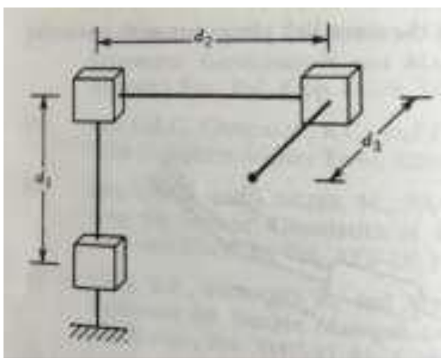
Name: Enrolment No:	

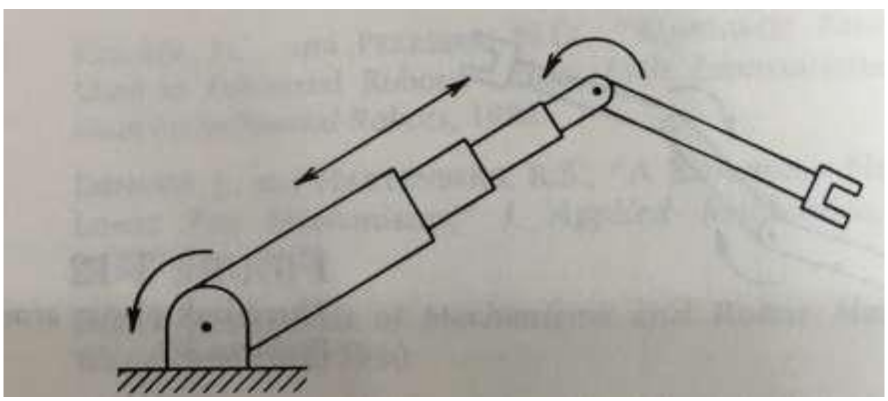
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2022

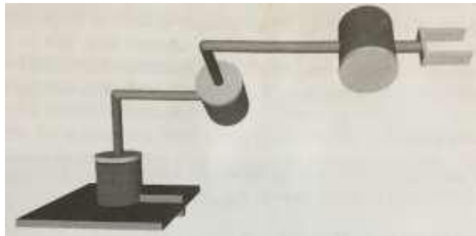
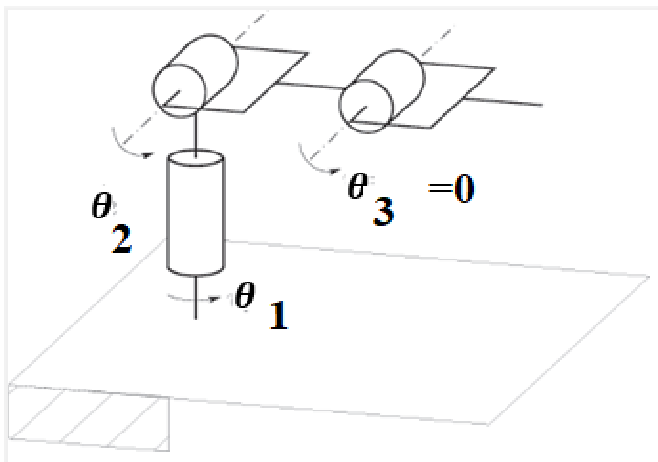
Course: M.Tech Automation and Robotics — **Semester: I**
Program: Introduction to Automation and Robotics — **Time: 03 hrs.**
Course Code: ECEG7022 — **Max. Marks: 100**

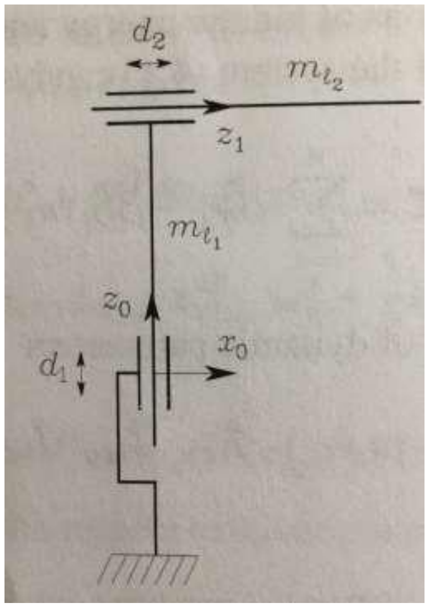
Instructions: All questions are compulsory. Use of scientific calculator is permitted.

