221TME007022303

Reg No.:____

Name:

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSI

First Semester M.Tech Degree Regular and Supplementary Examination December 2023 (202

Discipline: MECHANICAL ENGINEERING Course Code & Name: 221TME007 ROBOTICS AND AUTOMATION

Max. Marks: 60

7

Duration: 2.5 Hours

PART A

	Answer all questions. Each question carries 5 marks	Marks
1	Write at least four advantages of electric actuators over pneumatic actuators	(5)
2	Explain about the solvability criteria for inverse manipulator kinematics	(5)
3	What is meant by singularity and what is the effect of singularity on the inverse	(5)
	kinematics?	()
4	Explain with a neat sketch the situation in which the linear trajectory with parabolic	(5)
	blends trajectory can be applied.	(3)
5	With a next diagram briefly and in the state	

5 With a neat diagram, briefly explain how robot can be used for spot welding (5) operation

PART B

Answer any 5 questions. Each question carries 7 marks

6 Derive the Homogeneous transformation matrix using multiplication of rotation and (7) translation matrix generated from Euler's angle



Obtain the expression for the final homogeneous transformation matrix of the wrist frame with respect to the base frame in terms of D-H parameters for RRR robot. The link lengths (7)

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are $L_1 = L_2 = L_3 = 1$ & angle between joints are θ_1 , θ_2 , and $\theta_3 = 0^0$. Derive the forward kinematics for the robot for the angle values $\theta_1 = 50^0$, $\theta_2 = 30^0$, $\theta_3 = 0^0$

(7)

(7)

8 Find the 3x3 Jacobian matrix for the three degree of freedom RRT joint robot as shown in figure. Joint 1, joint 2 angles are θ_1 and θ_2 and joint 3 is translating d₃ units along Z₃ axis.



9 The forward kinematics and the desired position and orientation of an end effector (7) of a 3 link RRT planar serial manipulator is given by

	C_{123}	$-S_{123}$	0	$L_1C_1 + L_2C_{12}$	6 m	r0.819	-0.534	0	1.806
Baser	S123	C_{123}	0	$L_1S_1 + L_2S_{12}$	_	0.574	0.819	0	0.842
$Wrist^{I} =$	0	0	1	d_3	_	0	0	1	2
	0	0	0	1		Lo	0	0	1 J

Calculate the inverse kinematics of the configuration.

10 A one degree of freedom planar serial manipulator starts from point A and move to point C through the via point B as shown in figure. The manipulator position and velocity at point A is 5 degrees and 0 m/s, point B is 10 degrees and comes to rest and then starts moving, and at point C is 20 degrees and 0 m/s respectively as represented. The time taken for the manipulator to move from point A to B is 3 sec and from B to C is 4 sec. Compute the cubic spline trajectories from A to B and B to C.



Α	В	С
3 s	sec 4	sec
$\theta_a = 5^0$	$\theta_b = 10^0$	$\theta_c = 20^0$
$\dot{\theta}_a = 0$	$\dot{\theta}_b = 0$	$\dot{\theta}_c = 0$

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11 The Jacobian matrix for an RRP robot shown in the figure is

$$J = \begin{bmatrix} -s_1 d_3 c_2 & -c_1 s_2 d_3 & c_1 c_2 \\ -c_1 d_3 c_2 & -s_1 s_2 d_3 & s_1 c_2 \\ 0 & c_2 d_3 & s_2 \end{bmatrix}$$

Calculate the force F₃, torques τ_1 and τ_2 for an angles $\theta_1 = 30^0$, $\theta_2 = 50^0$ and $d_3 = 5$ units. The end effector force components act in x, y, z directions respectively are F_x, F_y, and 0 N.



- 12 Suppose you may be working as a robotic engineer in a reputed automobile firm. The operations performed in the firm are spray painting, spot welding, Arc welding, Drilling and Assembly operations. The firm management has given a task to design a robot having 3 DOF that can perform the arc welding, drilling and assembly operations. The operations are performed by changing the tool holder at the wrist joint.
 - i. Select the appropriate type of end effector to perform the job
 - ii. Calculate the final transformation matrix of tool tip with respect to base
 - iii. Define the safety considerations that you have considered inside the manufacturing cell

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(7)