PARALLEL ROBOTS

(PROFESSIONAL ELECTIVE-V)

Course Code: 20ME1257

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

CO1: describe generalized parallel manipulators and its classification (L2)

CO2: determine the forward and inverse kinematic models of parallel manipulators (L3)

CO3: apply Jacobian analysis and identify the singularities in parallel manipulators (L3)

CO4: differentiate types of workspaces in parallel manipulators (L2)

CO5: discuss static analysis and calibration methods in parallel manipulators (L2)

UNIT I **10 Lectures**

Introduction, Characteristics of classical robots, other types of architecture, Needs for robotics. **Generalized parallel manipulators:** definition, Parallel manipulators, fully parallel manipulators, Fully parallel manipulators analysis: Planar robots, General case. Classification of planar robots: 3DoF manipulators, Classification of parallel robots: 3 to 6 DoF manipulators.

Learning Outcomes: At the end of this unit, the student will be able to

1. Explain the characteristics of classical robots (L2)
2. differentiate parallel and fully parallel manipulators (L2)
3. describe the classification of parallel manipulators (L2)

UNIT II **10 Lectures**

Position analysis of parallel manipulators: Introduction, Position analysis of a planar 3-RPR and 3-RRR parallel manipulator and spatial 3-DoF orientation mechanism**:** Geometry of the manipulator, inverse kinematics and direct kinematics.

Learning Outcomes: At the end of this unit, the student will be able to

1. describe the geometry of 3RPR parallel manipulator (L2)
2. solve inverse kinematics of 3RRR parallel manipulator (L3)
3. determine end-effector pose using forward kinematics of spatial 3-DoF orientation mechanism (L3)

UNIT III **10 Lectures**

Jacobian analysis of parallel manipulators: Introduction, Jacobian matrices, singularity conditions, conventional Jacobian, Jacobian of a planar 3-RRR parallel manipulator, inverse kinematic singularities, direct kinematic singularities and combined singularities.

Learning Outcomes: At the end of this unit, the student will be able to

1. determine Jacobian matrix of a planar 3-RRR parallel manipulator (L3)
2. explain singularity conditions (L2)
3. examine singularity poses of a planar 3-RRR parallel manipulator (L3)

UNIT IV **10 Lectures**

Parallel manipulators workspace limits, representation and type: The different types of workspaces, orientation representation. **Workspace calculation methods:** Workspace calculation methods, discretisation method.

3-RPR Planar manipulator: Constant orientation workspace, Orientation workspace, Dextrous workspace, Maximal workspace.

Learning Outcomes: At the end of this unit, the student will be able to

1. explain workspace calculation methods (L2)
2. illustrate constant orientation workspace for 3-RPR Planar manipulator (L3)
3. differentiate between constant orientation dextrous and maximal workspace (L2)

UNIT V **10 Lectures**

Statics of parallel manipulators: Free-body diagram approach, application of the principle of virtual work of planar 3-RRR manipulator, stiffness analysis of parallel manipulators.

Calibration: General comparison of calibration methods, issues in calibration methods. External calibration: type of external measurements, calibration with direct kinematics, inverse kinematics, constant leg lengths, other geometrical elements and mechanical constraints.

Learning Outcomes: At the end of this unit, the student will be able to

1. determine stiffness matrix for planar 3-RRR manipulator (L3)
2. discuss the issues in calibration methods (L2)
3. describe external calibration using direct and inverse kinematics (L2)

Text books:

1. J. P. Merlet, *Parallel Robots*, Springer, 2006. (Unit-I, IV, V)
2. Lung-Wen-Tsai, *Robot Analysis: The Mechanics of Serial And Parallel Manipulators*, A Wiley-Interscience Publication, 1999. (Unit-II, III, V)

References:

1. Cecilia Norton, *Parallel Manipulators*, Nova Publishers, 2016.