6ELEN018W - Tutorial 5 Exercises

1 Revision of Lecture Slides

Go through all of the Lecture 5 slides, making sure you understand them. Ask your tutor any questions you might have.

2 A Robot Gripping an Object

This is a simulation of a 2 fingers robot gripping a rectangle object.

1. Write a Python function which accepts 4 arguments:
   - the magnitude of force F_1 corresponding to finger 1 of the robot
   - the magnitude of force F_2 of the second finger of the robot
   - the distance between the application of force F_1 and the center of mass
   - the distance between the application of force F_2 and the center of mass

   and returns the torque applied for the object.

   Hint: Study the robot gripping example from the slides. Note that the x distance is not given to you but the distance between F_2 and the center of mass is given to the function instead. Adjust your calculations accordingly.

   Pay extra attention to calculate the correct sign (positive or negative) for the torque generated.

   Call your function with different arguments and verify the correct results using a calculator (the operating system calculator or a calculator found on the internet and opened with a web-browser can be used)

2. Write a Python function which accepts 3 arguments:
   - the distance between the application of force F_1 and the center of mass
   - the distance between the application of force F_2 and the center of mass
   - the mass W of the rectangular object.

   The function should return a list with the values F_1 and F_2 of the magnitudes of forces of the 2 robot fingers so that the object is in equlibrium (balances) (see the lecture slides, the total sum of both forces and torques should be 0).

3 Lagrange-Euler and Newtonian Mechanics

Consider the cart spring system described in the lecture.

1. Write a Python function accepts as arguments the values of k, m, F and x and returns the acceleration of the cart.

2. Modify the system so that a second force F_2 is being applied to the cart by a human. Modify your Python code to make the correct calculations.

3. Experiment with different values for k for the spring. How do you think these affect the overall acceleration of the body? Plot the diagrams corresponding to different values of k against the resulting acceleration using the `matplotlib` module.

   Hint: You should look at the documentation of how to use the `plot` function of `matplotlib`, e.g. from the following link:

   `https://www.w3schools.com/python/matplotlib_plotting.asp`

4 Revision Exercise - Calculation of End-Effector Position

A point P with coordinates $[7, 3, 1]^T$ is attached to the end-effector of a robot, a moving frame F, which is subject to the following 3 successive transformations relative to the reference fixed world frame F_{xyz}:

1. Rotation of 90^o about the z-axis.

2. Followed by a rotation of 90^o about the y-axis.

3. Followed by a translation of $[4,\ -3,\ 7]$.

Write some Python code which calculates the coordinates of the point relative to the reference frame after all the transformations have taken place.

Hint: The order of the matrices written (calculated) is the opposite of the order of transformations performed because these are applied relative to the fixed world frame (i.e. we premultiply the corresponding transformations).

If these were applied relative to the previous transformation (i.e. the new coordinate frame that we got from the application of the previous transformation, then we would apply post-multiplication, i.e. the order would be the same as the transformations performed from left to right).

The result should calculate to $[5,\ 4,\ 10]$.