U.S.N.										

B.M.S. College of Engineering, Bengaluru-560019

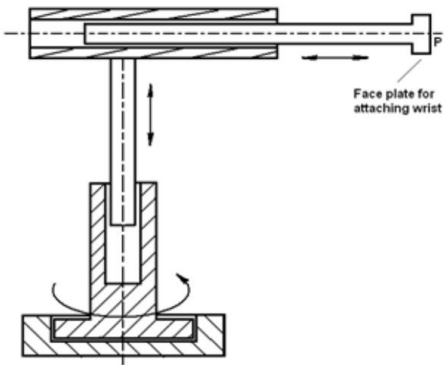
Autonomous Institute Affiliated to VTU

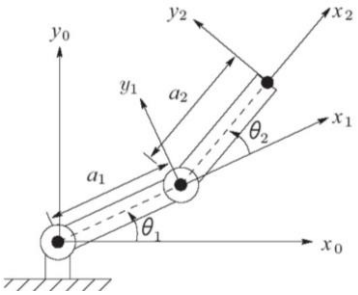
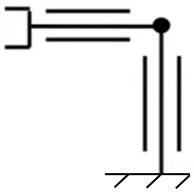
January 2024 Semester End Main Examinations

Programme: B.E. **Semester: VII**
Branch: Aerospace Engineering **Duration: 3 hrs.**
Course Code: 21AE7DEITR **Max Marks: 100**
Course: INTRODUCTION TO ROBOTICS

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

		UNIT - I	CO	PO	Marks
1	a)	Explain briefly the robot coordinates with a neat sketch.	*CO 1*	*PO 1*	**6**
	b)	Briefly the types of grippers in a neat sketch.	*CO 1*	*PO 1*	**7**
	c)	Write a note on the application of robots in the aerospace domain.	*CO 1*	*PO 1*	**7**
		UNIT - II			
2	a)	What is a homogenous transformation matrix? Explain its submatrices.	*CO 2*	*PO 1*	**6**
	b)	Derive rotational matrix for coordinate transformation.	*CO 2*	*PO 1*	**7**
	c)	For the cylindrical robot as shown in Figure 2c, write the D-H parameters.  Figure 2c	*CO 2*	*PO 3*	**7**
		OR			
3	a)	State the important steps in the Denavit-Hartenberg (D-H) convention.	*CO 2*	*PO 1*	**6**
	b)	A point a = (4, 3, 2) is attached to a rotating frame; the frame rotates 60 degrees about the OZ axis of the reference frame. Find the coordinates of the point relative to the reference frame after the rotation?	*CO 2*	*PO 3*	**7**

		c)	Write the expression for the end effector position using inverse kinematics for the two link planer (2R) elbow manipulator as shown in Figure 3c.  Figure 3c	*CO 2*	*PO 3*	**7**
			UNIT - III			
	4	a)	Explain the different methods for calculating the Jacobian.	*CO 3*	*PO 1*	**6**
		b)	Explain the Lagrangian formulation procedure for determining the torque or forces of joints.	*CO 3*	*PO 1*	**6**
		c)	Write the expression for the end effector velocity as a function of joint rates in terms of the base frame for the two-link planer (2R) manipulator as shown in Figure 3c. DH table and transformation matrix with usual notations are given as, Axis (i) | α_{i-1} | a_{i-1} | d_i | Θ_i 1 | 0 | L_1 | 0 | Θ_1 2 | 0 | L_2 | 0 | Θ_2 $${}^{i-1}_{i}T = \begin{bmatrix} \cos(\theta_i) & -\sin(\theta_i) & 0 & a_{i-1} \\ \cos(\alpha_{i-1})\sin(\theta_i) & \cos(\alpha_{i-1})\cos(\theta_i) & -\sin(\alpha_{i-1}) & -d_i\sin(\alpha_{i-1}) \\ \sin(\alpha_{i-1})\sin(\theta_i) & \sin(\alpha_{i-1})\cos(\theta_i) & \cos(\alpha_{i-1}) & d_i\cos(\alpha_{i-1}) \\ 0 & 0 & 0 & 1 \end{bmatrix}$$	*CO 3*	*PO 3*	**8**
			OR			
	5	a)	What is meant by singularities in a robot? Explain briefly workspace interior and boundary singularities.	*CO 3*	*PO 1*	**6**
		b)	What is meant by Joint and Cartesian-spaces description?	*CO 3*	*PO 1*	**6**
		c)	For a robot shown below Figure 5c with two prismatic joints (P_1, P_2), links (n_1, n_2), the link masses are of the links (m_1, m_2) and displacements (q_1, q_2), determine the expression for input force (F_1, F_2) that are required to be produced by the actuators using the Lagrangian formulation.  Figure 5c	*CO 3*	*PO 3*	**8**
			UNIT - IV			
	6	a)	List the advantages and disadvantages of trajectory generation in the joint space and Cartesian spaces.	*CO 4*	*PO 1*	**6**

		b)	What are the robot actuators? Briefly explain various types of actuators.	*CO 4*	*PO 1*	**7**
		c)	A single cubic trajectory is given by $q(t)= 30+t^2-6t^3$ is used for a period of 3 seconds. Draw the position, velocity, and acceleration profiles of the end effector.	*CO 4*	*PO 3*	**7**
			UNIT - V			
	7	a)	Discuss the five levels of autonomy in robots.	*CO 4*	*PO 1*	**6**
		b)	Discuss the various types of machine learning and AI techniques used for a robot.	*CO 4*	*PO 1*	**7**
		c)	Write a note on future trends in terms of market adoption and research directions for robotics.	*CO 4*	*PO 1*	**7**

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