L	T	P	C
3	0	2	4

Course Code: MCT501
Semester: I

Kinematics and Dynamics of Robots

Course Objectives:

1. To analyse and determine the kinematic and dynamic models of robots using computational tools
2. To design control systems for robotic manipulator used in various industrial applications

UNIT- I **11 Periods**
Forward Kinematics of Robots
Position and Orientation of a Rigid Body-Rotation Matrix-Change of Coordinates-Orientation of frames in a plane-Composition of rotation-Homogeneous Transformations-Computing inverse of a Homogeneous Transformation-Forward Kinematics-Kinematic Chains- Denavit-Hartenberg parameters

UNIT- II **11 Periods**
Inverse Kinematics of Robots
Inverse Kinematics- Solvability and robot workspace-Multiplicity of solutions-Examples-Solution methods-Analytical solution -Numerical solution-Newton method, Gradient method- Introduction to Inverse differential Kinematics-Angular velocity of a Rigid body-Robot Jacobian matrices-singularities

UNIT- III **12 Periods**
Robot Dynamics
Introduction to Dynamics-Euler Lagrange method-Kinetic energy and potential energy of links concepts-Robot inertia matrix-Centrifugal and Coriolis terms - Derivative of a vector in a moving frame-Dynamics of a rigid body-Newton Euler Equations-Forward Recursion-Computing velocities and accelerations-Backward recursion

UNIT- IV **11 Periods**
Robot Control
Review of conventional control system – Examples – Control system for robot manipulator –Position control system – Point to point control, Continuous path control - Torque control system – Trajectory Planning – Motion interpolation – Robot manipulator applications-Material handling, Machine loading and unloading, assembly, Inspection, Welding, Spray painting.

REFERENCES

1. B. Siciliano, L. Sciavicco, G. Villani & G. Oriolo, *Robotics: Modelling, Planning and Control*, 3rd Edition, Springer, 2009
2. Dan B. Marghitu, *Mechanisms and Robots Analysis with MATLAB*,1st Edition, Springer-Verlag London, 2009
3. Andrew Kurdila, Pinhas Ben-Tzvi, Dynamics and Control of Robotic Systems, 1st Edition,John Wiley & Sons, Inc., 2020
4. Mark W. Spong, Seth Hutchinson,M. Vidyasagar,Robot Modeling and Control, John Wiley,2nd Edition,,2006

5. Siciliano, Bruno; Khatib & Oussama, *Springer Handbook of Robotics*. Berlin: Springer, 2008.
6. Craig, John J. *Introduction to Robotics, Mechanics and Control*, 3rd Edition, Upper Saddle Hall: Pearson Education, 2005

ONLINE MATERIAL

https://onlinecourses.nptel.ac.in/noc18_me18/preview
http://nptel.ac.in/courses/112101099/32

UNIT-WISE LEARNING OUTCOMES

Upon successful completion of each unit, the learner will be able to:

Unit I	• analyse the mathematics involved in the development of Forward kinematic model of a robotic manipulator
Unit II	• solve problems related to inverse kinematics problems • analyse the Jacobians and can explain differential kinematics
Unit III	• apply the concept of kinematics in building the Euler Lagrange dynamic models of a Robotic manipulators • derive the forward dynamics of industrial manipulators • apply the concept of Newton's law and can derive the dynamical model of a robot manipulator
Unit IV	• analyse the closed-loop control system used in robotic manipulators • develop and apply control systems for robot manipulator used in various applications

LIST OF EXPERIMENTS (2 Hours per Week)

1. Manipulation of Rigid body using rotation matrix in MATLAB
2. Analysis of homogeneous transformation using MATLAB
3. Design of robot manipulator using V-Rep
4. Kinematic analysis of robot using Robo Analyser
5. Analysis of D-H Parameter of a robot manipulator using MATLAB
6. inverse kinematics analysis of Inverse kinematics of planar 2R arm and RRP arm using Robotics Toolbox in MATLAB
7. Analysis of inverted pendulum dynamics using MATLAB
8. Implementation of dynamic model of a 2R manipulator using MATLAB-Simulink
9. Design of position control system of robot manipulator
10. Trajectory generation for continuous path tracking of robot manipulator

COURSE LEARNING OUTCOMES

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

- analyse mathematically the forward and inverse kinematics of an industrial manipulator robot

- derive the Euler Lagrange and Newton approach of forward dynamics of an industrial manipulator robot