

Due: Monday, July 28 at 11:59 pm

- Homework 5 is a written assignment with 2 coding question; **Please read Nise Chp. 6-8.**
- For coding questions, attach a screenshot of the script and output (Simulink!)
- Please write neatly and legibly, because if *we can't read it, we can't evaluate it*. **Box** your final answer.
- In all of the questions, **show your work**, not just the final answer. Unless we explicitly state otherwise, you may expect full credit only if you explain your work succinctly, but clearly and convincingly.
- If you are asked to provide a “sketch,” it refers to a *hand-drawn* sketch, well-labeled to indicate all the salient features—not a plot generated by a computing device.
- If you have a confirmed disability that precludes you from complying fully with these instructions or with any other parameter associated with this problem set, please alert us immediately about reasonable accommodations afforded to you by the DSP Office on campus.
- **Start early. Some of the material is prerequisite material not covered in lecture; you are responsible for finding resources to understand it.**

Deliverables Submit a PDF of your homework to the Gradescope assignment entitled “{Your Name} HW1”. You may typeset your homework in L^AT_EX or any word-processing application (submit PDF format, not .doc/.docx format) or submit neatly handwritten and scanned solutions.

1 Honor Code

I will adhere to the Berkeley Honor Code: specifically, as a member of the UC Berkeley community, I act with honesty, integrity, and respect for others. Failure to comply with these guidelines can be considered an academic integrity violation. Please email Professor Anwar ganwar@berkeley.edu or post on Ed if you have any questions!

- **List all collaborators. If you worked alone, then you must explicitly state so.**
- **Declare and sign the following statement:**
“I certify that all solutions in this document are entirely my own and that I have not looked at anyone else’s solution. I have given credit to all external sources I consulted.”

Signature : _____ Date : _____

While discussions are encouraged, *everything* in your solution must be your (and only your) creation. Furthermore, all external material (i.e., *anything* outside lectures and assigned readings, including figures and pictures) should be cited properly. We wish to remind you that consequences of academic misconduct are *particularly severe!*

- **Violation of the Code of Conduct will result in a zero on this assignment and may also result in disciplinary action.**

2 Questions

1. For the unity feedback system shown in Figure P7.1, where

$$G(s) = \frac{450(s+8)(s+12)(s+15)}{s(s+38)(s^2+2s+28)}$$

Find the steady-state errors for the following test inputs: $25u(t)$, $37tu(t)$, $47t^2u(t)$

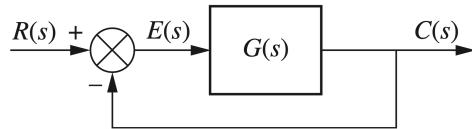


FIGURE P7.1

2. For the system shown in Figure P7.4.

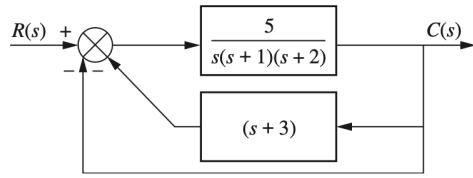


FIGURE P7.4

a. Find K_p , K_v , K_a .

b. Find the steady-state error for an input of $50u(t)$, $50tu(t)$, $50t^2u(t)$.

c. State the system type.

3. For the unity feedback system of Figure P7.1, where

$$G(s) = \frac{K(s+13)(s+19)}{s(s+6)(s+9)(s+22)}$$

Find the value of K to yield a steady-state error of 0.4 for a ramp input of $27tu(t)$.

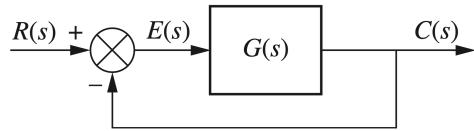


FIGURE P7.1

4. In Figure P7.16, let $G(s) = 5$ and $P(s) = \frac{7}{s+2}$.

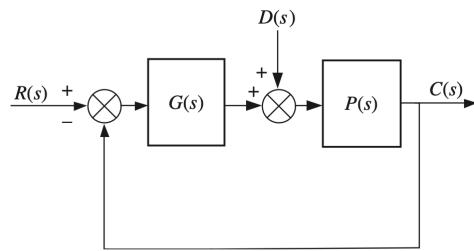


FIGURE P7.16

- a. Calculate the steady-state error due to a command input $R(s) = \frac{3}{s}$ with $D(s) = 0$.

