
AER525 Fall 2015

Assignment 2

Due: 10:10 am 21-Oct-2015

Question 1 For the two planar manipulators in Figure 1, sketch the reachable workspace of the tip of the second link based on the given joint angle limits.

- a) $0^\circ \leq \theta_1 \leq 270^\circ$ and $-90^\circ \leq \theta_2 \leq 90^\circ$ where $\ell_1 = 2\ell_2$
- b) $30^\circ \leq \theta \leq 60^\circ$ and $0 \leq d \leq \ell$ where $d = 0$ in the figure

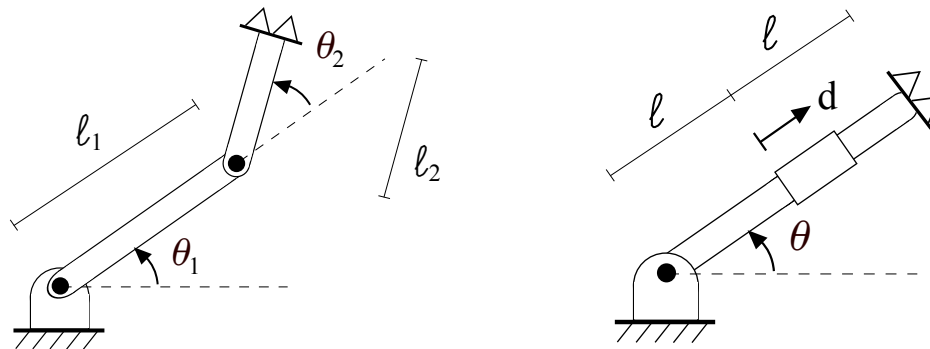
Question 2 Consider the SCARA manipulator in Figure 2. Solve the inverse kinematics problem from the wrist frame relative to the base. Assume that the end-effector position and orientation is given by x , y , z , and ϕ rotation about the \hat{Z}_0 (or \hat{Z}_W).

Question 3 Consider the manipulator in Figure 3.

- a) Find the transformation of the tool frame relative to the base.
- b) Find the Jacobian.
- c) Find the translational and angular velocities of the tool frame relative to, and expressed in, the base frame (as functions of joint speeds and manipulator configuration).

Question 4 Consider the manipulator in Figure 4.

- a) Find the transformation of the tool frame relative to the base.
- b) Find the Jacobian.
- c) Give a set of joint angles for which workspace-boundary singularities occur.
- d) Give a set of joint angles for which workspace-interior singularities occur.
- e) If a force f is applied vertically at the tip of the end-effector, find the torques at the joints to keep the manipulator in place.



(a) Manipulator for Question 1 a)

(b) Manipulator for Question 1 b)

Figure 1: Manipulators for Question 1

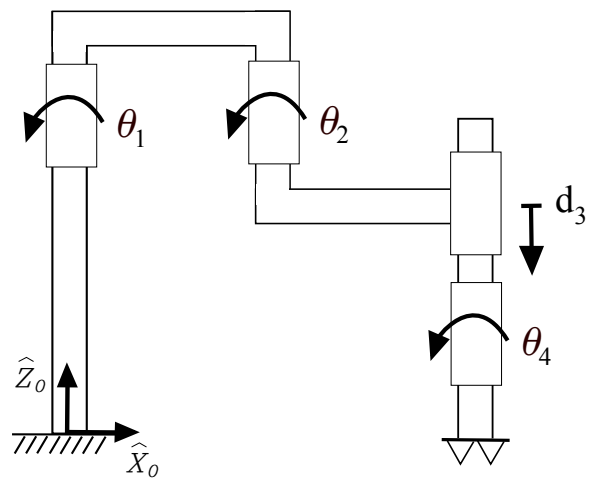


Figure 2: Manipulator for Question 2

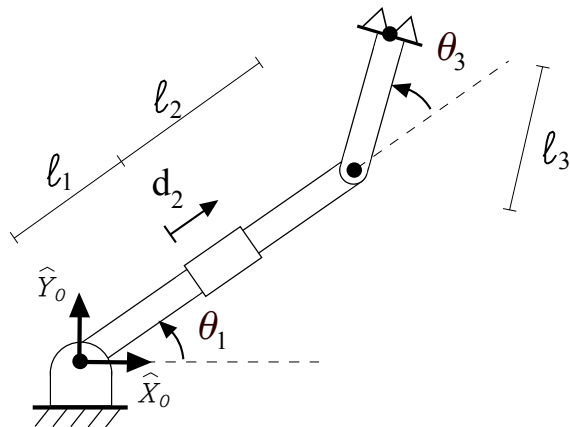


Figure 3: Manipulator for Question 3

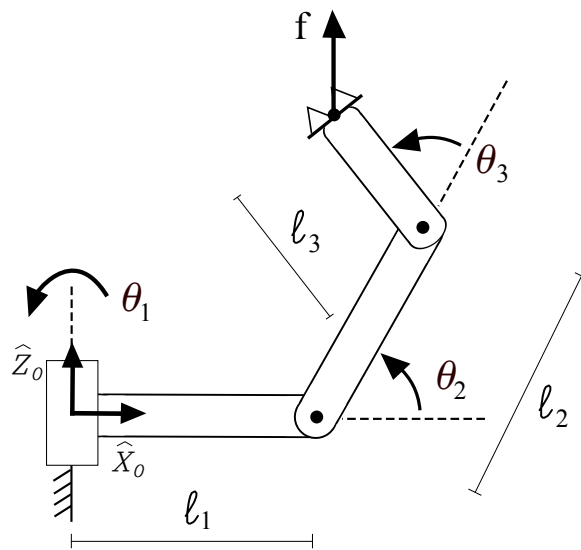


Figure 4: Manipulator for Question 4