| Name:<br>Enrolment No: | UPES |
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**UNIVERSITY OF PETROLEUM AND ENERGY STUDIES**
**End Semester Examination, December 2020**

**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) : 03**
**Instructions: 1. Assume any missing data**
**2. There is an internal choice in Section B in Q.7**

**SECTION A**
**(Answer in not more than 50 words)**

| S. No. | | Marks | CO |
|---|---|---|---|
| Q 1 | Describe in brief the various control schemes/strategies used for position and force control of manipulators. | 5 | CO4 |
| Q 2 | The arm lengths of a planar two-link manipulator having two revolute joints are 1 m each. If the joint velocities are constant at $\dot{\theta}_1 = 1$, $\dot{\theta}_2 = 2$, find the instantaneous velocity of the tool when $\theta_1 = \theta_2 = \frac{\pi}{4}$. | 5 | CO2 |
| Q 3 | Differentiate between forward and inverse kinematics. | 5 | CO2 |
| Q 4 | Discuss the advantages and disadvantages of computed torque control. | 5 | CO4 |
| Q 5 | Compare among the four fundamental robot arms giving at least one advantage and one disadvantage of each. | 5 | CO1 |
| Q 6 | Differentiate between path and trajectory. Describe various types of trajectories. | 5 | CO3 |

**SECTION B**
**(Answer in not more than 150 words)**

| | | | |
|---|---|---|---|
| Q 7 | a) Derive the pseudo-inertia matrix for a two-link planar manipulator having two revolute joints. Make use of DH parameters in your derivation.<br><br>**OR**<br><br>b) Derive the Jacobian matrix for a three-link planar manipulator having three revolute joints. | 10 | CO2 |
| Q 8 | It is required to insert a peg into a hole with the help of a robot. Divide your assembly task into simple sub-tasks and hence determine the natural and artificial constraints for each sub-task. | 10 | CO4 |
| Q 9 | A joint drive system consists of a DC servomotor with total inertia of 0.02 kg $m^2$ and bearing friction of 0.5 N/s and a gearbox with gear ratio of 32. The link inertia is 5 kg $m^2$ and the link bearing friction is 2 N/s. Determine<br>(i) the effective inertia and effective damping for the joint. | 10 | CO4 |

| | | | |
|---|---|---|---|
| | (ii) the closed loop transfer function for a proportional controller with proportional gain K = 10.<br>(iii) the unit step response .<br>(iv) the steady state error. | | |
| 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** | **CO3** |
| Q 11 | 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. | **10** | **CO4** |
| **SECTION-C** | | | |
| Q 12 | For the two-link planar manipulator having two revolute joints, design the hybrid position force controller to follow a surface defined as<br>$x = \cos(t); y = \sin(t)$<br>while maintaining a constant contact force $f_d$ with the friction surface. Draw the block diagram of the controller. (Note: *t* represents time) | **20** | **CO4** |