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

Autonomous Institute Affiliated to VTU

June 2025 Semester End Main Examinations

Programme: B.E. **Semester: VI**

Branch: Institutional Elective **Duration: 3 hrs.**

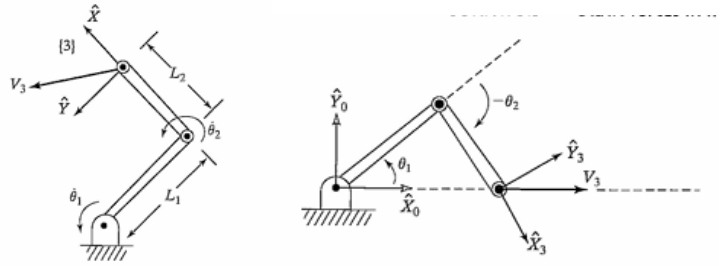
Course Code: 23ME6OEROB **Max Marks: 100**

Course: Fundamentals of 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)	A vector ${}^{A}P$ is rotated about $\hat{Z}_A$ by θ degrees and is subsequently rotated about $\hat{Y}_A$ by ϕ degrees. Give the rotation matrix that accomplishes these rotations in the given order.	CO1	PO1	**10**
	b)	Explain the various robot configurations with neat diagrams.	CO1	PO1	**10**
		OR			
2	a)	Obtain the equations to compute the position and the orientation of frame {3} relative to a frame {0} for PUMA 560 robot arm. Show the frame assignments and DH table. Transformation matrix for the link is as follows: $${}^{i-1}_{i}T = \begin{bmatrix} c\theta_i & -s\theta_i & 0 & a_{i-1} \\ s\theta_i c\alpha_{i-1} & c\theta_i c\alpha_{i-1} & -s\alpha_{i-1} & -s\alpha_{i-1}d_i \\ s\theta_i s\alpha_{i-1} & c\theta_i s\alpha_{i-1} & c\alpha_{i-1} & c\alpha_{i-1}d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$	CO2	PO2	**20**
		UNIT - II			
3	a)	What is meant by a singularity in robotics? Describe its types with appropriate examples.	CO2	PO2	**10**
	b)	Consider the two-link robot shown here, as it is moving its end-effector along the X axis at 1.0 m/s as shown in Fig. 3b. Show that joint rates are reasonable when far from a singularity, but that, as a singularity is approached at $\theta_2 = 0$, joint rates tend to infinity.	CO2	PO2	**10**

			 Fig. 3b			
			OR			
	4	a)	Discuss the solvability of the inverse kinematics problem.	*CO2*	*PO2*	**10**
		b)	Perform the inverse kinematics for a SCARA robot.	*CO2*	*PO2*	**10**
			UNIT - III			
	5	a)	A single-link robot with a rotary joint is motionless at θ = -5º. It is desired to move the joint in a smooth manner to θ = 80° in 4 seconds. Find the coefficients of a cubic which accomplishes this motion and brings the arm to rest at the goal. Plot the position, velocity, and acceleration of the joint as a function of time.	*CO3*	*PO3*	**10**
		b)	Discuss Cartesian path planning and geometric problems associated with it, using neat sketches.	*CO3*	*PO1*	**10**
			OR			
	6	a)	A single-link robot with a rotary joint is motionless at θ = -5º. It is desired to move the joint in a smooth manner to θ = 80° in 4 seconds and stop smoothly. Compute the corresponding parameters of a linear trajectory with parabolic blends. Plot the position, velocity, and acceleration of the joint as a function of time.	*CO3*	*PO3*	**10**
		b)	How many individual cubics are computed when a six-jointed robot moves along a cubic spline path through two via points and stops at a goal point? How many coefficients are stored to describe these cubics?	*CO3*	*PO1*	**10**
			UNIT - IV			
	7	a)	Discuss the architecture of PUMA 560 robot controller.	*CO3*	*PO3*	**10**
		b)	Discuss the resolved motion rate robot control scheme with a block diagram.	*CO3*	*PO3*	**10**
			OR			
	8	a)	Discuss how a single joint of a robot can be controlled with appropriate equations.	*CO3*	*PO3*	**10**
		b)	Show how PID control eliminates steady-state error in trajectory tracking control.	*CO3*	*PO3*	**10**

			UNIT - V			
	9	a)	List and explain the required characteristics of a sensor used in robots.	*CO4*	*PO3*	**10**
		b)	Explain with a neat diagram the working principle of tactile sensors mounted on the actuators/grippers.	*CO4*	*PO1*	**10**
			OR			
	10	a)	Discuss the working principle of a stepper motor with neat sketches.	*CO4*	*PO3*	**10**
		b)	Discuss any modern actuator used in robotics with an example application.	*CO4*	*PO1*	**10**

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