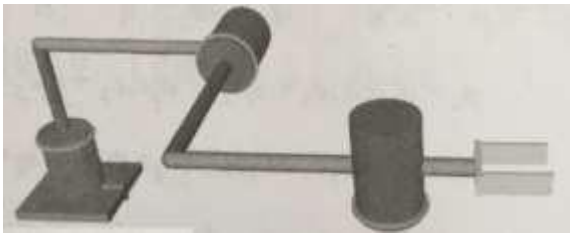
Name: **Enrolment No:**	

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, May 2023

Course: B.Tech Mechatronics — **Semester:** IV
Program: Robotics and Control — **Time:** 03 hrs.
Course Code: ECEG2040P — **Max. Marks:** 100

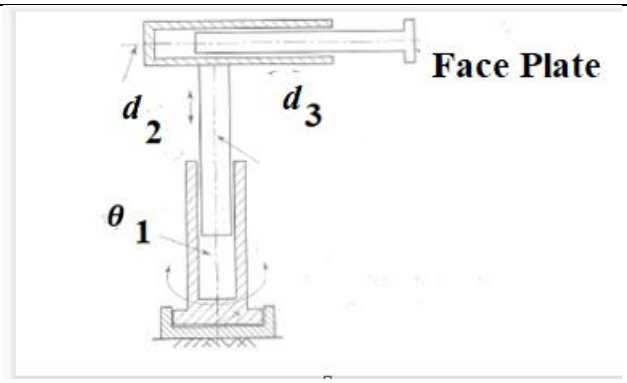
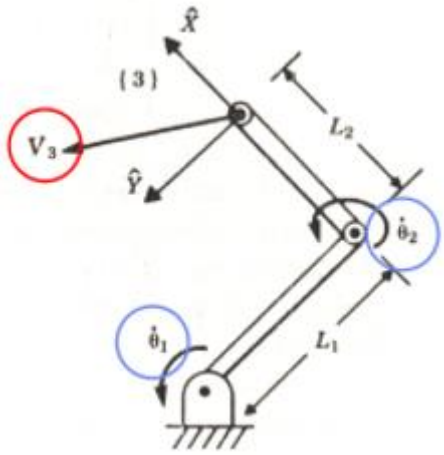
Instructions: All questions are compulsory. Scientific calculator is allowed.

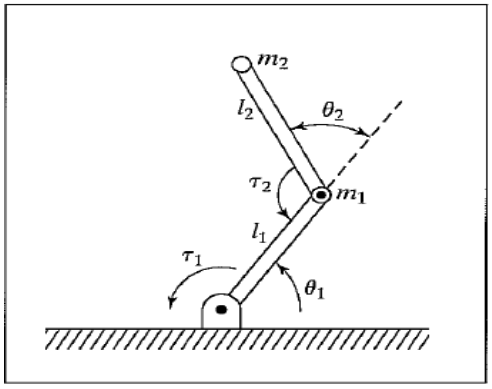
SECTION A
(5Qx4M=20Marks)

