CSci 5551: Introduction to Intelligent Robotic Systems
Spring 2020

Homework 3

Due: Sunday April 12, 2020, 23:59:00 hours

Answer all questions. As before, please show details of your work, not merely the answer.

1. [25 points] The arm with three degrees of freedom shown in Figure 1 is a 3R robot, except that joint 1's **Z** axis is not parallel to the other two. Instead, there is a twist of 90 degrees in magnitude between axes 1 and 2. Find D-H table parameters for this robot, and find the transform T_{13}, with F_1 being coordinate frame for the first joint.

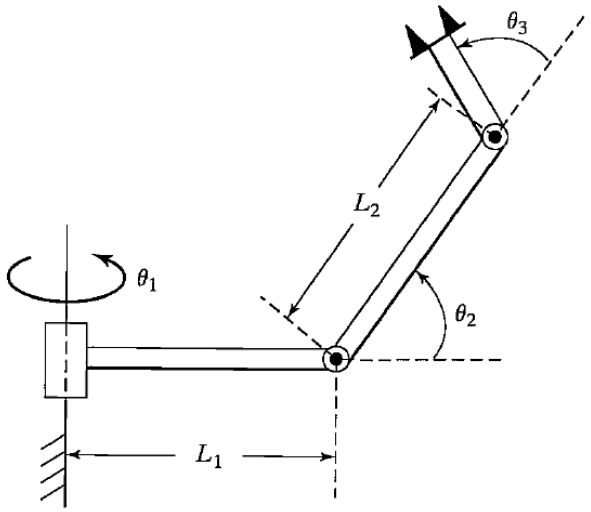

Figure 1: A 3R, 3-DOF robot arm.

2. [25 points] Find the D-H table parameters for the CanadaArm manipulator shown in Figure 2. Also, find T_{04}. Note that the Z-directions are given in red arrows for the revolute joints. Orientation of F_0 is given, as is that of F_t. The circular joints are revolute, and the diamond-shape joints are prismatic.

3. [25 points]: See the MOM manipulator shown in Figure 3. Create the table of D-H parameters for the MOM manipulator. The first joint is revolute and is driven by the shoulder motor (1). The next two joints are prismatic and slide along the shoulder (8) and the forearm (5) respectively. Assume a standard spherical wrist. With Frame F_0 being the base of the robot, find T_{03} and T_{06}.

4. [25 points] A kinematic model of the human arm (see Figure 4) co-locates joints (1-3) at the shoulder creating spherical joint; joint (4), a pin joint axis – shown coming out

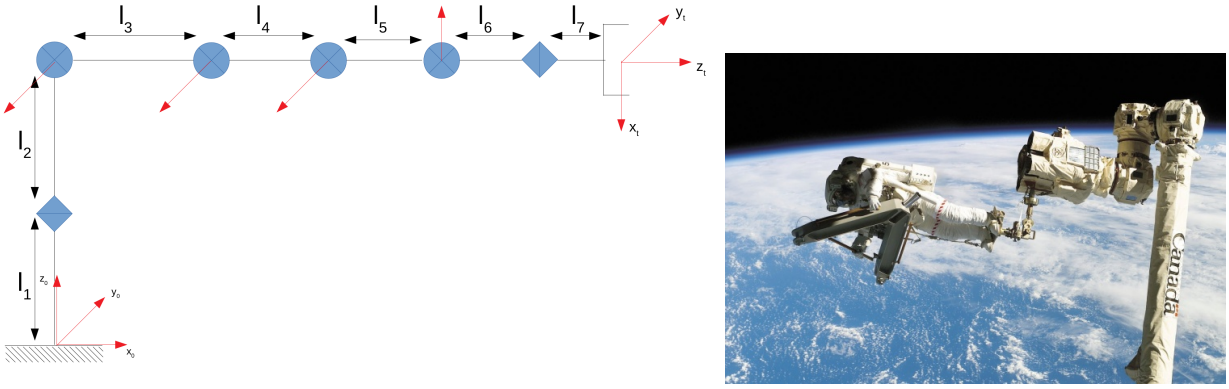

Figure 2: The CanadaArm2 schematic (left) and the real thing on the ISS.

of the page – at the elbow; joint (5) along the forearm (axial roll), and then joints (6,7) at the wrist for yaw and then pitch. Starting with the z_0 axis coming out at you from the page, and the x_0 axis to your left, as shown (*i.e.*, θ_1 rotation lowers/raises the arm from the side), **neatly draw and label** all the z and x axes and make a complete DH table. **Show and label** all non-zero displacements on the diagram (on Figure 4) and include them in your table. **Give the tool transform** to the tip of the hand frame as shown. Points will be given for clarity.

