ME 132 Dynamic Systems and Feedback
Summer 2025 George Anwar

HW3

Due: Monday, July 7 at 11:59 pm

- Homework 3 is a written assignment with 3 coding question; **Please read Nise Chp. 3 and 4**.
- For coding questions, attach a screenshot of the script and output.
- 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 LaTeX 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."

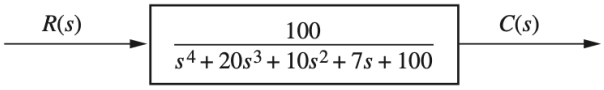
Signature : _____ *Date* : _____

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*!

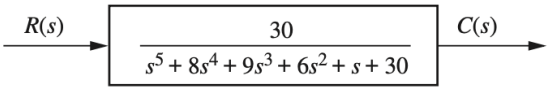
- Violation of the Code of Conduct will result in a **zero** on this assignment and may also result in disciplinary action.

2 Questions

1. Find the state-space representation in phase-variable form for each of the systems shown in Figure P3.8. [Sec: 3.5]



(*a*)



(*b*)

FIGURE P3.8

2. Repeat problem 1 using MATLAB. Please include your code and output. [Sec: 3.5]

3. For each system shown in Figure P3.9, write the state equations and the output equation for the phase-variable representation. [Sec: 3.5]

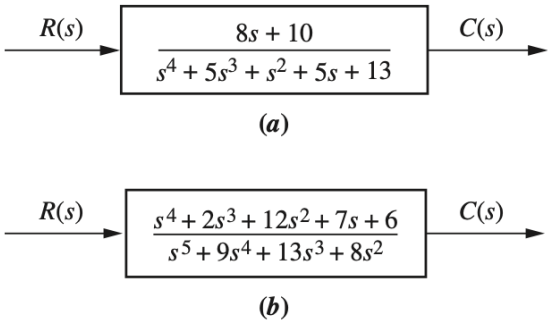


FIGURE P3.9

4. Find the transfer function $G(s) = Y(s)/R(s)$, **by hand**, for each of the following systems represented in state space: [Section: 3.6]

   a. $\dot{\mathbf{x}} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -3 & -2 & -5 \end{bmatrix} \mathbf{x} + \begin{bmatrix} 0 \\ 0 \\ 10 \end{bmatrix} r$

   $y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \mathbf{x}$

b. $\dot{\mathbf{x}} = \begin{bmatrix} 2 & -3 & -8 \\ 0 & 5 & 3 \\ -3 & -5 & -4 \end{bmatrix} \mathbf{x} + \begin{bmatrix} 1 \\ 4 \\ 6 \end{bmatrix} r$

$y = \begin{bmatrix} 1 & 3 & 6 \end{bmatrix} \mathbf{x}$

c. $\dot{\mathbf{x}} = \begin{bmatrix} 3 & -5 & 2 \\ 1 & -8 & 7 \\ -3 & -6 & 2 \end{bmatrix} \mathbf{x} + \begin{bmatrix} 5 \\ -3 \\ 2 \end{bmatrix} r$

$y = \begin{bmatrix} 1 & -4 & 3 \end{bmatrix} \mathbf{x}$

5. Modern robotic manipulators that act directly upon their target environments must be controlled so that impact forces as well as steady-state forces do not damage the targets. At the same time, the manipulator must provide sufficient force to perform the task. In order to develop a control system to regulate these forces, the robotic manipulator and target environment must be modeled. Assuming the model shown in Figure P3.14, represent in state space the manipulator and its environment under the following conditions (*Chiu, 1997*). [Sec: 3.5]

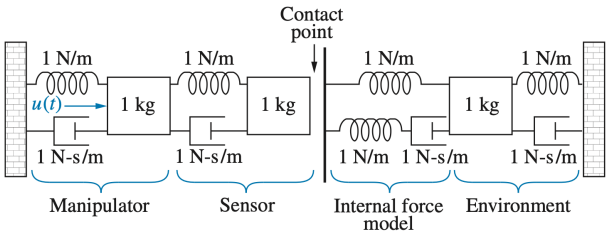


FIGURE P3.14 Robotic manipulator and target environment[11]

a. The manipulator is not in contact with its target environment.

b. The manipulator is in constant contact with its target environment.

6. Find the output response, $c(t)$, for each of the systems shown in Figure P4.1. Also find the time constant, rise time, and settling time for each case. [Sec: 4.2, 4.3]

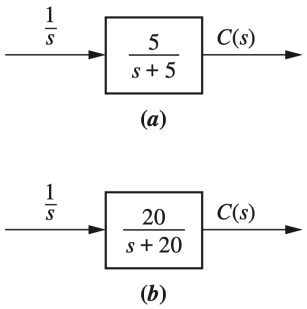


FIGURE P4.1

7. Plot the step responses for the previous problem using MATLAB.

8. For the system shown in Figure P4.3, (a) find an equation that relates settling time of the velocity of the mass to M; (b) find an equation that relates rise time of the velocity of the mass to M. [Sec: 4.2, 4.3]

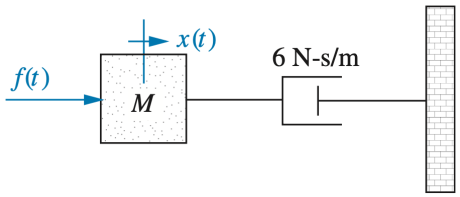


FIGURE P4.3

9. Plot the step response for the previous problem using MATLAB. From your plots, find the time constant, rise time, and settling time. Use $M = 1$ and $M = 2$.

10. For each of the transfer functions shown below, find the locations of the poles and zeros, plot them on the s-plane, and then write an expression for the general form of the step response without solving for the inverse Laplace transform. State the nature of each response (overdamped, underdamped, and so on). **This must be done by hand.** [Sec: 4.3, 4.4]

    a. $T(s) = \frac{2}{s+2}$

    b. $T(s) = \frac{5}{(s+3)(s+6)}$

    c. $T(s) = \frac{10(s+7)}{(s+10)(s+20)}$

d. $T(s) = \frac{20}{s^2+6s+144}$

e. $T(s) = \frac{s+2}{s^2+9}$

f. $T(s) = \frac{(s+5)}{(s+10)^2}$