Name :.....
Roll No:.....

MAR ATHANASIUS COLLEGE OF ENGINEERING
(Government Aided Autonomous Institution)
Kothamangalam, Kerala - 686 666
DEPARTMENT OF MECHANICAL ENGINEERING

B24ME3T04 ROBOTICS AND AUTOMATION

Second Sessional Examination October 2026

Duration: 1 hour and 30 minutes | S5 ME A & B BATCH | Max mark: 40

Part A

(1) What is the Jacobian matrix of a robot? Explain its physical significance.(CO3) **(3)**

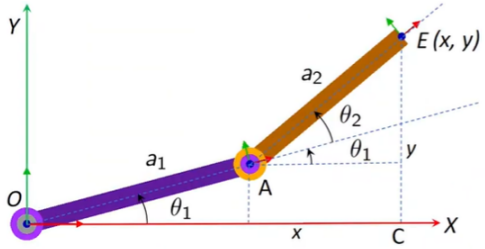
(2) What is a manipulability ellipse? Explain how it represents the directional velocity and force capabilities of a robotic manipulator.(CO3) **(3)**

(3) State the different components contributing to the joint torque in the robot dynamics equation.(CO4) **(3)**

(4) Differentiate between a robot path and a robot trajectory with suitable examples.(CO4) **(3)**

Part B

(1) a. A 2-DOF planar manipulator has link lengths $a_1 = 400$ mm and $a_2 = 300$ mm. Its joint angles are θ_1 and θ_2. Derive the linear velocity Jacobian matrix relating the joint velocity $\begin{bmatrix}\dot{\theta}_1 & \dot{\theta}_2\end{bmatrix}^T$ to the end-effector velocity $\begin{bmatrix}\dot{x} & \dot{y}\end{bmatrix}^T$. Further calculate the end-effector velocity $\begin{bmatrix}\dot{x} & \dot{y}\end{bmatrix}^T$ when robot at $\theta_1 = 30°$ and $\theta_2 = 60°$, the joint velocities are $\dot{\theta}_1 = 0.8$ rad/s and $\dot{\theta}_2 = -0.4$ rad/s.(CO3) **(7)**



b. What is a singularity in a robotic manipulator? Explain the wrist, elbow, and shoulder singularities, stating the typical geometric condition and the main problem associated with each type. (CO3) **(7)**

(2) a. Compare the Lagrange–Euler and Newton–Euler formulations used in robot dynamics. Mention the key differences in their basic principle and approaches. (CO4) **(7)**

b. A robot joint is required to move from x_0 to x_f in t_f seconds. The joint starts and ends at rest, i.e., velocity $\dot{x}(0) = \dot{x}(t_f) = 0$. Using cubic polynomial trajectory planning, derive the trajectory equation. Draw the position, velocity, and acceleration profiles as functions of time from $t = 0$ to $t = t_f$. (CO4) **(7)**

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2. To mould disciplined and socially committed engineers capable of assuming professional leadership upholding national integrity.