			Marks	BL	PO	CO	PSO
Q.5	i.	Describe the joint space technique for robotic path planning. How does it differ from Cartesian space planning?	**4**	2	1, 2, 3, 5, 12	4	1
	ii.	Express a cubic polynomial for path generation of a robot assuming initial and final velocity as zero. How joint velocity and acceleration can be calculated from the above expression? Also calculate the coefficients involved in the expression.	**6**	3	1, 4, 5, 12	4	1
OR	iii.	Consider a single link robot manipulator with a rotary joint. Design a cubic trajectory, which starts from the initial angular position $\theta_i(0) = 10°$ and ends at the final angular position $\theta_i(2) = 90°$, with zero initial velocity and zero final velocity.	**6**	3	1, 3, 5, 12	4	1
Q.6		Attempt any two:					
	i.	Derive the Lagrangian for a simple 2DOF manipulator.	**5**	3	1, 3, 12	5	1
	ii.	What are the primary terms in the dynamic model derived from the Lagrange-Euler formulation? Explain each term briefly.	**5**	2	1, 2, 12	5	1
	iii.	A 2DOF manipulator is controlled using a PID controller to maintain a target position. Describe how each component of the PID controller would respond if the manipulator's position deviates from the target.	**5**	2	1, 5, 12	5	1

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Total No. of Questions: 6 *Total No. of Printed Pages:4*

Enrollment No.....................................

Faculty of Engineering
End Sem Examination Dec 2024
RA3CO48 Principles of Robotics

Programme: B.Tech. Branch/Specialisation: RA

Duration: 3 Hrs. **Maximum Marks: 60**

Note: All questions are compulsory. Internal choices, if any, are indicated. Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d. Assume suitable data if necessary. Notations and symbols have their usual meaning.

			Marks	BL	PO	CO	PSO
Q.1	i.	Which of the following is an end effector? (a) Gripper (b) Welding torch (c) Suction cup (d) All of these	**1**	1	1	1	1
	ii.	Which one of the following robots is based on physical configuration? (a) Point to point (b) SCARA (c) Controlled path (d) Continuous path	**1**	1	1	1	1
	iii.	A homogeneous transformation is used to describe the- (a) Position (b) Orientation (c) Directions (d) All of these	**1**	1	1	2	1
	iv.	The Denavit-Hartenberg matrix is- (a) Articulated matrix (b) Homogeneous matrix (c) Inverse matrix (d) None of these	**1**	1	1	2	1
	v.	Which is true for a Jacobian matrix of robots with three joints? (a) 6 rows and 6 columns (b) 3 rows and 6 columns (c) 3 rows and 3 columns (d) 6 rows and 3 columns	**1**	1	1	3	1

	vi.	Conditions of collinearity in joint axis of robot is termed as- (a) Articulation of a robot (b) Singularity of a robot (c) Collapse of a robot (d) All of these	**1**	1	1	4	1
	vii.	In joint space technique, the motion planning is done at- (a) Joint level (b) Link level (c) End effector level (d) None of these	**1**	1	1	4	1
	viii.	In cartesian space technique the position and orientation are computed as function of- (a) Velocity (b) Time (c) Joint angle (d) None of these	**1**	1	1	5	1
	ix.	The Lagrange-Euler formulation is commonly applied to determine- (a) The inverse kinematics of a manipulator (b) The dynamics of a manipulator (c) The workspace of a manipulator (d) The manipulator's programming language	**1**	1	1	5	1
	x.	In the PID control scheme, the derivative component is responsible for- (a) Correcting accumulated errors over time (b) Adjusting control based on the present error only (c) Counteracting future errors based on current rate of change (d) None of these	**1**				
Q.2	i.	Explain the primary design considerations when constructing a robot. How do these affect a robot's functionality?	**2**	2	1, 2, 12	1	1
	ii.	Describe the various robot specifications. Why is understanding these specifications important in selecting a robot for a particular application?	**3**	2	1, 4, 12	1	1