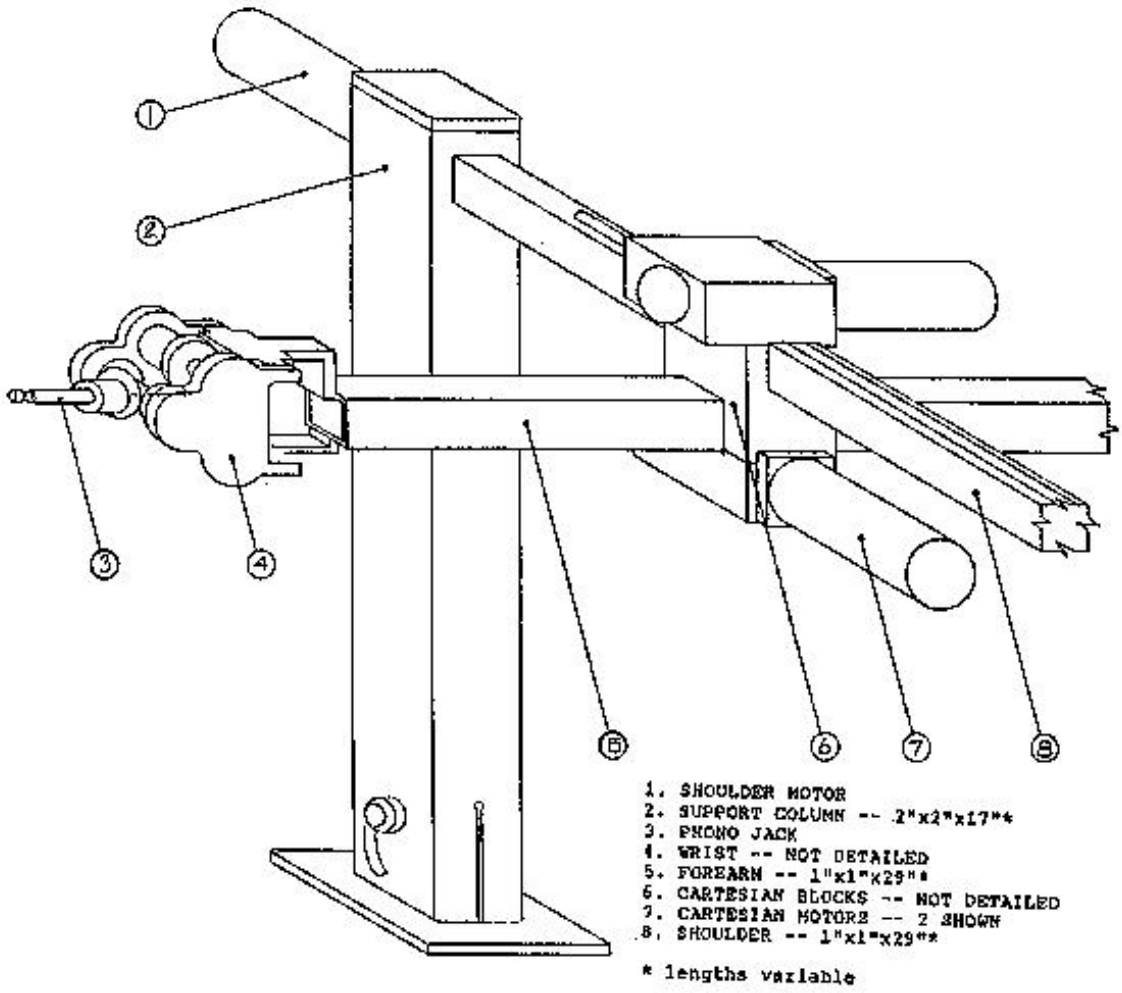

Figure 3: The MOM robot.

