

# Homework Assignment 5

## Dynamics Of Non Linear Robotic Systems

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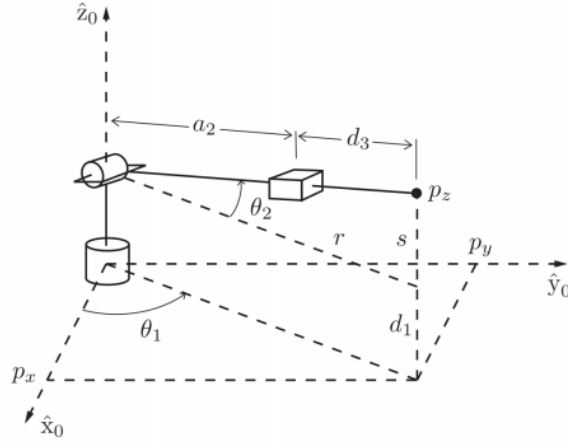


Figure 1: RRP robot.

## Newton-Euler Solution

Let's derive transformation matrices through the algebraic approach for the robot depicted in figure 1.

The robot's axis you can see in the figure 2.

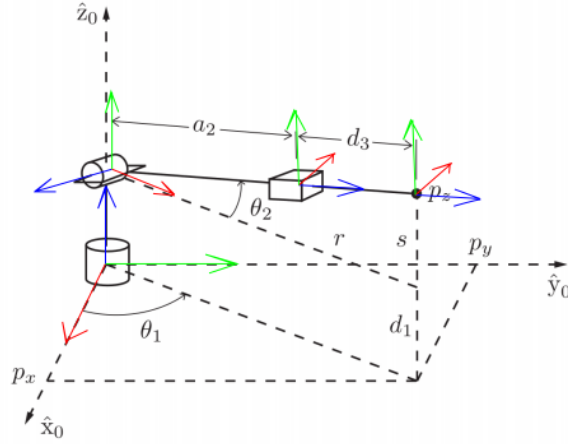


Figure 2: RRP robot with axis.

$$T_3^0 = R_z(\theta_1)T_z(l_1)R_x(\frac{\pi}{2})R_z(q_2)T_x(l_2)R_y(\frac{\pi}{2})T_z(q_3) \quad (1)$$

$$T_1^0 = R_z(\theta_1)T_z(l_1)R_x(\frac{\pi}{2}) \quad (2)$$

$$T_2^1 = R_z(q_2)T_x(l_2)R_y(\frac{\pi}{2}) \quad (3)$$

$$T_3^2 = T_z(q_3) \quad (4)$$

And I exported from this transformation homogeneous matrices  $R_i^{i-1}$ ,  $R_i^0$  and  $d$  to use it in NE Approach.

Robot's parameters			
	Link 1	Link 2	Link 3
mass	2.5	3.5	2
Length	5	7	$d_3$
Joint Law	$3 \sin(t)$	$4 \cos(2t)$	$5 \sin(3t)$

Table 1: Robot's parameters and Joints' Laws

I implemented formulas for NE Approach from [\[1, 282-289\]](#).

I didn't copied them in here because I did this HA in 3 days and I must prepare for other subjects. Sorry about that.

## Results

Let's see results of my NE implementation. All the matrices for all the terms: velocities, accelerations, gravity, coriolis you can find by running the code.

Centrifugal terms:

