Name: Enrolment No:	UPES

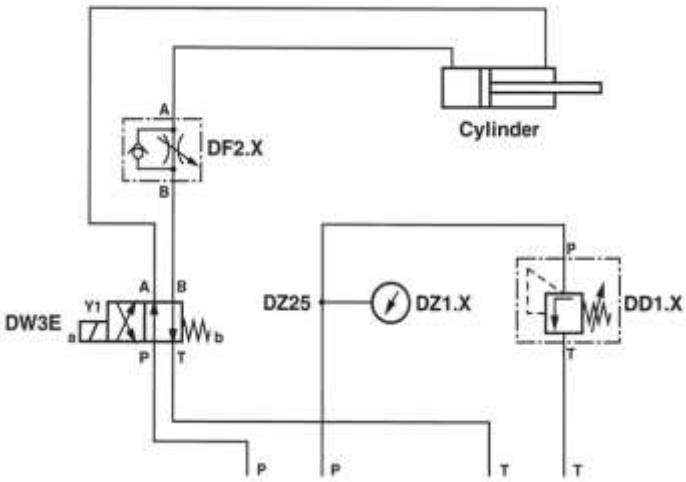
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

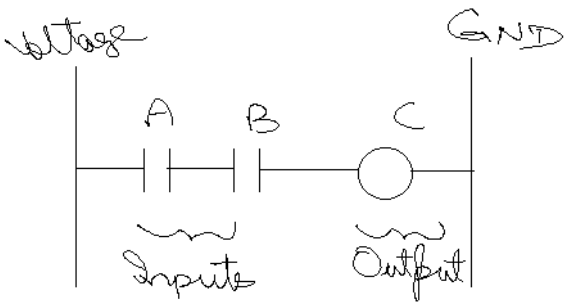
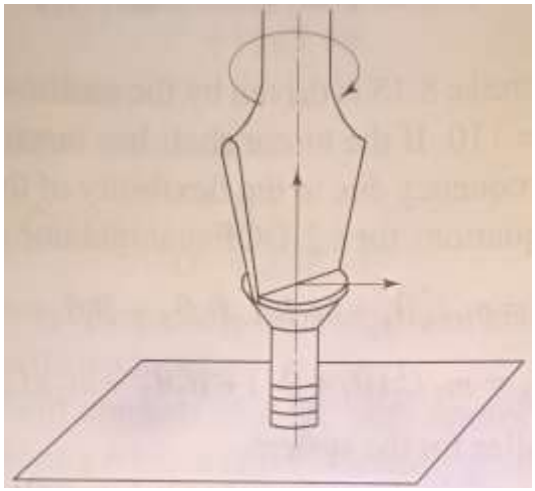
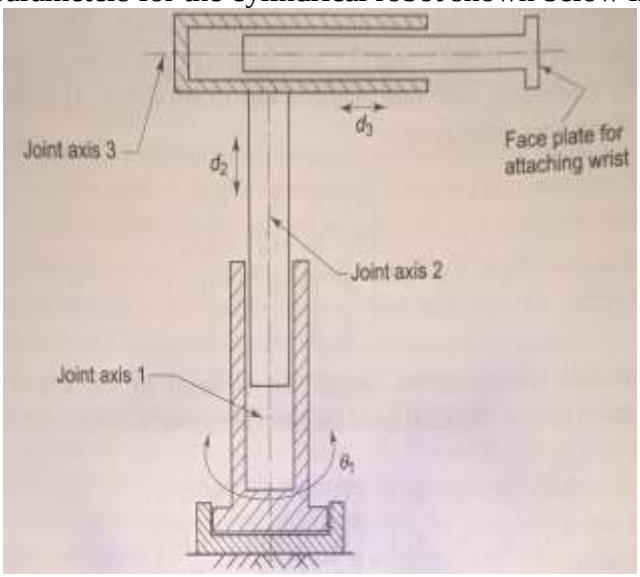
End Semester Examination, June 2021

Programme Name: M.Tech. Automation and Robotics **Semester : II**
Course Name : Robotics based Industrial Automation **Time : 03 hrs**
Course Code : ECEG7005 **Max. Marks : 100**
Nos. of page(s) : 04

Instructions: Assume any missing data. Write down your roll number, date, page number and SAP ID on top of your answer sheets.

SECTION A (30 marks)

S. No.		Marks	CO
Q 1	Describe timers.	5	CO2
Q 2	Describe the symbols: DF2.X; DW3E; DZ1.X; DD1.X, P and T used in the hydraulic circuit diagram shown below in Fig. 1.  Fig. 1: Hydraulic circuit	5	CO3
Q 3	Describe PLC with the help of a brief note.	5	CO2
Q 4	Discuss the role of a direction control valve in pneumatic actuation systems. How are they designated?	5	CO4
Q 5	Discuss the significance of relay ladder diagrams in sequence control.	5	CO2
Q 6	For the ladder diagram shown below in Fig. 2, write down the logic equation and the PLC program using mnemonics.	5	CO2

	 Fig. 2: Ladder diagram for Q 6		
SECTION B (50 marks)			
Q 7	For the task of driving a screw of pitch p at a desired angular velocity ω_d using a screwdriver, determine the natural and artificial constraints. The schematic of the task is shown below in Fig. 3.  Fig. 3: A screw driver driving a screw.	**10**	**CO2**
Q 8	Find out the DH parameters for the cylindrical robot shown below in Fig. 4.  Fig. 4: A cylindrical robot	**10**	**CO2**