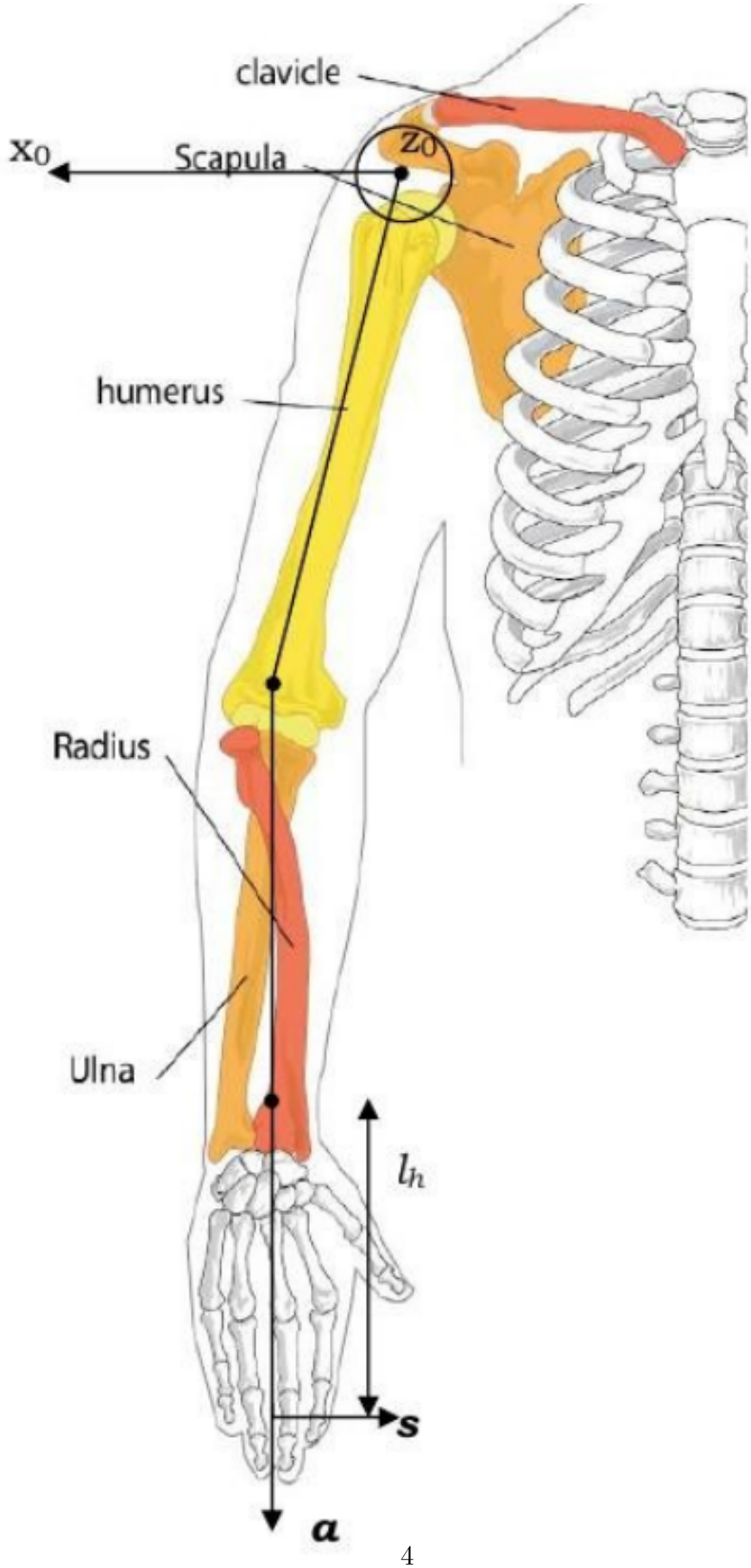

Figure 4: The human arm with joints.