Ref. No.: Ex/ME/T/424O/2018

B.E. MECHANICAL ENGINEERING FOURTH YEAR SECOND SEMESTER – 2018

Subject: ROBOTICS

Time: 3 hours **Full Marks: 100**

Group 1

1. (a) What is the impact of industrial application of robot on society?
(b) Define forward and inverse kinematics in connection with robotics. (2+3)

Group 2

Answer Question no. 2 and any one from Question no. 3 & 4

2. A 4-DOF manipulator is shown in Fig. Q2 The tool is required to assume position and orientation during its operation, which are represented by the transformation matrix T. Determine by the method of inverse kinematics the necessary joint displacements that are to be given to the actuators. 15

$$T = \begin{bmatrix} 0.5 & -0.866 & 0 & -50 \\ 0.866 & -0.5 & 0 & -35 \\ 0 & 0 & -1 & 65 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

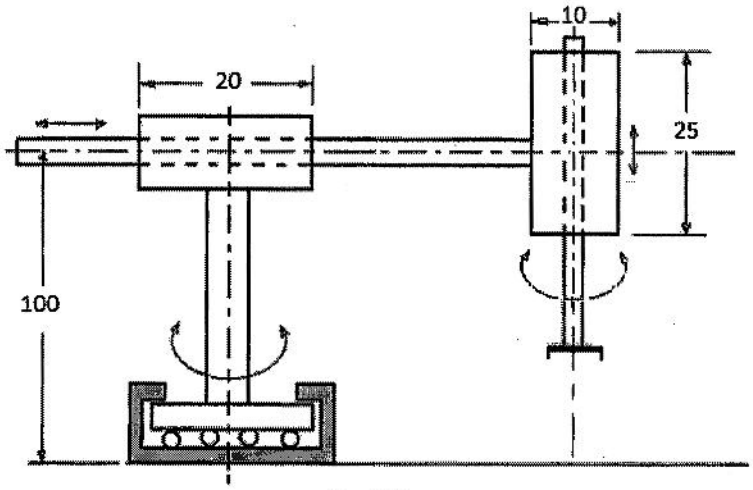

Fig. Q2

3. For the robot arm manipulator shown in Fig. Q3 do the following:
(a) Apply D-H algorithm to assign link coordinate frames;
(b) Construct link parameter table;
(c) Write transformation matrices corresponding to each joint; and
(d) Write the T_n^0 matrix. 15

Given: $a_1 = 30,\ a_2 = 10,\ a_3 = 35,\ a_4 = 40,\ a_5 = 20, a_6 = 15, \theta_1 = 60^0, \theta_2 = 45^0$

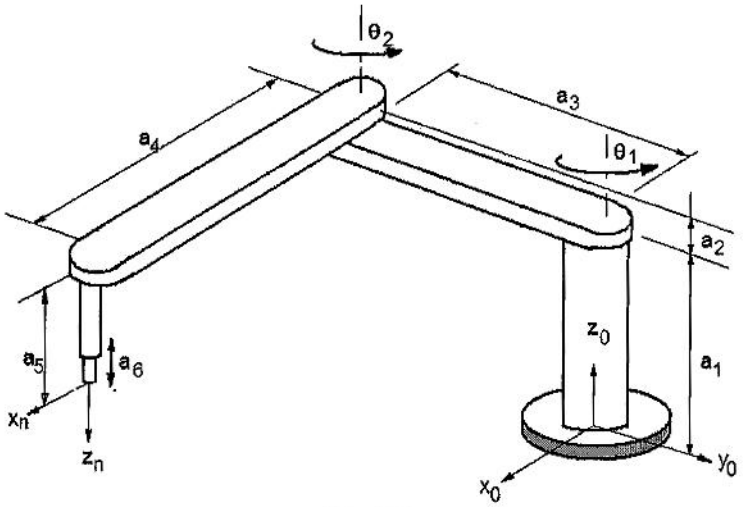

Fig. Q3

4. A cylindrical robotic manipulator is shown in Fig. Q4. With respect to the base coordinate system the coordinates of P is $(25, 15, 10, 1)^T$. If the robot is subjected to the transformation of $\theta = -30^0$, $d_1 = 50$ unit and $d_2 = 60$ unit, determine the new coordinates of P. 15