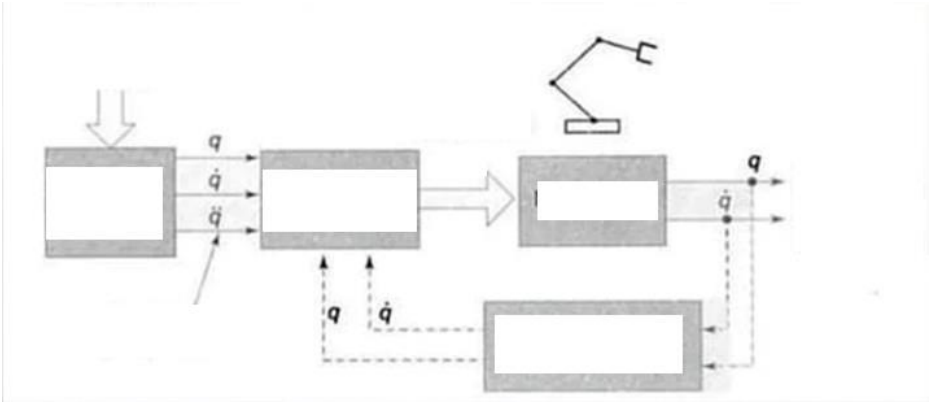
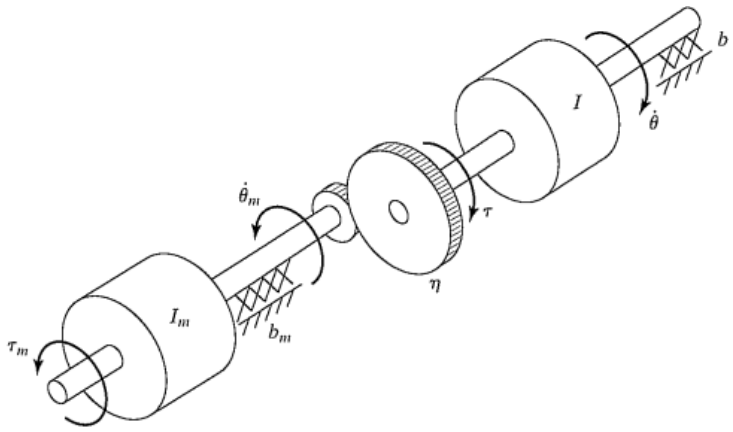
S. No.		Marks	CO
Q 1	Draw the workspace of the (SCARA) Robot?	**4**	**CO1**
Q 2	Differentiate between Joint space and Cartesian space trajectory?	**4**	**CO1**
Q 3	Why critically damped system is preferred over other systems in terms of performance of controller?	**4**	**CO2**
Q 4	Consider the 3R manipulator of Fig. 1. Derive the forward kinematic equations using the DH-convention.  Fig. 1. Schematic diagram of the RRR Manipulator.	**4**	**CO2**
Q 5	Derive the linear and Angular acceleration relation for rigid body?	**4**	**CO1**

SECTION B
(4Qx10M= 40 Marks)

Q6	Draw the D-H table and obtain the forward kinematic model of three DOF (RPP) manipulator arm shown in Fig. 2.	**10**	**CO3**

	 Fig. 2: RPP manipulator arm		
Q 7	Compute the velocity of the tip of the arm as a function of joint velocities?  Fig. 3. Schematic diagram of the 2R Manipulator.	**10**	**CO3**
Q 8	Find the coefficients of a cubic that accomplishes the motion and brings the manipulator to rest at the goal. The motion is "A single link robot with a rotary joint is motionless at θ = 25 degrees. It is desired to move the joint in a smooth manner to θ = 75 degrees in 5 seconds''.	**10**	**CO4**

Q 9	A certain 2 link manipulator, derive the relation for the Jacobian with respect to the base? For the configuration of the robot having joint angles $\boldsymbol{\theta}$=[40^o, 20^o] with the and dimension are $L_1 = 2\ m, L_2 = 2\ m$ find the torques required at the joints in order hold a static force vector $0_F = 15\hat{\imath} + 6\hat{\jmath} + 0\hat{k}$. **OR** Design the control equations for PID controller?	**10**	**CO2**
SECTION-C (2Qx20M=40 Marks)			
Q 10	Design the dynamic equation of motion for two-link manipulator?  Fig. 4. Schematic diagram of the 2R Manipulator	**20**	**CO3**

Q 11	Using the reference of the given Fig. 5, design the controller for single joint. Further explain the controller for desired circular trajectory for two-link manipulator.  Fig. 5. Reference control loop. **OR** Design the torque balance system for reference Fig. 6. If the apparent link inertia, *I*, varies between 5 and 10 *Kg-m*^{2}, the rotor inertia is $I_m = 0.01$, and gear ratio = 20, what are the minimum and maximum of effective inertia?  Fig. 6 Single joint rotor system.	**20**	**CO4**