MMOE4001 INTRODUCTION TO ROBOTICS (3-0-0)

Course Objectives : The course aims to:

1. Introduce the fundamentals, evolution, classification, and components of robotic systems.
2. Develop mathematical foundations for modeling robotic manipulators using coordinate transformations and Denavit-Hartenberg (D-H) convention.
3. Enable analysis of forward and inverse kinematics, Jacobians, workspace, and singularities.
4. Introduce basic dynamic modeling and control concepts of robotic manipulators.
5. Familiarize students with sensors, actuators, trajectory planning, and robot programming fundamentals.
6. Explore industrial, service, and emerging applications of robotics including automation and collaborative robots.

Module I: Fundamentals of Robotics (9 Hours)

Evolution and history of robotics, Definition and laws of robotics, Robot classifications (industrial, service, mobile, collaborative), Robot anatomy and components, Degrees of freedom, work volume and workspace, Resolution, accuracy, repeatability, Robot configurations (Cartesian, Cylindrical, SCARA, Articulated, Delta), Economic, ethical and social issues in robotics, Present and emerging trends (Industry 4.0, AI in robotics, cobots)

Module II: Mathematical Modeling and Forward Kinematics (9 Hours)

Coordinate frames and mapping between frames, Description of position and orientation in space, Transformation matrices, Homogeneous transformations, Mechanical structure of manipulators, Links and joints, Denavit–Hartenberg (D-H) notation, Forward kinematics of serial manipulators, Manipulator transformation matrix

Module III: Inverse Kinematics, Jacobian and Dynamics (9 Hours)

Inverse Kinematics: Analytical and numerical solutions, Workspace analysis, Manipulator Jacobian, Velocity relationships, Jacobian singularities, Static force analysis.

Dynamic Modeling: Introduction to robot dynamics, Lagrangian formulation, Newton–Euler formulation, Two-link planar manipulator dynamics

Module IV: Actuators, Sensors, Control and Applications (9 Hours)

Actuators: Hydraulic and pneumatic actuators, DC motors, BLDC motors, Stepper motors, Servo motors, Drive selection criteria, Introduction to micro-actuators and grippers.

Sensors: Internal and external sensors, Position, velocity and acceleration sensors, Force and torque sensors, Vision sensors (basic introduction), Sensor performance characteristics.

Trajectory Planning and Control: Joint space trajectory planning, Cartesian space planning, Point-to-point and continuous path control, Basic feedback control concepts.

Applications: Material handling, Assembly, Welding, Inspection, Machine loading/unloading, Obstacle avoidance, Introduction to mobile and collaborative robots.

Course Outcomes (COs)

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

CO1: Explain the fundamentals, classification, components, and applications of robotic systems.
CO2: Develop forward kinematic models using coordinate transformations and Denavit-Hartenberg parameters.
CO3: Solve inverse kinematics problems and analyze manipulator workspace, Jacobian, and singularities.
CO4: Formulate basic dynamic equations of robotic manipulators using Lagrangian and Newton-Euler methods.
CO5: Identify and compare various sensors and actuators used in robotic systems and justify their selection.
CO6: Plan simple robot trajectories and explain industrial and emerging applications of robotics.

Text Books

1. John J. Craig, Introduction to Robotics: Mechanics and Control, PHI.
2. S.K. Saha, Introduction to Robotics, McGraw Hill.
3. R.K. Mittal and I.J. Nagrath, Robotics and Control, TMH.

Reference Books

1. M.W. Spong, S. Hutchinson, M. Vidyasagar, Robot Modeling and Control, Wiley.
2. K.S. Fu, R.C. Gonzalez and C.S.G. Lee, Robotics: Control, Sensing, Vision and Intelligence, McGraw Hill.
3. S.B. Niku, Introduction to Robotics: Analysis, Systems and Applications, PHI.
4. A. Ghosal, Robotics: Fundamental Concepts and Analysis, Oxford University Press.
5. M.P. Groover, Industrial Robotics: Technology, Programming and Applications, TMH.