

Enrollment No./Seat No.:

GUJARAT TECHNOLOGICAL UNIVERSITY
Bachelor of Engineering - SEMESTER - V EXAMINATION - WINTER 2025

Subject Code: N115AO01

Date: 06-12-2025

Subject Name: Mechanics of Robotics

Time: 10:30 AM TO 01:00 PM

Total Marks: 70

Instructions

- 1. Attempt all questions.**
- 2. Make suitable assumptions wherever necessary.**
- 3. Figures to the right indicate full marks.**
- 4. Simple and non-programmable scientific calculators are allowed.**

	Marks
Q.1 (a) Define Euler angles and explain their significance in robotics.	03
(b) Explain the difference between rotation matrix and homogeneous transformation matrix with examples.	04
(c) Derive the transformation matrix for a body that is rotated 90° about Z-axis and translated by 5 units along X-axis.	07
Q.2 (a) State the Denavit–Hartenberg (D-H) parameters.	03
(b) Write the homogeneous transformation matrix for a two-link planar manipulator.	04
(c) Solve the forward kinematics problem for a 2R (two-revolute joint) manipulator using D-H convention.	07
OR	
(c) Derive the Jacobian for a 2-link planar manipulator and discuss its singular configurations.	07
Q.3 (a) Define Jacobian and its role in robotic motion.	03
(b) Explain the concept of kinematic singularity with a simple example.	04
(c) Compare Newton–Euler and Lagrangian methods for deriving robot dynamics with suitable examples.	07
OR	
(a) State Newton’s and Euler’s equations for rigid body dynamics.	03
(b) Write the Lagrangian equation of motion for a single link pendulum robot.	04
(c) Solve the forward kinematics of a two-link planar manipulator with following configuration: link lengths $L_1 = 2\text{m}$ $L_2 = 1\text{m}$, $\theta_1 = 45^\circ$ $\theta_2 = 30^\circ$ Find end-effector coordinates.	07

- Q.4 (a)** What is forward kinematics? **03**
- (b)** State the velocity-force duality principle. **04**
- (c)** For a two-link manipulator ($L_1=1\text{m}$, $L_2=1\text{m}$, $\theta_1=30^\circ$, $\theta_2=45^\circ$), compute Jacobian and find singularity. **07**

OR

- (a)** Explain force ellipsoid with neat sketch. **03**
- (b)** Discuss virtual work principle in robotic statics. **04**
- (c)** A single-link manipulator of length $L=1\text{ m}$ and mass $m=2\text{ kg}$ is rotating about a fixed joint. Derive the equation of motion using Lagrangian formulation. **07**
- Q.5 (a)** Differentiate between static and dynamic analysis in robotics. **03**
- (b)** State Newton's equation of motion for a rigid body. **04**
- (c)** A point $P(2,3,5)$ in frame A is rotated 90° about Y-axis and translated by $(2,0,3)$ to frame B. Find the final coordinates of P in frame B using transformation matrices. **07**

OR

- (a)** Explain iterative Newton–Euler formulation with steps. **03**
- (b)** Explain inverse kinematics problem with an example. **04**
- (c)** Using Euler angles ($\Phi=45^\circ$, $\Theta=60^\circ$, $\Psi=30^\circ$), derive the rotation matrix. **07**
