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

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

Subject: ROBOTICS AND AUTOMATION

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

Answer any five questions

1. (a) Mention industrial applications of robot with illustration. (4+5+4+4+3)

(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) Explain closed form solution in connection with inverse kinematics.

2. A 3-DOF robotic manipulator is shown in Fig. Q2. 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. 20

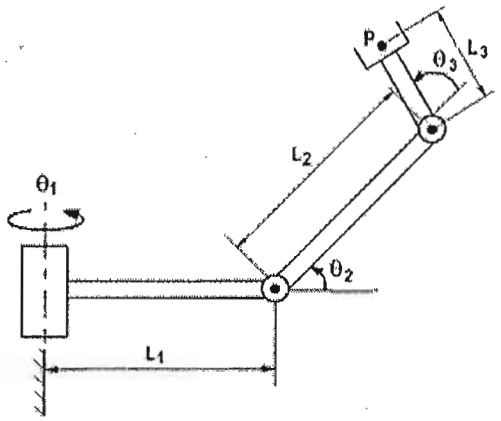

Fig. Q2

3. The joint-link parameters of a robotic manipulator are listed in Table 2. The end-effector is required to assume the position and orientation expressed by the matrix T. Determine the unknown parameters. 20

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 50 MM, (iv) SPEED 75, (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. (a) Joint 2 of a 6-axis robot arm is to go from the initial angle of $\theta_i = 50^0$ to the final angle of $\theta_f = 120^0$ in 5 seconds with a cruising velocity of $\omega_1 = 10^0$/sec. Deduce the necessary equations and find the blending time for a trajectory with linear segment and parabolic blends. Also plot the joint positions, velocities and accelerations.

(b) Explain the utilities of higher order polynomial curves for trajectory planning. (15+5)

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

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

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