NIRMA UNIVERSITY

Institute:	**Institute of Technology, School of Technology**
Name of Programme:	**BTech CSE**
Course Code:	4CS206ME25
Course Title:	**Robotics and Automation**
Course Type:	**Department Elective-IV**
Year of Introduction:	**2025-26**

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Course Learning Outcomes (CLO):

At the end of the course, the students will be able to –

1. explain the basic concepts associated with the design, functioning, and applications of Robots (BL2)
2. examine the drives and sensors used in Robots (BL4)
3. appraise fundamentals of robot kinematics and robot programming (BL5)
4. interpret algorithms related to mobile robotic path planning (BL5)

Unit	Contents	Teaching Hours (Total 45)
Unit-I	**Fundamentals of robot:** Definition, Robot Anatomy, Co-ordinate Systems, Work Envelope, types and classification, Specifications, Pitch, Yaw, Roll, Joint Notations, Speed of Motion, Pay Load – Robot Parts and Functions – Need for Robots and Applications	06
Unit-II	**Robot drive systems and end effectors:** Pneumatic Drives, Hydraulic Drives, Mechanical Drives, Electrical Drives, D.C. Servo Motors, Stepper Motor, A.C. Servo Motors, Salient Features, Applications and Comparison of Drives End Effector, Grippers, Mechanical Grippers, Pneumatic and Hydraulic Grippers, Magnetic Grippers, Vacuum Grippers; Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers; Selection and Design Considerations	06
Unit-III	**Sensors and machine vision:** Requirements of a sensor, Principles and Applications of the following types of sensors – Position of sensors (Piezo Electric Sensor, LVDT, Resolvers, Optical Encoders, Pneumatic Position Sensors), Range Sensors (Triangulation Principle, Structured, Lighting Approach, Time of Flight Range Finders, Laser Range Meters), Proximity Sensors (Inductive, Hall Effect, Capacities, Ultrasonic and Optical Proximity Sensors), Touch Sensors, (Binary Sensors, Analog Sensors), Wrist Sensors, Compliance Sensors, Slip Sensors. Camera, Frame Grabber, Sensing and Digitizing Image Data – Signal Conversion, Image Storage.	10

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Unit-IV	**Robot kinematics and robot programming:** Forward Kinematics, Inverse Kinematics and Differences; Forward Kinematics and Reverse Kinematics of Manipulators with Two, Three Degrees of Freedom (In 2 Dimensional), Four Degrees of Freedom (In 3 Dimensional), Deviations and Problems. Teach Pendant Programming, Lead through programming, Robot programming Languages, VAL Programming, Motion Commands, Sensor Commands, End effecter commands, and Simple programs	13
Unit-V	**Introduction to Mobile Robotics**: Introduction, Locomotion Configurations, Localization, Path Planning, Perception, Mapping, SLAM, etc., and algorithms for autonomous mobile robots.	10

Self-Study:

The self-study contents will be declared at the commencement of the semester. Around 10% of the questions will be asked from self-study content.

Suggested Readings/ References:

1. Siegwart, Nourbakhsh and Scaramuzza, *Introduction to Autonomous Mobile Robots*; Prentice Hall India
2. M. P. Groover, *Industrial Robotics – Technology, Programming and Applications*, McGraw-Hill
3. Fu. K. S. Gonzalez. R.C., and Lee C.S.G., *Robotics Control, Sensing, Vision and Intelligence*, McGraw-Hill

Suggested List of Experiments:

Sr.	Name of Experiments/Exercises	Hours
1	Objective: Introduction to MATLAB and basic robot anatomy. • Explore MATLAB's interface and basic commands. • Create a simple script to model basic robot anatomy, including coordinate systems and work envelopes. • Visualize different types of joints (pitch, yaw, roll) using 3D plots.	04
2	Modeling and Simulation of Robot Drive Systems Objective: Understand and simulate different robot drive systems • Simulate a DC servo motor and stepper motor using MATLAB. • Compare the response of different drive systems (pneumatic, hydraulic, mechanical, electrical). • Analyze the effect of varying parameters like speed, torque, and load.	02
3	Objective: Design and simulate various types of robotic grippers. • Model mechanical, pneumatic, hydraulic, magnetic, and vacuum grippers • Simulate the operation of two-fingered and three-fingered grippers. • Explore the selection and design considerations for different end effectors.	04
4	Objective: Integrate and process data from various sensors in a simulated robotic environment. • Simulate the output of position sensors (e.g., optical encoders, LVDT) and range sensors (e.g., laser range meters). • Implement proximity and touch sensors in a MATLAB simulation. • Use sensor data to control a simple robotic manipulator.	04

5	Objective: Implement basic machine vision techniques in MATLAB. • Capture and process image data using MATLAB's image processing toolbox. • Implement algorithms for edge detection and feature extraction. • Simulate object recognition and apply it to a robotic inspection task. • Prepare a report to guide the design of the mapper and reducer.	02
6	Objective: Understand and implement forward and inverse kinematics for a simple robotic arm. • Derive and simulate the forward kinematics of a 2-DOF planar robot. • Implement inverse kinematics to achieve desired end-effector positions. • Visualize the robot's movement and analyze the results.	02
7	Objective: Extend kinematic analysis to 3D robotic manipulators. • Model the forward and inverse kinematics of a 3-DOF or 4-DOF robotic arm. • Simulate and solve kinematics problems in a 3D workspace. • Explore the differences and challenges in 2D vs. 3D kinematics.	04
8	Objective: Introduce basic robot programming using VAL in a simulated environment. • Create simple motion, sensor, and end effector commands using VAL programming concepts. • Implement a basic pick-and-place task using a simulated robotic arm. • Explore the use of teach pendant and lead-through programming methods.	02
9	Objective: Simulate the issues faced when implementing robots in industrial environments. • Model an industrial workspace and simulate the movement of a robot within it. • Analyze the safety considerations and collision detection using MATLAB. • Simulate and compare the economic benefits of robot implementation using different methods (payback, EUAC, rate of return).	04
10	Objective: Perform an economic analysis of implementing a robotic system • Develop MATLAB scripts to calculate the payback period, EUAC, and rate of return for a robotic system. • Simulate different scenarios and analyze the financial viability of robotics in various industrial applications.	02