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

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2019 (SET-2)

Course: Introduction To Robotics — **Semester : I**
Program: M. Tech A&RE — **Max. Time: 3 hrs.**
Course Code: ECEG7002 — **Max. Marks: 100**

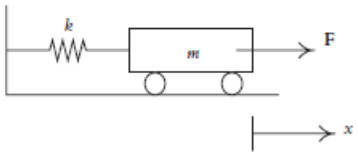
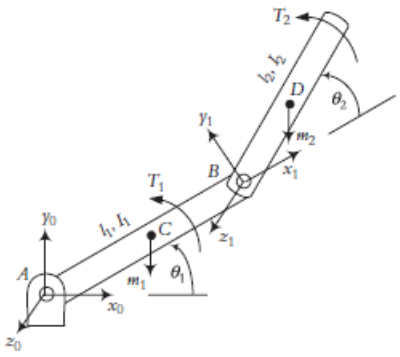
Instructions: All Questions are compulsory to attempt.

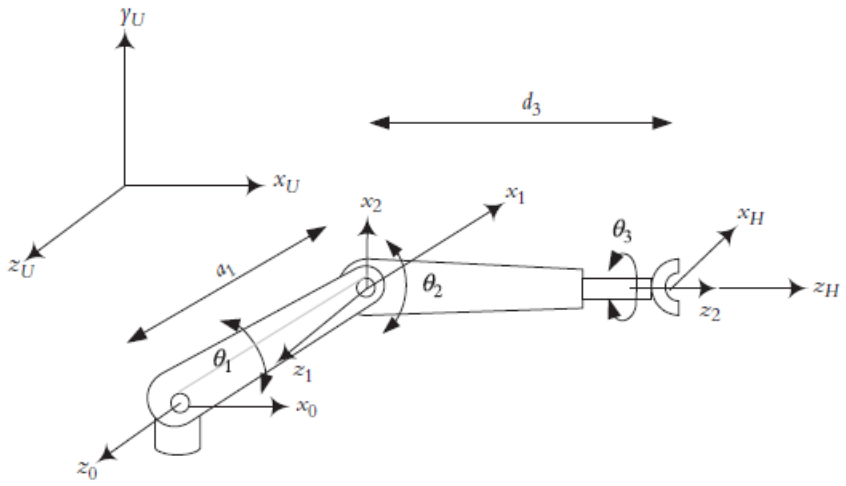
SECTION A

S. No.		Marks	CO
Q 1	Apply the inverse Laplace transform to map the following function in s domain to time domain: $$F(s) = \frac{(s+5)}{(s^2+4s+3)}$$	**4**	**CO1**
Q 2	With respect to the characteristics of sensor elucidate the following terms: (i) Resolution (ii) Sensitivity (iii) Linearity (iv) Range	**4**	
Q 3	Find the coordinates of point P (5, 6, 8) ^{T} relative to the reference frame after a rotation of 90° about the z-axis.	**4**	
Q 4	Find the new location of point P (2, 9, 1) ^{T} relative to the reference frame after a rotation of 90° about the x-axis followed by a rotation of 30° about the z-axis.	**4**	
Q 5	A point p (2,3,4) ^{T} is attached to a rotating frame. The frame rotates 90° about the x-axis of the reference frame. Find the coordinates of the point relative to the reference frame after the rotation and verify the result graphically.	**4**	

SECTION B

Q 6	Suppose the 6 DOF robot arm is moving continuously to the next point, where the joint is to reach 105◦ in another 3 seconds. Draw the position, velocity, and acceleration curves for the motion.	**10**	**CO4**
Q 7	A robot is to be driven from an initial position through two via points before it reaches its destination using a 4-3-4 trajectory. The positions, velocities, and time duration for the three segments for one of the joints are given below. Determine the trajectory equations and plot the position, velocity, and acceleration graphs for the joint.	**10**	

	$\theta_1 = 30^\circ \quad \dot{\theta}_1 = 0 \quad \ddot{\theta}_1 = 0 \quad \tau_{1i} = 0 \quad \tau_{1f} = 2$ $\theta_2 = 50^\circ \quad \tau_{2i} = 0 \quad \tau_{2f} = 4$ $\theta_3 = 90^\circ \quad \tau_{3i} = 0 \quad \tau_{3f} = 2$ $\theta_4 = 70^\circ \quad \dot{\theta}_4 = 0 \quad \ddot{\theta}_4 = 0$		
Q 8	Derive the force-acceleration relationship for the 1-DOF system shown in figure, using both the Lagrangian mechanics as well as the Newtonian mechanics. Assume the wheels have negligible inertia. 	**10**	
Q 9	(A) Design the schematic representation of a 3-DOF mobile robot by using appropriate symbols. **OR** (B) Derive the matrix that represents a pure rotation about the y-axis of the reference frame.	**10**	
	SECTION-C		
Q 10	Using the Lagrangian method, derive the equations of motion for the 2-DOF robot arm, as shown in figure. The centre of mass for each link is at the centre of the link. The moments of inertia are I1 and I2. 	**20**	**CO5**
Q 11	(A) Assign the necessary frames to the robot of following figure and derive the forward kinematic equation of the robot.	**20**	



OR

(B) A motor with rotor inertia of 0.015 Kgm^2 and maximum torque of 8 Nm is connected to a uniformly distributed arm with a concentrated mass at its end, as shown in figure. Ignoring the inertia of a pair of reduction gears and viscous friction in the system, calculate the total inertia felt by the motor and the maximum angular acceleration it can develop if the gear ratio is (i) 3 or (ii) 30.