- b. Verify the result of Part a) using Simulink.

c. Calculate the steady-state error due to a disturbance input $D(s) = -\frac{1}{s}$ with $R(s) = 0$.

d. Verify the result of Part c) using Simulink.

e. Calculate the total steady-state error due to a command input $R(s) = \frac{3}{s}$ and a disturbance $D(s) = -\frac{1}{s}$ applied simultaneously.

f. Verify the result of Part e) using Simulink.

5. Sketch the root locus BY HAND for the unity feedback system shown in Figure P8.3 for the following transfer functions:

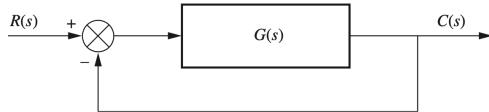


FIGURE P8.3

a. $G(s) = \frac{K(s+2)(s+6)}{s^2+8s+25}$

b. $G(s) = \frac{K(s^2+4)}{s^2+1}$

c. $G(s) = \frac{K(s^2+1)}{s^2}$

d. $G(s) = \frac{K}{(s+1)^3(s+4)}$

6. Let the system's transfer function $G(s)$ be defined as

$$G(s) = \frac{-K(s+1)^2}{s^2 + 2s + 2}$$

with $K > 0$ in Figure P8.3.

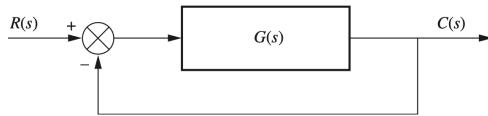


FIGURE P8.3

- Find the range of K for closed-loop stability. *Hint: you may find the Routh-Hurwitz Stability Criterion to be helpful...*
- Sketch the system's root locus.
- Find the position of the closed-loop poles when $K = 1$ and $K = 2$.

7. The characteristic polynomial of a feedback control system, which is the denominator of the closed-loop transfer function, is given by $s^3 + 2s^2 + (20K + 7)s + 100K$. Sketch the root locus for this system.

8. Plot the root locus for the unity feedback system shown in Figure P8.3, where

$$G(s) = \frac{K(s+2)(s^2 + 4)}{(s+5)(s-3)}$$

For what range of K will the poles be in the right half-plane?

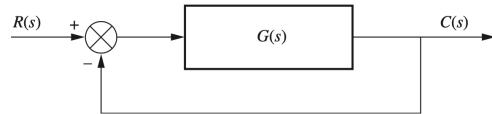
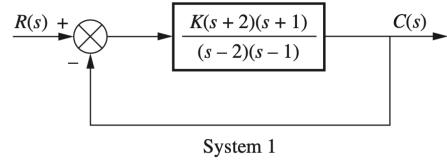


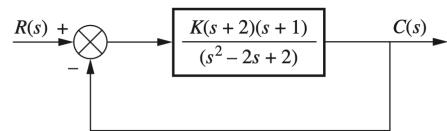
FIGURE P8.3

9. For each system shown in Figure P8.6, make an accurate plot of the root locus and find the following:
[Sec: 8.5]

- The breakaway and break-in points
- The range of K to keep the system stable
- The value of K that yields a stable system with critically damped second-order poles
- The value of K that yields a stable system with a pair of second-order poles that have a damping ratio of 0.707



System 1



System 2

FIGURE P8.6

10. Create the model and transfer function for a normal (not inverted) pendulum. Use the symbol L for the length of the pendulum, M for the mass of the pendulum and c for the rotary damping coefficient at the pivot. Assume a massless rod. Use the small angle approximation to linearize the model to arrive at the transfer function. Plot the response of the system to an unit impulse input using MATLAB, for a unit mass, unit length and unit damping coefficient. Attached are a couple of data file with the free responses of the actual pendulum in 120 Hesse. Using MATLAB, try your best to identify the parameters M , and c for the actual pendulum. The length L of the pendulum from the pivot point to the center of the mass is approximately 47 cm. Keep in mind your model assumed a massless rod. Discuss what is the consequence of that assumption on the value of the parameters derived from fitting the actual data. Include your MATLAB model in your submission.