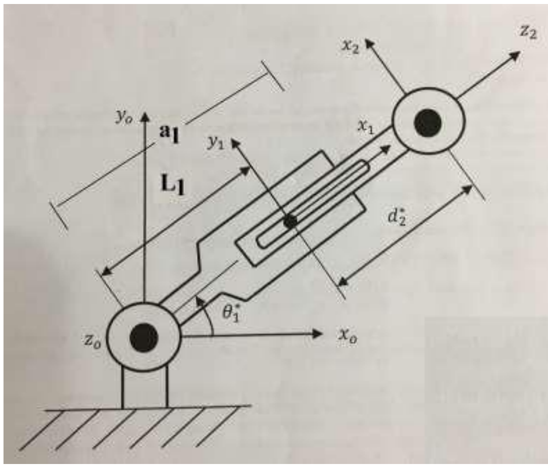
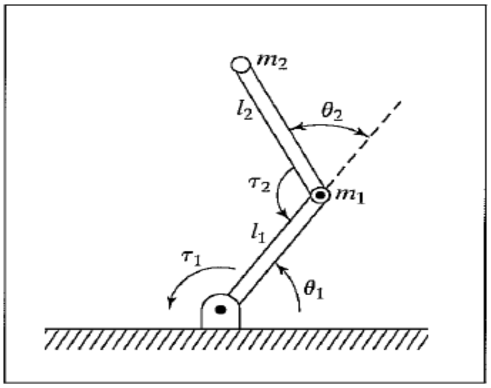
SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Explain the configuration of SCARA and articulated robot?	**4**	**CO1**
Q 2	Describe the various types of automation? Which type of automation is suitable for hospital management?	**4**	**CO2**
Q 3	Solve the inverse position kinematics for the Cartesian manipulator of Fig 1. Consider the given tip position as (d_x, d_y, d_z).  Fig. 1. Schematic diagram of Cartesian Manipulator.	**4**	**CO2**
Q 4	The following frame definitions are given as known: $${}^{U}_{A}T = \begin{bmatrix} 0.866 & -0.500 & 0 & 11 \\ 0.500 & 0.866 & 0 & -1 \\ 0 & 0 & 1 & 8 \\ 0 & 0 & 0 & 1 \end{bmatrix};$$	**4**	**CO1**

	$${}^{B}_{A}T = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0.866 & -0.5 & 10 \\ 0 & 0.5 & 0.866 & -20 \\ 0 & 0 & 0 & 1 \end{bmatrix};$$ $${}^{C}_{U}T = \begin{bmatrix} 0.866 & -0.500 & 0 & -3.0 \\ 0.433 & 0.750 & -0.5 & -3.0 \\ 0.250 & 0.433 & 0.866 & 3.0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$ Draw a frame diagram to show their arrangement qualitatively, and solve for ${}^{B}_{C}T$		
Q 5	A frame {B} is located initially coincident with a frame {A}. Let us rotate {B} about Z_B by 30 degrees, and then rotate the resulting frame about X_B by 45 degrees. Give the rotation matrix that will change the description of vectors from ${}^{B}P$ to ${}^{A}P$?	**4**	**CO1**
SECTION B (4Qx10M= 40 Marks)			
Q 6	Derive the forward kinematic equation using the DH-convention for the three- link planar arm with prismatic joint shown in Fig. 2.  Fig. 2. Schematic diagram of three-link planar manipulator with prismatic joint.	**10**	**CO2**

Q 7	Solve the Inverse Kinematics for the general 3R robot in Fig.2.  Fig. 3. Schematic diagram of 3R Manipulator.	**10**	**CO2**
Q 8	Analysis the Jacobian Matrix of the Anthropomorphic Arm shown below.  Fig. 4. Anthropomorphic Arm.	**10**	**CO3**
Q 9	A single link robot with a rotary joint is motionless at θ = 15 degrees. It is desired to move the joint in a smooth manner to θ = 75 degrees in 3 seconds. Obtain the coefficients of a cubic that accomplishes this motion and brings the manipulator to rest at the goal? **OR** Develop the Jacobian Matrix expression in terms of only z and p if the configuration of the manipulator is RRRPRPR?	**10**	**CO4**

SECTION-C (2Qx20M=40 Marks)			
Q 10	Consider the two-link Cartesian arm shown in Fig. 1, for which the vector of coordinates is **q** = [d1, d2]^T. Let ml1, ml2 be the masses of the two links. Design the equation of motion with the absence of friction and tip contact forces.  Fig. 5. Two link Cartesian Arm.	**20**	**CO4**

Q 11	Consider the two-link RP planar arm shown in Fig. 2. Assume that the links have lengths a1 and a2. Let I1 and I2 be the inertia tensors defined at the centers of mass of the two links, respectively. The joint variables are q1 and q2. Let ml1, ml2 be the masses of the two links. Design the equation of motion with the absence of friction and tip contact forces.  Fig. 6. RP manipulator. OR Design the dynamic equation of motion for two link manipulator?  Fig. 7. RR manipulator.	**20**	**CO3**