In the name of God

Department of Aerospace Engineering

Automatic Control
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Spring 2024
Homework 1
Due: Feb 29, 2024

Please notice the following:

- Write the answers to the exercises in a neat and readable manner and create a PDF file for it using the CamScanner.
- You may use MATLAB and Simulink only to solve exercises that are marked with the [**M**] symbol and the rest of the exercises must be solved through manual steps. It should be noted that there is no problem with using MATLAB to verify your answers for other exercises, but *do not use MATLAB first*. You will not gain any intuition by looking at results — you need to learn to solve the problems by hand to understand how the method works and improve your problem-solving acumen.
- For exercises that require the use of MATLAB and Simulink, prepare a *maximum of a 3-minute* recorded video to answer each question and reduce the size of the file as much as possible. In the recorded video, describe the activities performed to obtain the solution and deliver your analysis of the results. To solve each question, it is *mandatory* to submit the written code along with the recorded video. Note that answers without a video or code will not be graded.
- Submit a compressed file with the naming format AC_HW1_StudentNumber on the Sharif Courseware (CW). The file should include the answers PDF file along with any MATLAB files and videos (if applicable). Please ensure that the files are organized in their corresponding folders for each question.
- Students are expected to submit homework by 11:59 pm on the due date. However, If you are unable to submit the homework by the deadline due to any circumstances, you may still submit it up to one week late with a 20% penalty deducted from the earned grade. Submissions after one week past the due date will not be accepted. Please plan your time carefully to avoid needing this extension.
- The homework assignments are meant to be completed *individually*. While getting guidance from friends is acceptable, it is expected that you have sufficiently thought about the problem beforehand. However, any form of collaboration beyond seeking advice, such as exchanging solutions or copying code is strictly prohibited, and submitting similar answers will result in a grade of zero.
- The use of AI tools such as ChatGPT to write code is not allowed, and even if you modify the code generated by the AI, it is still detectable and will not be given any grades.
- If you have any questions regarding the exercises, please ask your questions through the Telegram group, as your question is likely a question that other friends may have as well.

Questions

1. What is the difference between active control systems and passive control systems? find an example of using passive control systems in aerospace engineering. (Hint: you may study about satellite stabilization methods)

2. Discuss whether the following systems are open-loop or closed-loop systems.Then, specify each system component (if applicable), including input, output, controller, actuator, and sensor. Finally, sketch the corresponding block diagram of the control system.

   (a) Air-conditioner

   (b) Washing machine

   (c) A wheeled mobile robot following an object using image processing

   (d) An autonomous UAV that is tasked for crop monitoring using aerial photography. The UAV must photograph and transmit the entire land area by flying a pre-specified trajectory as accurately as possible.

3. Find the Laplace transform of the following time functions

   (a) $f_1(t) = 3(t-1) + e^{-(t+1)}$

   (b) $f_2(t) = \cos(5t - \frac{\pi}{4}) + 3te^{-t}$

   (c) $f_3(t) = \sin(t)\cos(3t) + t\sin^2(t)$

4. Find the inverse Laplace transform (corresponding time function) of the following transforms:

   (a) $F_1(s) = \dfrac{6s^2 - 2s - 2}{s(s^2-1)}$

   (b) $F_2(s) = \dfrac{1}{s^2(s^2+6s+10)}$

   (c) $F_3(s) = \dfrac{s^2 + 2s + 3 + e^{-s}}{s^2 + 2s + 1}$

   (d) $F_4(s) = \dfrac{2(s+2)e^{-2s}}{s(s+1)(s^2+4)^2}$ [**M**]

5. Consider the following ordinary differential equation:

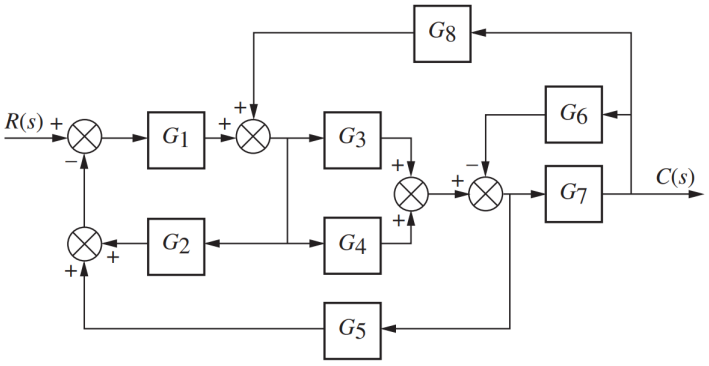
$$\dddot{y} + 6\ddot{y} + 11\dot{y} + 6y = \dot{u} + 5u; \;\; y(0) = 2, \; \dot{y}(0) = 1, \; \ddot{y}(0) = 0, \; u(0) = 0$$

   (a) Find the corresponding transfer function of the system ($\dfrac{Y(s)}{U(s)}$).

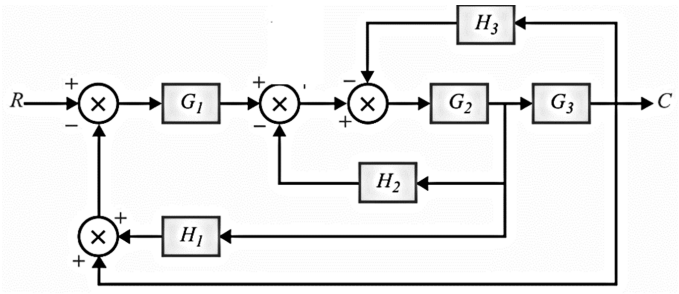
   (b) Find the unit-step response and initial condition response of the system by solving the governing differential equation of the system using the Laplace transform method.

   (c) Use the Final Value Theorem to compute the steady-state value of the output. Then compare the result with the final value obtained from the response in part (b).

6. Simplify the following block diagrams using block diagram reduction rules. Then obtain the closed-loop transfer function $\dfrac{C(s)}{R(s)}$.

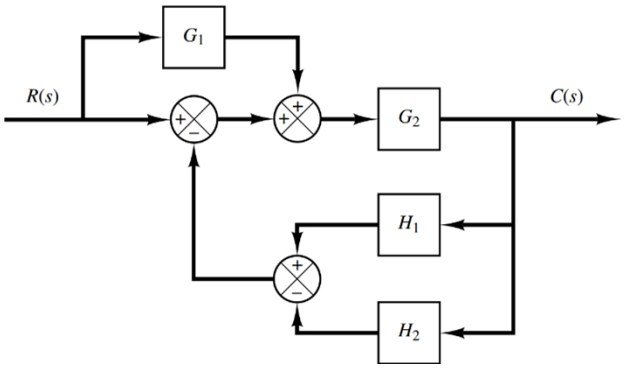


(a) Block diagram 1



(b) Block diagram 2

7. Consider the following block diagram:



$$G_1(s) = \frac{1}{s+2},\ G_2(s) = \frac{1}{s^2+5s+6},\ H_1(s) = \frac{1}{s+1},\ H_2(s) = \frac{1}{s}$$

(a) Utilize *series*, *parallel* and *feedback* MATLAB commands to obtain the closed-loop transfer function $\frac{C(s)}{R(s)}$ of the system. [**M**]

(b) (Bonus) Utilize *connect* (Block diagram interconnections of dynamic systems) and *sumblk* (Summing junction for name-based interconnections) MATLAB commands to obtain the closed-loop transfer function $\frac{C(s)}{R(s)}$ of the system. [**M**]

Good Luck
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