

**Due: Monday, August 11 at 11:59 pm**

- Homework 7 is a written assignment; **Please read Nise Chp. 11 and 12** (Skip 12.4).
- 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<sup>A</sup>T<sub>E</sub>X 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](mailto: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.”*

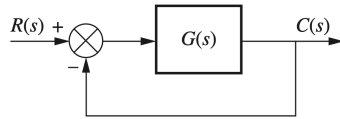
*Signature :* \_\_\_\_\_ *Date :* \_\_\_\_\_

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. Design the value of gain,  $K$ , for a gain margin of 10dB in the unity feedback system of Figure P11.1 if



**FIGURE P11.1**

a.  $G(s) = \frac{K}{(s+4)(s+10)(s+15)}$

b.  $G(s) = \frac{K}{s(s+4)(s+10)}$

c.  $G(s) = \frac{K(s+2)}{s(s+4)(s+6)(s+10)}$

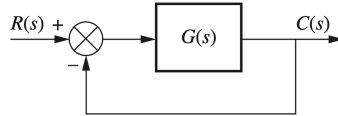
2. For each of the systems in Problem 1, design the gain,  $K$ , for a phase margin of  $40^\circ$ .

a.  $G(s) = \frac{K}{(s+4)(s+10)(s+15)}$

b.  $G(s) = \frac{K}{s(s+4)(s+10)}$

c.  $G(s) = \frac{K(s+2)}{s(s+4)(s+6)(s+10)}$

3. Given the unity feedback system of Figure P11.1, use frequency response methods to determine the value of gain,  $K$ , to yield a step response with 20% overshoot if:



**FIGURE P11.1**

a.  $G(s) = \frac{K}{s(s+8)(s+15)}$

b.  $G(s) = \frac{K(s+4)}{s(s+8)(s+10)(s+15)}$

c.  $G(s) = \frac{K(s+2)(s+7)}{s(s+6)(s+8)(s+10)(s+15)}$

4. Observability and controllability properties depend on the state-space representation chosen for a given system. In general, observability and controllability are affected when pole-zero cancellations are present in the transfer function. Consider the following two systems with representations:

$$\begin{aligned}\dot{\mathbf{x}}_i &= \mathbf{A}_i \mathbf{x}_i = \mathbf{B}_i r \\ y &= \mathbf{C}_i \mathbf{x}_i;\end{aligned}$$

$$\mathbf{A}_1 = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}; \mathbf{B}_1 = \begin{bmatrix} 0 \\ 1 \end{bmatrix}; \mathbf{C}_1 = [2 \quad 0]$$

$$\mathbf{A}_2 = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix}; \mathbf{B}_2 = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}; \mathbf{C}_2 = [6 \quad 2 \quad 0]$$

- a. Show that both systems have the same transfer function  $G_i(s) = \frac{Y(s)}{R(s)}$  after pole-zero cancellations.

- b. Evaluate the observabilities of both systems.

5. Problem 22 in Chapter 3 introduced the model for patients treated under a regimen of a single day of Glargine insulin (*Tarín, 2005*). The model to find the response for a specific patient to medication can be expressed in phase-variable form with

$$\mathbf{A} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -501.6 \times 10^{-6} & -128.8 \times 10^{-3} & -854 \times 10^{-3} \end{bmatrix}$$

$$\mathbf{B} = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}; \mathbf{C} = [0.78 \times 10^{-4} \quad 41.4 \times 10^{-4} \quad 0.01]; \mathbf{D} = 0$$

The state variables will take on a different significance in this expression, but the input and the output remain the same. Recall that  $u$  = external insulin flow, and  $y$  = plasma insulin concentration.

- a. Obtain a state-feedback gain matrix so that close-loop system will have two of its poles placed at  $-1/15$  and the third pole at  $-1/2$ .

- b. Use MATLAB to verify that poles appear at the positions specified in Part **a**.