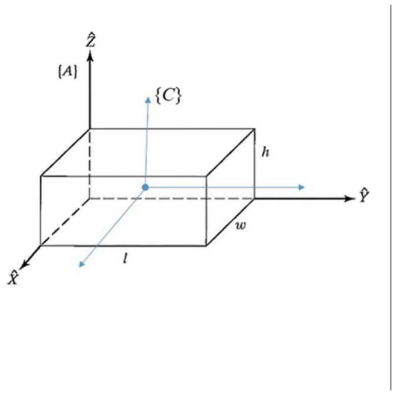
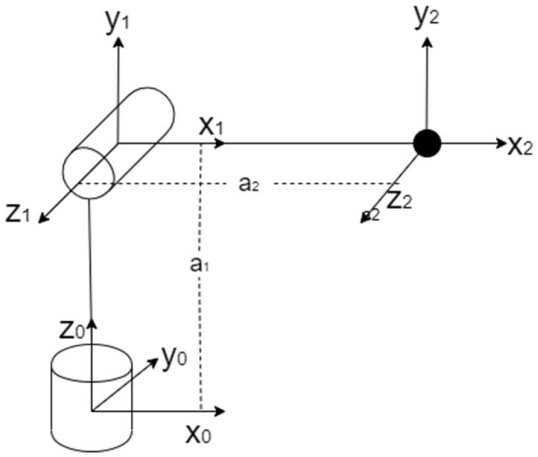
DEPARTMENT OF MECHATRONICS
VI SEMESTER B. TECH (MECHATRONICS)
END-SEMESTER, [May] [2024]

Subject: Robot Dynamics and Control **Subject Code: MTE 4060**

Date: 8-05-2024

Time: 3 Hour **Exam Time: 2:30 PM - 5:30 PM** **Max Marks: 50**

Q.No	Question	M	CO	PO	LO	BL
1A	One of the axis of robot requires a linear displacement of 30cm over a prismatic joint, with its kinematic parameter being, velocity 15cm/s and acceleration 20cm/s². Solve for the time required, for its displacement to be largely linear with parabolic blends at its start and end. Also plot the trajectories of velocity, displacement and acceleration by considering discrete intervals during the task. (Assume the time intervals in terms of 0.25)	5	1	1, 2, 3, 4	1, 2, 3	3
1B	Appraise the concept of tracking problem for a constant reference signal (Linear control) also comparing it with regulatory problem.	3	3	1, 2, 3, 4, 9	1, 2, 3, 16	5
1C	Identify the broad classification of Manipulator control and sub classification as well.	2	3	1, 2, 3, 4, 9	1, 2, 3, 16	3
2A	Estimate the forward and the inverse kinematics of 2R planar robot given in. Also categorize six factors and considerations that must be taken into account when designing an end effector for an industrial environment.	5	1	1, 2, 3, 4	1, 2, 3	5
2B	Analyse the relationship between the desired joint position (θd) and the actual joint position (θ) of a 3-joint robotic arm, with the base motor controlled by a P controller.	3	3	1, 2, 3, 4, 9	1, 2, 3, 16	4
2C	Examine the singularity condition of Jacobian for RP robot with appropriate diagram.	2	2	1, 2, 3, 4	1, 2, 3	4
3A	Determine the forward and inverse kinematics of a spherical robotic arm.	4	1	1, 2, 3, 4	1, 2, 3	5

3B	Formulate the inertia tensor for the rectangular body of uniform density ρ with respect to the coordinate system shown in the (with origin at the center of mass) Fig. 3B  Figure: 3B	3	2	1, 2, 3, 4	1, 2, 3	6
3C	Apply your knowledge of kinematics to determine the required joint displacement of a 2R planar robot, given the end effector's x and y positions are given by 70cm, 15cm respectively and the lengths of the two links are l1 to be 50cm, l2 to be 40cm.	3	1	1, 2, 3, 4	1, 2, 3	3
4A	Conclude the velocity propagation matrix and parameters-for the same 2R planar robot given in Fig. 4A  Figure: 4A	5	1	1, 2, 3, 4	1, 2, 3	5
4B	Justify the behavior of a nonlinear mechanical spring-damper system described by the equation X'' + b(X') + k(X) = 0. Using appropriate stability theorem. Energy Function => $V(X,X') = \frac{1}{2} X'^2 + 0\int^{k} k(\lambda)\, d\lambda$	3	4	1, 2, 3, 4, 9	1, 2, 16	5

4C	Distinguish between force/hybrid position control and compliance control.	2	4	1, 2, 3, 4, 9	1, 2, 16	4
5A	Analyse how Lyapunov stability theorem can be used to explain robot stability.	3	4	1, 2, 3, 4, 9	1, 2, 16	4
5B	Considering a general 6DoF determine the Jacobian in force Domain. Using that formula determine the torques of 2R robot with L1 = 100mm, L2 = 75mm. $\theta_1 = 60°$, $\theta_2 = 30°$. A force of 100N acts at the end effector at 45° to the horizontal, with diagram.	5	1	1, 2, 3, 4	1, 2, 3	5
5C	Demonstrate linearization using control partitioning method for a system with non-linearities. Consider EOM with minimum 4 parameters. Also explain the pre-requisites for this method.	2	4	1, 2, 3, 4, 9	1, 2, 16	3