

MECH 5970/6970 Feedback Homework #5  
(Due Wednesday, 3/19/2025 in class)

- 1) Chapter 8: 8.1, 8.5-9
- 2) Discretize and simulate a 2<sup>nd</sup> order system with a settle time of 1 second and overshoot of 15%. Compare the results with  $\Delta t=0.1, 0.2, 0.5$  seconds and the actual solution. Do this in both state space and transfer function formulations.
- 3) Design a second order low-pass filter with a damping ratio of 0.707 and natural frequency of 5 Hz. Discretize the filter with sample rate of 0.01 seconds.
  - a. Compare the continuous and discrete frequency responses (i.e. bode plots)
  - b. Process a signal that contains a 1 Hz sine wave and 20 Hz sine wave with your digital filter.
  - c. Compare your results with matlab's "butter" and "filter"
- 4) Determine the closed-loop eigenvalue in the z-domain for problem 4 in HW#4 for different sample rates. Does this explain what you saw in your simulation.
- 5) Design a lead controller for a simple  $\frac{1}{s^2}$  plant that is to be sampled at 0.1 seconds. Simulate the various design approaches below and comment on the difference/advantages of each.
  - a. Add delay TF and design in continuous RL and convert  $K(s)$  to  $K(z)$
  - b. Add delay in Bode and design in continuous bode and convert  $K(s)$  to  $K(z)$
  - c. Discretize plant and design  $K(z)$ .
- 6) Try to design and implement a pure PD controller in discrete for a simple  $\frac{1}{s^2}$  plant assuming position and velocity measurements.
- 7) Using frequency based techniques, take another shot at determining the differential equation for "ID\_this\_system." If you already used frequency based techniques, then attempt to identify it using transient techniques given some things mentioned about noise in class.
- 8) Continue to work on your Ball and Beam and Vehicle models as well as the controllers for them.