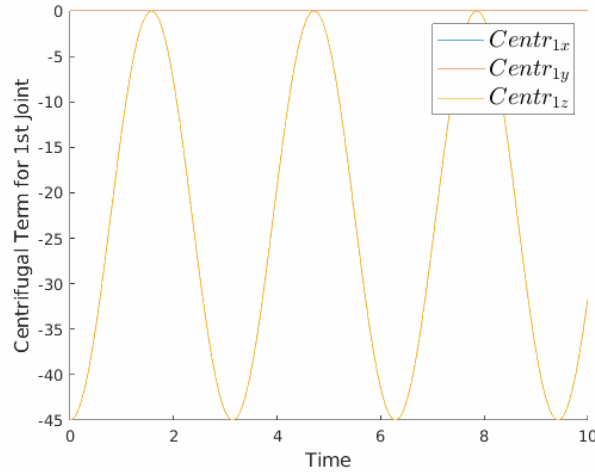


Figure 3: Centrifugal Term for the 1st Joint

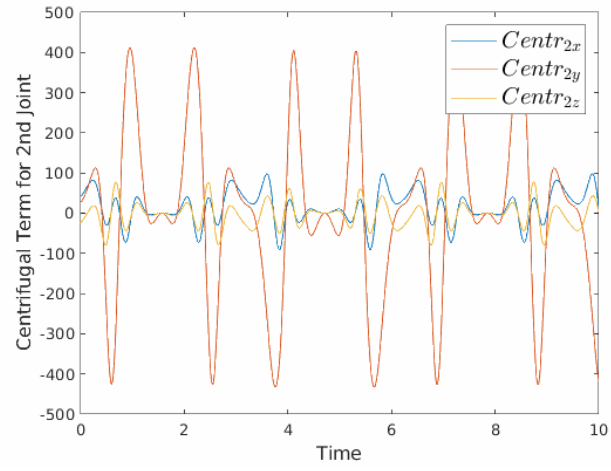


Figure 4: Centrifugal Term for the 2nd Joint

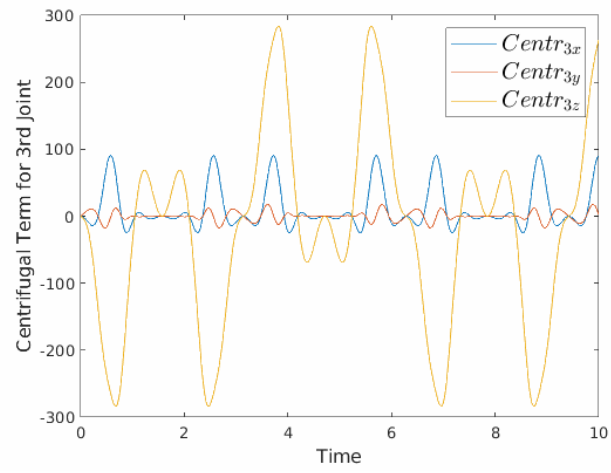


Figure 5: Centrifugal Term for the 3rd Joint

Gravity terms:

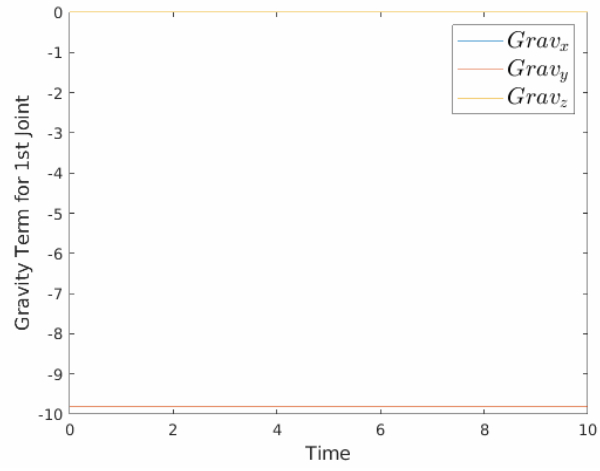


Figure 6: Gravity Term for the 1st Joint

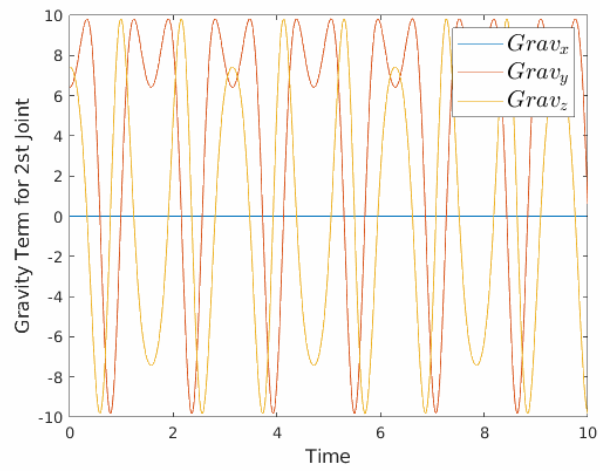


Figure 7: Gravity Term for the 2nd Joint

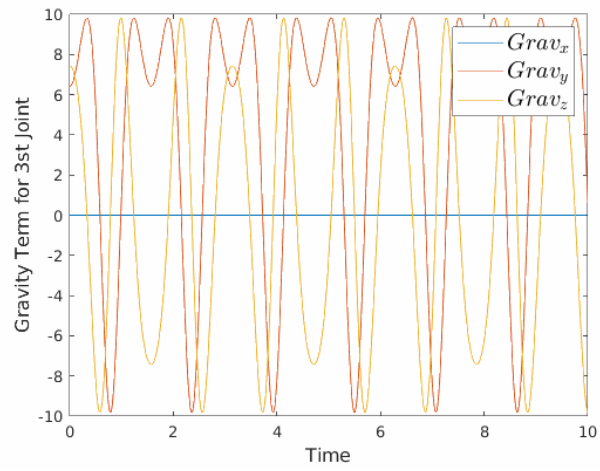


Figure 8: Gravity Term for the 3rd Joint

Coriolis Term:

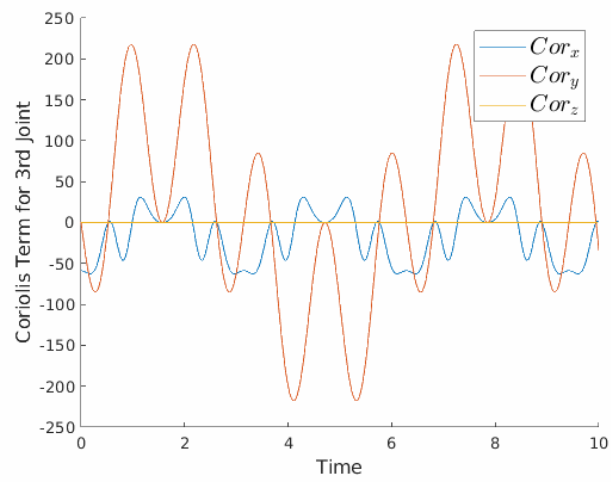


Figure 9: Coriolis Term for the 3rd Joint

Forces:

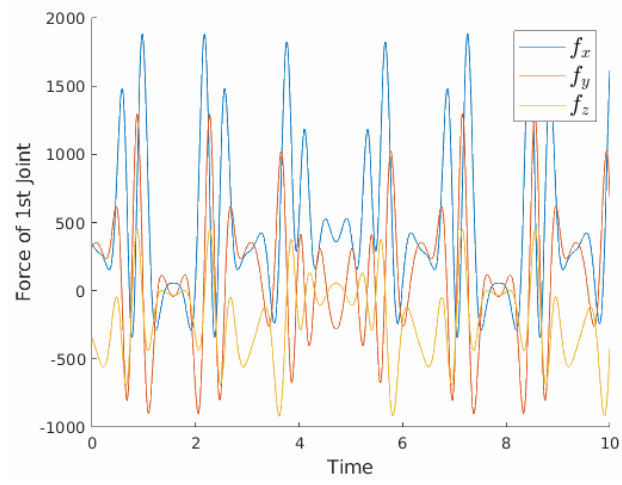


Figure 10: Force for the 1st Joint

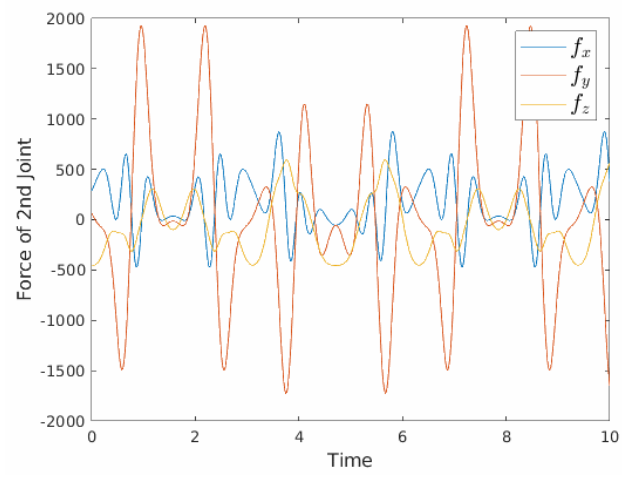


Figure 11: Force for the 2nd Joint

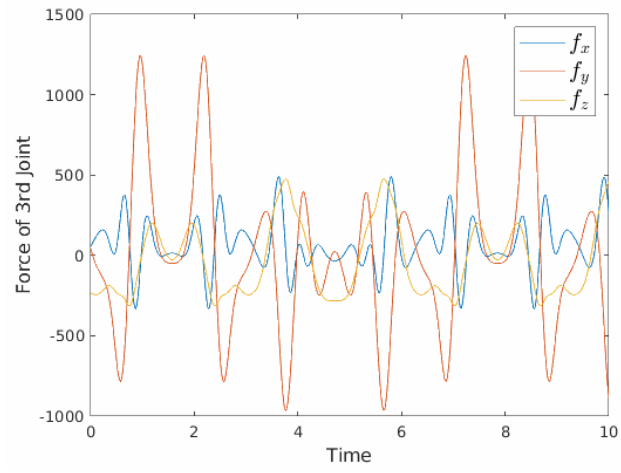


Figure 12: Force for the 3rd Joint

Torques:

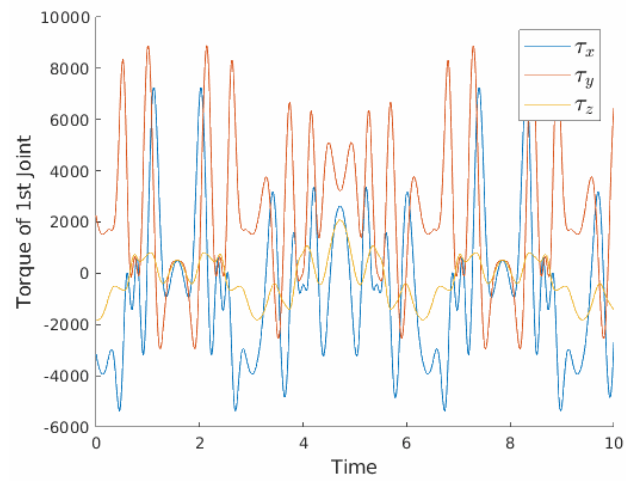


Figure 13: Torque for the 1st Joint



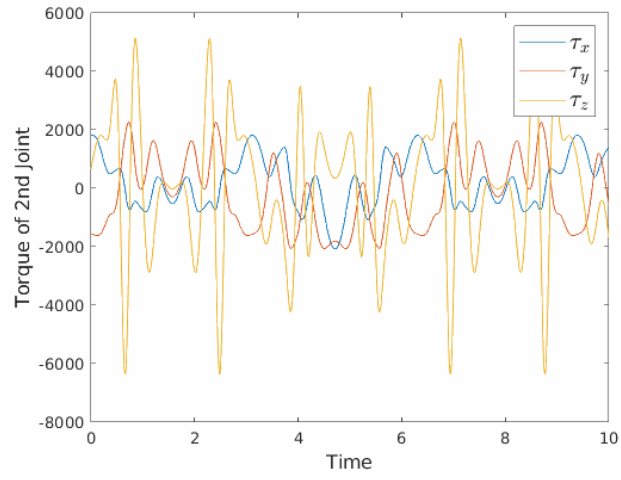


Figure 14: Torque for the 2nd Joint

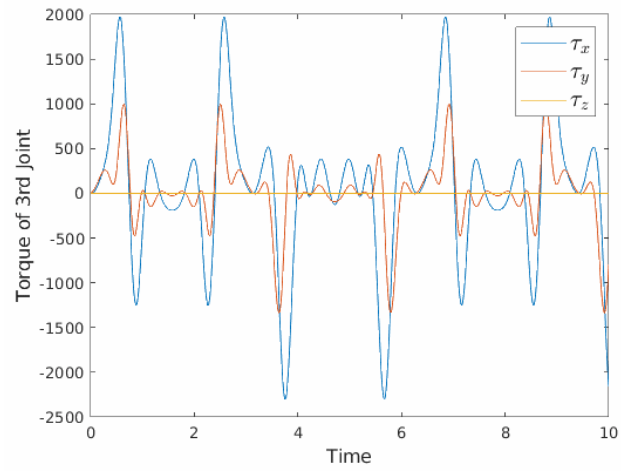


Figure 15: Torque for the 3rd Joint

Acceleration and velocities of the last Joint:

