EE 368 机器人运动与控制方法（Robotic Motion and Control）
Assignment #2

Due time: 5:00pm on Monday, April 10, 2023 via Blackboard

Q-1. Assign link frames to the RPR planar robot shown in Figure Q-1, give the D-H table (linkage parameters).

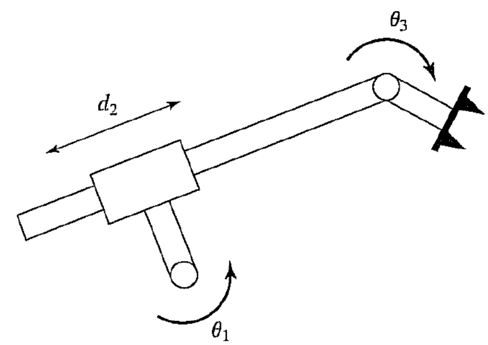

Figure Q-1

Q-2. For the two-link manipulator shown in Figure Q-2(a), the link-transformation matrices, ${}^0_1T$ and ${}^1_2T$, were constructed. Their product is

$$
{}^0_2T = \begin{bmatrix} c\theta_1 c\theta_2 & -c\theta_1 s\theta_2 & s\theta_1 & l_1 c\theta_1 \\ s\theta_1 c\theta_2 & -s\theta_1 s\theta_2 & -c\theta_1 & l_1 s\theta_1 \\ s\theta_2 & c\theta_2 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

The link-frame assignments used are indicated in Figure Q-2(b). Note that frame {0} is coincident with frame {1} when θ_1= 0. The length of the second link is l_2. Find an expression for the vector ${}^0P_{tip}$, which locates the tip of the arm relative to the {0} frame.

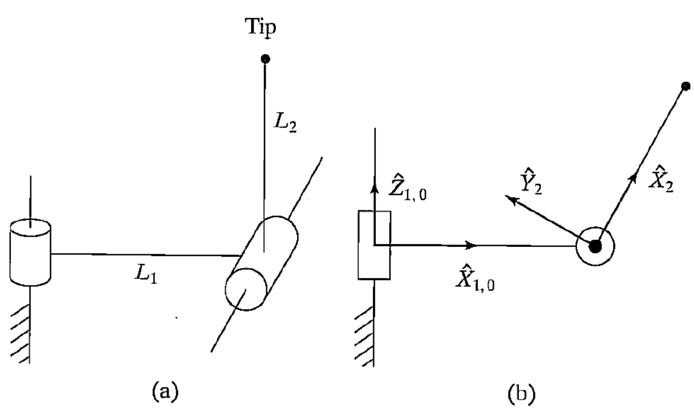

Figure Q-2

Q-3. Sketch the fingertip workspace of the three-link manipulator illustrated in Figure Q-3, for the case of $l_1 = 15$, $l_2 = 10$, and $l_3 = 3$.

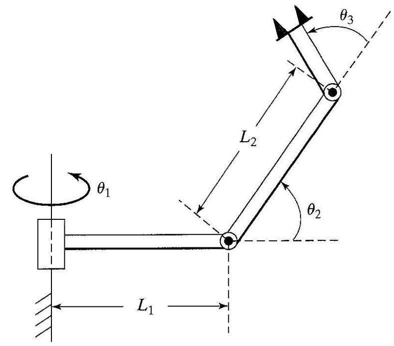

Figure Q-3

Q-4. For the cases of (1) both the desired orientation and position of the tip frame with respect to the base frame are given as:

$$
{}^0_3T = \begin{bmatrix} r_{11} & r_{12} & r_{13} & p_x \\ r_{21} & r_{22} & r_{23} & p_y \\ r_{31} & r_{32} & r_{33} & p_z \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

and (2) only the desired position of the tool frame is given as: ${}^3P_{tool} = [\ l_3 \quad 0 \quad 0\ ]^T$, derive the inverse kinematics of the three-link manipulator in Figure Q-3, knowing that

$$
{}^0_3T = \begin{bmatrix} c_1c_{23} & -c_1s_{23} & s_1 & c_1(c_2l_2 + l_1) \\ s_1c_{23} & -s_1s_{23} & -c_1 & s_1(c_2l_2 + l_1) \\ s_{23} & c_{23} & 0 & s_2l_2 \\ 0 & 0 & 0 & 1 \end{bmatrix}.
$$

Q-5. (a) Describe a simple algorithm for choosing the nearest solution from a set of possible solutions.

(b) There exist 6-DOF robots for which the kinematics are NOT closed-form solvable. Does there exist any 3-DOF robot for which the (position) kinematics are NOT closed-form solvable?

Q-5. ${}^A_BR$ is a 3 x 3 matrix with eigenvalues 1, and e^{+ai}, and e^{-ai}, where $i = \sqrt{-1}$. What is the physical meaning of the eigenvector of ${}^A_BR$ associated with the eigenvalue 1?