THE UNIVERSITY OF TEXAS AT SAN ANTONIO
EE 3413
ANALYSIS AND DESIGN OF CONTROL SYSTEMS

HOMEWORK # 4 SOLUTION

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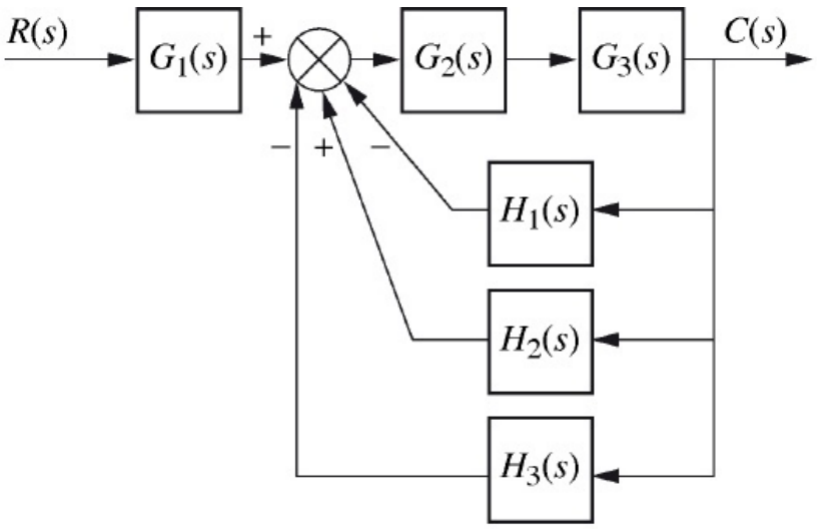
February 22, 2020

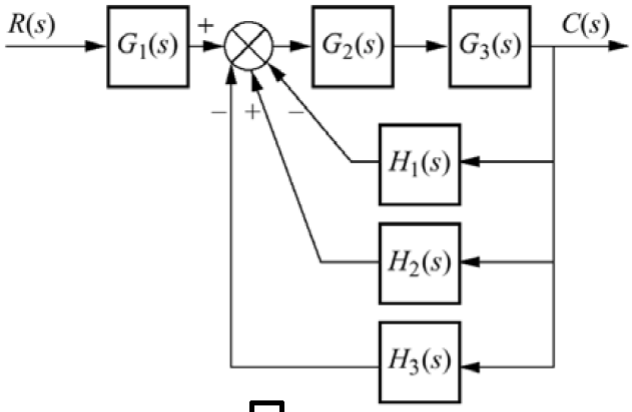
The objective of this homework is to test your understanding of the content of Module 4. Due date of the homework is: **Friday, February 12th, 2016.**

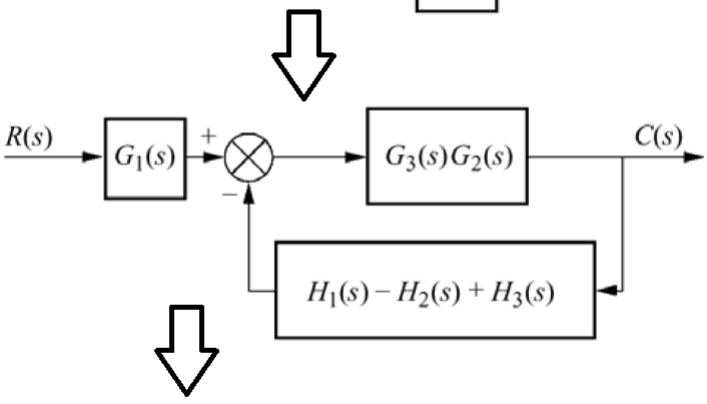
You have to upload a scanned version of your solutions on Blackboard. If you don't have a scanner around you, you can use Cam Scanner—a mobile app that scans images in a neat way, as if they're scanned through a copier. Here's the link for Cam Scanner: https://www.camscanner.com/user/download.

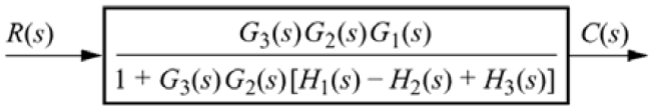
Find the transfer functions for the following block diagrams:

