Tutorial 4: Velocity Kinematics

These questions are from the Practice Exercises of the Modern Robotics book. The solutions can be found on the book website. Please try your best before referring to the solutions.

Question 1: KUKA LBR iiwa 7R robot arm

Figure 1 shows the KUKA LBR iiwa 7R robot arm. The figure defines an $\{s\}$ frame at the base with the $\hat{y}_s$-axis pointing out of the page and a $\{b\}$ frame aligned with $\{s\}$ at the end-effector. The robot is at its home configuration. The screw axes for the seven joints are illustrated (positive rotation about these axes is by the right-hand rule). The axes for joints 2, 4, and 6 are aligned, and the axes for joints 1, 3, 5, and 7 are identical at the home configuration. The dimensions are $L_1 = 0.34\ m$, $L_2 = 0.4\ m$, $L_3 = 0.4\ m$, and $L_4 = 0.15\ m$.

a. What is the space Jacobian when the robot is at its home configuration?
b. Assume the angles of the joints are $^{i\pi}/_{16}$ for joints $i = 1 \cdots 7$. What is the space Jacobian?

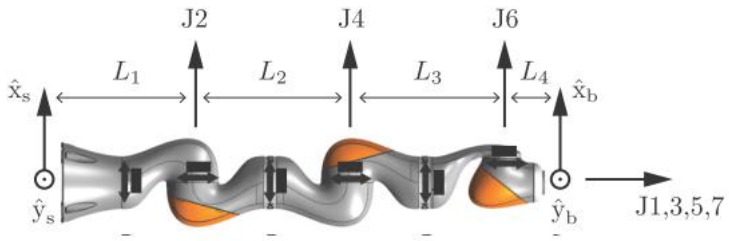

Figure 1. The KUKA LBR iiwa 7-dof robot.

Question 2: RPR robot arm

Figure 2 shows an RPR robot that is confined to the plane of the page. An end-effector frame $\{b\}$ is illustrated, where the $\hat{x}_b$-axis is out of the page. The directions of positive motion of the three joints are indicated by arrows. The axes of the two revolute joints are out of the page, and the prismatic joint moves in the plane of the page. Joint 1 is at $q_1 = (0, -5, 7)$ in $\{b\}$ and joint 3 is at $q_3 = (0, -1, -3)$ in $\{b\}$. Write the body Jacobian $J_b(\theta)$ for the configuration shown. All entries of your $J_b(\theta)$ matrix should be numerical (no symbols or math).

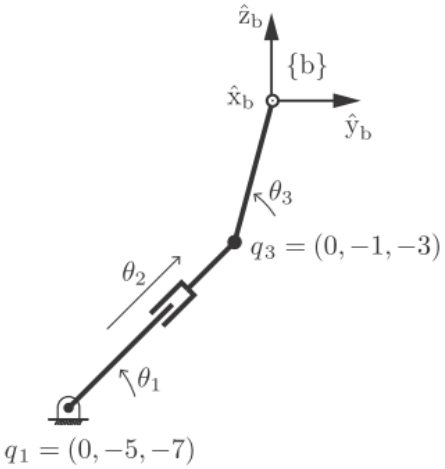

Figure 2. An RPR Robot.