MECH 5970/6970 Feedback Homework #6
(Due Wednesday, 4/2/2025 in class)

1) Chapter 8: 8.10-15
2) Consider the following plant (a DC motor with negligible inductance) : $\frac{\theta}{V} = \frac{50}{s^2+5s}$
   Discretize the plant (Ts=0.1) and compare the continuous and discrete bode plots (and root-locus). What is the minimum steady state error to a unit-ramp that can be achieved with a proportional controller (in continuous vs. discrete)? What is the crossover frequency and closed-loop BW (in continuous vs. discrete)?
   a. Design a discrete lead controller to decrease the error in half. What is the new crossover frequency and closed-loop BW?
   b. Design a discrete lag controller? What is the steady state error now? What is the drawback of this design?
   c. Design a discrete lead/lag to achieve both (a) and (b).
3) Write a discrete controller (matlab or Simulink) for a simple *1/s* plant. Assume a unit step input for the reference, *r(t)*.
   a. What type of controller did you use. Provide the Gain Margin, Phase Margin, closed-loop eigenvalues, and steady state error
   b. What is the steady state error if the reference *r(t)* is a unit ramp input and parabolic input?
   c. Redesign the controller to track the ramp input and repeat part (a-b).
   d. Redesign the controller to track a parabolic input and repeat part (a-b)
4) Discretize the following plant and plot the discrete bode and Nyquist plots $\frac{x}{u} = \frac{50}{s^3+2s^2+100s}$
   a. What values of K will it be stable?
   b. For K=1, what is the Gain Margin and Phase Margin? K=2?
5) Develop a discrete controller for the inverted pendulum (use both Root Locus and Bode to design/analyze your controller). Test your controller against the system on the website. Provide your control law (as well as which measurements you used) and a plot of the response to r=0 deg and r=10 deg. How does it compare to your previous designs?
6) Develop a discrete controller for the Ball on Beam (use both Root Locus and Bode to design/analyze your controller). Test your controller against the system on the website. Provide your control law and a plot of the response for x_{des}=10 cm (Ts=0.1 seconds)
7) Develop a discrete yaw controller for the vehicle model. Test your controller with the system on-line. Use a desired yaw rate of 50 deg/sec at 30 m/s. Provide plots of steer angle, yaw rate and position vs. time. Additionally provide a plot of E-N position.
8) Develop a discrete position controller for the vehicle model. Test your controller with a desired lateral position of 4 meters at 30 m/s. Provide plots of steer angle, yaw rate and position vs. time. Additionally provide a plot of E-N position.