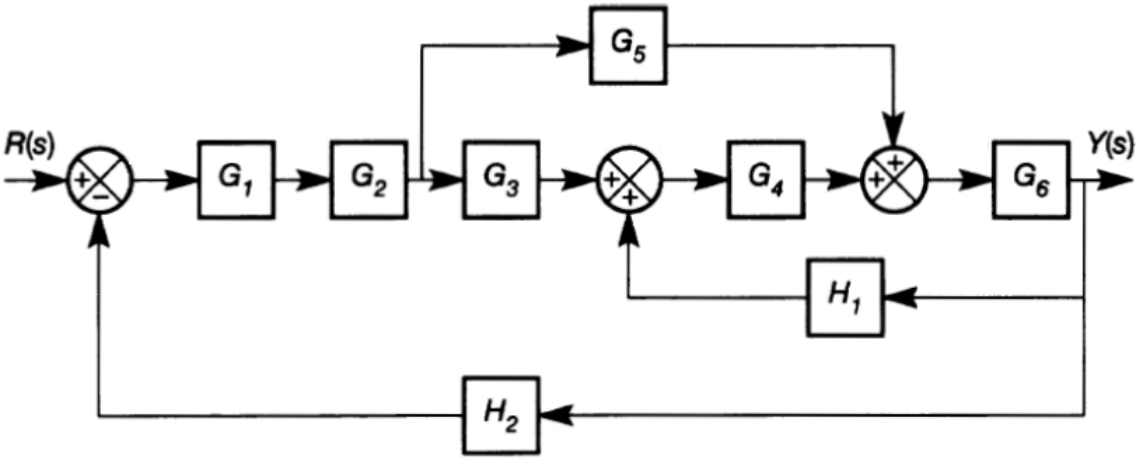


Solution:

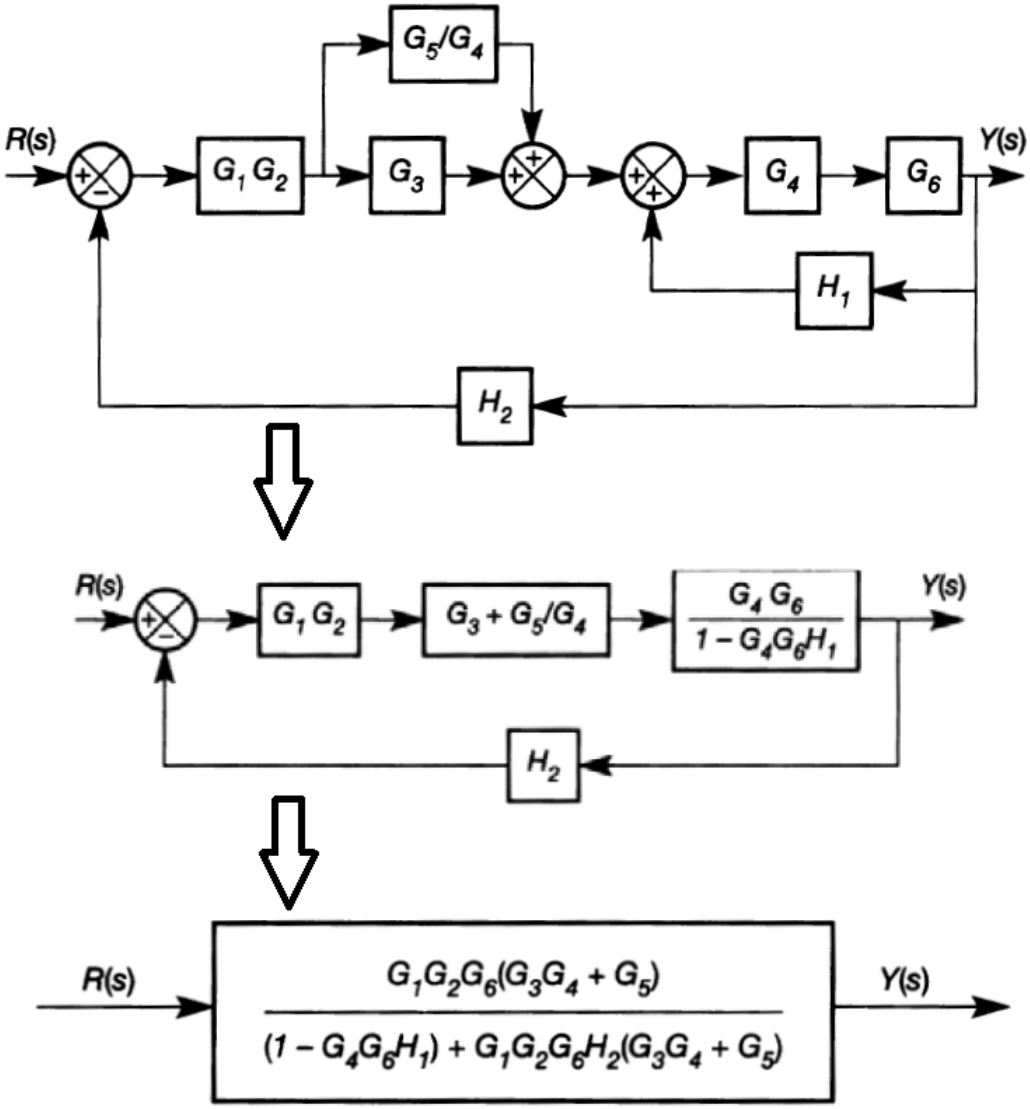

R(s)
G1(s)
+
G2(s)
G3(s)
C(s)
−
+
−
H1(s)
H2(s)
H3(s)

