Name: Enrolment No:	

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2021

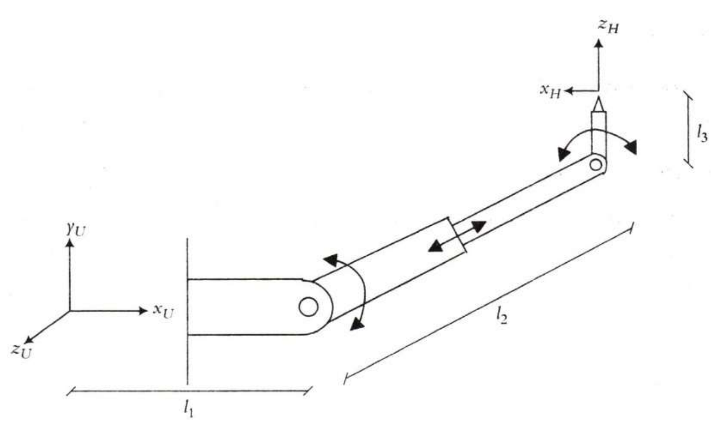
Programme Name: B.Tech. Mechatronics Engineering | **Semester : V**
Course Name : Robotics and Control | **Time : 03 hrs.**
Course Code : ECEG3001 | **Max. Marks : 100**
Nos. of page(s) : 02

Instructions: 1. Assume any missing data
2. There is an internal choice in Section B in Q.8 and an internal choice in Section C in Q.10.

SECTION A
(Answer in not more than 50 words)

S. No.		Marks	CO
Q 1	Describe the various robot characteristics.	**4**	**CO1**
Q 2	Differentiate between forward and inverse kinematics.	**4**	**CO2**
Q 3	The forward kinematics of robots based on DH representation depends upon the home position. Comment.	**4**	**CO2**
Q 4	Compare among the four fundamental robot arms giving at least one advantage and one disadvantage of each.	**4**	**CO1**
Q 5	Differentiate between path and trajectory. Describe various types of trajectories.	**4**	**CO3**

SECTION B
(Answer in not more than 150 words)

Q 6	A special 3-DOF spraying robot has been designed as shown in Fig. 1. Assign the coordinate frames based on the D-H representation and fill out the parameters table.  Fig.1: A 3-DOF spraying robot	**10**	**CO2**
Q 7	Suppose that a robot is made of a Cartesian and Euler combination of joints. Find the necessary Euler angles to achieve the following:	**10**	**CO4**

	$$T = \begin{bmatrix} 0.780 & -0.373 & 0.716 & 0 \\ 0.627 & 0.927 & -0.174 & 0 \\ -0.509 & 0.533 & 0.854 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$		
Q 8	A point P in space is defined as P = $(2,3,5)^T$. Apply the following transformations and find the new position of point P. (i) Rotate 90º about x-axis, then (ii) Rotate 90º about local a-axis, then (iii) Translate 3 units about y-, 6 units about z-, and 5 units about x-axes. **OR** Determine the inverse kinematics equations for a two-degree of freedom planar manipulator having two revolute joints.	**10**	**CO2**
Q 9	It is desired to have the first joint of a six-axis robot to move from the initial position, $\theta_0 = 15^o$, to a final position, $\theta_f = 75^o$, in 3 seconds using a cubic polynomial. Determine the trajectory.	**10**	**CO3**
	SECTION-C		
Q 10	For a robotic controller it is proposed to implement partitioned proportional integral (PPI) control strategy. Develop the block diagram and mathematical model for PPI controller. **OR** Analyze a robotic joint with the help of an appropriate SISO model.	**20**	**CO4**
Q 11	For a 4-DOF, RPPR manipulator, the joint-link transformation matrices, with joint variables θ_1, d_2, d_3, and θ_4 are $^0\boldsymbol{T}_1= \begin{bmatrix} C_1 & -S_1 & 0 & 0 \\ S_1 & C_1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$; $^1\boldsymbol{T}_2= \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & -1 & 0 & d_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$; $^2\boldsymbol{T}_3= \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & d_3 \\ 0 & 0 & 0 & 1 \end{bmatrix}$; $^3\boldsymbol{T}_4= \begin{bmatrix} C_4 & -S_4 & 0 & 0 \\ S_4 & C_4 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$ If the tool configuration matrix at a given instant is as given below, obtain the magnitude of each joint variable. $$\boldsymbol{T}_E = \begin{bmatrix} -0.250 & 0.433 & -0.866 & -89.10 \\ 0.433 & -0.750 & -0.500 & -45.67 \\ -0.866 & -0.500 & 0.000 & 50.00 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$	**20**	**CO2**