Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

DEPARTMENT OF MECHATRONICS

I SEMESTER M TECH. (INDUSTRIAL AUTOMATION AND ROBOTICS)

END SEMESTER EXAMINATIONS, [Jan] [2023]

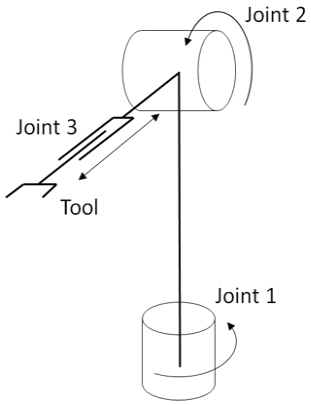
SUBJECT: ROBOT KINEMTICS AND DYNAMICS

SUBJECT CODE: MTE 5151 **DATE:07/01/2023**

Time: 09:30 to 12:30 AM **MAX. MARKS:50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data if any can be suitably assumed.

Q. No	Question	M	CO	LO	BL
1A	Illustrate the classification of the robots based on geometry/kinematic arrangements with neat sketches in detail.	5	1	2	3
1B	Identify the DH table of the following 2RP configuration which is shown in the Fig. 1B.  Fig 1B	3	2	2	3
1C	Illustrate the sensor cycle interaction of the real time environment with a neat diagram	2	1	2	3
2A	Assign the frames, find D-H table, and transformation matrix ${}^{0}T_{3}$ of 3-DOF, RPP configuration arm shown in Fig.Q2A using D-H convention.	5	2	2	4

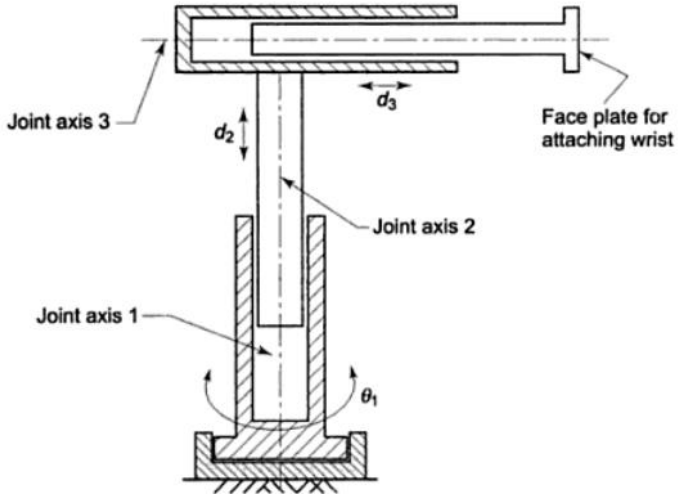
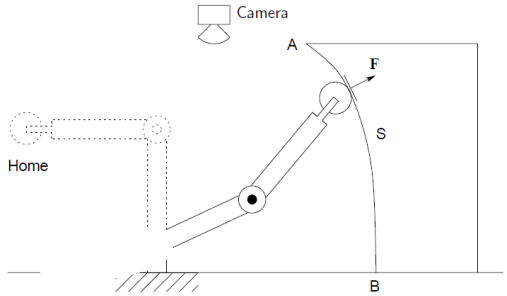
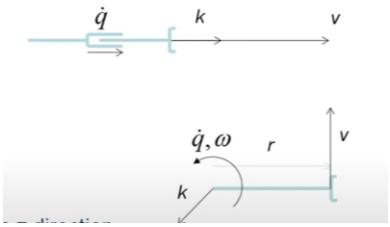
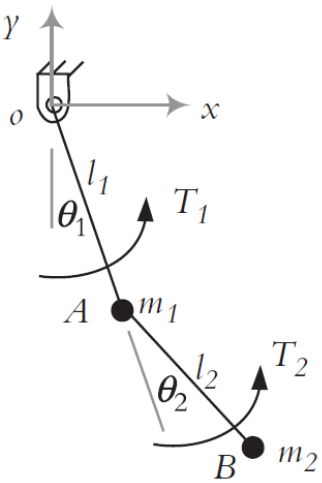
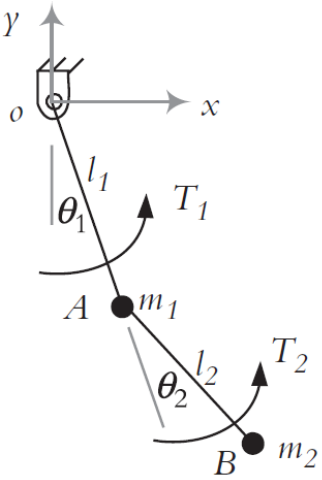


Fig. Q2A

2B	Illustrate the forward kinematics of the below given Fig. 2B in terms of position and orientation of the tool using geometric method.  Fig. 2B	3	2	1	3
2C	Identify the coordinates of point Q and the new position of point P if the coordinates of point P in frame {1} are $[3\ 2\ 1]^T$. The position vector P is rotated about the Z axis by 45^0.	2	2	2	3
3A	Solve the joint variables (θ_1, θ_2, d_3 and θ_4) for 4-DOF SCARA manipulator. When: $$T_E = \begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} \\ r_{21} & r_{22} & r_{23} & r_{24} \\ r_{31} & r_{32} & r_{33} & r_{34} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$ $$^0T_4 = \begin{bmatrix} C_{124} & S_{124} & 0 & L_2C_{12} + L_{11}C_1 \\ S_{124} & -C_{124} & 0 & L_2S_{12} + L_{11}S_1 \\ 0 & 0 & -1 & L_{12} + d_3 - L_4 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$ Where, $\text{Cos}(\theta_1) = C_1$ $\text{Sin}(\theta_1) = S_1$ $\text{Cos}(\theta_1 + \theta_2) = C_{12}$ $\text{Sin}(\theta_1 + \theta_2) = S_{12}$ $\text{Cos}(\theta_2) = C_2$ $\text{Sin}(\theta_2) = S_2$ $\text{Cos}(\theta_1 + \theta_2 - \theta_4) = C_{124}$	5	2	2	4

	Sin $(\theta_1 + \theta_2 - \theta_4) = S_{124}$				
3B	Identify the inverse of the Jacobian matrix of the following Fig. 3B.  Fig. 3B	3	4	2	3
3C	Illustrate about the Jacobian? Solve the full Jacobian matrix.	2	4	1	3
4A	Develop equations of motions of 2-degree of freedom manipulator shown in Fig using Lagrangian formulation. Calculate: The kinetic and potential energy of link 1 and 2.  **Fig. Q4A**	4	3	3	4
4B	For the given Fig. Q4B identify the torques at the respective joints  **Fig. Q4B**	4	3	3	4
4C	Illustrate about the dynamic parameters of the link considered for a two revolute joint manipulator using Newton Euler Method.	2	3	2	3

5A	Illustrate Trajectory Planning? Demonstrate the third-order polynomial trajectory planning?	4	4	2	3
5B	Using a third-order polynomial, calculate the joint angle at 1, 2, and 4 seconds, if the first joint of a 6-axis robot go from initial angle of 30^0 to a final angle of 75^0 in 5 seconds.	4	4	2	3
5C	Define the following: (i) Knot Points (ii) Spline	2	4	1	3