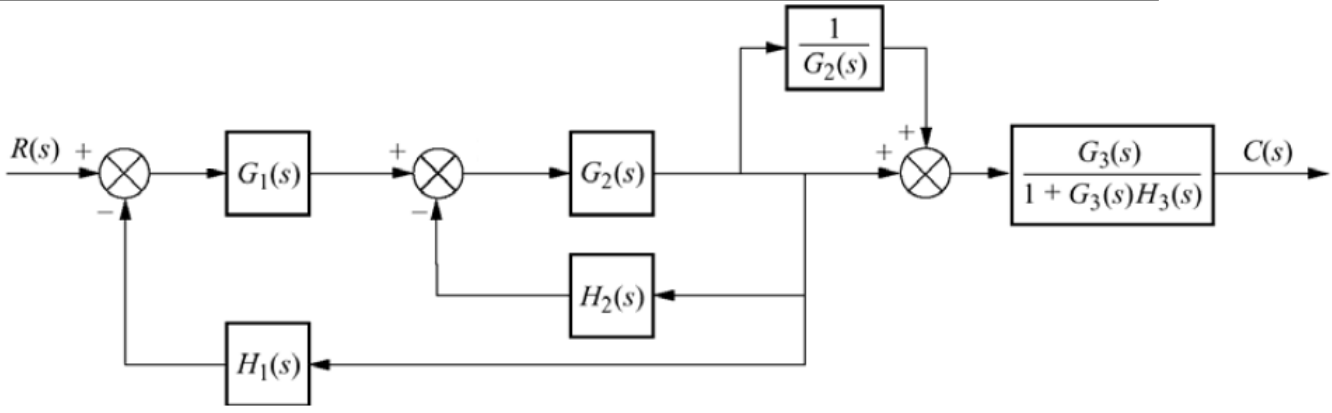

R(s)
G1(s)
+
−
G3(s)G2(s)
C(s)
H1(s) − H2(s) + H3(s)


R(s)
G3(s)G2(s)G1(s)
1 + G3(s)G2(s)[H1(s) − H2(s) + H3(s)]
C(s)

