ECE 4560
Assignment 2

Due: September 5th, 11:59pm

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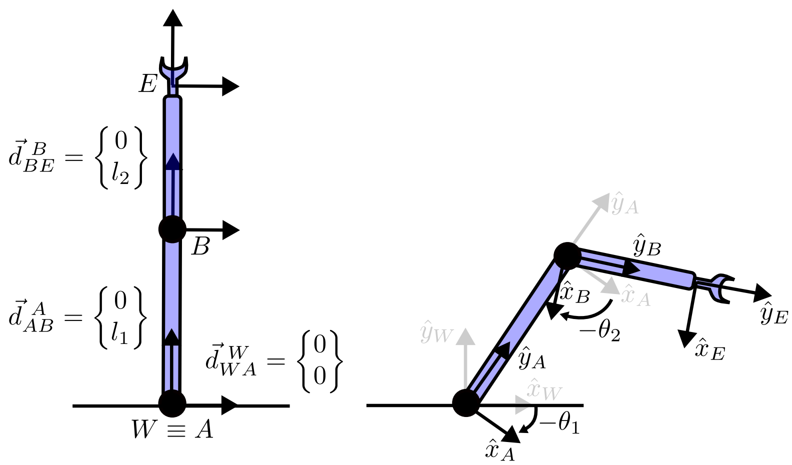
1. (0 points) Please denote the number of hours you spent on this homework. Please separate your time into homework vs. lab hours. I am *not* keeping track of effort per student, I just want to know if the homeworks are a reasonable length on average.

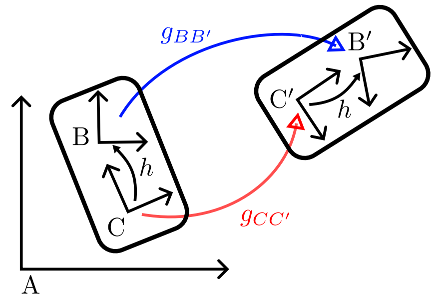
2. Consider the planar robot with the zero configuration shown on the left (configuration in which $\theta_1 = 0$ and $\theta_2 = 0$). Assume that the origin of world frame (W) is located at $(0, 0)$. Lastly, assume that the link lengths are $l_1 = 4$ and $l_2 = 2$.



   (a) (3 points) Solve for the configuration of the end-effector frame using simple trigonometry/geometry (i.e., solve for g_{WE}) when $\theta_1 = -\pi/4$ and $\theta_2 = -\pi/2$ (this configuration is approximately shown in the figure on the right).

   (b) (3 points) Now, solve for the configuration of the end-effector using the composition of transformations $g_{WE} = g_{WA} \cdot g_{AB} \cdot g_{BE}$.

3. (3 points) Consider the example we presented in class (shown below)

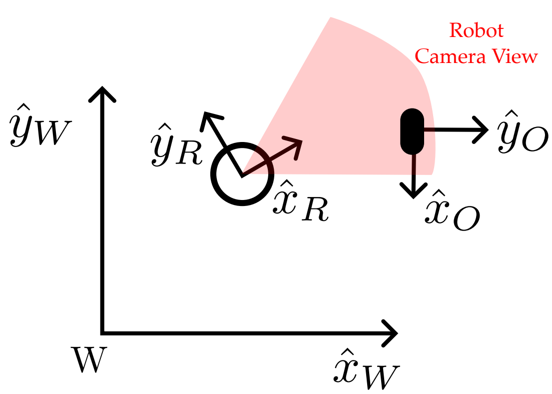


Assume that the same scenario holds where the diagram represents a table with you sitting in one seat (frame B) and your friend sitting in the other seat (frame C). Assume that the professor asks you to move your table to a new location. You know how much you moved ($g_{BB'}$) as well as the transformation between yourself and your friend (h). These transformations are explicitly represented as:

$$g_{BB'} = \left(\underbrace{(10, 1)}_{\vec{d}^{B}_{BB'}}, \underbrace{-\pi/4}_{\theta_{BB'}} \right), \qquad h = \left(\underbrace{(0.1, 1)}_{\vec{d}^{C}_{CB'}}, \underbrace{-\pi/8}_{\theta_{CB}} \right)$$

How much did your friend have to move (with respect to their own frame, i.e., $g_{CC'}$)? **Show your work!**

4. Consider the scenario depicted in the figure below, in which there is a mobile robot (frame R). The robot has a mapping algorithm that keeps track of its coordinates with respect to the world frame. These coordinates are given by $g_{WR} = (\vec{d}^{\,W}_{WR}, R(\theta_{WR}))$. The robot has a camera mounted on it (with an object localization algorithm) that is able to detect the relative position of objects in reference to the robot's body frame, (i.e., the robot can obtain $g_{RO} = (\vec{d}^{\,R}_{RO}, R(\theta_{RO})))$.



(a) (3 points) The robot detects an object at a displacement of $\vec{d}^{\,R}_{RO} = (3, 1)$ and an orientation $\theta_{RO} = -\pi/3$. The robot's coordinates with respect to the world frame are $g_{WR} = (2, 3, \pi/4)$. What is are the coordinates for the object in the world frame? **Show your work!** (Hint: Solve for g_{WO}).

5. **LAB COMPONENT:** This week the lab objective is to successfully set up a communication pipeline with your robot of choice (i.e., serial communication). The instructions for how to do this will differ based on the track you selected:

   - SO-101 Robot Arm: We will be calibrating the robot and testing if the calibration was successful using the open source teleoperation code. There are many different tutorials online, but I recommend following the instructions we have provided on the course website.
   - Old Robot Arm: Run the "calibration" code for the Piktul planar robot arm: Piktul setup instructions.
   - Mobile Robot: Run the "turtlebot_bringup" launch file using ROS to teleoperate the Turtlebot3. Instructions are provided here.
   - Biped Project: Complete the "Dynamixel Tutorial" to know how to connect with the biped robot motors. Instructions are provided here.

   I recommend going during the TA office hours so that you can ask the TAs for help with the robots.

   (a) (3 points) To document your effort towards lab this week, please provide a brief writeup of what you did and any issues you encountered. Please also include at least one picture of your robot and/or lab setup. I will award full points if you have made a good faith effort to set up your robot.