EC4.401 Robotics: Dynamics and Control
Assignment 2

Robotics Research Center
International Institute of Information Technology Hyderabad

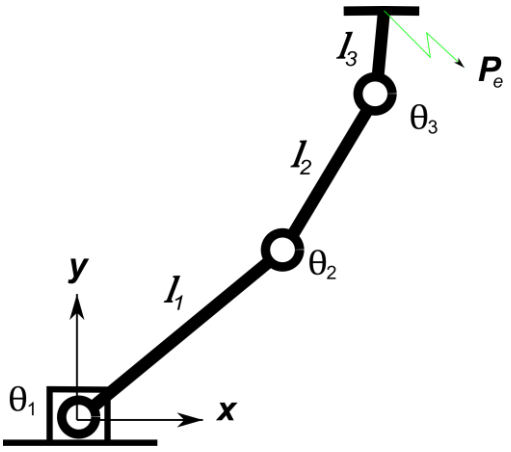
Total Marks : (85)
Due Date : 25-09-2023
Late Submission : Each day after the due date will receive a penalty of 1 mark - deduced from the total marks obtained.

Instructions:
Students should 1) write the code individually.
2) submit the script, video, and document with the program outputs.

Answer all the questions:

1. Using the Euler angles ZYX convention, parameterize the rotation matrix (**R**) **(15 marks)**
   - 1.1 *Find* **R**: Assume all the consecutive rotations occur with respect to {s} frame. Write a function that takes Euler angles $(\theta_1, \theta_2, \theta_3)$ as inputs and outputs **R** matrix (3)
   - 1.2 *Solve for the Euler angles*: Write a function that takes **R** as input and outputs $(\theta_1, \theta_2, \theta_3)$ (8)
   - 1.3 Test the algorithm considering the nonsingular and singular configurations (1)
   - 1.4 Graphically show {b} and {s} frames for the given $(\theta_1, \theta_2, \theta_3)$ (3)

2. Refer to the 3R planar manipulator shown below. **(15 marks)**
   - 2.1 Find the end-effector tool position (5)
   - 2.2 Graphically demonstrate the forward kinematics and show the dexterous workspace. For every change in joint angles, show the corresponding configuration graphically. (10)



3. We have already discussed the relation between the axis-angle and the rotation matrix in the class. **(20 marks)**

$$\boldsymbol{R} = \left(\mathbf{I} + \sin\theta\hat{\mathbf{n}} + (1 - \cos\theta)\hat{\mathbf{n}}^2\right)$$

3.1 In continuation with that, find $\boldsymbol{n} = [n_1 \quad n_2 \quad n_3]^T$ and θ for a given generalized rotation matrix $\boldsymbol{R} = \begin{bmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{bmatrix}$. (8)

3.2 Write a program that takes $\boldsymbol{n}$, θ as inputs and returns the corresponding rotation matrix, and vice versa. Show the output graphically. (12)

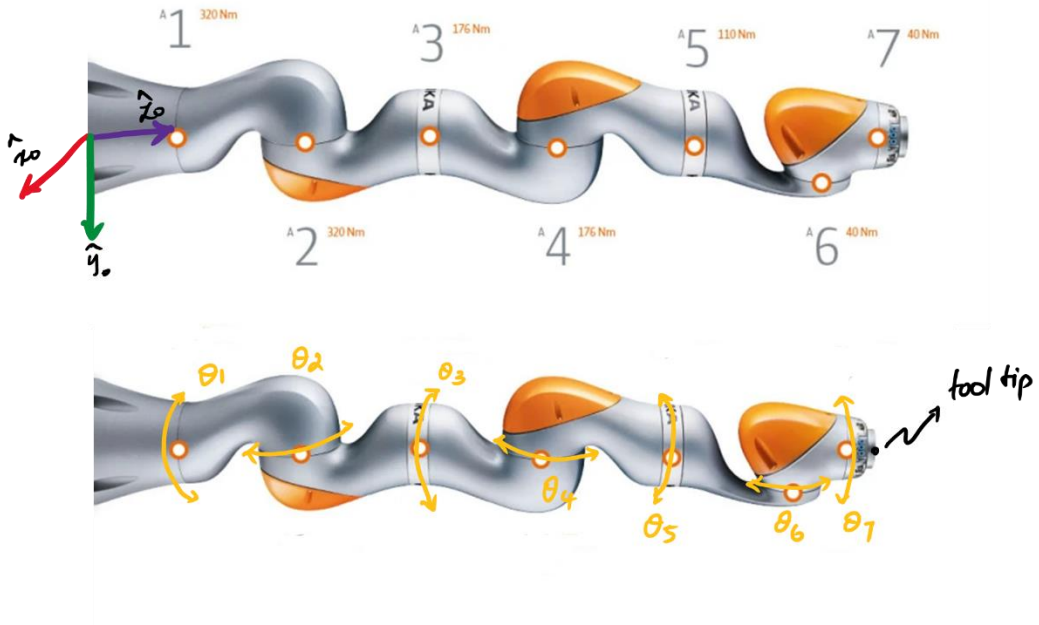
4. DH representation for a 7DoF manipulator **(35 marks)**

4.1 Find the DH parameters for the robot shown below*. (10)

4.2 Write a function that inputs DH parameters and returns the transformation matrix. Using this function, derive the end-effector pose with respect to the base frame {0}. (15)

4.3 Validate with the home configuration. (3)

4.4 Shown the robot configuration graphically. (7)



5. (Bonus) Simulate 3R Manipulator. **(5 marks)**