HW #7 (4/17/2023)

1) Chapter 7: 7.2, 7.3d, 7.4d. 7.5d, 7.6-7.7, 7.15, 7.20, 7.22-7.25, 7.27-7.28, 7.29b-c, 7.31-7.32

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 design a state space controller for the position of the motor (assume knowledge of all the states) that matches your specifications from your prior design.
   a. Provide the gain matrix K and state how it compares to your prior design.
   b. Compare the gains, response, input, and cost ($J = \int_0^\infty (y^2 + u^2)\, dt$ for a controller that achieves a 1.5 second settle time with ζ=0.707 versus an overdamped response on the symmetric root locus
   c. Add integral control and repeat parts (a-b).

3) Write a discrete state space controller (matlab or Simulink) for a simple *1/s* plant. Assume a unit step input for the reference, *r(t)*.
   a. What is K? Where are the closed loop eigenvalues?
   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) Develop a discrete state space controller for the inverted pendulum with the parameters shown below (assume knowledge of all the states). Test your controller against the system on the website. Provide the control gain matrix and a plot of the response to r=0 deg and r=10 deg. How does the gain matrix compare to your previous controller gains?

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

   a. Plot the symmetric root locus and comment how your design choice compares to an optimized closed-loop pole location.
   b. Repeat using the maxon motor for problem #5

5) Develop a discrete state space controller for the Ball on Beam problem with the parameters shown below (assume knowledge of all the states). 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). State how the gain matrix compare to your previous design?

J_{beam}=0.001 kgm^2
m_{ball}=0.05 kg
r_{ball}=0.02 m
L=0.6m (total length, motor is centered at 0.3 m)
Motor: Maxon EC-max 40 (if you can't get this to work you can select another motor in the Maxon catalog)
Ki=0.014 Nm/A
Kb=0.014 Vs/rad
R=0.36 ohms
V_{max}=12 volts
J=51.2 gcm^2