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Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Fifth Semester B.Tech Degree Regular and Supplementary Examination December 2023 (2019 Scheme)

Course Code: RAT 301

Course Name: INTRODUCTION TO ROBOTICS

Max. Marks: 100 Duration: 3 Hours

PART A

(Answer all questions; each question carries 3 marks) **Marks**

1		Define degrees of freedom. What is the minimum number of degrees of freedom that a robot needs to have to locate its end effector at an arbitrary point with an arbitrary orientation in space?	3
2		Explain 3R concurrent wrist.	3
3		Distinguish between fundamental and composite rotation matrix.	3
4		A mobile frame M is rotated about the fixed frame F by an angle $\pi/2$ about the f^2 axis. Determine the fundamental rotation matrix	3
5		Differentiate joint space and cartesian space description.	3
6		Define straight-line trajectory.	3
7		Explain the Euler-Lagrange equation for dynamic modelling.	3
8		What are the disadvantages of single-axis PID control?	3
9		What are the core issues faced by wheeled robots	3
10		What are optical encoders? Explain with a diagram.	3

PART B

(Answer one full question from each module, each question carries 14 marks)

Module -1

11	a)	Explain the anatomy of a robot manipulator.	8
	b)	Explain SCARA.	6
12	a)	With suitable diagrams, explain the various robot configurations.	7
	b)	Write a short note on different types of grippers	7

Module -2

13	a)	A point p with a position as $[7,3,1]^T$ is attached to frame M and subjected to the following transformation:	7
		i) Rotation of 90° along the z-axis	

ii) Followed by rotation of 90° along the y-axis

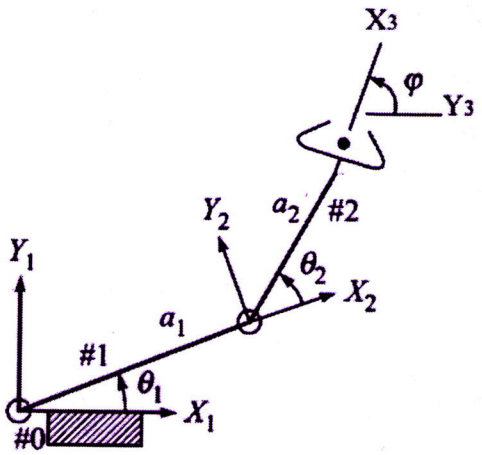
iii) Followed by translation of [4,-3,7]

Find the coordinate of the point relative to the fixed frame

b) Write the algorithm for DH representation. 7

14 a) Determine all the fundamental rotation matrices along the x, y, and z axis with suitable axis rotation diagrams 6

b) Obtain the D-H Parameters of a two-link planar arm. Also, derive its forward kinematic equations. 8



Module -3

15 a) It is desired to have the fifth joint of a 6-axis robot go from an initial angle of 20^0 to a final angle of 60^0 in 5 seconds. Plan a third-order (cubic) polynomial for this requirement with a drawing of the displacement, velocity and acceleration profiles. 8

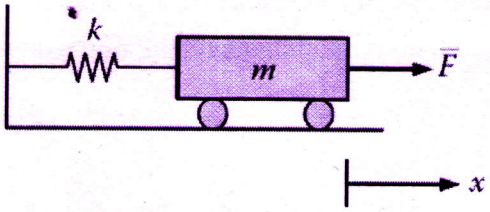
b) Explain how the A* algorithm can be used in robot trajectory planning. 6

16 a) Describe the application of cubic polynomials to trajectory planning in joint space. 8

b) Explain potential field-based path planning for robots. 6

Module -4

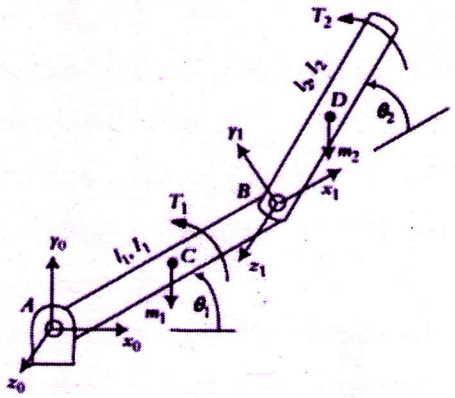
17 a) Derive the force-acceleration relationship for the 1-DOF system shown in Figure below, using both the Lagrangian mechanics. Assume the wheels have negligible inertia. 5



b) Derive the closed loop transfer function of single-axis PID control with the necessary block diagram. 9

18 a) Derive the dynamic model of a 1 DOF robot, including the motor and gearbox. 6

b) Derive of the equations of motion for the 2-DOF 2R planar manipulator robot arm, shown in Figure below. The centre of mass for each link is at the centre of the link. The moments of inertia are I_1 and I_2. 8



Module -5

19 a) Write a short note on the industrial application of robots. 7

b) Explain the robot considerations for an application. 7

20 a) Define the various sensor characteristics. 7

b) Explain open loop and feedback control with necessary diagrams. 7

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