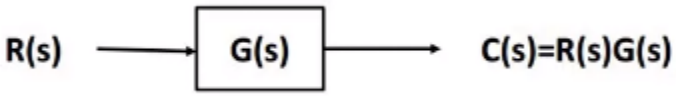
Email: abbas.jawad@uomus.edu.iq

Block Diagram Reduction of a Control System

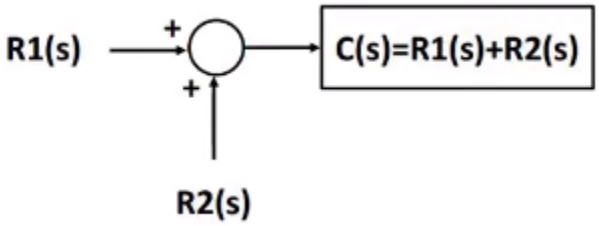
Rules of Block Diagram

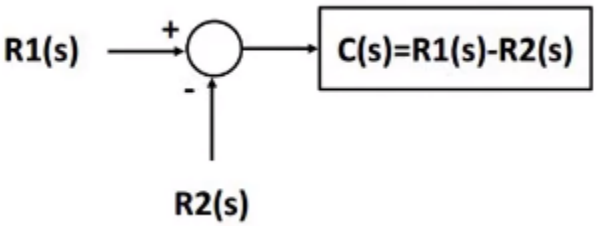
Rule #1:

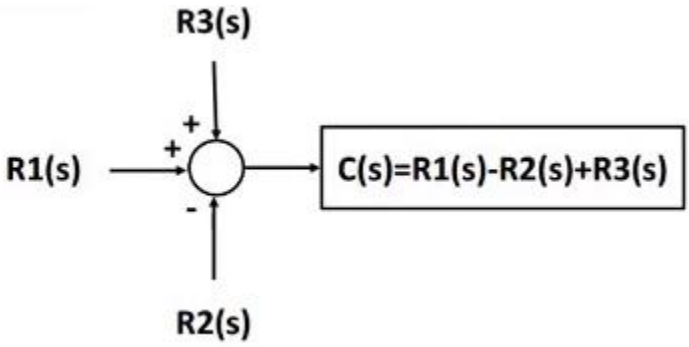


Rule #2:

Summing Junction

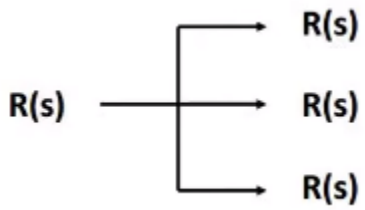






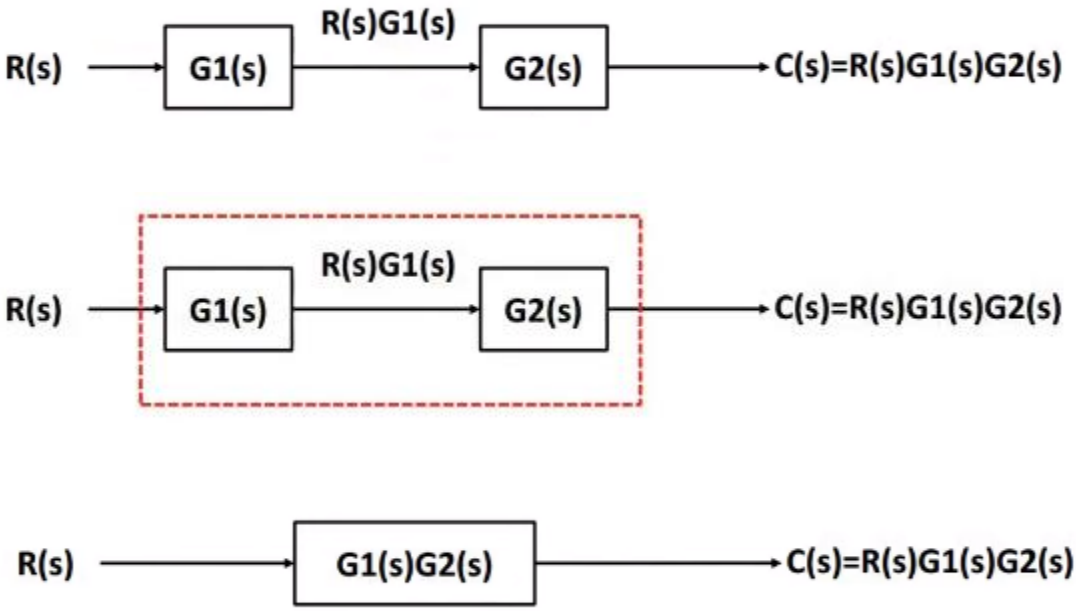
Rule #3:

Pick off point



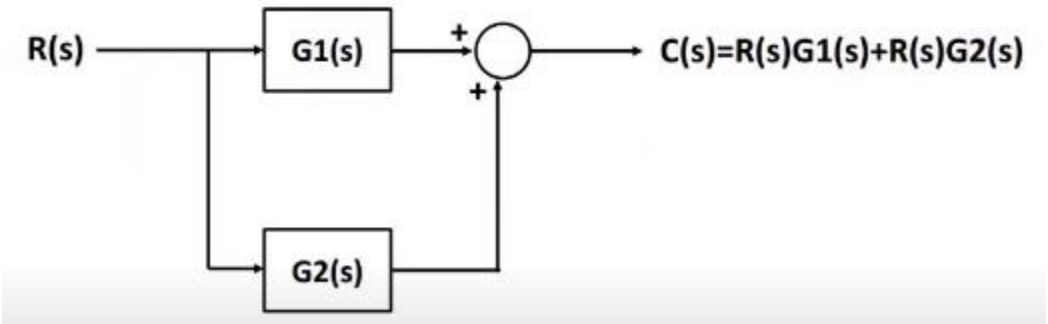
Rule #4:

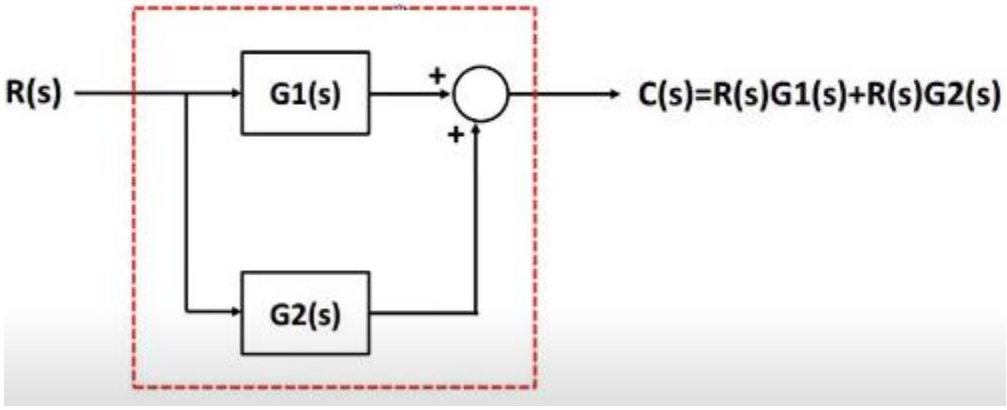
Cascade form (combining blocks in series)

