experience.	K3

 # Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: ***Remember***	**K2:** ***Understand***	**K3:** ***Apply***
K4: ***Analyse***	**K5:** ***Evaluate***	**K6:** ***Create***

III Semester	COMPREHENSIVE VIVA	L	T	P	C
		0	0	0	2

III Semester	DISSERTATION PART A	L	T	P	C
		0	0	20	10

COURSE OBJECTIVES:

- To impart fundamental and disciplinary concepts and methods in ways appropriate to their principal areas of study.
- To familiarise how to incorporate skill and knowledge of current information and technological tools and techniques specific to the professional field of study.
- Expose to the critical aspects like identifying, analysing and solving problems creatively through sustained critical investigationusing effective oral, written and visual communications.
- To inculcate the key aspects like awareness and application of appropriate personal, societal and professional ethical standardsto excellence needed to engage in lifelong learning.

COURSE OUTCOMES:
Upon successful completion of this course, the student will be able to:

	Course Outcome	*BTL (K#)*
CO1	Carryout a critical review of literature on a chosen topic of research and identify gaps in the literature to define a problem for research work.	K3 & K4
CO2	Formulate/adapt a clear methodology using multi-disciplinary approach and modern tools.	K3& K6

 # Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: ***Remember***	**K2:** ***Understand***	**K3:** ***Apply***
K4: ***Analyse***	**K5:** ***Evaluate***	**K6:** ***Create***

SEMESTER – IV

IV Semester	DISSERTATION PART B	L	T	P	C
		0	0	32	16

COURSE OBJECTIVES:

- To impart fundamental and disciplinary concepts and methods in ways appropriate to their principal areas of study.
- To familiarise how to incorporate skill and knowledge of current information and technological tools and techniques specific to the professional field of study.
- Expose to the critical aspects like identifying, analysing and solving problems creatively through sustained critical investigation using effective oral, written and visual communications.
- To inculcate the key aspects like awareness and application of appropriate personal, societal and professional ethical standardsto excellence needed to engage in lifelong learning.

COURSE OUTCOMES:
Upon successful completion of this course, the student will be able to:

	Course Outcome	***BTL (K#)***
CO1	Carryout design/analysis of a product/system or devise experiments to study and develop a system/process/product.	K3 & K4
CO2	Interpret & validate results of analysis/experiments conducted to study behaviour of a product /system/ process considered for the research leading to valid conclusions that add value to the body of knowledge.	K3 & K5
CO3	Write and present a technical report of the project work.	K6

 # Based on suggested Revised Blooms Taxonomy Level (BTL)

K1: ***Remember***	**K2:** ***Understand***	**K3:** ***Apply***
K4: ***Analyse***	**K5:** ***Evaluate***	**K6:** ***Create***