EECS 460 Fall 2025 Homework 2
Coverage: Concepts up to and including Lecture 5
Assigned: Friday September 12
Due: Friday September 19 at 5:00pm
Total pts: 100

1. [68 pts] Submit a pdf file on Canvas containing written (or LaTeX) answers
2. [32 pts] Answer the HW2 Quiz on Canvas for the questions marked with **[Quiz]**

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1. For each of the following transfer functions $G(s)$
   i. [4 pts: 2 pts per TF] What is the DC gain? **[Quiz]**
   ii. [4 pts: 2 pts per TF] Is the system stable? **[Quiz]**
   iii. [8 pts: 4 pts per TF] What is the general form of the initial condition response? Your answer should contain variables c_i
   iv. [6 pts: 3 pts per TF] What is the general form of the input response (with arbitrary initial conditions) for input $u(t) \equiv 2$? Your answer should contain variables c_i
   v. [8 pts: 4 pts per TF] What is the input response (i.e., zero initial conditions) for input $u(t) \equiv 2$? Your answer should not contain any variables

   (a) $$G(s) = \frac{4s - 8}{s^2 + 2s - 9}$$
   (b) $$G(s) = \frac{10}{s^2 + 2s + 10}$$

2. Consider the following first-order system:

   $$\dot{y}(t) + 3y(t) = 4u(t)$$

   (a) [2 pts] Is this system stable? **[Quiz]**
   (b) [2 pts] What is the time constant for this system? **[Quiz]**
   (c) [4 pts] Simulate the system's response to a step input, assuming $y(0) = 0$. Label on your plot the steady-state value and settling time.
   (d) [5 pts] Simulate the system's response to a step input, assuming $y(0) = 1$. Label on your plot the steady-state value and settling time.

3. For each of the following second-order systems
   i. [4 pts: 2 pts per system] Is the system overdamped, underdamped, or critically damped? **[Quiz]**
   ii. [4 pts: 2 pts per system] What is the settling time of the system? **[Quiz]**
   iii. [6 pts: 3 pts per system] What is the peak overshoot M of the system? **[Quiz]**
   iv. [6 pts: 3 pts per system] Starting with zero initial conditions, simulate the system's response to the following input: $u(t) = \begin{cases} 0 & t < 1 \\ 2 & t \geq 1 \end{cases}$. Label the peak value of $y(t)$. How does this compare to your answer from part iii.?

(a) $\ddot{y}(t) + 2\dot{y}(t) + 10y(t) = 12u(t)$

(b) $\ddot{y}(t) + 20\dot{y}(t) + 4y(t) = 8u(t)$

4. Consider the following system

$$G(s) = \frac{8000}{s^5 + 77s^4 + 2051s^3 + 21325s^2 + 80000s + 406250}$$

   (a) [2 pts] What are the poles of $G(s)$?

   (b) [2 pts] What is the time constant associated with each pole?

   (c) [3 pts] If you were to construct a dominant pole approximation for this system, would you use a first-order or second-order approximation? **[Quiz]**

   (d) [6 pts] Construct a dominant pole approximation for this system. Let's call this approximate system $G_a(s)$

   (e) [5 pts] Use `MATLAB` to plot the step responses of the original system $G(s)$ and your approximate system $G_a(s)$ on the same axes. Label which is which.

5. Consider the following system

$$H(s) = \frac{8000}{s^5 + 637s^4 + 7571s^3 + 44685s^2 + 194400s + 406250}$$

   (a) [2 pts] What are the poles of $H(s)$?

   (b) [2 pts] What is the time constant associated with each pole?

   (c) [3 pts] Construct a dominant pole approximation for this system. Let's call this approximate system $H_a(s)$.

6. [5 pts: 3 for quiz + 2 for justification] You have just constructed two dominant pole approximations. Which approximation is better, G_a (as an approximation of G) or H_a (as an approximation of H)? Why? **[Quiz]**

7. [7 pts] You are given a system with transfer function $J(s) = \frac{(s^2+a_1s+a_0)}{(s^2+2s+10)}$. You are not told what a_1 and a_0 are, but you are given the following plot of the step response of J:

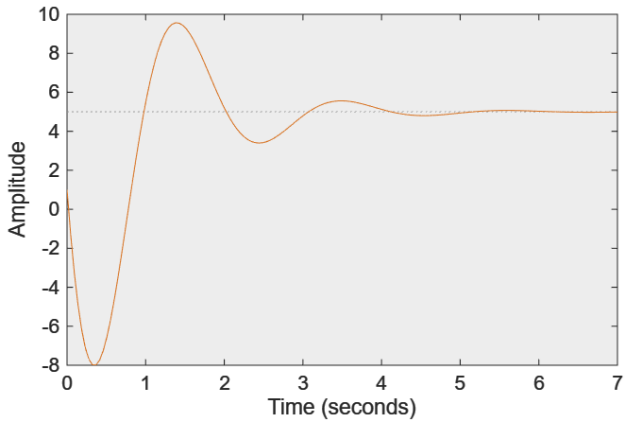

Figure 1: Step response of $J(s)$

What are the values of a_0 and a_1? **Hint:** first, think about the DC gain.