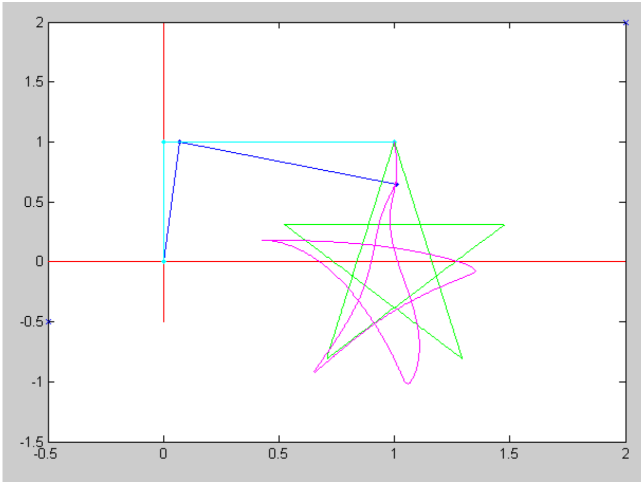
ECE 761 - Homework #11

Control of a 2-Link Robotic Arm



Use the dynamics you derived in homework #10 for a 2-link arm. The dynamics should look something like this (equations for m1 = m2 = 1kg. Your numbers will be slightly different due to using different masses).

$$\begin{bmatrix} (4+2c_2) & (1+c_2) \\ (1+c_2) & 1 \end{bmatrix} \begin{bmatrix} \ddot{\theta}_{r1} \\ \ddot{\theta}_{r2} \end{bmatrix} = T - g \begin{bmatrix} 3c_1 + c_{12} \\ c_{12} \end{bmatrix} + \begin{bmatrix} 2s_2\dot{\theta}_1\dot{\theta}_2 + s_2\dot{\theta}_2^2 \\ -s_2\dot{\theta}_1^2 \end{bmatrix}$$

1) Simulate the motion of a RR robot under freefall (T = 0) from the initial condition of [0, 0]. Check to see if the motion is reasonable (gravity is down).

Problem 2-6: Write a program (modify PD_Control.txt) to trace out a star (or another shape you like) with corners at

	P1	P2	P3	P4	P5	P6=P1
X	1.0000	1.2939	0.5245	1.4755	0.7061	1.0000
Y	-1.5000	0.3090	-0.8090	-0.8090	0.3090	-1.5000

and a 2-second motion from point to point

Simulate and plot the tracking error for

2) PD control

$$T = 100(\theta_r - \theta) + 14\left(-\frac{d\theta}{dt}\right)$$

3) PD + Feedforward Control (gravity)

- The gravity matrix here is for m1 = m2 = 1kg (your numbers will be different)
- If done correctly, the feedforward term (gravity) should cancel the gravity term in your dynamics

$$T = 100(\theta_r - \theta) + 14\left(-\frac{d\theta}{dt}\right) + g\begin{bmatrix} 3c_1 + c_{12} \\ c_{12} \end{bmatrix}$$

4) PD + Gravity + Velocity feedforward terms

$$T = 100(\theta_r - \theta) + 14\left(\frac{d\theta_r}{dt} - \frac{d\theta}{dt}\right) + g\begin{bmatrix} 3c_1 + c_{12} \\ c_{12} \end{bmatrix}$$

5) PD + Gravity + Velocity + Coriolis feedforward terms

- The he gravity and coroilis matrices are for m1 = m2 = 1kg (your numbers will differ slightly)
- If done correctly, the feedforward terms should cancel corresponding terms in your dynamics

$$T = 100(\theta_r - \theta) + 14\left(\frac{d\theta_r}{dt} - \frac{d\theta}{dt}\right) + g\begin{bmatrix} 3c_1 + c_{12} \\ c_{12} \end{bmatrix} - \begin{bmatrix} 2s_2\dot{\theta}_1\dot{\theta}_2 + s_2\dot{\theta}_2^2 \\ -s_2\dot{\theta}_1^2 \end{bmatrix}$$

6) PD + Gravity + Velocity + Coriolis + Acceleration

- ditto

$$T = 100(\theta_r - \theta) + 14\left(\frac{d\theta_r}{dt} - \frac{d\theta}{dt}\right) + g\begin{bmatrix} 3c_1 + c_{12} \\ c_{12} \end{bmatrix} - \begin{bmatrix} 2s_2\dot{\theta}_1\dot{\theta}_2 + s_2\dot{\theta}_2^2 \\ -s_2\dot{\theta}_1^2 \end{bmatrix}$$

$$+\begin{bmatrix} (4+2c_2) & (1+c_2) \\ (1+c_2) & 1 \end{bmatrix}\begin{bmatrix} \ddot{\theta}_{r1} \\ \ddot{\theta}_{r2} \end{bmatrix}$$