# Robotics and Control 1
# Homework 1

March 26, 2025

## 1 Robotic Arm

Consider the planar $3R$ robotic arm seen during the lectures. The lengths $a_1, a_2, a_3$ of the links are assumed to be all equal to 1, i.e., $a_1 = a_2 = a_3 = 1$. Let $q = [\theta_1 \ \ \theta_2 \ \ \theta_3]^T$ be the vector of generalized coordinates and let

$$x_e = \kappa(q) = \begin{bmatrix} \cos(\theta_1) + \cos(\theta_1 + \theta_2) + \cos(\theta_1 + \theta_2 + \theta_3) \\ \sin(\theta_1) + \sin(\theta_1 + \theta_2) + \sin(\theta_1 + \theta_2 + \theta_3) \\ \theta_1 + \theta_2 + \theta_3 \end{bmatrix}$$

be the direct kinematic equations. Let $x_e^d = [2 \ 1 \ 0]^T$ be the desired posed to be attained by the end effector. Address the following questions:

1. Solve analytically the inverse kinematics problem;
2. Implement the gradient method for inverse kinematics starting from the two initial conditions

$$q(0) = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \qquad q(0) = \begin{bmatrix} \pi/2 \\ \pi/2 \\ \pi/2 \end{bmatrix}$$

   and assuming first $\alpha = 1/2$ and then $\alpha = 1/10$; discuss the results obtained.

3. Implement the Newton method for inverse kinematics starting from the two initial conditions

$$q(0) = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \qquad q(0) = \begin{bmatrix} \pi/2 \\ \pi/2 \\ \pi/2 \end{bmatrix}.$$

   Discuss the results obtained.