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**BTECH-MINOR**  
**(SEM V) THEORY EXAMINATION 2024-25**  
**MECHANICS OF ROBOTS**

**TIME: 3 HRS****M.MARKS: 100****Note:** Attempt all Sections. In case of any missing data; choose suitably.**SECTION A****1. Attempt all questions in brief.****2 x 10 = 20**

Q no.	Question	CO	Level
a.	Given two transformations $T_1$ and $T_2$ , derive the compound transformation $T=T_1 \cdot T_2$ .	1	K3
b.	Provide an example of a robotic manipulator with two links.	1	K3
c.	Compare fixed angles and Euler angles for orientation representation.	1	K3
d.	Define manipulator kinematics.	2	K3, K4
e.	Provide a detailed example of a two-link planar manipulator.	2	K3, K4
f.	Describe the concept of a kinematic chain in robotics.	2	K3, K4
g.	Derive the virtual work principle for a robotic manipulator.	3	K2, K4
h.	Discuss the impact of mechanical design on the kinematics of robotic linkages.	3	K2, K4
i.	Discuss optimization techniques for real-time control.	4	K3, K6
j.	Explain the role of dynamic simulation in robotics.	4	K3, K6

**SECTION B****2. Attempt any three of the following:****10 x 3 = 20**

Q no.	Question	CO	Level
a.	Explain how a point in 3D space is represented in a local coordinate frame. Derive the transformation matrix for converting a point's coordinates between two different frames.	1	K3
b.	Prove that a valid rotation matrix is orthogonal and has a determinant of 1. Discuss how these properties are verified in practical applications.	1	K3
c.	Derive the Denavit-Hartenberg (D-H) parameters for a 3-DOF robotic arm. Explain how these parameters simplify kinematic analysis.	2	K3, K4
d.	Derive the Jacobian matrix for a 2-link planar manipulator. Explain its role in determining the end-effector's velocity.	3	K2, K4
e.	Discuss the concept of a force ellipsoid in the context of dynamics. Derive its relationship with the manipulator's Jacobian.	4	K3, K6

**SECTION C****3. Attempt any one part of the following:****10 x 1 = 10**

Q no.	Question	CO	Level
a.	Define Euler angles and derive the rotation matrix for a 3-2-1 sequence of rotations. Discuss the advantages and limitations of using Euler angles in robotics.	1	K3
b.	A point $P=[3,4,5]^T$ is described in Frame A. Frame B is rotated $30^\circ$ about the z-axis and translated by $[1,2,0]^T$ . Find the coordinates of P in Frame B.	1	K3



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**TIME: 3 HRS****M.MARKS: 100****4. Attempt any one part of the following: 10 x 1 = 10**

Q no.	Question	CO	Level
a.	For a 4-DOF robotic manipulator with given D-H parameters, derive the forward kinematics equations. Discuss their role in trajectory planning.	2	K3, K4
b.	Using the geometric approach, derive the joint angles for a robotic arm with two rotational joints to reach a given position in Cartesian space.	2	K3, K4

**5. Attempt any one part of the following: 10 x 1 = 10**

Q no.	Question	CO	Level
a.	Compare different methods for representing the position and orientation of a robotic end-effector, such as homogeneous matrices and quaternions.	2	K3, K4
b.	Define kinematic singularity. Provide an example of a singular configuration in a robotic manipulator and discuss its implications.	3	K2, K4

**6. Attempt any one part of the following: 10 x 1 = 10**

Q no.	Question	CO	Level
a.	Derive the Jacobian matrix for a manipulator in the base frame {0}. Explain how this is used in velocity and force analysis.	3	K2, K4
b.	Define the concept of a force ellipsoid. Derive its equation for a 2-DOF planar manipulator and explain its significance.	3	K2, K4

**7. Attempt any one part of the following: 10 x 1 = 10**

Q no.	Question	CO	Level
a.	Compare the Lagrangian and Newton-Euler methods for deriving robotic dynamics. Discuss their relative advantages and limitations in different applications.	4	K3, K6
b.	Derive the equations for the acceleration of a rigid body with a given mass distribution. Explain how these equations are applied in robotic dynamics.	4	K3, K6