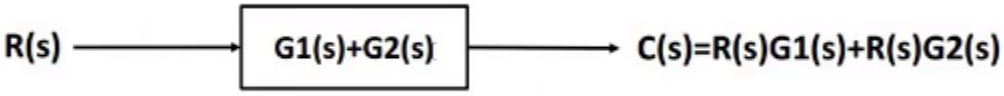


Rule #4:

Combining blocks in parallel



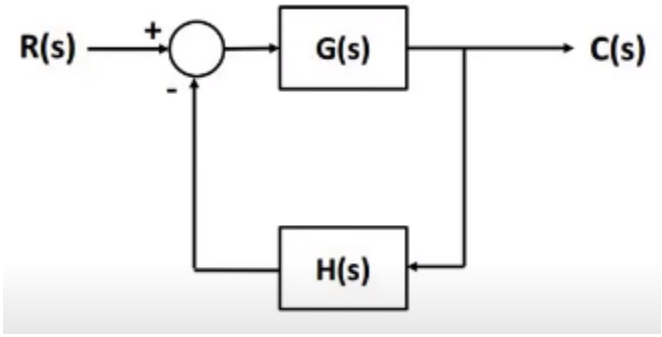


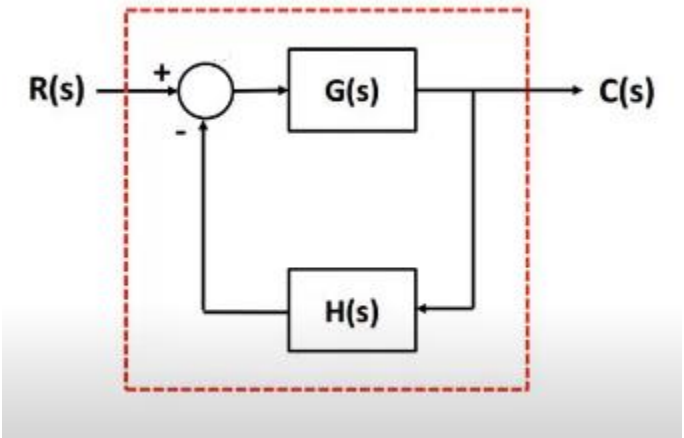


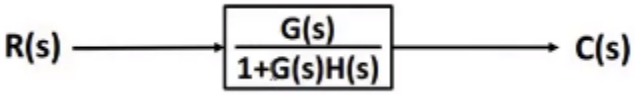
Rule #5:

Feedback form

Case #1



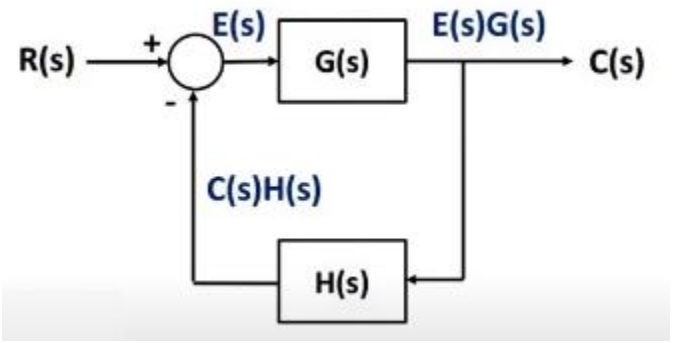




E(s)=R(s)-C(s)H(s)
And
C(s)=E(s)G(s)

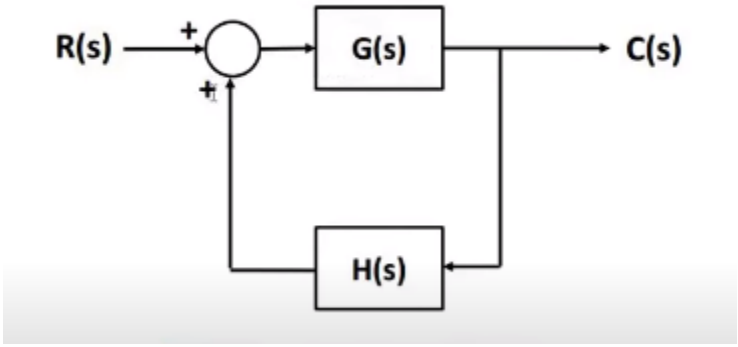
C(s)=R(s)G(s)-C(s)H(s)G(s)
C(s)+C(s)H(s)G(s)=R(s)G(s)
C(s)(1+H(s)G(s))=R(s)G(s)

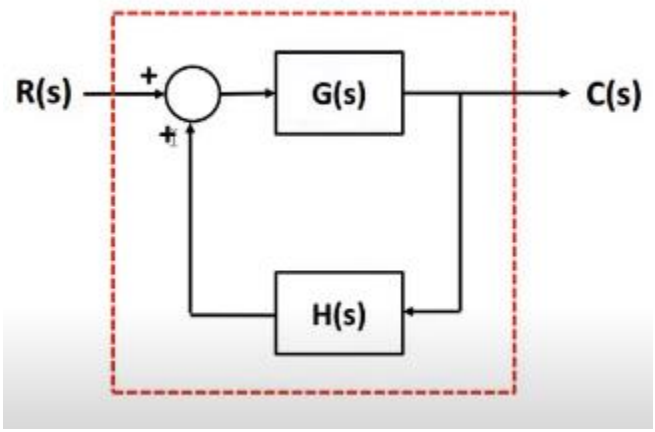
$$\frac{C(s)}{R(s)} = \frac{G(s)}{1+G(s)H(s)}$$

