ME 5200/6200 and ECE 5615/6615 Classical Controls **Fall 2024**

Homework 04 **Due Thursday, Sept. 19 by the end of class**

Do the following problems and show all your work for full credit. Note: not all problems will be graded, but you must complete all problems to get full credit.

Problem 1

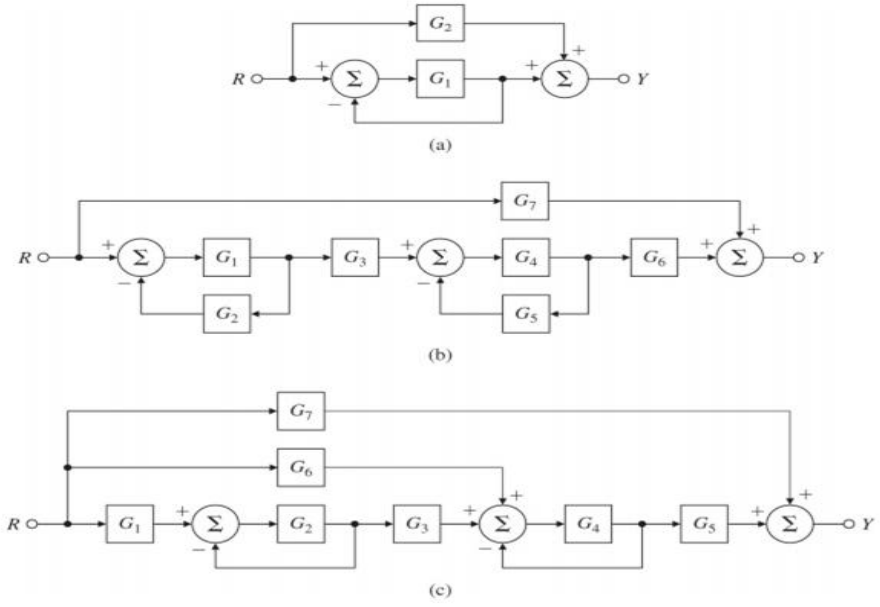
Consider the two systems shown below, where each system has a zero.

(a) Use Matlab to plot the step responses for both systems. Label all axes and provide a hardcopy of your Matlab code that you used to generate the step response.
(b) Compare and contrast the step responses. Note that both systems have the same poles, but the zeros are different. How does this affect the response? (Hint – You may want to use partial fraction expansion to explain the output response when the input is a step. One of the systems is nonminimum phase – briefly describe what this behavior is. Refer to your text for additional details as well as the description in the notes).

$$G_1(s) = \frac{s+2}{s^2+3s+2};\ G_2(s) = \frac{-s+2}{s^2+3s+2}$$

Problem 2

Find the transfer function from R to Y for each block diagram using the block diagram algebra reduction method. Your results for each should include detailed steps on how you manipulated the blocks.

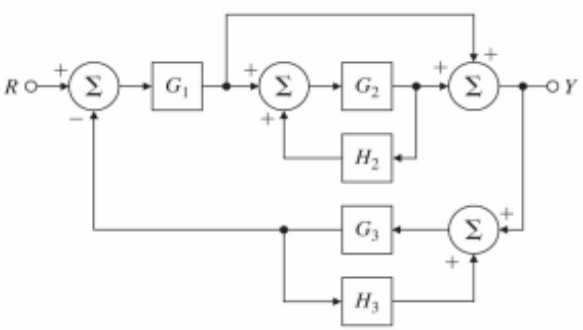


Problem 3

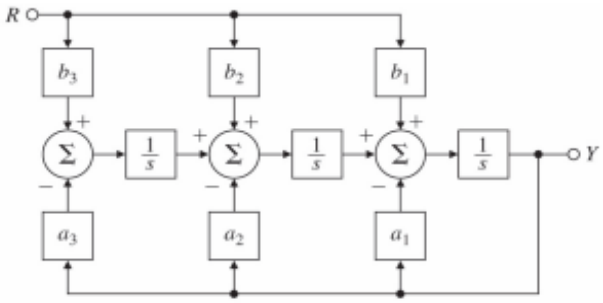
Find the transfer function from R to Y for Problem 2 above using Mason's rule. You need to show clearly the signal flow graph, labelling all nodes, branches, and listing all of the paths and loops. Your answers should match Problem 2.

