I YEAR M. TECH (MACHINE DESIGN) SECOND SEMESTER

17MEMD2T4 **ADVANCED ROBOTICS** **Credits 4**

Lecture: 4 periods/week **Internal assessment: 40 marks**

Tutorial: - - **Semester end examination: 60 marks**

COURSE OBJECTIVES:

- Learns the fundamentals of robotics and homogeneous transformations
- Formulate the direct and inverse kinematic equations and solve the equations for position and orientation of a joint and joint variables.
- Understands about the dynamic analysis of a robots and principles involved in trajectory planning
- Learns about the motion control system algebra and working principles of various sensors and actuators.

COURSE OUTCOMES:

After completed course, the students are expected to be able to:

1. Apply the knowledge of Mathematics and science to carry out the position and orientation analysis of robot using homogeneous transformations
2. Develop the mathematical models, analyze, solve forward and inverse kinematics equations of a robot
3. Develop the mathematical models for dynamic analysis and trajectory planning of a robot
4. Understand the principles of Block diagram algebra in motion control systems and working principles of various types of sensors and actuators.

UNIT-I

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 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.

UNIT-II

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.

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.

UNIT-III

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.

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

UNIT-IV

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

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.

ROBOT SENSORS: Sensor characteristics, Position, Velocity and Acceleration sensors, force and pressure sensors, proximity sensors, sniff sensors, advantages, disadvantages and applications of sensors.

Learning Resources

Text Books:

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

References:

1. Introduction to Robotics: Mechanics and Control, (3rd edition) by John J. Craig, , Pearson Education India
2. Robotics: Fundamental Concepts and Analysis, (1st edition) by Ashitava Ghosal, Oxford University Press.