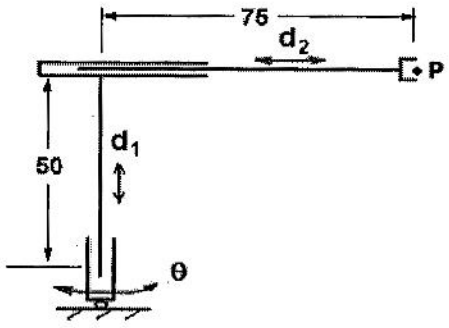

Fig. Q4

Group 3
Answer any one question

5. A 2-DOF robotic manipulator is shown in Fig. Q5. Using the Lagrangian method derive the equations of motion of the manipulator in matrix form. Assume the centre of mass for each link is at the centre of the link. Following are the moments of inertia, masses, lengths and angular displacements of the two links: I_1 & I_2, m_1 & m_2, L_1 & L_2 and θ_1 & θ_2. 30

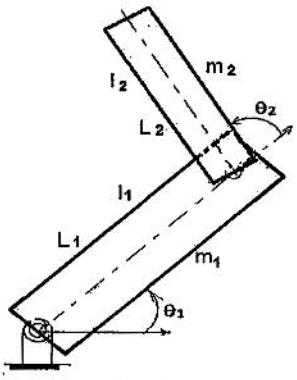

Fig. Q5

6. Find the Jacobian for the 4R robot arm of which the link coordinate diagram is shown in Fig. Q6. The link parameters are listed in Table Q6. 30

Table Q6

Axes	α_i	a_i	d_i	θ_i
1	$\pi/2$	0	0	θ_1
2	0	l_2	0	θ_2
3	0	l_3	0	θ_3
4	0	l_4	0	θ_4

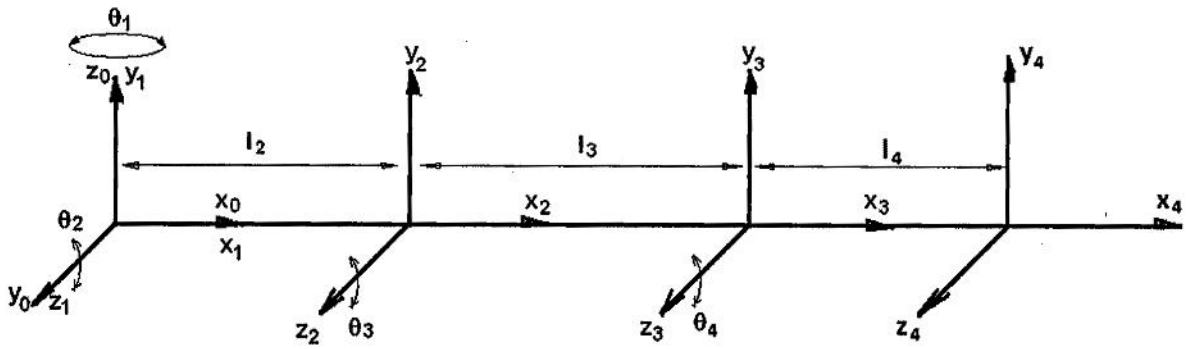

Fig. Q6

Group 4

7. (a) It is required to design trajectory for a single link robot arm with an R-pair. The manipulator should be motionless at $\theta = 15^0$ and should move to $\theta = 90^0$ smoothly in 10 seconds. What polynomial do you suggest for this motion? Deduce the displacement, velocity and acceleration equations and draw them. Calculate the joint angle at 1, 3, 4 and 9 seconds. 10

(b) If the trajectory is required for a rest-to-rest (positions *i* and *f*) path with no acceleration at rest positions, design the path for $\theta_i=30^0$ and $\theta_f=60^0$. Draw the path you design. 8

(c) What will be the trajectory for jerk to be zero at start and stop? 2

Group 5

7. (a) Write notes on: (i) Piezoelectric actuators,(ii) Magnetostrictive actuators,(iii) Shape-memory-effect actuators. 3x3

(b) Write notes on: (i) Touch and tactile sensors, (ii) Proximity sensors 2x3