Prelab is due on Wednesday, Oct 14 **EE571** Experiment #3 (Counts as HW#13 and 14)

Objective:
1. To design a Feedback Regulator for the Motomatic
2. To design a Feedback Controller for the Motomatic

Pre-Lab: (Counts as HW#13 - Due Wednesday, Oct. 14). Recall the objective of the first two experiments was to obtain a model for the Motomatic. While we obtained three different models (two from Lab 1 and one from Lab 2), the model which best describes our system dynamics with unity feedback is:

$$\dot{x} = \begin{bmatrix} 0 & 3.1 \\ -68.0164 & -5.27 \end{bmatrix} x + \begin{bmatrix} 0 \\ 68.0164 \end{bmatrix} V_{in}$$

where $x=[V_{out}\ V_g]^T$ (recall that $V_{out}=K_p\theta_{out}$ and $V_g = K_g\omega_m$). If we eliminate the unity feedback loop and operate the Motomatic in open-loop (i.e., without feeding back the potentiometer voltage, $-V_{out}$) we obtain the following state variable model (can you show this?):

$$\dot{x} = \begin{bmatrix} 0 & 3.1 \\ 0 & -5.27 \end{bmatrix} x + \begin{bmatrix} 0 \\ 68.0164 \end{bmatrix} V_{in}$$

It is this model that we will use in Lab 3.

1 a) Design a feedback regulator such that the following specifications are met:
1) Vout has no overshoot
2) Vout settles to 2% of it's initial value within 0.3s

b) Simulate your regulator on Matlab using lsim* (or Simulink!!) given the initial state, $x(0) = [10\ 0]^T$

c) If your design does not meet specifications, change your design until it does and explain why your initial design did not work (hint: recall the settling time measures how fast the decoupled modes go to zero!)

d) Use Matlab to make a plot of the decoupled modes versus time using the relationship that $z_{decoupled}=P^{-1}x$. (hint: you can do this in Matlab via the statement: plot(t,inv(P)*x) where P is the matrix of eigenvectors of **(A-BK)**)

2 a) Now, design a controller to meet the following specs:
1) Vout has no overshoot
2) Vout settles within 0.3s
3) $Vout_{steady\text{-}state}$ = 4 volts
4) The steady-state error between Vout and 4 volts is about zero

(Note: we are actually performing position control of the Motomatic D.C. servo! If Vout goes to 4 volts in steady-state, then θ_{out} will go to Vout/Kp = 4/5.1394 = 0.778 radians!)

b) Use Matlab (or Simulink!!) to simulate your controller. Make any adjustments needed to meet specs

c) Draw a block diagram of your controller with your model for the Motomatic

In Lab!!: (Due Monday, Oct. 19)

1. Implement your regulator (i.e., Nx=Nu=0) in Lab and obtain a zero-input response with $x(0) = [10\ 0]^T$. You can do this by turning the flywheel until 10 volts appears on the test meter then run the regulator with a step input of 0. Does the zero-input response agree with your Pre-Lab simulation?

2. Now set the initial conditions to zero and find the regulator step response. What is the steady-state error? Why is it so large?

3. Measure t_s and compare to the results of your Pre-Lab. If t_s does not meet specs, adjust your regulator design until it does!

4. Implement your controller design and obtain a step-response so that Vout goes to 4 volts (or θ_{out} goes to 0.778 radians). Again, measure the steady-state error and compare to Pre-Lab results. Explain any discrepancies.

5. Although we designed our controller to follow a step (constant y_{ref}, obtain a ramp response with slope of 0.5 (i.e., w(t)=0.5r(t)) for 2 seconds. What is the steady-state error?

*LSIM Simulation of continuous-time linear systems to arbitrary inputs.
LSIM(A,B,C,D,U,T) calculates and plots the time response of the system:

dx/dt = Ax + Bu
y = Cx + Du

to input time history U. Matrix U must have as many columns as there are inputs, U. Each row of U corresponds to a new time point, and U must have LENGTH(T) rows.

[Y,X] = LSIM(A,B,C,D,U,T) also returns the state time history LSIM(A,B,C,D,U,T,X0) can be used if initial conditions exist.