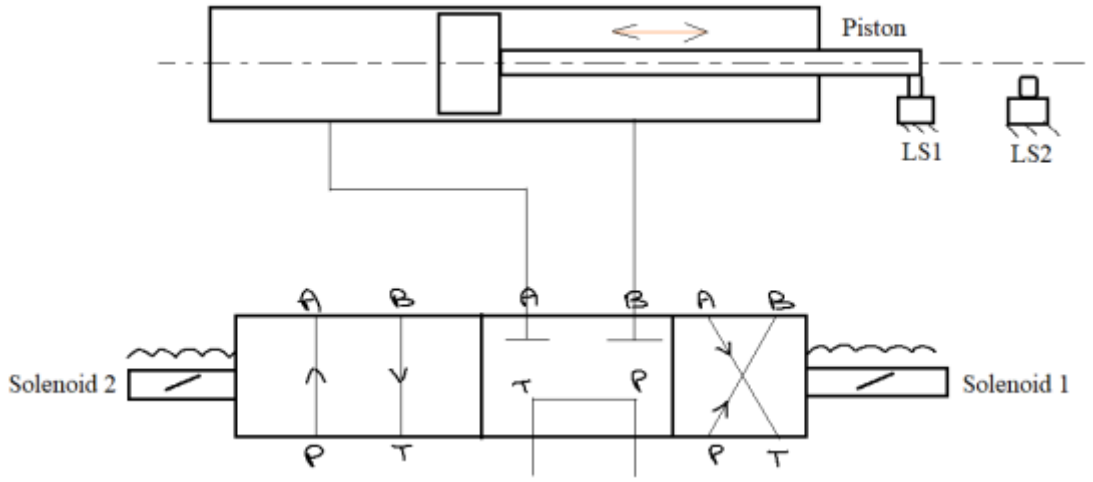
Q 9	Perform the inverse kinematics of a 2-DoF planar robot having two revolute joints. If the length of each link L_1 and L_2 is 1 ft. and the position and orientation of the end effector is given by matrix ${}^0T_H$, calculate the values of joint variables: θ_1 and θ_2. Check for multiple solutions, if any. $${}^0_H T = \begin{bmatrix} -0.2924 & -0.9563 & 0 & 0.6978 \\ 0.9563 & -0.2924 & 0 & 0.8172 \\ 0 & 0 & 1 & 0.0000 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$ The transformation matrices for the two joints are as follows. $${}^0_1 T = \begin{bmatrix} C_1 & -S_1 & 0 & L_1 C_1 \\ S_1 & C_1 & 0 & L_1 S_1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}; {}^1_2 T = \begin{bmatrix} C_2 & -S_2 & 0 & L_2 C_2 \\ S_2 & C_2 & 0 & L_2 S_2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$	**10**	**CO2**
Q 10	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**	**CO2**
Q 11	For a cylindrical robot having joint parameters: θ_1, d_2 and d_3, the final transformation matrix is given as follows. $${}^0_3 T = \begin{bmatrix} C_1 & 0 & -S_1 & -d_3 S_1 \\ S_1 & 0 & C_1 & d_3 C_1 \\ 0 & -1 & 0 & d_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$ Find the Jacobian matrix.	**10**	**CO2**
SECTION-C (20 marks)			
Q 12	Draw relay ladder diagram of an electro-hydraulic system using a double acting cylinder in which a piston rod extends and retracts between limit switches LS1 and LS2. The motion is started by pressing a switch. A 4/3 double solenoid hydraulic valve is used as in Fig. 5. Use two relays with suitable contacts. Write down the logic equations also. 	**20**	**CO5**

Fig. 5: Electro-hydraulic system for Q 12

If a shaper tool is attached to the piston for making a linear groove on a workpiece as shown in Fig. 6 then find out the natural and artificial constraints for the process.

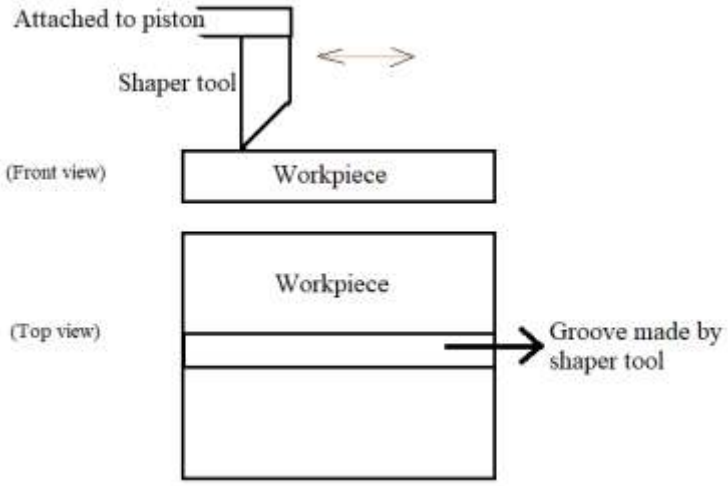


Fig. 6: Planning force-control task for the electro-hydraulic system of Fig. 5

Design a nonlinear controller based on the computed torque control law for the above system.