

ENG ME/SE 740

Exercises (Set 2) (Due 2/19/26)

1. Consider a planar manipulator with link lengths $r_1 = r_2 = 1$ and $r_3 = 1/2$. Find θ_1 , θ_2 , and θ_3 such that the end effector is at (1,1) with orientation $\phi = -45^\circ$.

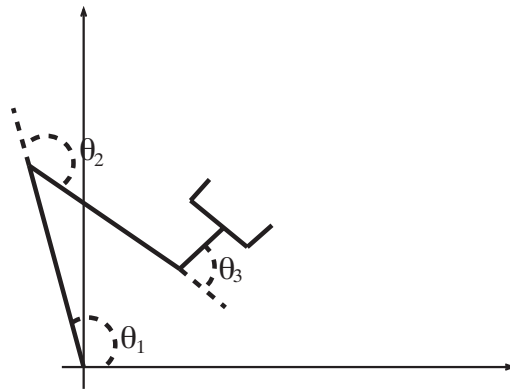


Figure 1: Mechanism of problem 1 but not in the configuration of the problem 1 statement.

2. We have seen a number of ways to describe the orientation of a rigid body with respect to a given coordinate frame. Consider the following rotation matrix:

$$\begin{pmatrix} 2/3 & -1/3 & 2/3 \\ 2/3 & 2/3 & -1/3 \\ -1/3 & 2/3 & 2/3 \end{pmatrix}.$$

Find the corresponding axis / angle parameters, the Euler-angles and the Tait-Bryan (pitch/roll/yaw) angles.

3. Which of the following subsets of $SE(3, \mathbb{R})$ are also subgroups?

$$(a) \quad \left\{ \begin{pmatrix} \cos \theta & 0 & \sin \theta & x \\ 0 & 1 & 0 & 0 \\ -\sin \theta & 0 & \cos \theta & z \\ 0 & 0 & 0 & 1 \end{pmatrix} : x, z \in \mathbb{R}; -\pi < \theta \leq \pi \right\},$$

$$(b) \quad \left\{ \begin{pmatrix} \cos \phi & -\sin \phi & 0 & 0 \\ \sin \phi & \cos \phi & 0 & y \\ 0 & 0 & 1 & z \\ 0 & 0 & 0 & 1 \end{pmatrix} : y, z \in \mathbb{R}; -\pi < \phi \leq \pi \right\}$$

Justify your answer.