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Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S5 (S,FE) Examination May 2025 (2019 Scheme)

Course Code: RAT301

Course Name: INTRODUCTION TO ROBOTICS

Max. Marks: 100 Duration: 3 Hours

PART A

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

1		Distinguish between servo and non-servo control robots.	3
2		Describe with diagrams open and closed kinematic chains.	3
3		Suppose the mobile coordinate frame M is rotated about the fixed coordinate frame F by an angle $\pi/3$ about the f^{l} axis. If p is a point whose coordinates in the mobile M frame are $[2, 0, 3]^{T}$. Determine the coordinates of p with respect to the fixed frame F.	3
4		Define the screw transformation.	3
5		Explain the advantages and disadvantages of Cartesian space planning.	3
6		What is the significance of the trapezoidal velocity profile used in LSPB trajectory planning?	3
7		What is the Lagrangian function in dynamics? How is generalized force Fi acting on the ith joint computed from the Lagrangian?	3
8		What are the disadvantages of the single axis PID controller?	3
9		Explain with a diagram the synchro drive in wheeled mobile robots.	3
10		Describe the kinematic constraints of a fixed standard wheel.	3

PART B

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

Module -1

11	a)	Explain with a diagram, the anatomy of a robotic manipulator.	6
	b)	Describe with necessary diagrams the various types of joints that can be used in a robotic manipulator.	8
12	a)	Describe mechanical grippers with necessary diagrams.	6
	b)	Explain the four basic robotic configurations with neat diagrams.	8

Module -2

13 a) Suppose the tool is rotated about the fixed axes starting with a yaw of -π, followed by a pitch of - π/2, and finally a roll of π. Obtain the composite rotation matrix. Suppose the point p at the tool tip has mobile coordinates $[p]^M = [0.5, 0, 0]^T$. Find the coordinates of point p with respect to the fixed frame $[p]^F$ following the yaw-pitch-roll transformation. 7

b) Calculate the inverse of the given transformation matrix: 7

$$T = \begin{bmatrix} 0.5 & 0 & 0.866 & 3 \\ 0.866 & 0 & -0.5 & 2 \\ 0 & 1 & 0 & 5 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

14 a) Summarize the four kinematic parameters associated with the physical design of the robotic arm. 8

b) Obtain the D-H Parameters of the Spherical Arm. Also, derive its forward kinematic equation (Arm Equation). 6

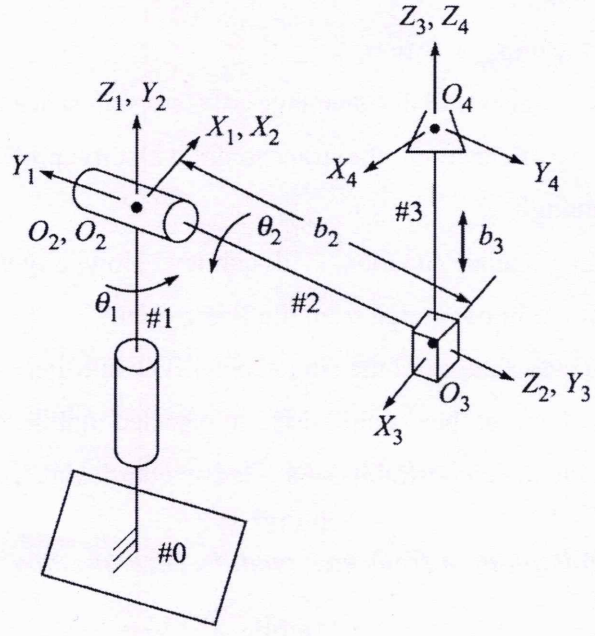

Figure: Spherical Arm

Module -3

15 a) Describe the application of cubic polynomials to trajectory planning in joint space. 7

b) Explain how the A* algorithm can be used in robot trajectory planning. 7

16 a) It is desired to have the fifth joint of a 6-axis robot go from an initial angle of 7

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.

b) Explain potential field-based path planning for robots. 7

Module -4

17 a) Derive the expression for total kinetic energy of a robotic arm using the manipulator velocity Jacobian matrix. 14

18 a) Derive the expression for the residual forces acting on a robotic arm once the inertial forces and gravitational forces have been removed. 7

b) Derive the expression for the closed loop transfer function of a single axis PID controller with necessary diagrams. What are the conditions for stability of the PID controller? 7

Module -5

19 a) Describe the use of robots in any two industrial applications with the specifications required for these robots. 8

b) Describe open loop type of kinematic controller in wheeled mobile robots. 6

20 a) Explain the working of optical encoders with necessary diagrams. 7

b) Describe with a diagram the working of IMUs. What is its major disadvantage? 7

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