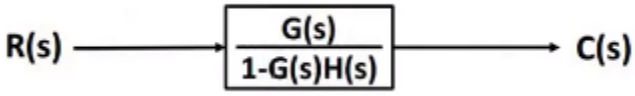


Feedback form

Case #2



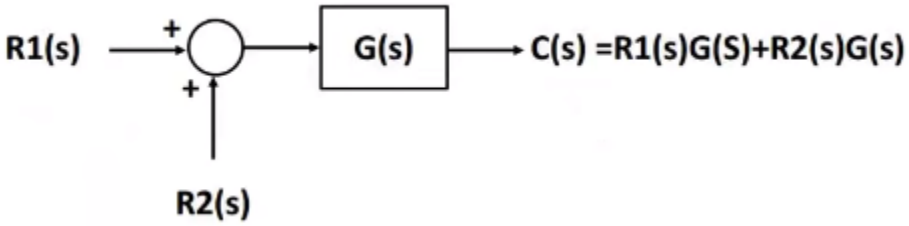


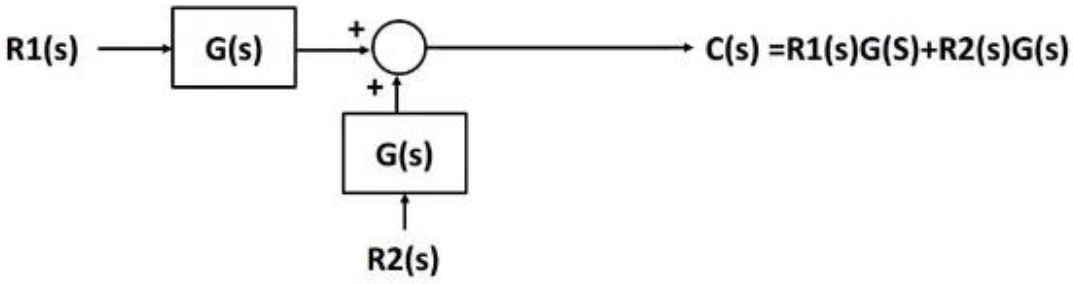


Rule #6:

