FRA 333 : Intro to Robotics
Assignment 2: Translation & Transformation

1 : Inverse of Homogeneous Transformation (Written)

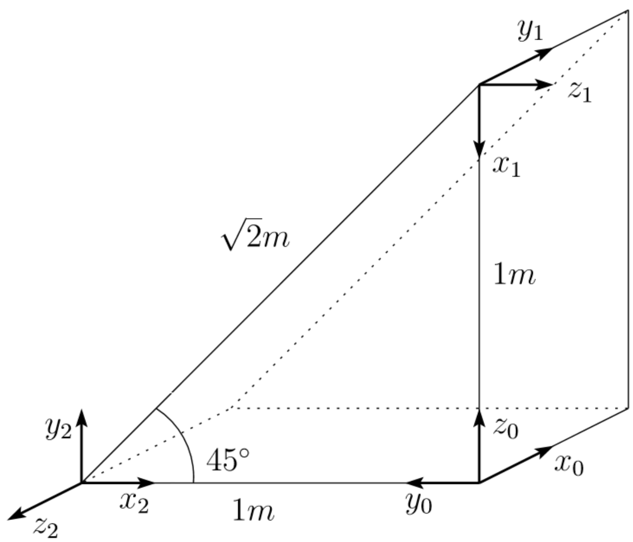
Given a rotation matrix R, translation vector $\vec{p}$, and

$$H = \begin{bmatrix} R & \vec{p} \\ \vec{0}_3 \times 1 & 1 \end{bmatrix}$$

Show that the inverse of a homogeneous transformation matrix H can be written as the following.

$$H^{-1} = \begin{bmatrix} R^T & -R^T\vec{p} \\ \vec{0}_{3\times 1} & 1 \end{bmatrix}$$

2 : Constructing Homogeneous Transformation Matrix (Written)



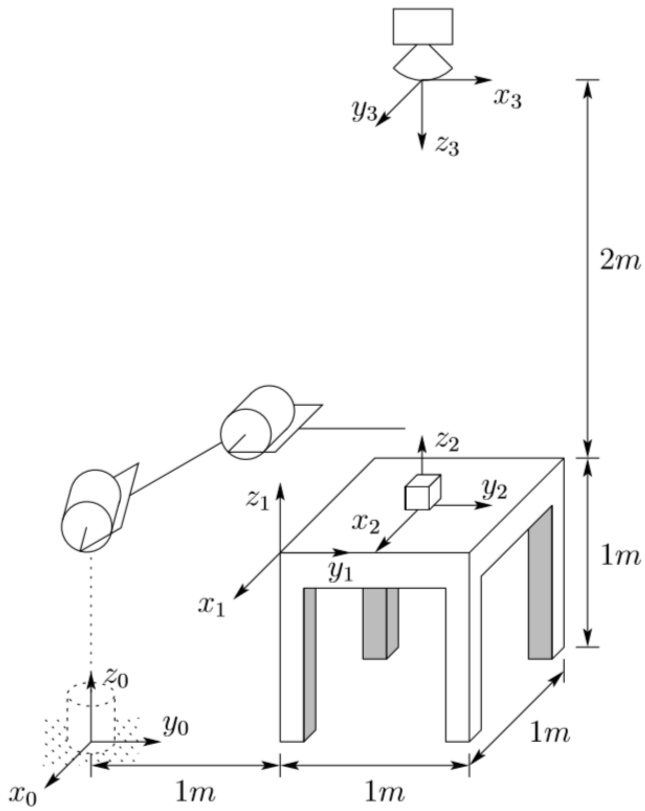
Problem 2-3

Consider the given diagram. without using a sequence of translation and rotation, find the homogeneous transformations H_1^0, H_2^0, and H_2^1 representing the transformations among the three frames shown. Describe how you construct the matrices.

3 : Constructing Homogeneous Transformation Matrix (Written)

Consider the same diagram. This time, use a sequence of translation and rotation to find the homogeneous transformations H_1^0, H_2^0, and H_2^1 representing the transformations among the three frames shown. Also show that $H_2^0 = H_1^0 H_2^1$

4 : Homogeneous Transformation Matrix (Written)



Problem 4

Consider the diagram of Figure Problem 4. A robot is set up 1 meter from a table. The table top is 1 meter high and 1 meter square. A frame $o_1x_1y_1z_1$ 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 $o_2x_2y_2z_2$ established at the center of the cube as shown. A camera is situated directly above the center of the block 2 meters above the table top with frame $o_3x_3y_3z_3$ attached as shown. Find the homogeneous transformations relating each of these frames to the base frame $o_0x_0y_0z_0$ Find the homogeneous transformation relating the frame $o_2x_2y_2z_2$ to the camera frame $o_3x_3y_3z_3$

5 : Function for rotation and translation (MATLAB Programming)

Write 2 MATLAB functions, "rot" and "trans". The function "rot" takes an angle of rotation and a character ('x', 'y', and 'z') indicating the axis of rotation, then return 4x4 homogeneous transformation matrix corresponding to the rotation. The function "trans" takes distance of translation and a character ('x', 'y', and 'z') indicating the axis of translation, then return 4x4 homogeneous transformation matrix corresponding to the translation.