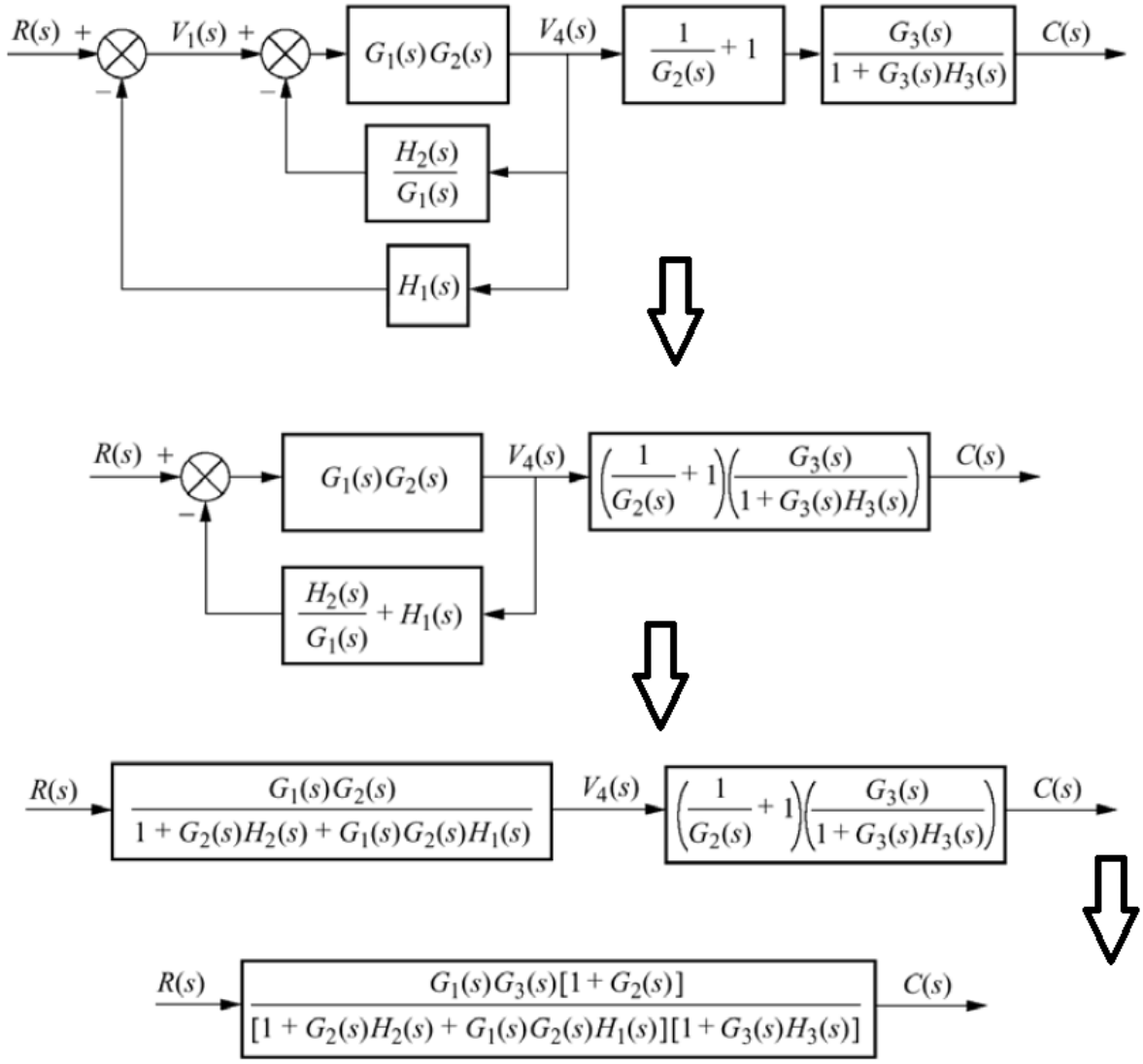

G5
R(s)
G1
G2
G3
G4
G6
Y(s)
H1
H2

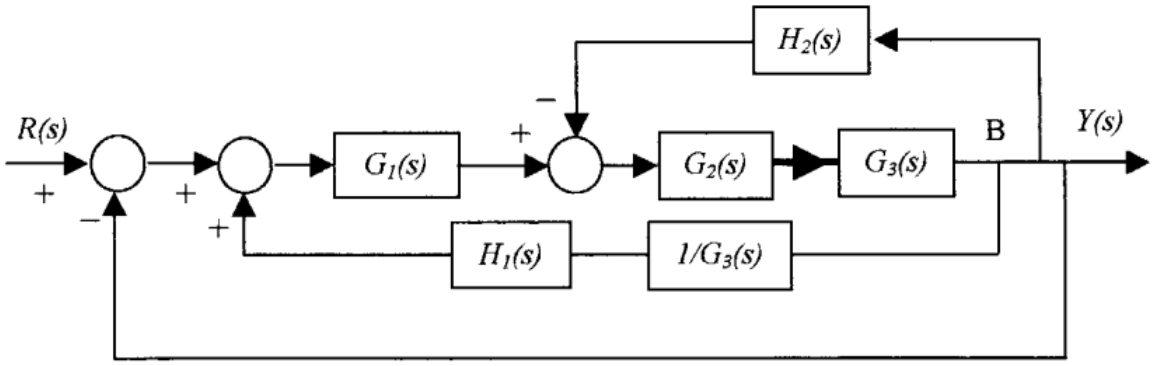
Solution:


R(s)
G1 G2
G3
G5/G4
G4
G6
Y(s)
H1
H2
R(s)
G1 G2
G3 + G5/G4
G4 G6 / 1 − G4G6H1
Y(s)
H2
R(s)
G1G2G6(G3G4 + G5) / (1 − G4G6H1) + G1G2G6H2(G3G4 + G5)
Y(s)