Problem 4

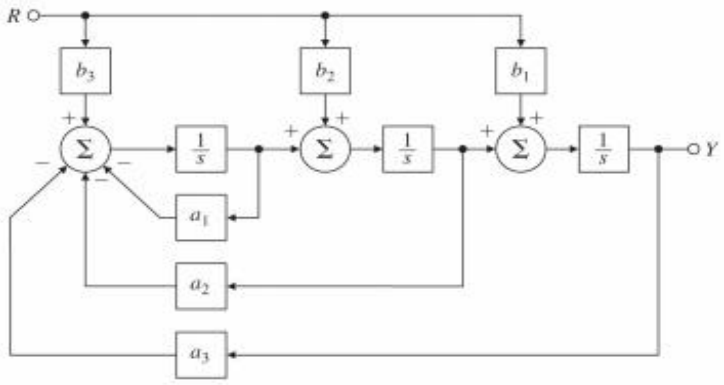
- Find the transfer function from R to Y for (a) using both block diagram algebra and Mason's rule. Show all your steps for full credit.
- Find the transfer function from R to Y using Mason's rule for (b)-(d). Show all your steps for full credit.



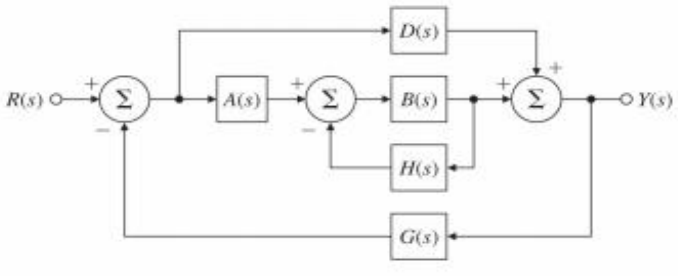
(a)



(b)



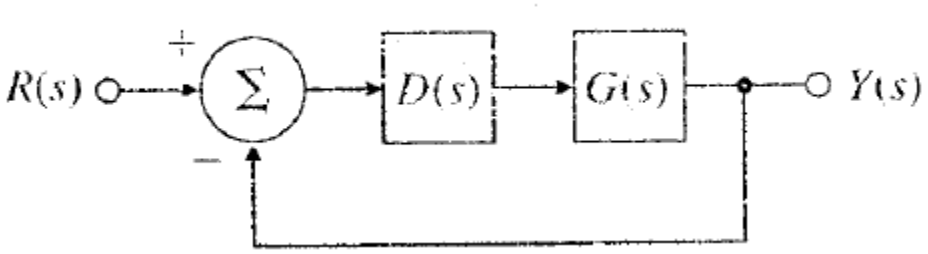
(c)



(d)

Problem 5

Suppose you have the following closed-loop system:



where

$$G(s)=\frac{1}{s(s+3)} \quad \text{and} \quad D(s)=\frac{K(s+z)}{s+p}.$$

Answer these questions (show all your work):

a) What is the order of the open-loop system?
b) What is the order of the controller?
c) What is the order of the closed-loop system?
d) Now suppose the controller is just a basic proportional controller with gain K (no zero or pole). Design a proportional controller (i.e., find the value of K) so that the step response of the closed-loop system is as **fast as possible without oscillation**. What value is K? Show all your work.
e) Prove that your design works by showing a step response of the closed-loop system using Matlab. Include of plot of output vs. time, and also your Matlab code (PDF of the m-file and/or Simulink model).