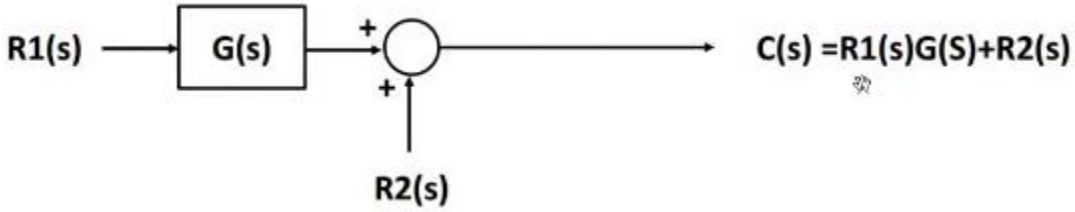
Moving Blocks

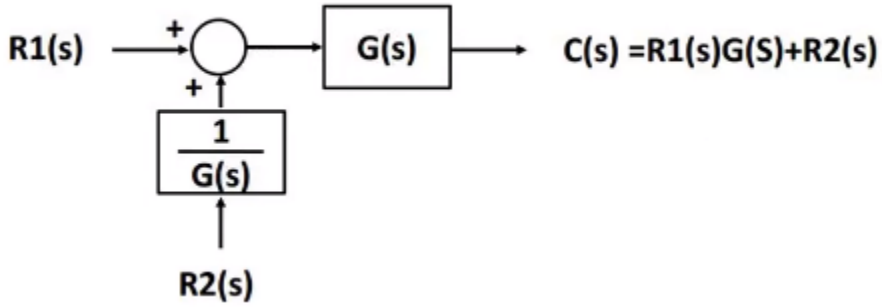
Case #1



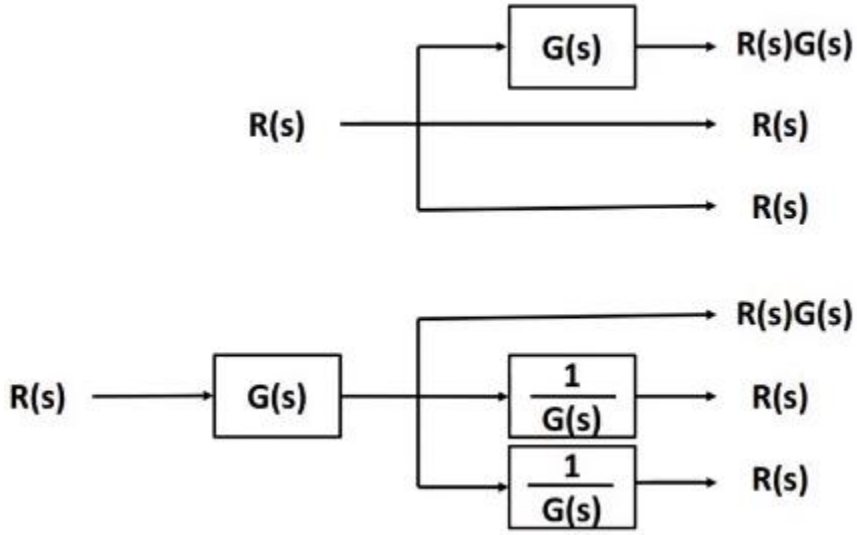


Case #2

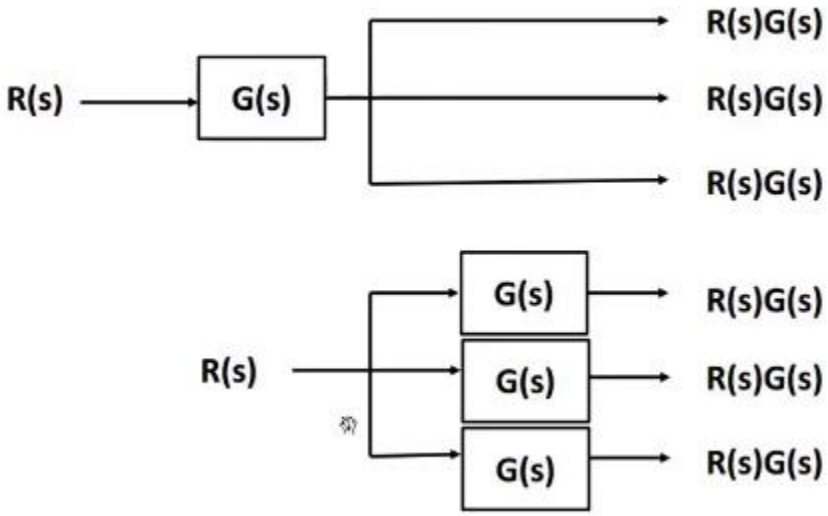




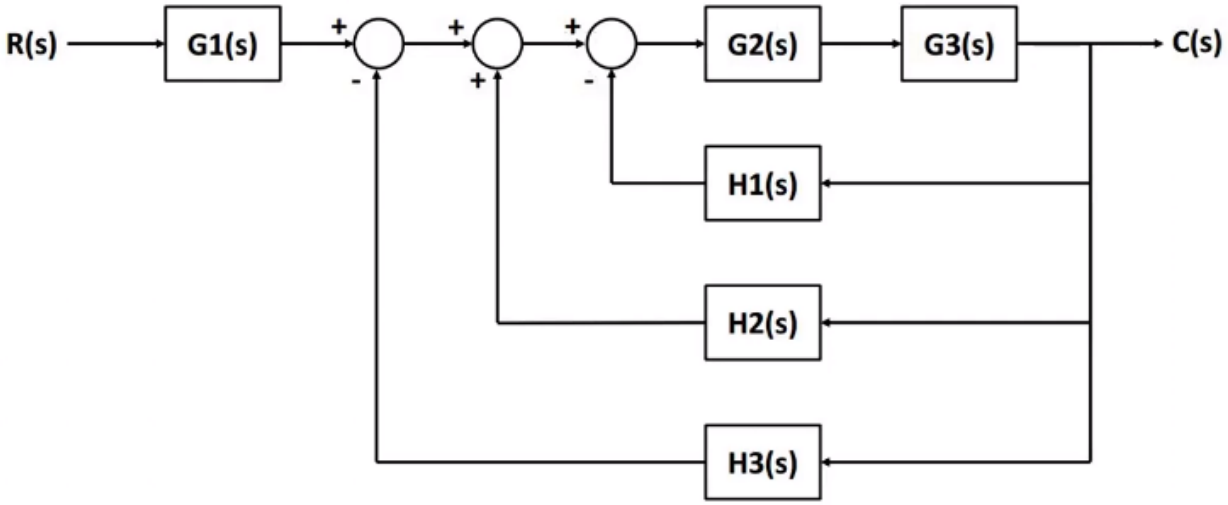
Case #3

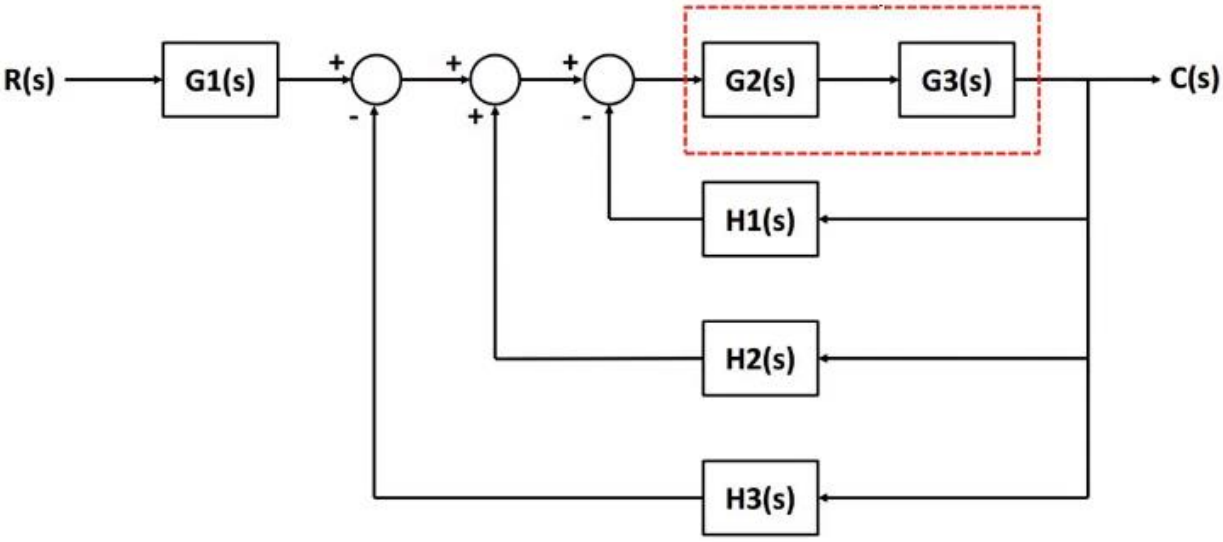

G(s)
R(s)G(s)
R(s)
R(s)
R(s)
G(s)
R(s)G(s)
1
G(s)
R(s)
1
G(s)
R(s)

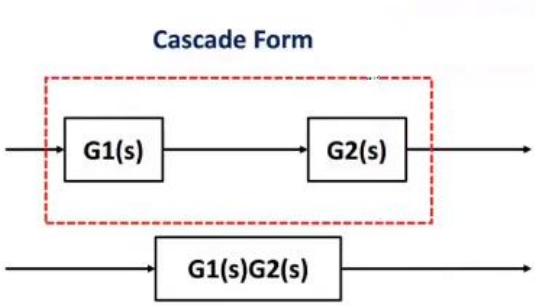
Case #4

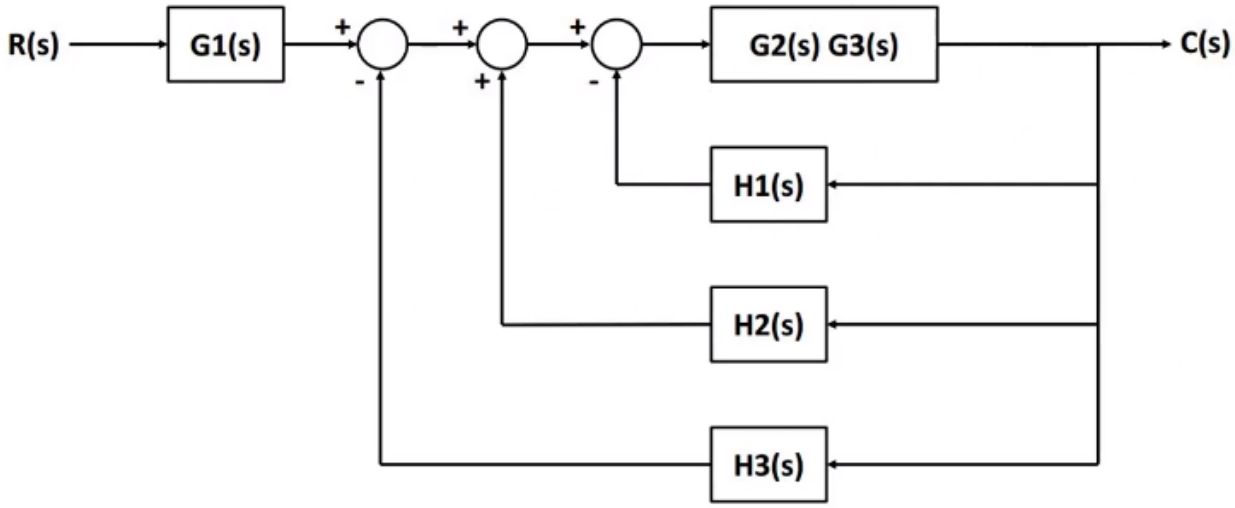

R(s)
G(s)
R(s)G(s)
R(s)G(s)
R(s)G(s)
R(s)
G(s)
G(s)
G(s)
R(s)G(s)
R(s)G(s)
R(s)G(s)

