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Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Fifth Semester B.Tech Degree Regular and Supplementary Examination December 2022 (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	Explain briefly DOF and the Grubler-Kutzbach criterion.	3
2	Describe with a diagram a gripper that can be used to handle large flat objects of any type of material.	3
3	Determine the fundamental rotation matrix and the homogeneous rotation matrix for rotation by π about the f^3 axis.	3
4	Obtain the screw transformation matrix for translation by a distance $\lambda = 3$ and rotation by an angle $\pi/2$ about the f^2 axis.	3
5	Compare cartesian space and joint space trajectory planning.	3
6	Distinguish between Point to Point and Continuous Path planning.	3
7	Describe the conditions for using linear control schemes for the control of robotic manipulators.	3
8	Explain how Lagrangian mechanics is applied in dynamic modelling of robots.	3
9	Differentiate between Proprioceptive and Exteroceptive sensors with suitable examples.	3
10	What is the minimum number of legs required for static walking? Justify your answer.	3

PART B

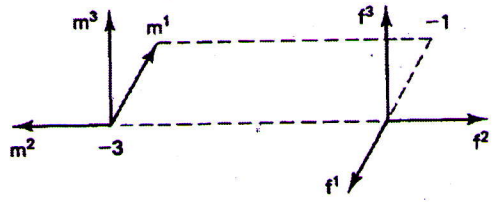
(Answer one full question from each module, each question carries 14 marks)

Module -1

11	a)	Describe SCARA and PUMA robots with neat diagrams.	8
	b)	Classify robots based on motion control and drive technologies.	6
12		Explain the various types of grippers with necessary diagrams	14

Module - 2

13 a) Let F = {f^1, f^2, f^3} and M = {m^1, m^2, m^3} be two initially coincident fixed and mobile orthonormal coordinate frames respectively. Suppose we translate M along f^2 by 3 units and then rotate M about f^3 by π radians. Find $[m^1]^F$ after the composite transformation. 7



b) Derive the relation between joint and end effector velocities in terms of the tool configuration Jacobian. 7

14 a) If a frame is rotated by an angle $\pi/4$ about the m^1 axis, and translated by 3 units along m^2 axis of the mobile frame, obtain the transformation matrix and the coordinates with respect to the fixed frame of a point $p = [2,1,3]^T$ given in terms of the mobile frame. 6

b) Obtain the D-H Parameters of a two-link planar arm given in the figure below. Also, derive its forward kinematic equation. 8

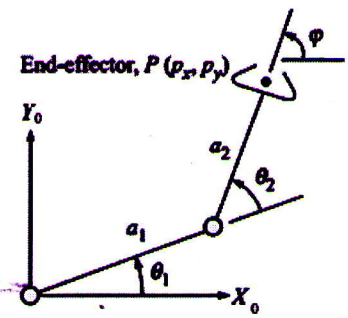


Figure: Two link Planar Arm

Module -3

15 a) It is desired to have the third joint of a 5-axis robot go from an initial angle of 15^0 to a final angle of 45^0 in 6 seconds. Plan a cubic polynomial for this requirement with a drawing of the displacement, velocity and acceleration profiles. 7

b) Explain Cartesian Space Trajectory Planning and schemes to plan straight line and circular trajectories in cartesian space. 7

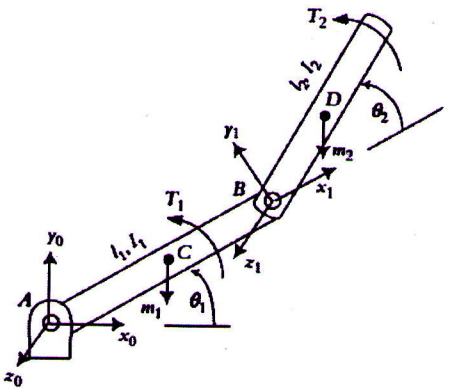
16 a) What is the disadvantage of straight-line trajectory planning in joint space? Explain how Linear Trajectory with Parabolic Blends can overcome this disadvantage. 7

b) Apply the Artificial Potential Field method to obstacle avoidance in mobile robots. 7

Module -4

17 a) Obtain the expression for the velocity Jacobian that maps instantaneous joint velocities to instantaneous linear and angular tool velocity. 7

b) Develop the dynamic model of a 2R planar manipulator shown in the figure below. 7



18 a) Explain generalised force in robot dynamic modelling. 7

b) Describe PD gravity control with necessary equations and block diagrams. 7

Module -5

19 a) Summarize the characteristics to be considered when choosing a robot for a particular application. 8

b) Determine the degree of mobility, degree of steerability and degree of maneuverability of the differential drive robot shown in the figure below. 6

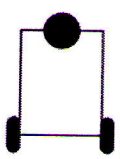


Fig: Differential drive robot

20 a) How can ultrasonics be applied to active ranging? 8

b) Choose the appropriate characteristics required for a spot welding and arc welding robots. 6

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