Assignment 3

The figure below shows a planar manipulator with two rotational joints. The manipulator is shown in its zero configuration, and joint angles are defined using the right-hand rule about axes z_1 and z_2. We are interested in the movement of the tool frame with respect to an initial reference frame, called Frame 0, as a function of the two joint angles.
We will consider Frame 0 located at two different positions:
(1) at the base frame of the robot, and
(2) at the location of the tool frame in the zero configuration.

For each case, do the following:

a) Give the homogeneous transformation $g_{0t}(0)$, which relates Frame t to Frame 0 when $\theta = 0$, as it is shown in the figure.

b) Give the screw parameters that geometrically describe the screw motions of the joints with respect to Frame 0.

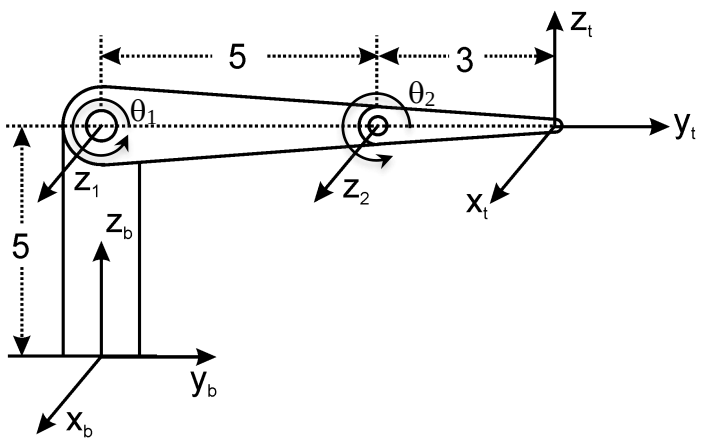
c) Express the geometric "screws" in their abstract mathematical "twist" notations.

d) Give the homogeneous transformation g_{b0}, which relates Frame 0 to the robot base frame.

e) Find $g_{0t}(\theta)$ and write a MATLAB script that takes in the two joint angles and returns the homogeneous transformation $g_{bt}(\theta)$, using the product of exponentials.

f) The robot joints can move within the following ranges: $\theta_1 = [-\pi/4, \pi/2]$ and $\theta_2 = [-\pi/2, \pi/2]$. For every combination of the two joints at 5-degree increments, plot the origin of the tool frame with respect to the base frame (in the y-z plane). For one case, use "o"s, and for the other use "x"s. If you have done the forward kinematics correctly, the "x"s and "o"s should line up on your plot. Make sure that the axes are drawn with equal magnitude so that the workspace of the manipulator is not distorted.

   The relative density of the points in the workspace, using this method of equally spaced joint angles, gives information about the manipulability of the manipulator (which we will discuss more in the future). In locations where the points are densely packed, the robot is better conditioned.



g) The robotic arm below is shown in its initial configuration (θ_i=0° for all joints). Introduce the missing coordinate systems following the DH convention. Find the link parameters: the link lengths, twists, offsets and the joint angles.