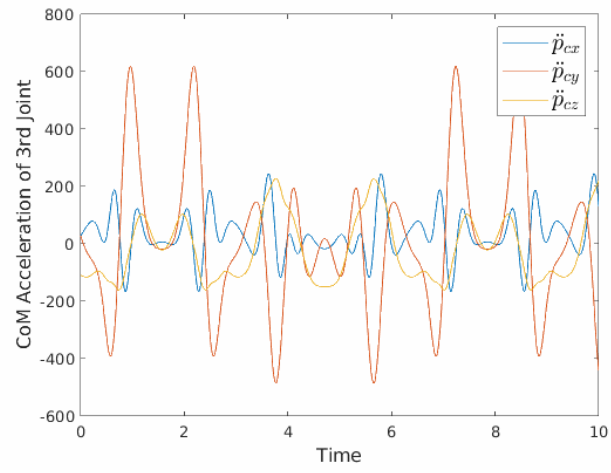


Figure 16: CoM Acceleration for the 3rd Joint

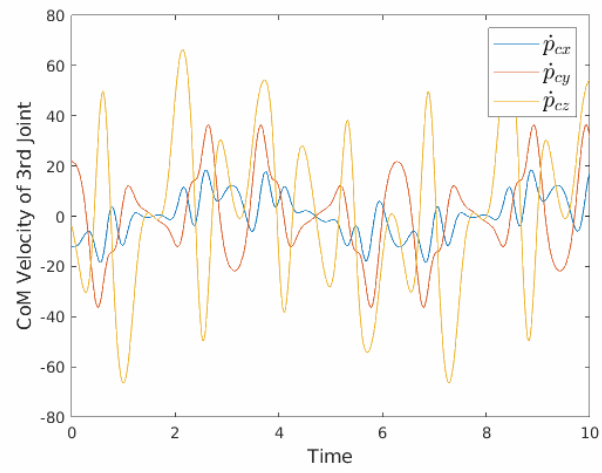


Figure 17: CoM Velocity for the 3rd Joint

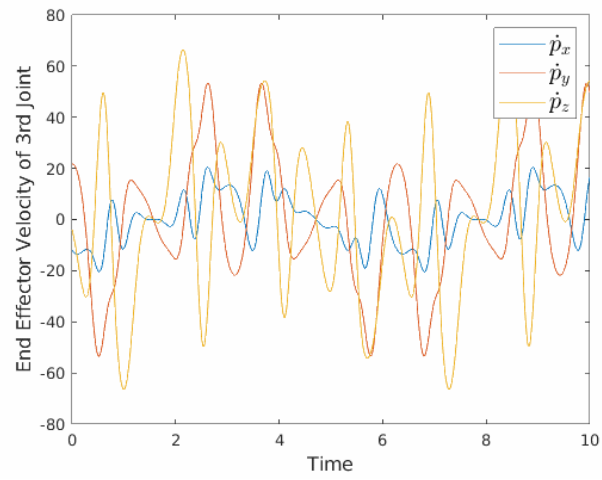


Figure 18: "EndEffector" Velocity for the 3rd Joint

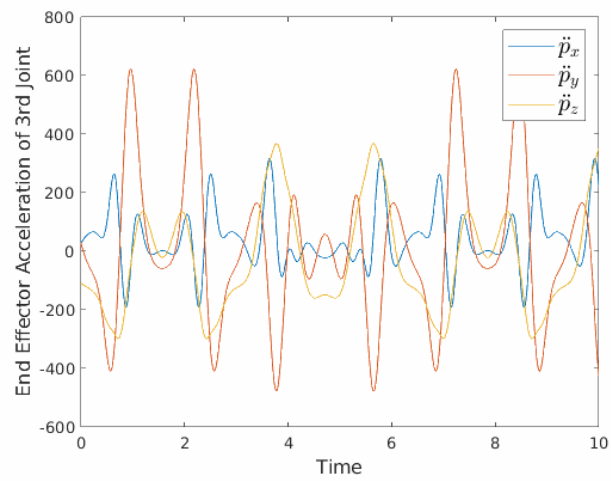


Figure 19: "EndEffector" Acceleration for the 3rd Joint

# Bibliography

- [1] Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo Springer Science & Business Media, Aug 20, 2010 - Technology & Engineering - 632 pages