Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

UPES

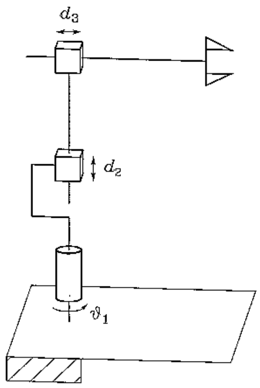
End Semester Examination, December 2024

Course:	**Advanced Robotics**	**Semester:**	**III**
Program:	**M. Tech in Robotics Engineering**	**Time:**	**03 hrs.**
Course Code:	**ECEG8022**	**Max. Marks:**	**100**

Instructions:

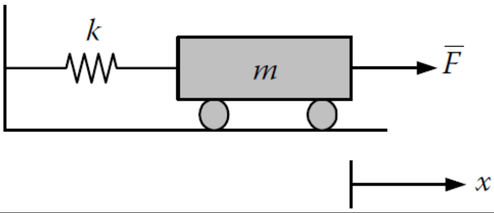
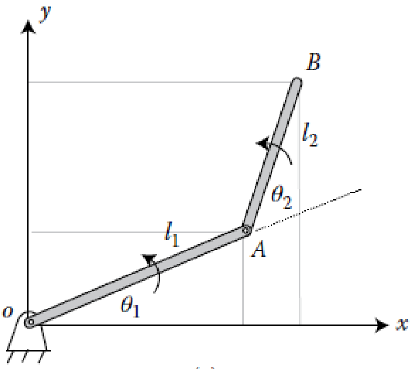
1. Read the instructions carefully.
2. Use of a scientific calculator is allowed.
3. You may assume any missing but relevant information and data.
4. This question paper has 3 pages and 11 questions.

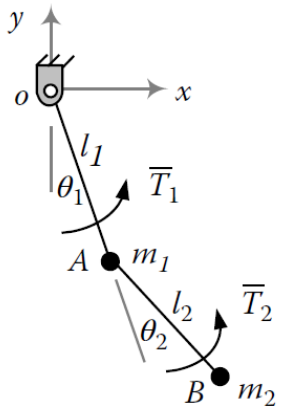
SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Calculate Matrix that represents $Rot(y,46°)^{-1}$	**4**	**CO1**
Q 2	Explain the frame in the context of robot kinematic.	**4**	**CO1**
Q 3	Discuss the importance of dynamic analysis of the robot.	**4**	**CO2**
Q 4	Create and fill in the Denavit-Hartenberg (DH) parameters table for the robot shown in the figure.  	**4**	**CO2**
Q 5	Define forward and inverse kinematics.	**4**	**CO1**

SECTION B
(4Qx10M= 40 Marks)

Q 6	Consider a 2-DOF planar robot arm with the following parameters: Link 1 (L1): Length = 6 units Link 2 (L2): Length = 2 units Joint Angles: $\theta_1 = 60°$ and $\theta_2 = 45°$ The end effector is located at point (x, y), which depends on the angles θ_1 and θ_2. Calculate the position (x, y) of the end effector using forward kinematics. Derive the Jacobian matrix J for the 2-DOF robot arm.	**10**	**CO3**

Q 7	Explain the following statement: Lagrangian of a mechanical system is a function of the generalized coordinates defined as the difference between the kinetic energy and the potential energy of the system.	**10**	**CO3**
Q 8	Derive the force-acceleration relationship for the 1-DOF system shown in Figure, using both Lagrangian mechanics. Assume the wheels have negligible inertia.  	**10**	**CO3**
Q 9	Find the effect of a differential rotation of 0.01 radians about the y-axis followed by a differential translation of [0.03, 0.04,0] on the given frame B. $B=\begin{bmatrix}0&0&1&8\\1&0&0&2\\0&1&0&3\\0&0&0&1\end{bmatrix}$ **OR** Calculate the value of joint differential motions ($\dot{\boldsymbol{\theta}}$) for three joints of the robot. While twist vector $\boldsymbol{t_e}$ and Jacobian $\boldsymbol{J}$ are given as follows: $\boldsymbol{t_e}=\begin{bmatrix}0.05\\0.02\\0.07\end{bmatrix}, \boldsymbol{J}=\begin{bmatrix}5&10&0\\3&0&0\\0&1&1\end{bmatrix}$	**10**	**CO3**
SECTION-C **(2Qx20M=40 Marks)**			
Q 10	Discuss the singularity of the robotic arm and do the singularity analysis of a planner arm that has 2 revolute joints as shown in the figure.  **OR** A camera is attached to the hand frame T_H of a robot as given. The corresponding inverse Jacobian of the robot at the location is also shown. The robot makes a differential motion described as $D=[0.05\ 0\ -0.1\ 0\ 0.1\ 0.03]^T$.	**20**	**CO4**

	a) Find which joints must make a differential motion, and by how much, to create the indicated differential motions. b) Calculate the differential operator (Δ). c) Find the change in the Hand Frame d) Find the new location of the camera		
Q 11	Derive the equation of motion for the double-pendulum system (2-DOF system) shown in the figure. 	**20**	**CO4**