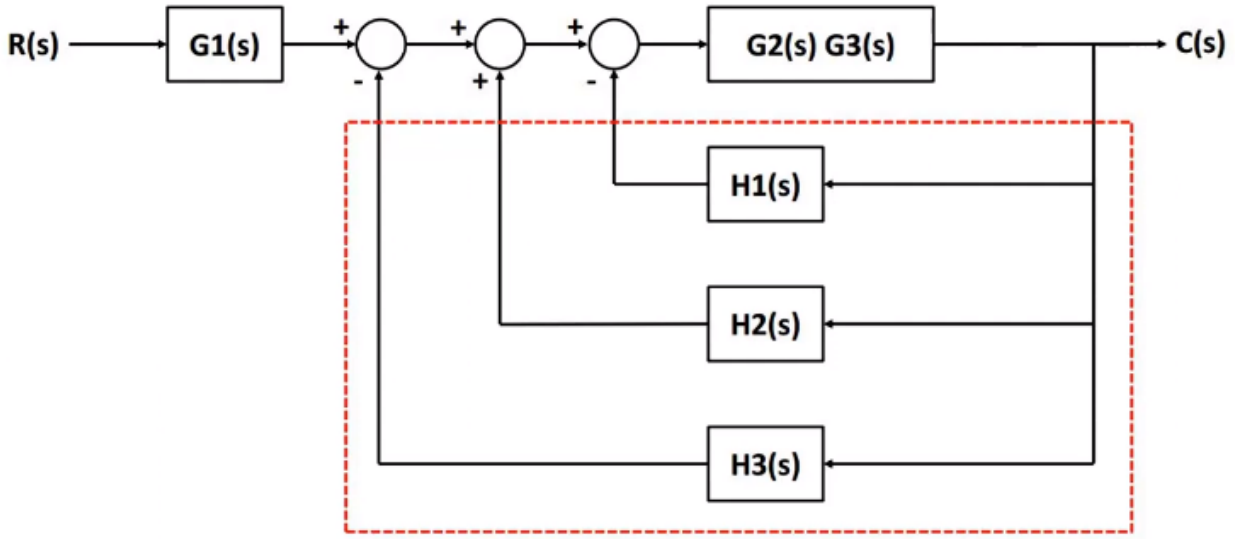
Example #1: Reduce the below block diagram to a single transfer function.



