MECH 5970/6970 Feedback Homework #2
(Due Friday, 1/31/2025 in class)

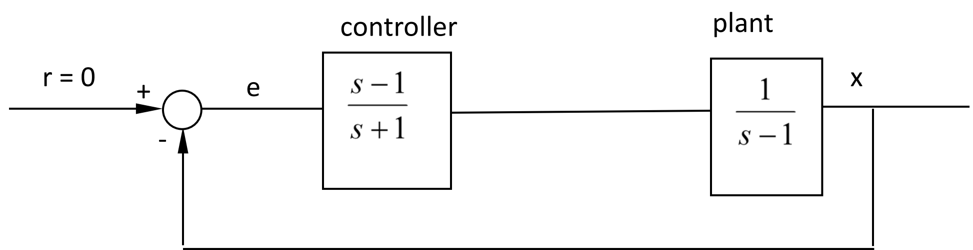
1) Chapter 3:
   Problems: 3.41, 3.51

2) Chapter 4:
   Problems: 4.4, 4.8, 4.10, 4.12-4.13, 4.15-4.16, 4.19, 4.22, 4.24, 4.26, 4.30-4.32, 4.34

   (You can use root locus for any problem that says use Routh's Stability if you want)

I don't need tons of plots, each problem should be answered on a single page

3) Consider the system below. Determine if the system is unstable due to reference inputs. What about disturbance inputs? What about sensor noise imputs?



4) Try and improve your estimate of the system "ID_this_system"

5) Develop a PI controller for the plant in problem #3. Design your controller such that the closed-loop natural frequency is 10 rad/sec with a damping ration of 0.707.
   a. Show the that response matches the designed response when there is no saturation
   b. Show what happens to the response when you add a saturation limit of 50% of the max input
   c. Use anti-windup to improve the PI controller. How does it compare to the theoretical ("design") performance? What was your anti-windup threshold?
   d. Repeat parts b and c for 25% of the max input
   e. Add a disturbance to the system and show the performance. What happens if your anti-windup threshold is too big? What happens if it is too small?

6) Develop a PD controller for the inverted pendulum to have a 0.1 second rise time and 5% overshoot. Test your pendulum control with an initial offset of 20 degrees.

J_{CG}=0.02 kgm^2 l= 0.3 m (Length to the CG) m=0.1 kg T_{max}= 0.46 Nm

a. Limit the input torque to 50% of the original maximum value and then 25% and 10% of the maximum value. What happens? Approximate the "apparent" closed loop roots.
b. Add a time delay to your control input (what is the most delay in time your controller can handle)? This can be done multiple ways, the easiest is to use an old measurement or old control input, i.e. tau=tau(k-n), where n is the number of samples delayed.
c. Change the control update rate to 20 Hz (note you should continue to use at least 100 Hz, or ode45 to simulate your system). Alternatively, you may also use the pendulum system on the website to verify your design and simulation.
d. Modify your design for this new sample rate – what is the best response you can get? Provide your PD Gains and test using the website inverted pendulum.

7) Redsign your controller including the Maxon EC-max 40 motor and voltage as the input. Test the controller with an initial offset of 10 degrees.

J_{CG}=0.02 kgm^2 l= 0.3 m (Length to the CG) m=0.1 kg V_{max}= 12 V

L=0.0464 mH R=0.36 Ohms Jm=51.2 gcm^2 Ki=Kb=0.014

a. Provide your controller and how you came up with your deisgn (i.e. what method(s) did you use)
b. Test your controller using position only with the pendulum system on the website.
c. Test the controller's ability to track a 10 degree sinusoidal reference at 1 Hz (i.e. r=(pi/18)sin(2*pi*t). Compare with the sensititivy transfer function bode plot as well as the closed loop bode plot.
d. Now assuming your have position and velocity measurents. Are you able to improve the performance. Provide your new design if it changed.