	iii.	Explain the importance of workspace and reachability considerations with neat sketches in robot design.	**5**	2	1, 2, 3, 12	1	1
OR	iv.	Identify common design and control challenges in robotics. How are these issues typically addressed?	**5**	3	2, 4, 12	1	1
Q.3	i.	How are D-H parameters used to represent the relationships between joints in a robotic arm?	**3**	3	1, 2	2	1
	ii.	If we rotate J (3, 4, -1) in a counter clockwise direction by 45° degrees about the z-axis, what are the coordinates?	**7**	3	1, 5, 12	2	1
OR	iii.	Compare and contrast closed-form and numerical methods for solving inverse kinematics problems. What are the advantages and disadvantages of each method?	**7**	4	1, 2, 5, 12	2	1
Q.4	i.	Derive the expression for the linear and angular velocity of a robot's end-effector in terms of joint velocities.	**3**	3	1, 5, 12	3	1
	ii.	Calculate the Jacobian matrix for a simple two-link robotic arm with prismatic and rotary joints.	**7**	3	1, 3, 12	3	1
OR	iii.	A 2-DOF planar robotic manipulator has two revolute joints with link lengths l_1=1 m and l_2= 0.5 m. The joint angles are θ_1=30° and θ_2=45°, and the joint angular velocities are θ_1=0.5 rad/s and θ_2=0.3 rad/s. Compute the end-effectors linear velocity $(\dot{x}, \dot{y})$ using the Jacobians matrix.	**7**	3	1, 4, 5,12	3	1

Marking Scheme
RA3CO48 (T) Principles of Robotics (T)

Q.1	(d) All of the above	**1**
	(b) SCARA	**1**
	(d) All of the above	**1**
	(b) Homogeneous matrix	**1**
	(d) 6 rows and 3 columns	**1**
	(b) Singularity of a robot	**1**
	(a) Joint level	**1**
	(b)Time	**1**
	(b) The dynamics of a manipulator	**1**
	(c) Counteracting future errors based on current rate of change	**1**
Q.2	Design consideration: 1 mark. Effect on functionality: 1 mark	**2**
	Specifications: 1 mark. Selection criteria: 2 marks	**3**
	Importance: 2 marks. neat sketches: 3 marks	**5**
OR	Design and control challenges: 2 marks. Solutions: 3 marks	**5**
Q.3	Name of four D-H parameters: 1 mark. Transformation matrix: 2 marks	**3**
	Matrix: 1 mark; substitution of values in matrix: 2 marks; multiplication by coordinate points: 2 marks. Answer: The coordinates after rotation are = ($-\frac{\sqrt{2}}{2}$, $\frac{7\sqrt{2}}{2}$, -1): 2 marks	**7**
OR	Description of methods: 3 marks. Advantages and disadvantages of methods: 4 marks	**7**
Q.4	Define the Jacobian matrix: 1 mark. Expression for linear and angular velocities: 2 marks	**3**
	Linear and angular components for each joint (partial derivates): 3 marks. Jacobian matrix: 4 marks	**7**
OR	Setup the Jacobian matrix: 3 marks; calculations: 2 marks. Answer: (-0.6363 m/s, 0.5356 m/s) 2marks	**7**
Q.5	Description of joint and cartesian space: 2 marks. Differences: 2 marks	**4**
	Expression for cubic polynomial: 1 mark. Define boundary conditions: 1 mark. Calculations: 1 mark. Final expression: 3 marks	**6**
OR	Cubic trajectory and boundary conditions: 1 mark. Expression: [$\theta(t)=10+30t^2-5t^3$] 5 marks	**6**
Q.6	System configuration: 1 mark. Kinetic energy expression for two links: 1 mark. Potential energy expression for two links: 2 marks. Lagrangian expression: 1 mark	**5**
	Name of terms: 2 marks. Description: 3 marks	**5**
	Component description: 1 mark. Response of components: 4 marks	**5**

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