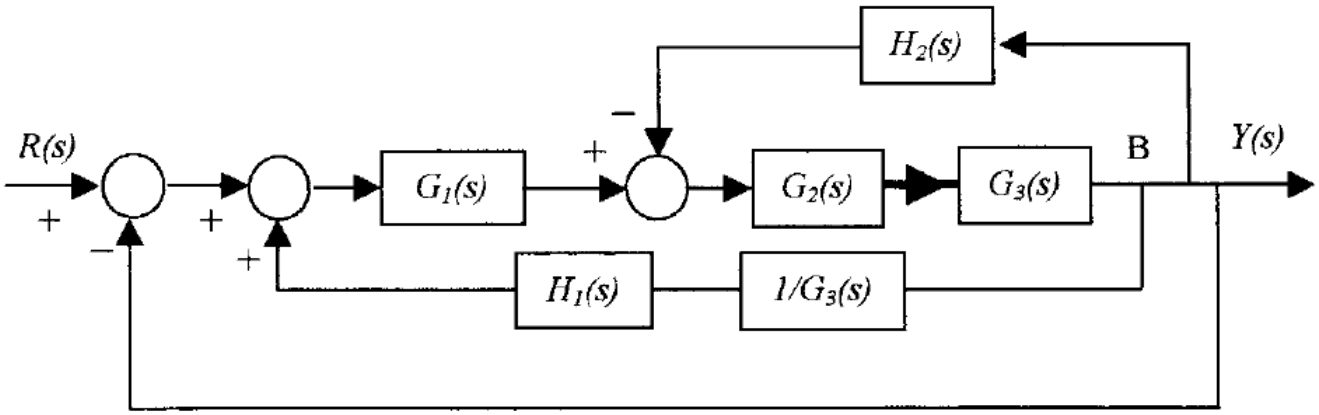

R(s)
G1(s)
G2(s)
1 / G2(s)
G3(s) / 1 + G3(s)H3(s)
C(s)
H2(s)
H1(s)

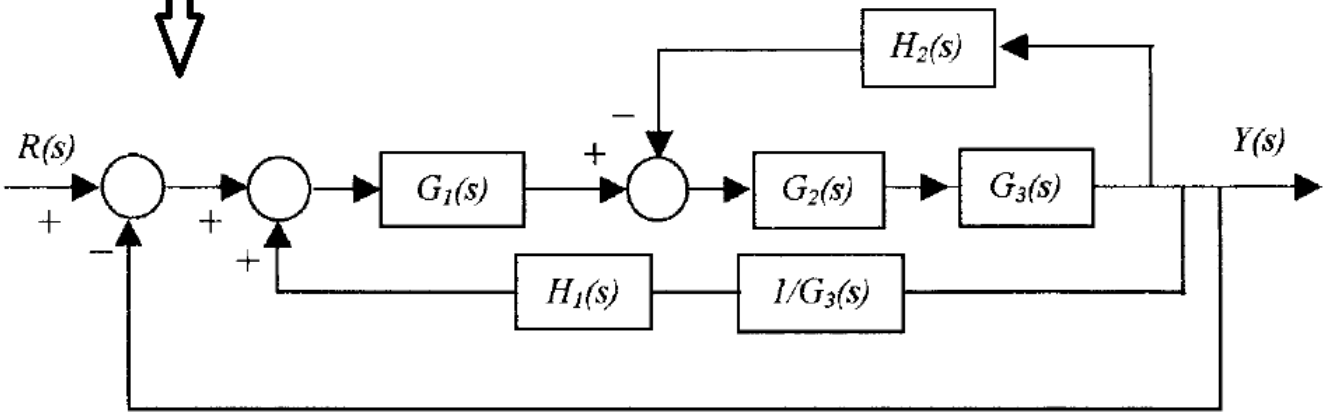
Solution:

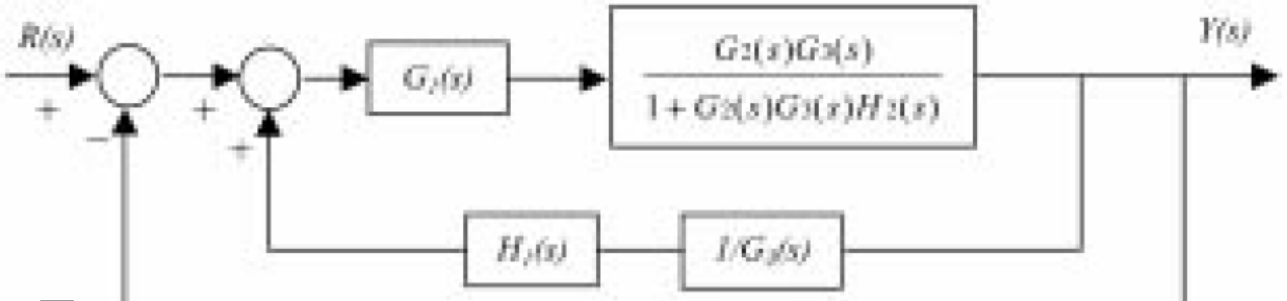

R(s)
V1(s)
G1(s)G2(s)
V4(s)
1/G2(s) + 1
G3(s)/(1 + G3(s)H3(s))
C(s)
H2(s)/G1(s)
H1(s)
R(s)
G1(s)G2(s)
V4(s)
(1/G2(s) + 1)(G3(s)/(1 + G3(s)H3(s)))
C(s)
H2(s)/G1(s) + H1(s)
R(s)
G1(s)G2(s)/(1 + G2(s)H2(s) + G1(s)G2(s)H1(s))
V4(s)
(1/G2(s) + 1)(G3(s)/(1 + G3(s)H3(s)))
C(s)
R(s)
G1(s)G3(s)[1 + G2(s)]/[1 + G2(s)H2(s) + G1(s)G2(s)H1(s)][1 + G3(s)H3(s)]
C(s)