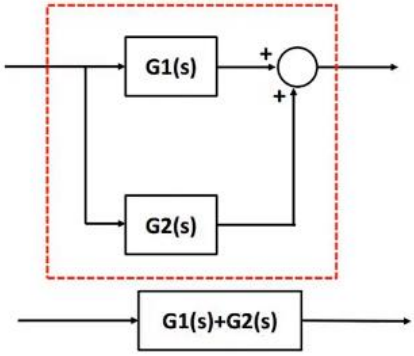


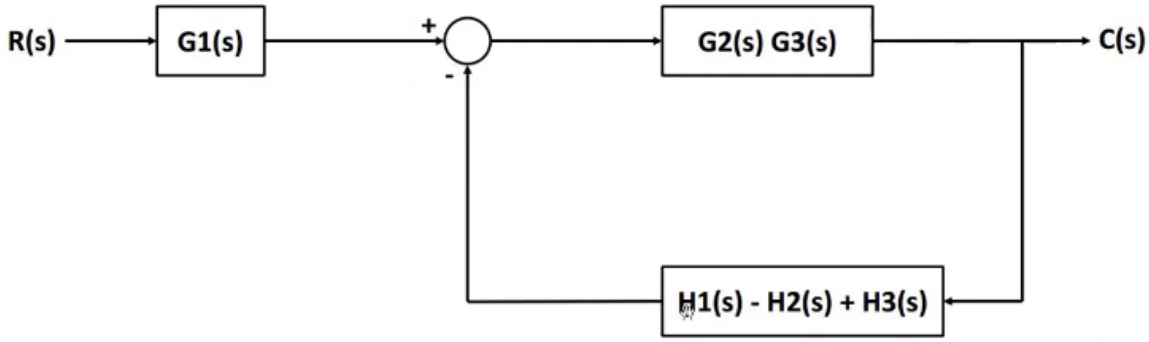


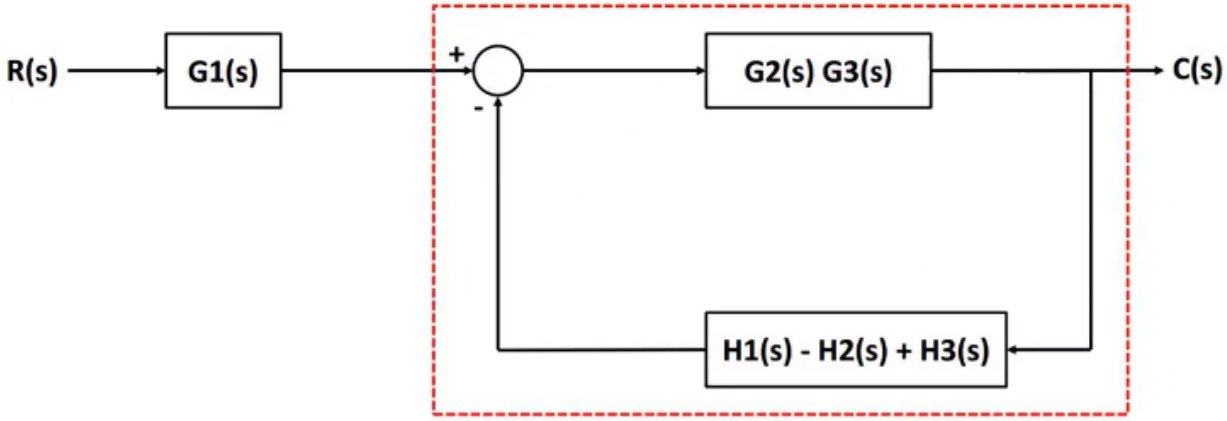




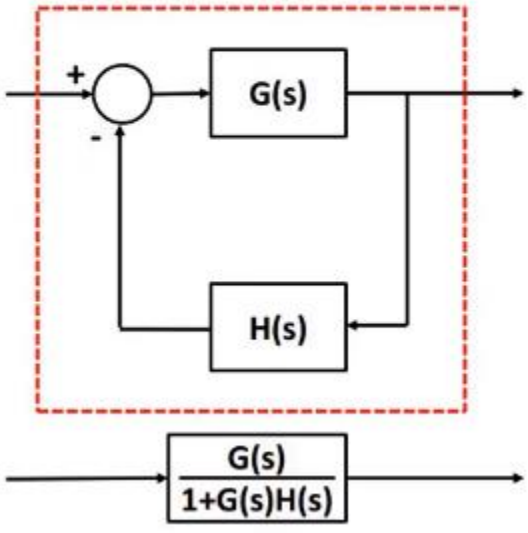
Parallel Form

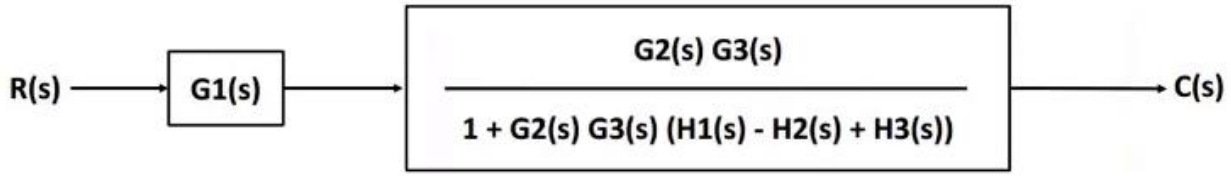


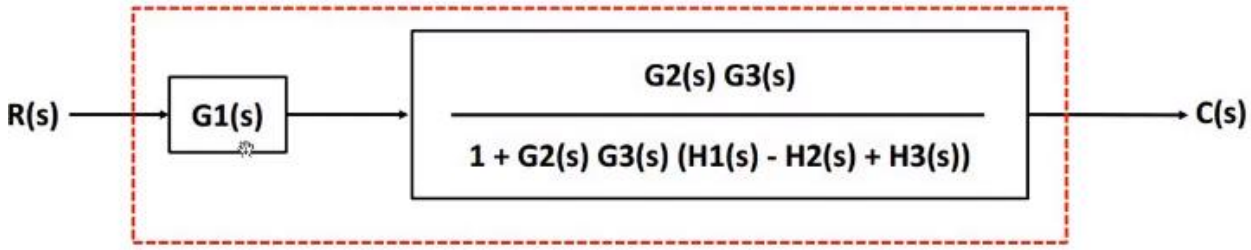




Feed-back Form

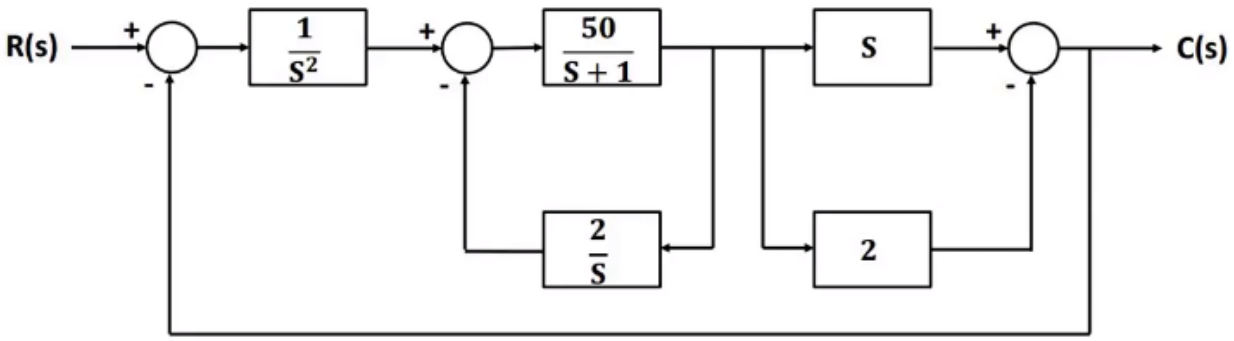


