Homework 8

16-311: Introduction to Robotics

Contents

Learning Objectives

1. Develop intuition about degrees of freedom.
2. Express position through vectors and matrices.
3. Develop intuition for relative translation and rotations.
4. Practice expressing movements in matrices.
5. Practice deriving forward kinematics of different robot arm configurations.

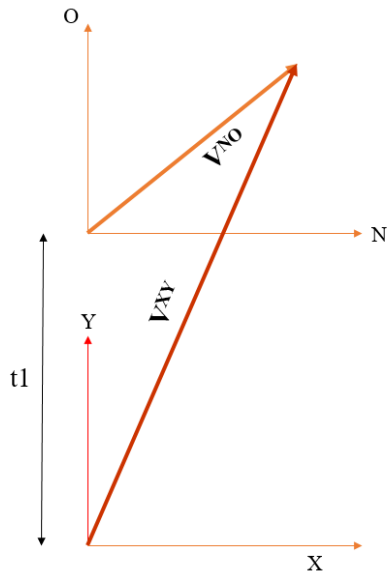
1 Degrees of Freedom

1. How many degrees of freedom does your pointer finger have? Explain your answer.

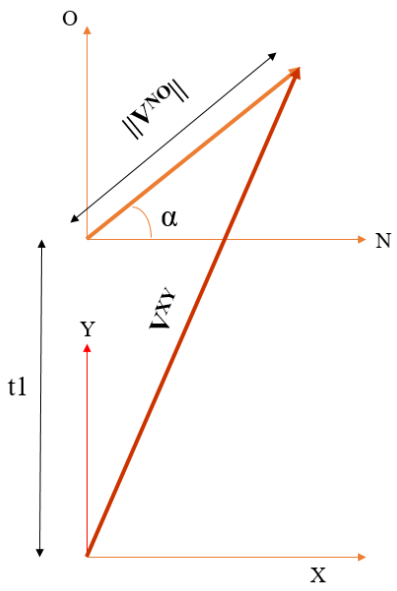
2. How many degrees of freedom does an airplane have? Explain your answer.

2 2D Translation and Rotations

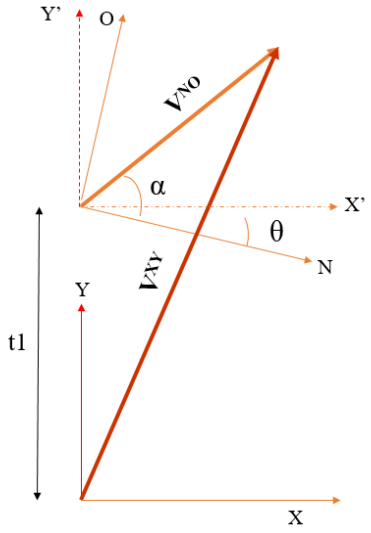
1. Express V^{XY} using V^N, V^O and t_1.



2. Express V^{XY} using $||V^{NO}||$, α, and t_1.



3. Express V^{XY} using V^N, V^O, t_1, and θ.



3 3D Translations and Rotations

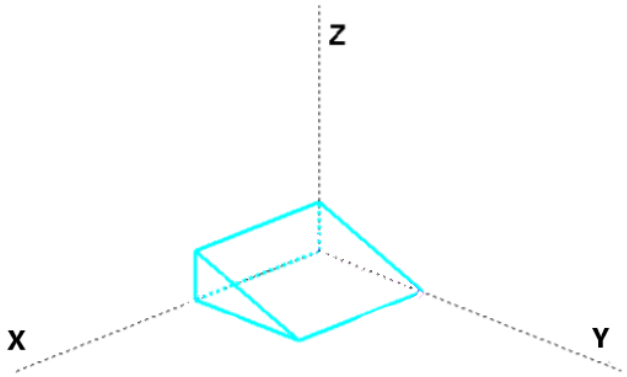


Figure 1: Original wedge position and orientation.

Draw what happens to a wedge that goes through the following transformations (all motions are RELATIVE to the wedge, not the original world frame). You can write a program to generate the pictures or draw them by hand or in a computer program. The movements build on each other but each step should be drawn on its own.

1. Translate 3 units in the y direction.
2. Rotate 90 degrees about the z axis.
3. Translate 2 units in the y direction.

4 Homogeneous Transformations

$$H = \begin{bmatrix} 1 & 0 & 0 & -2 \\ 0 & \sqrt{2}/2 & \sqrt{2}/2 & 5 \\ 0 & -\sqrt{2}/2 & \sqrt{2}/2 & 9 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

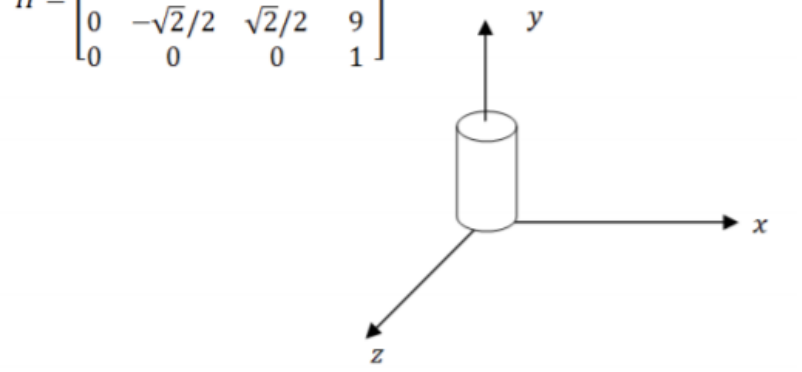


Figure 2: Original cylinder position and orientation.

1. Break up this homogeneous transformation matrix into its rotation part and its translation part. Write the two parts separately.

2. Express the two parts in words. Be specific about each axis.

3. Draw the result of this transformation to this cylinder. You can write a program to generate the picture or draw it by hand or in a computer program. The cylinder has a radius of 1 and a height of 3 units.

5 Forward Kinematics

Derive the forward kinematics for the following RRP robot with base at the origin. Express the x, y, and θ of the end effector in terms of θ_1, θ_2, and s.

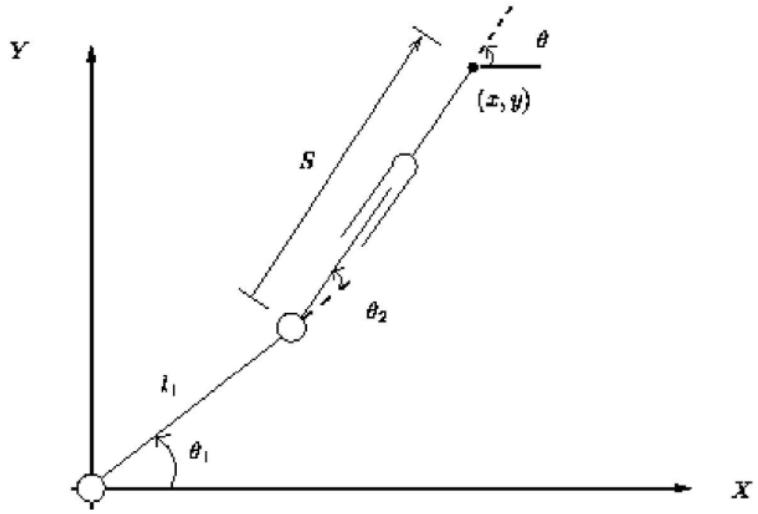


Figure 3: RRP arm

What To Submit

Submissions are due on Autolab/Gradescope by the date specified in the Syllabus.

1. Create a .pdf file with the written answers ALL THE SECTIONS named hw8.pdf and submit to Gradescope.