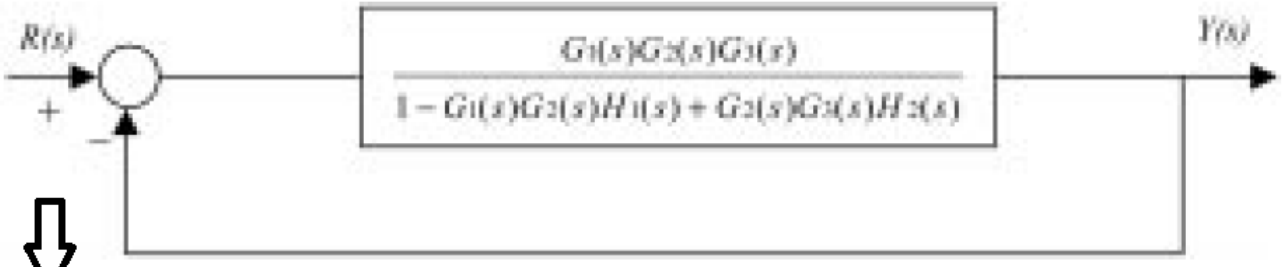

H2(s)
R(s)
G1(s)
G2(s)
G3(s)
B
Y(s)
H1(s)
1/G3(s)

Solution:

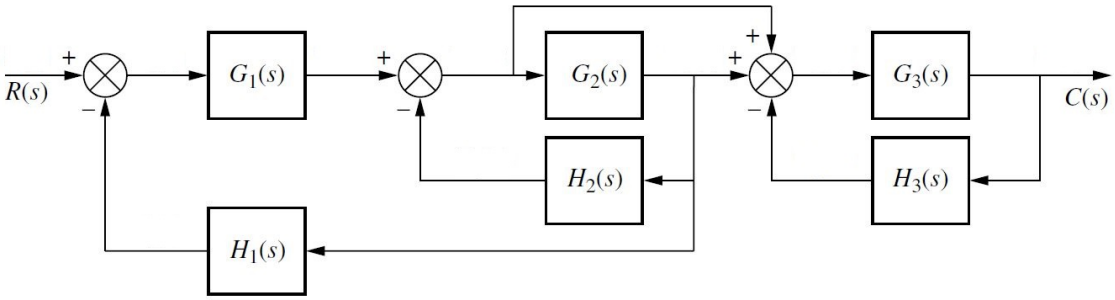

R(s)
Y(s)
B
G1(s)
G2(s)
G3(s)
H2(s)
H1(s)
1/G3(s)


R(s)
Y(s)
G1(s)
G2(s)
G3(s)
H2(s)
H1(s)
1/G3(s)

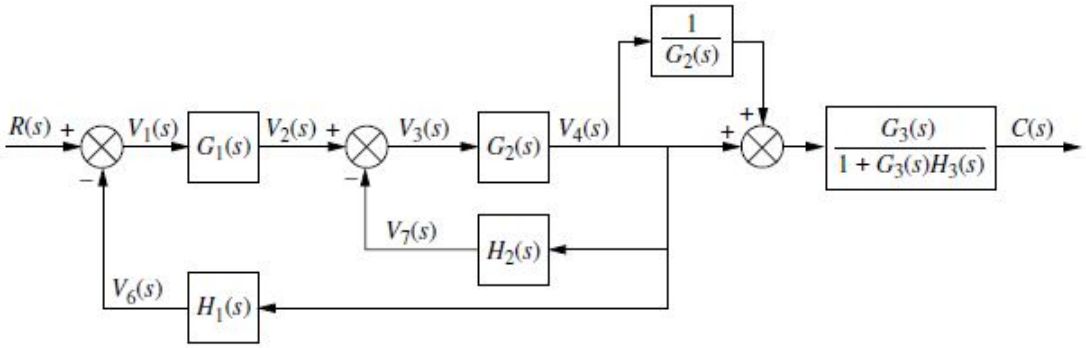

R(s)
Y(s)
G1(s)
$\frac{G_2(s)G_3(s)}{1+G_2(s)G_3(s)H_2(s)}$
H1(s)
1/G1(s)