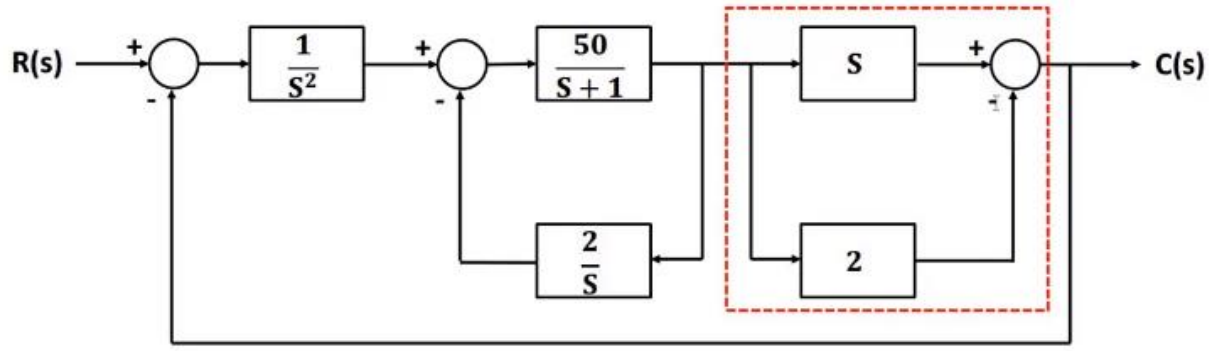


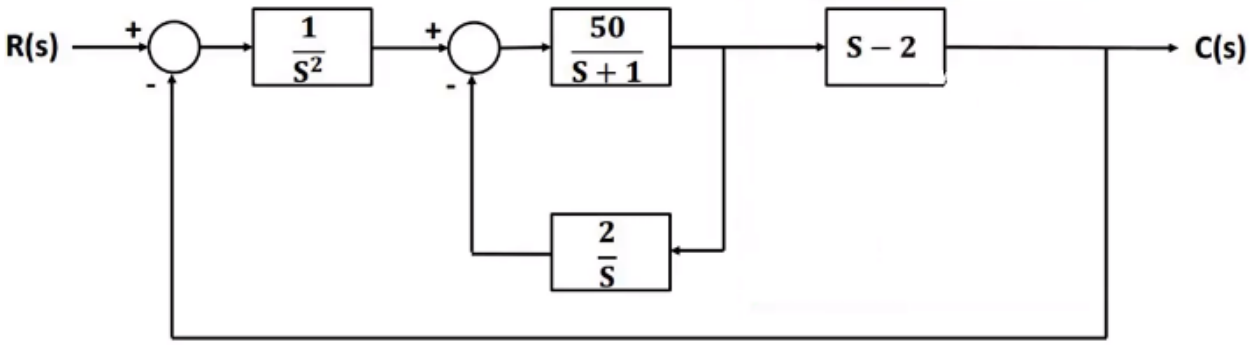


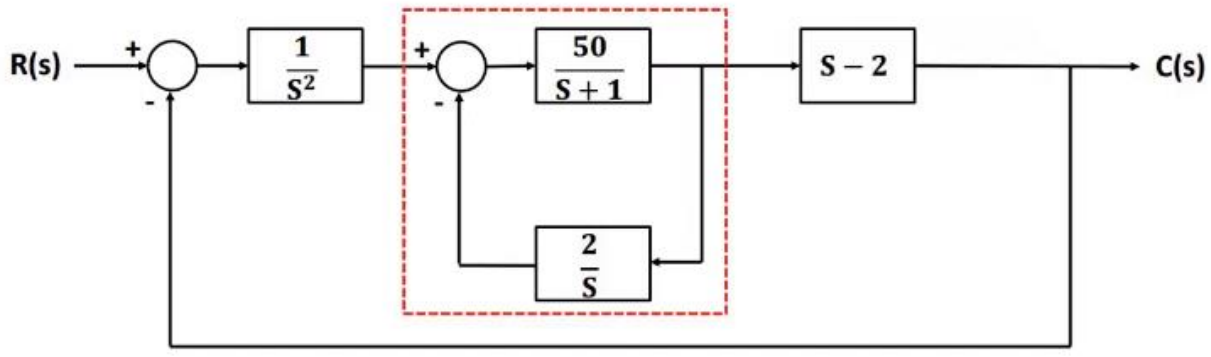
$$G(s) = \frac{C(s)}{R(s)} = \frac{G1(s)\,G2(s)\,G3(s)}{1 + G2(s)\,G3(s)\,(H1(s) - H2(s) + H3(s))}$$

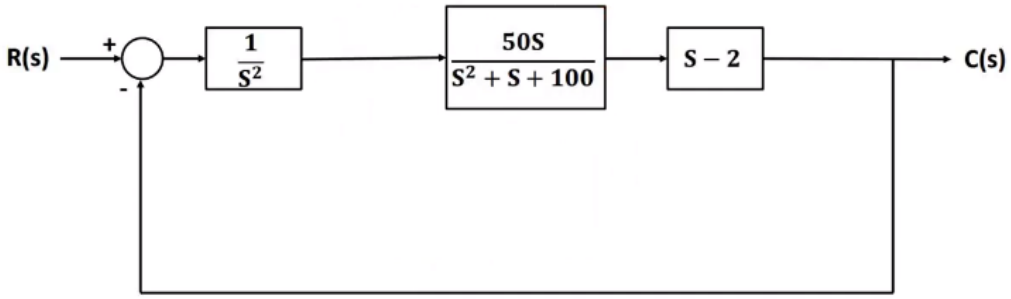
Example #2: Reduce the below block diagram to a single transfer function.

