

CSci 5551: Introduction to Intelligent Robotic Systems
Spring 2020

Homework 1

Due: Tuesday February 25, 2020, 11:59:00pm, on GradeScope only

In square brackets are the points assigned to each problem. Do not just write the final result. Present your work in detail explaining your methodology at every step. **See the other side for question 4!**

1. [15 points] If the coordinate frame $o_1x_1y_1z_1$ is obtained from the coordinate frame $o_0x_0y_0z_0$ by a rotation of $\frac{\pi}{2}$ about the x-axis followed by a rotation of $\frac{\pi}{2}$ about the fixed y-axis, find the rotation matrix R representing the composite transformation. Sketch the initial and final frames.
2. [20 points] Suppose that three coordinate frames $o_1x_1y_1z_1$, $o_2x_2y_2z_2$, and $o_3x_3y_3z_3$ are given, and suppose

$$R_{12} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \frac{1}{2} & -\frac{\sqrt{3}}{2} \\ 0 & \frac{\sqrt{3}}{2} & \frac{1}{2} \end{bmatrix} \text{ and } R_{13} = \begin{bmatrix} 0 & 0 & -1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix} \text{ Find the matrix } R_{23}.$$

3. [15+10=25 points] Derive the rotation matrix corresponding the set of Euler Angles Z-X-Z. What happens when $\sin\theta = 0$?

4. [20+20=40 points] Consider the following diagram. A robot is set up 1 meter from a table, two of whose legs are on the y_0 axis as shown. The table top is 1 meter high and 1 meter square. A frame $O_1 \equiv (x_1 y_1 z_1)$ is fixed to the edge of the table as shown. A cube, measuring 20 cm on a side is placed in the center of the table with frame $O_2 \equiv (x_2 y_2 z_2)$ established at the center of the cube as shown. A camera is situated directly above the center of the cube, 2m above the table top with frame $O_3 \equiv (x_3 y_3 z_3)$ as shown.

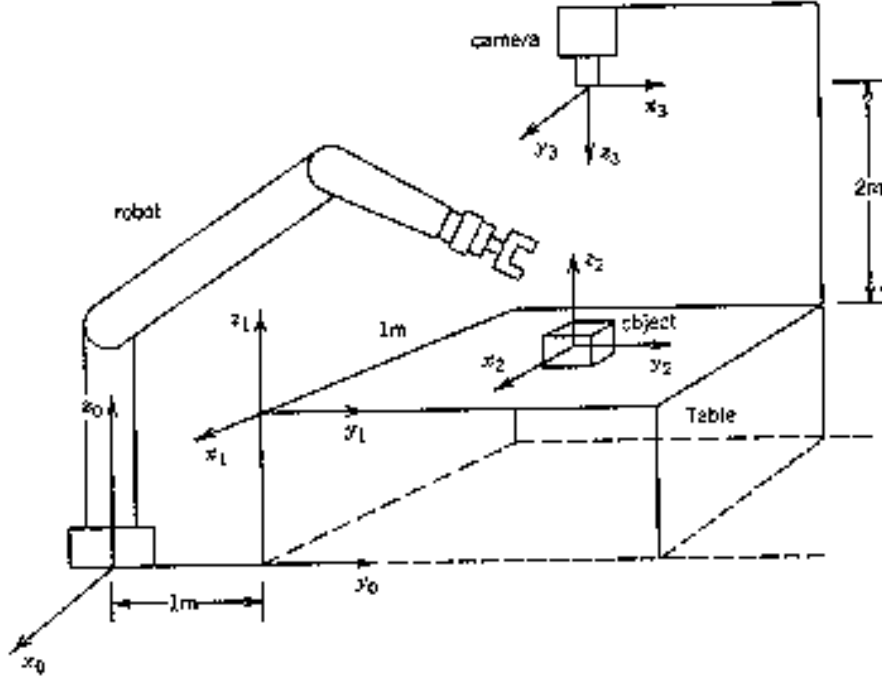


Figure 1: Figure for question 4.

- Find the homogeneous transformations relating each of these frames to the base frame $O_0 \equiv (x_0 y_0 z_0)$.
- Find the homogeneous transformation relating the frame $O_2 \equiv (x_2 y_2 z_2)$ to the camera frame $O_3 \equiv (x_3 y_3 z_3)$.