R(s)
Y(s)
$\frac{G_1(s)G_2(s)G_3(s)}{1-G_1(s)G_2(s)H_1(s)+G_2(s)G_3(s)H_2(s)}$

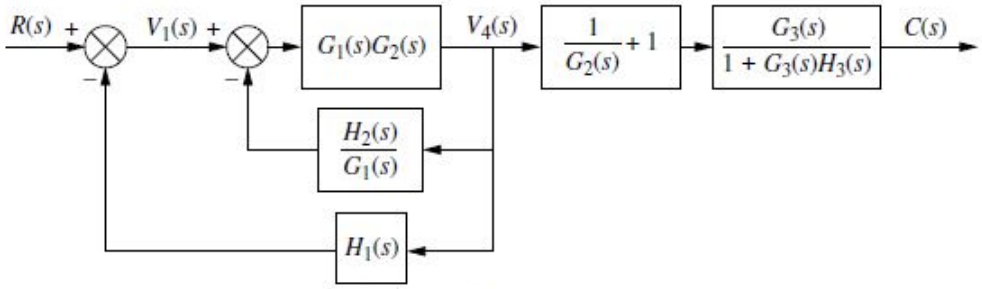

R(s)
Y(s)
$\frac{G_1(s)G_2(s)G_3(s)}{1-G_1(s)G_2(s)H_1(s)+G_2(s)G_3(s)H_2(s)+G_1(s)G_2(s)G_3(s)}$



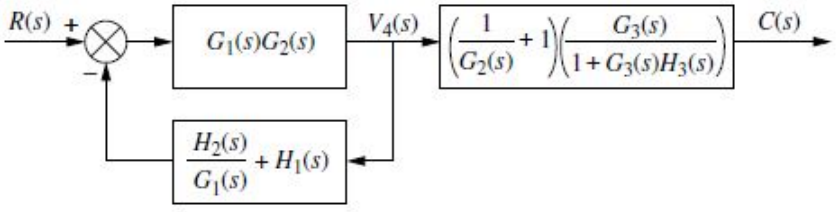
Solution:



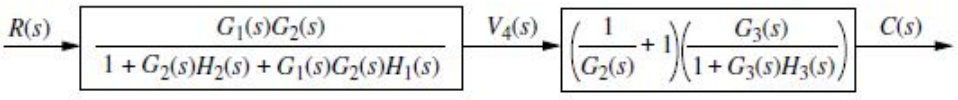
(*a*)



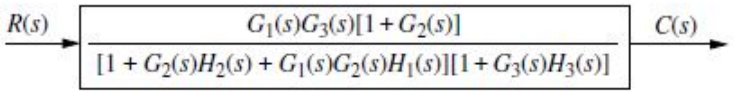
(*b*)



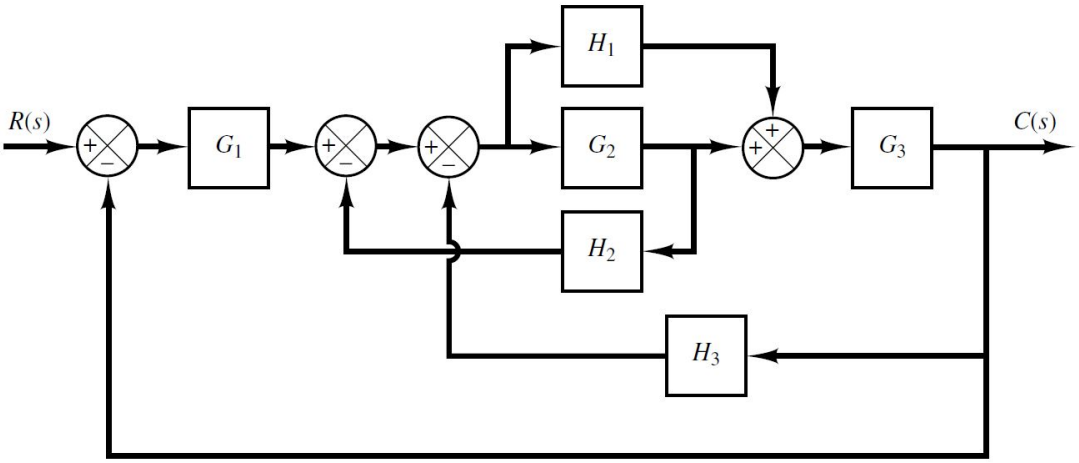
(*c*)



(*d*)

