EE 368 机器人运动与控制方法（Robotic Motion and Control）
Assignment #3

Due time: 5:00pm on Friday, April 28, 2023 via Blackboard

Q-1. For a 3-DOF robot, given the following transformation matrices, find the Jacobian ${}^{0}J$.

$$ {}^{0}_{1}T = \begin{bmatrix} c_1 & -s_1 & 0 & 0 \\ s_1 & c_1 & 0 & 0 \\ 0 & 0 & 1 & h \\ 0 & 0 & 0 & 1 \end{bmatrix}, {}^{1}_{2}T = \begin{bmatrix} c_2 & -s_2 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ s_2 & c_2 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, {}^{2}_{3}T = \begin{bmatrix} c_3 & -s_3 & 0 & e \\ s_3 & c_3 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, {}^{3}_{4}T = \begin{bmatrix} 1 & 0 & 0 & f \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

where h, e, f are the lengths of the 1st, 2nd and 3rd link, respectively.

$$ {}^{0}_{4}T = \begin{bmatrix} c_1c_{23} & -c_1s_{23} & s_1 & ec_1c_2 + fc_1c_{23} \\ s_1c_{23} & -s_1c_{23} & -c_1 & es_1c_2 + fs_1c_{23} \\ s_{23} & c_{23} & 0 & h + es_2 + fs_{23} \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

Q-2. Find the Jacobian of the manipulator shown in Figure Q-2. Write it in terms of frame {4} located at the tip of the robot and having the same orientation as frame {3}.

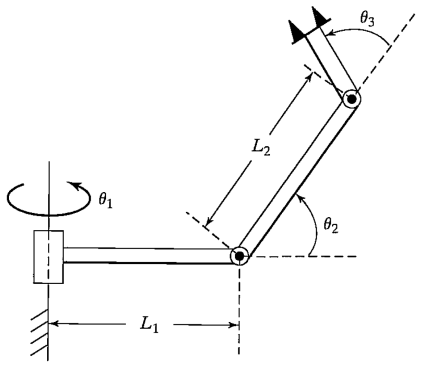

Figure Q-2

Q-3. For the three-link robot manipulator shown in Figure Q-2, give a set of joint angles for which the manipulator is at a workspace-boundary singularity and another set of angles for which the manipulator is at a workspace-interior singularity.

Q-4. Prove that singularities in the force domain exist at the same configurations as the singularities in the position domain.