# ADVANCED ROBOTICS

| **Course Code** | 22MEMD2T4 | **Year** | I | **Semester** | II |
|---|---|---|---|---|---|
| **Course Category** | Programme core | **Branch** | Machine Design | **Course Type** | Theory |
| **Credits** | 4 | **L-T-P** | 4-0-0 | **Prerequisites** | Engineering Mechanics |
| **Continuous Internal Evaluation:** | 40 | **Semester End Evaluation:** | 60 | **Total Marks:** | 100 |

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

| **CO** | **Statement** | **BTL** | **Units** |
|---|---|---|---|
| CO1 | Apply the knowledge of Mathematics and science to carry out the position and orientation analysis of robot using homogeneous transformations | L3 | 1 |
| CO2 | Develop the mathematical models, analyze, solve forward and inverse kinematics equations of a robot | L3 | 2 |
| CO3 | Develop the mathematical models for dynamic analysis and trajectory planning of a robot | L3 | 3 |
| CO4 | Understand the principles of Block diagram algebra in motion control systems and working principles of various types of sensors and actuators. | L2 | 4 |

**Contribution of Course outcomes towards achievement of programme outcomes & Strength of correlations (High:3, Medium: 2, Low:1)**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO 1 | 3 | 3 | 2 | | | 1 | | 1 | | | | 1 | 3 | 1 |
| CO 2 | 3 | 3 | 2 | | | 1 | | 1 | | | | 1 | 3 | 1 |
| CO 3 | 3 | 3 | 2 | | | 1 | | 1 | | | | 1 | 3 | 1 |
| CO 4 | 3 | 3 | 2 | | | 1 | | 1 | | | | 1 | 3 | 1 |

| **Syllabus** | | |
|---|---|---|
| **Unit** | **Contents** | **Mapped CO** |
| **1** | **Fundamentals:** Introduction, definition of robot, classification of robots, robot components, degree of freedom, robot joints, robot coordinates, reference frames, robot characteristics, robot work space, advantages, disadvantages and applications of robots. matrix representation of a point in a | **CO1** |

| | | |
|---|---|---|
| | space, representation of a vector in space, representation of a frame at the origin of a reference frame, representation of a frame in a reference frame, representation of a rigid body. representation of a pure translation, pure rotation about an axis, representation of combined transformations, transformations relative to the rotating frame, inverse of transformation matrices. | |
| **2** | **Robot Kinematics:** Forward and inverse kinematics of robots-forward and inverse kinematic equations for position, forward and inverse kinematic equations for orientation, forward and inverse kinematic equations for position and orientation, Denavit-Hartenberg (D-H) representation of forward kinematic equations of robots, The inverse kinematic solution of robots Degeneracy and Dexterity, problems with D-H representation.<br>**Differential Motions and Velocities:** Introduction, differential relationship, Jacobian, differential motions of a frame-translations, rotation, rotating about a general axis, differential transformations of a frame. Differential changes between frames, differential motions of a robot and its hand frame, calculation of Jacobian, relation between Jacobian and the differential operator, Inverse Jacobian. | **CO2** |
| **3** | **Dynamic Analysis and Forces:** Introduction, Lagrangian mechanics, Effective moments of inertia, dynamic equations for multi-degree of freedom robots-kinetic energy, potential energy, the Lagrangian, robot's equations of motion, static force analysis of robots.<br>**Trajectory Planning:** Introduction, basics of trajectory planning, joint space trajectory planning-third order polynomial trajectory planning, fifth order polynomial trajectory planning, linear segments with Parabolic blends, linear segments with parabolic blends via points Higher order trajectories | **CO3** |
| **4** | **Motion Control Systems:** Basic components and terminology, Block Diagrams, Laplace Transform, Transfer function, Block diagram algebra, first and second order transfer functions, Pole/Zero Mapping, Steady state error, Root Locus Method, Proportional controls Proportional Plus Integral controllers, proportional plus derivative controllers, PID Controller<br>**Robot Actuators:** characteristics of Actuating systems, comparison of actuating systems, hydraulic devices, pneumatic devices, Electric motors, servomotors, stepper motors, Advantages, Disadvantages & applications of Robot Actuators.<br>**Robot Sensors**: Sensor characteristics, Position, Velocity and Acceleration sensors, force and pressure sensors, proximity sensors, sniff sensors, advantages, disadvantages and applications of sensors. | **CO4** |

**Learning Resources**

**Text Book(s):**

1. Introduction to Robotics – Analysis, System, Applications, Saeed B. Niku, 2nd edition Wiley India Pvt. Ltd.

**References:**

1. Introduction to Robotics: Mechanics and Control, John J. Craig, 3rd edition, Pearson Education India