ME 132 Dynamic Systems and Feedback
Summer 2025 George Anwar

HW1

Due: Monday, June 23 at 11:59 pm

- Homework 1 is an entirely written assignment; **Please read Nise Chp. 1 and 2.1-2.5**.
- 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. A temperature control system operates by sensing the difference between the thermostat setting and the actual temperature and then opening a fuel valve an amount proportional to this difference. Draw a functional closed-loop block diagram similar to figure 1.8(d) identifying the input and output transducers, the controller, and the plant. Further, identify the input and output signals of all subsystems previously described. [Sec 1.4: Introduction to a Case Study]

2. A Segway® Personal Transporter (PT) (Figure P1.3) is a two-wheeled vehicle in which the human operator stands vertically on a platform. As the driver leans left, right, forward, or backward, a set of sensitive gyroscopic sensors sense the desired input. These signals are fed to a computer that amplifies them and commands motors to propel the vehicle in the desired direction. One very important feature of the PT is its safety: The system will maintain its vertical position within a specified angle despite road disturbances, such as uphills and downhills or even if the operator over-leans in any direction. Draw a functional block diagram of the PT system that keeps the system in a vertical position. Indicate the input and output signals, intermediate signals, and main subsystems. (https://segway.com)

3. Solve the following differential equations using classical methods. Assume zero initial conditions. [Review]

   a. $\frac{dx}{dt} + 7x = 5\cos 2t$

   b. $\frac{d^2x}{dt^2} + 6\frac{dx}{dt} + 8x = 5\sin(3t)$

   c. $\frac{d^2x}{dt^2} + 8\frac{dx}{dt} + 25x = 10u(t)$

4. Derive the Laplace transform for the following time functions:[Sec: 2.2]

   a. $u(t)$
   b. $tu(t)$
   c. $\sin(\omega t)u(t)$
   d. $\cos(\omega t)u(t)$

5. Using the Laplace transform pairs of Table 2.1 and the Laplace Transform theorems of Table 2.2, derive the Laplace transforms for the following time functions: [Sec: 2.2]

   a. $e^{-at}\sin(\omega t)u(t)$

   b. $e^{-at}\cos(\omega t)u(t)$

   c. $t^3u(t)$

6. A system is described by the following differential equation:

$$\frac{d^3y}{dt^3} + 3\frac{d^2y}{dt^2} + 5\frac{dy}{dt} + y = \frac{d^3x}{dt^3} + 4\frac{d^2x}{dt^2} + 6\frac{dx}{dt} + 8x$$

Find the expression for the transfer function of the system, $Y(s)/X(s)$. [Sec: 2.3]

7. Write the differential equation for the system shown in Figure P2.1. [Sec: 2.3]

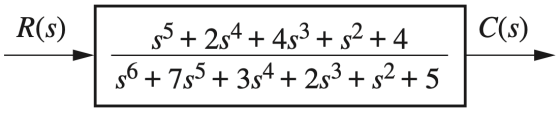

FIGURE P2.1

8. A system is described by the following differential equation: [Sec 2.3]

$$\frac{d^2x}{dt^2} + 4\frac{dx}{dt} + 5x = 1$$

with initial conditions $x(0) = 1$, $\dot{x}(0) = -1$. Show a block diagram of the system, giving its transfer function and all pertinent inputs and outputs. (Hint: the initial conditions will show up as added inputs to an effective system with zero initial conditions.

9. Find the transfer function, $G(s) = X_1(s)/F(s)$, for the translational mechanical system shown in Figure P2.9. [Sec: 2.5]

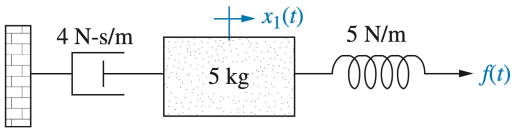

FIGURE P2.9

10. Find the transfer function, $X_3(s)/F(s)$, for each system shown in Figure P2.14. [Sec: 2.5]

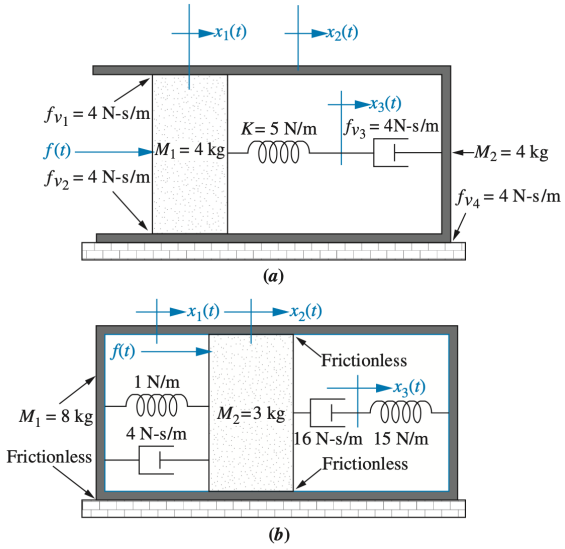

FIGURE P2.14