Ref. No.: Ex/PG/ME/T/1210F/2018

M.E. MECHANICAL ENGINEERING FIRST YEAR SECOND SEMESTER – 2018

Subject: ROBOTICS AND AUTOMATION

Time: 3 hours Full Marks: 100

Answer question no 7 and any four from the rest

1. Answer any four questions (4x5)

(a) Mention industrial applications of robot with illustration.

(b) Illustrate a robot centred work cell for machine loading and unloading.

(c) What types of sensors are used for robot-based process applications?

(d) Define reachable workspace and dexterous workspace.

(e) What are shape-memory-effect actuators?

(f) State pros and cons of application of robots in industries.

2. A 5-DOF robotic manipulator is represented by the Fig. Q2. Determine the overall transformation matrix from base to tool.

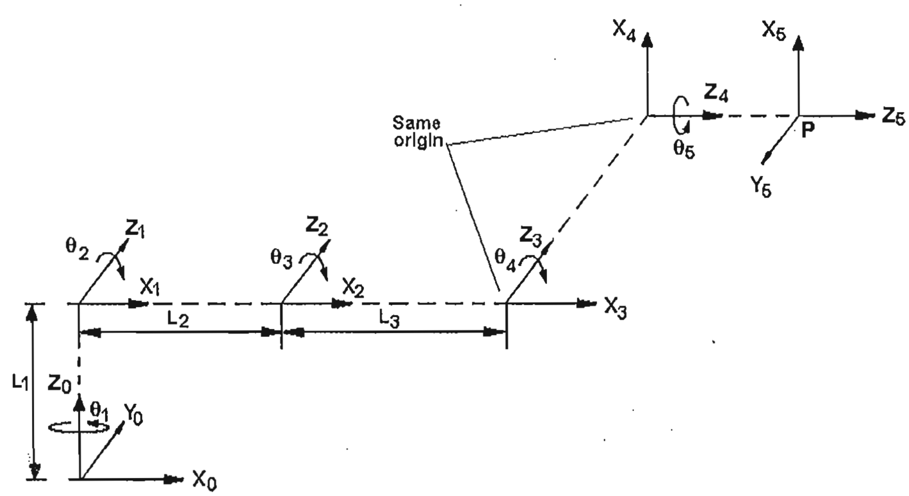

Fig. Q2

3. (a) A 3-DOF robotic manipulator is shown in Fig. Q3. The point P on its end-effector is required to reach the coordinates of (20, 30, 40). If $L_1 = 50$, $L_2 = 60$ and $L_3 = 30$ determine the angles θ_1, θ_2 and θ_3 through which the joints should be rotated for achieving that position of P. 10

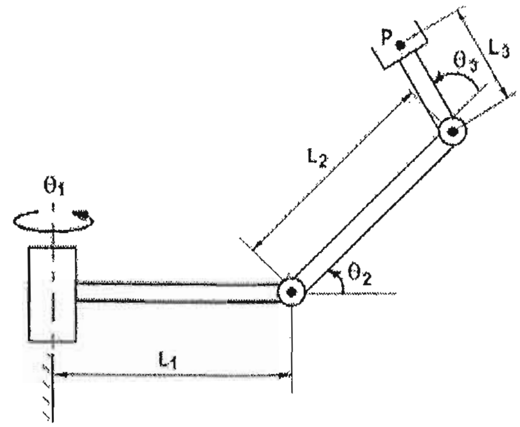

Fig. Q3

(b) The joint-link parameters of a robotic manipulator are listed in Table Q3. The end-effector is required to assume the position and orientation expressed by the matrix T. Determine the unknown parameters. 10

Table Q3

Axes	*a*	α	*d*	θ
1	3	90	2	θ_1
2	6	90	2	θ_2
3	0	0	0	θ_3

$$T = \begin{bmatrix} 0.04 & -0.93 & -0.37 & 3.9 \\ -0.98 & 0.04 & -0.21 & 1.68 \\ 0.21 & 0.37 & -0.91 & -0.27 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

4. (a) What is the need of robot programming language? (2+8+6+4)

(b) What are Textual Robot Languages (TRL), A Manufacturing Language (AML), VAL Robot Programming Language and Automatically Programmed Tooling (APT)?

(c) State significance of the following VAL II commands:

(i) OPEN & CLOSE, (ii) OPENI & CLOSEI, (iii) CLOSE 60 MM, (iv) SPEED 50, (v) CLOSE 5.0 LB, (vi) SIGNAL 5, ON & WAIT 15, ON

(d) State the features that future generation robot programming languages should possess.

5. (a) Explain joint-space and Cartesian-space trajectory planning for robot arm. (5+15)

(b) It is desired to have the first joint of a 6-axis robot go from initial angle of 60^0 to final angle of 100^0 in 5 seconds. A third order polynomial joint-space trajectory is used for the purpose. Determine the polynomial coefficients. Also find the joint angles, velocities and accelerations at 1, 2, 3, 4, 5 seconds. Plot the position, velocity and acceleration curves. The joint should be at rest for both start and end.

6. In connection with differential motion and velocities of a robotic manipulator deduce the following equation:

$$[\mathbf{dq}] = [\mathrm{B}]^{-1}[\mathbf{D}]$$

Where [D], [B] and [dq] are respectively the velocity vector, the Jacobian matrix and the vector of joint velocities. 20

7. A 2-DOF robotic manipulator is shown in Fig. Q7. Using the Lagrangian equations derive the equation of motion of the manipulator in matrix form. Assume that the centre of mass of each link is at the centre of the link. Following are respectively the moments of inertia, masses, lengths and angular displacements of the links: I_1 & I_2, m_1 & m_2, L_1 & L_2 and θ_1 & θ_2. Also write the equation for effective moments of inertia. 20

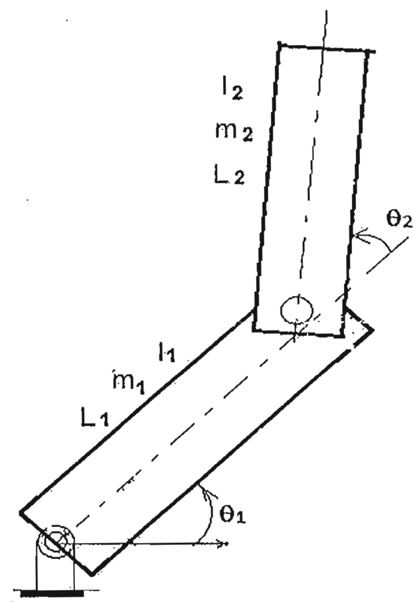

Fig. Q7