Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2019

Course: Robotics and Control **Semester: V**
Program: B.Tech. Mechatronics **Time 03 hrs.**
Course Code: ECEG 3001 **Max. Marks: 100**
Pages: 02
Instructions: Assume any missing data.

SECTION A

S. No.		Marks	CO
Q 1	Describe the necessity of position control and force control in a robotic application.	**5**	**CO1**
Q 2	Draw the workspace of a SCARA robot. Describe its features.	**5**	**CO1**
Q 3	Define path and trajectory. Differentiate between joint-space and Cartesian space trajectories.	**5**	**CO1**
Q 4	Differentiate between forward and inverse kinematics.	**5**	**CO2**

SECTION B

Q 5	Derive the equations of motion for a one-link arm with payload at its free-end using the approach of Lagrangian dynamics. Take acceleration due to gravity as *g*. Develop a linear second-order SISO model of the joint of the one-link arm. Draw block diagram and determine the transfer function.	**10**	**CO2**
Q 6	Analyze the force-control tasks for the task of driving a screw of pitch *p* at a desired angular velocity ω_d using a screwdriver.	**10**	**CO4**
Q 7	Describe the architecture of the hybrid position/force control and compare it with impedance control. **OR** For a robot controller it is proposed to implement partitioned proportional integral (PPI) control strategy. Develop the block diagram and mathematical model for PPI Controller.	**10**	**CO4**
Q 8	The transfer function of a system is $$G(s) = \frac{0.2}{0.1s^2 + 0.6s + 1}$$ Determine the natural frequency, damping ratio and the time response of the system for a unit step input.	**10**	**CO4**

SECTION-C

Q 9	The second joint of a 6-axis robot is to go from an initial angle of 20° to an intermediate angle of 80° in 5 seconds and continue to its destination of 25° in another 5 seconds.	**20**	**CO3/ CO2**

	Calculate the coefficients for third-order polynomial in joint-space. Plot the joint angles, velocities and accelerations. Assume the joint stops at intermediate points. **OR** Describe the method for deriving the dynamic equations of motion for multiple-DoF robots.		
Q 10	Consider a two-link rigid planar robot having two revolute joints. The end-effector of the robot moves in X-Y plane from initial position A $\left(\frac{\sqrt{3}+1}{2}, \frac{\sqrt{3}+1}{2}\right)$ to final position B $\left(\frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}} + 1\right)$ in 10 seconds. Compute the following. a) The joint angles corresponding to positions- A and B of the end-effector. b) The differential joint velocities. c) If the joints follow the third-order polynomial trajectories, determine the principal inertia torque required at Joint-2 in moving from position A to position B using the following expression. $$Inertia\ torque = \sum_{j=1}^{n} D_{ij}\ddot{q}_j$$ where: $D_{ij} = \sum_{p=\max(i,j)}^{n} Trace\left(U_{pj} J_p U_{pi}^T\right)$ (Note: The symbols used in above expressions have been discussed in the class.) Physical parameters for the two-link rigid planar robot are as follows: Length of each link = 1m Mass of each link = 1 kg	**20**	**CO2**