6 : 2-DOF Manipulator

For this assignment, you will use what you learned from the class and apply to a robotic system. A 2-link planar manipulator is a very well-known system due to its simplicity in kinematics and dynamics. You and your team are asked to determined the position and orientation of its end-effector with respect to the workspace. The whole system can be described below.

A given workspace has rectangular shape. The origin of the workspace's coordinate frame, F_0, is located at the bottom-left corner as shown in the picture. The origin is also on the flat surface. The workspace has the length of 3 meters (along x-direction), and width of 2.5 meters (along y-direction). For the end-effector to be inside the workspace, only x- and y- positions of the end-effector have to be inside the workspace boundary.

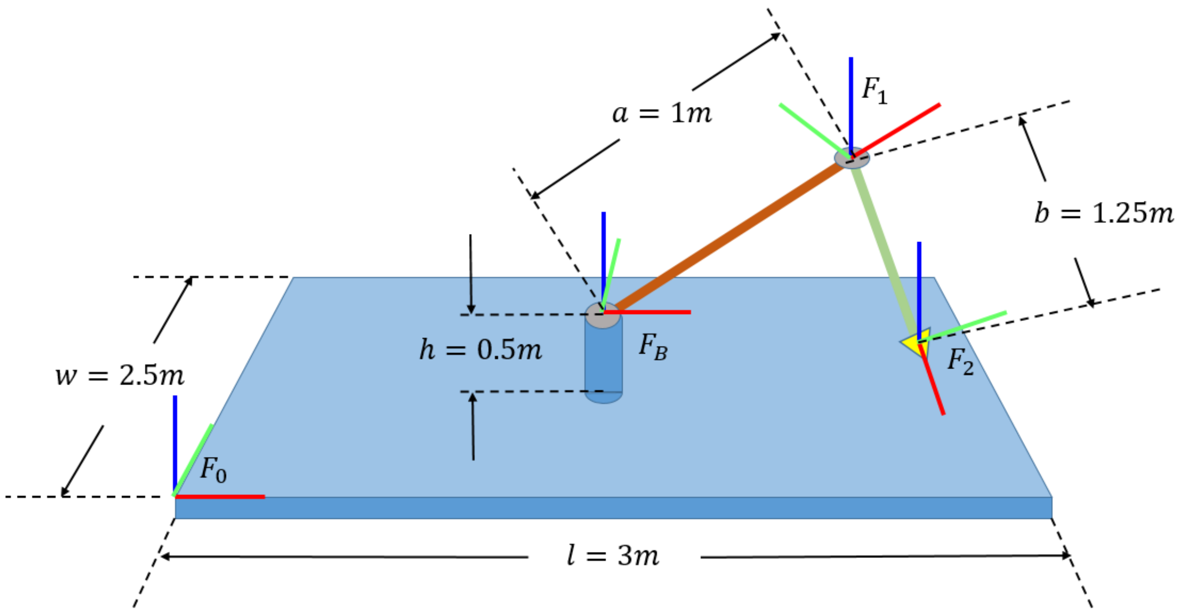
The base of the manipulator is located at the middle of the workspace. The entire manipulator is lifted off by 0.5 meter above the ground. The rotation axes of both joints are perpendicular to the flat surface. The first rotation axis is located at the middle of the workspace. The first link has a length of 1 meter. The second link has a length of 1.25 meter. The end-effector is located at the end of the second link

There are 3 other coordinate frames. The coordinate frame of the base, F_B, is located at the middle of the workspace. The origin of the frame is 0.5 meters above the flat surface. All axes of the base frame are parallel with the axes of the workspace coordinate frame. The coordinate frame of the first link, F_1, is rigidly attached to the end of the first link. The x-axis of the frame points outward along the length of the link. The coordinate frame of the second link, F_2, is rigidly attached to the end of the second link. The x-axis of the frame points outward along the length of the link as well.

Write a single program in MATLAB to do the following.

1. For a given configuration (a set of joint values corresponding to the rotation of each joints), return the homogeneous transformation matrix that represents transformation from the end-effector's frame to the workspace's frame.

2. Return a 3x3 rotation matrix that describes the orientation of end-effector frame



Workspace

3. Return a 3x1 position vector that describes the position of the end-effector

4. Return a string saying "Yes" or "No" indicating whether the end-effector stays inside the workspace's boundary.