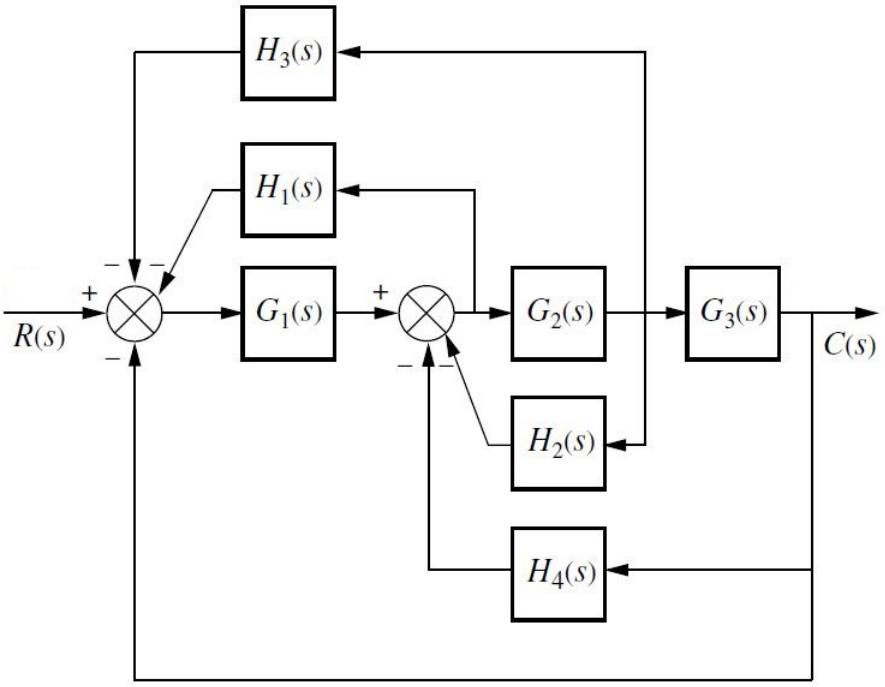


(*e*)



Solution:

$$\frac{C(s)}{R(s)} = \frac{G_1 G_2 G_3 + G_1 G_3 H_1}{1 + G_2 H_2 + G_2 G_3 H_3 + G_3 H_1 H_3 + G_1 G_2 G_3 + G_1 G_3 H_1}$$

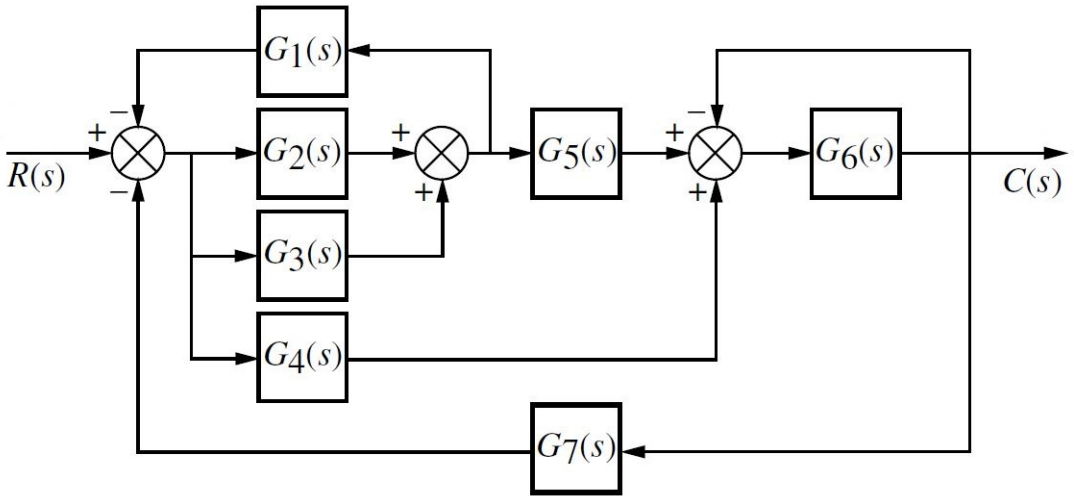


Solution:

$$T(s) = \frac{G_1(s)G_2(s)G_3(s)}{1 + G_1(s)G_2(s)G_3(s)H_{eq}(s)}$$

where

$$H_{eq}(s) = \frac{H_3(s)}{G_3(s)} + \frac{H_1(s)}{G_2(s)G_3(s)} + \frac{H_2(s)}{G_1(s)G_3(s)} + \frac{H_4(s)}{G_1(s)} + 1$$



Solution:

$$T(s) = \frac{G_6\,(G_4 + G_5 G_3 + G_5 G_2)}{G_6\,(G_7 G_4 + G_7 G_5 G_3 + G_7 G_5 G_2 + G_3 G_1 + G_2 G_1 + 1) + G_1\,(G_3 + G_2) + 1}$$