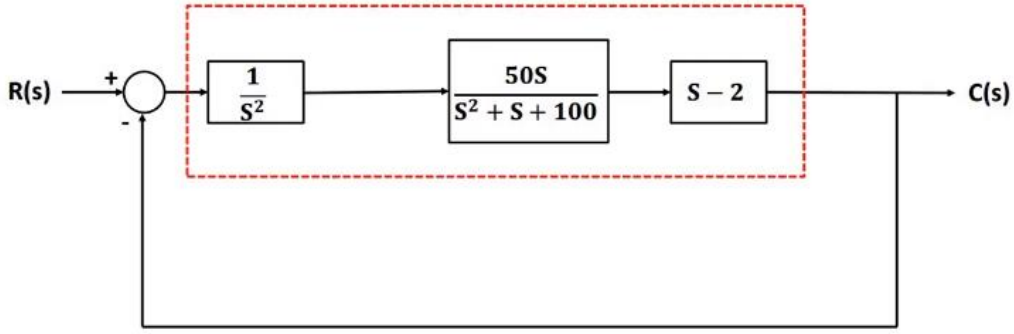


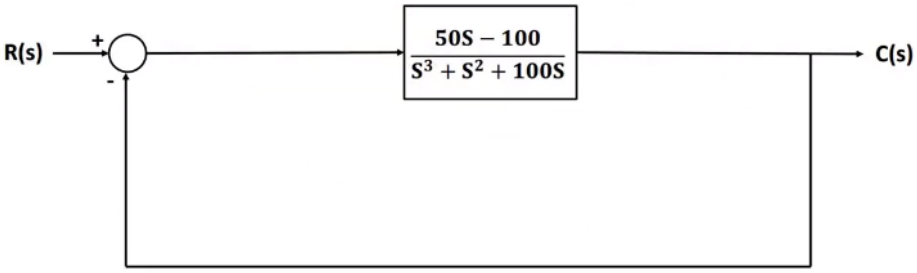


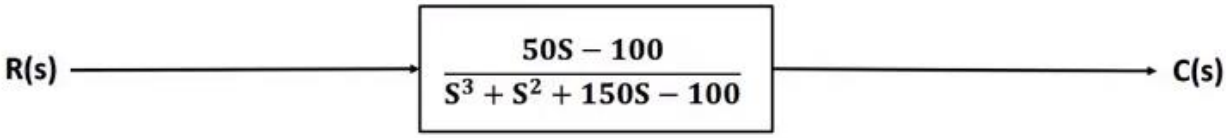






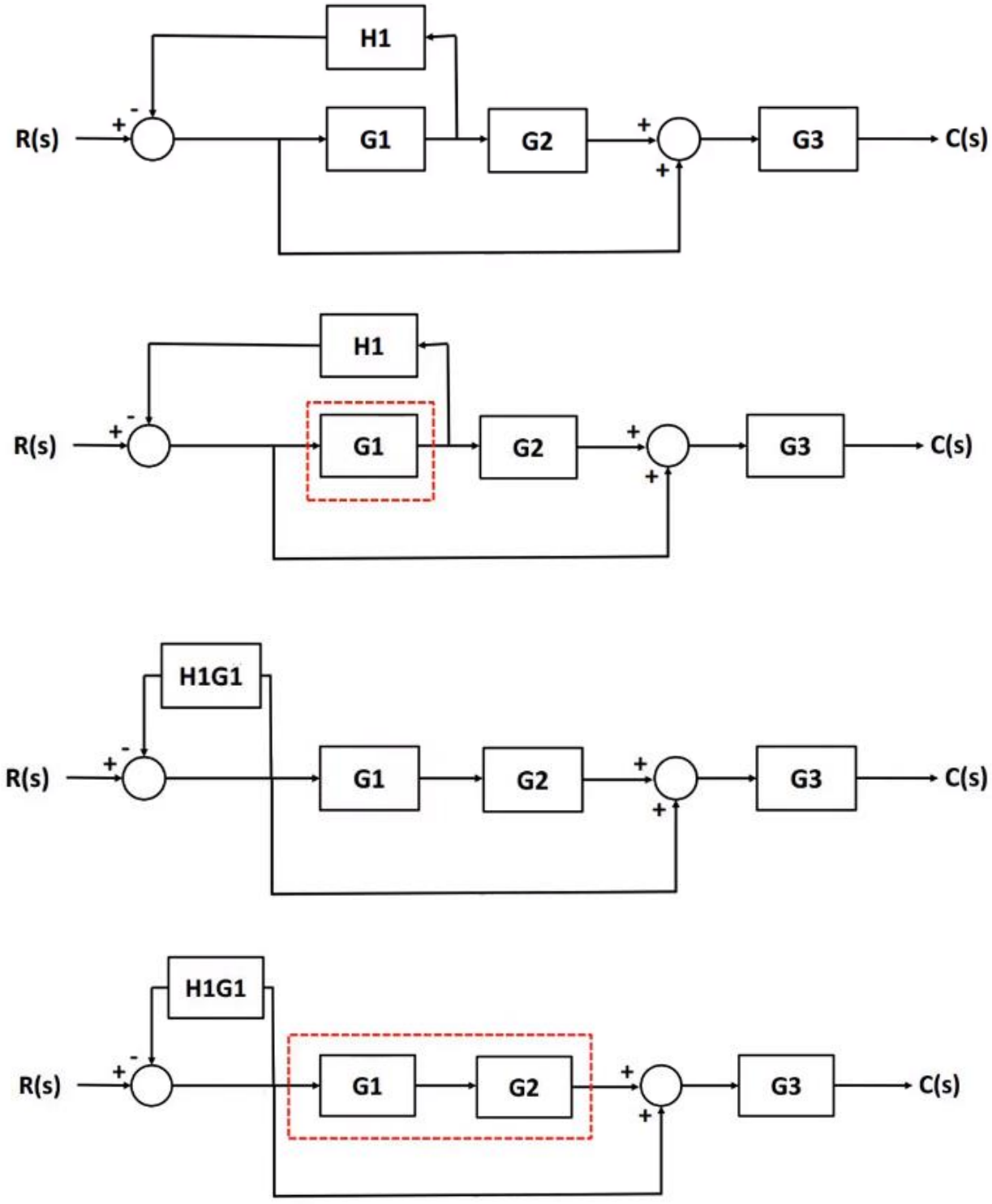


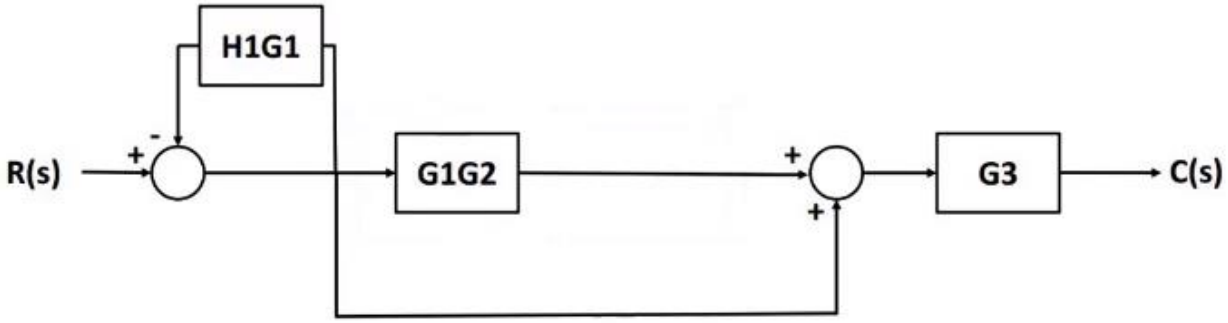


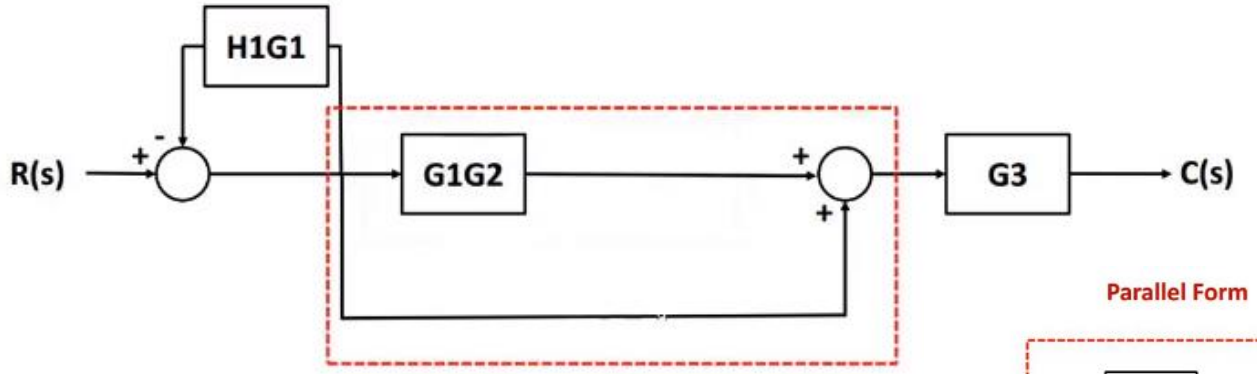


$$G(s) = \frac{C(s)}{R(s)} = \frac{50S-100}{S^3+S^2+150S-100}$$

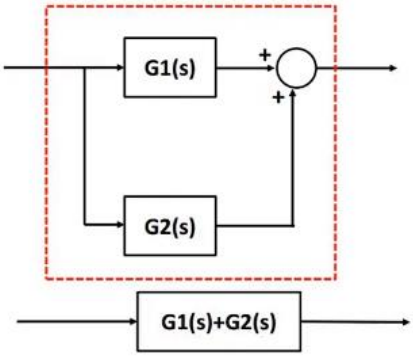
Example #3: Reduce the below block diagram to a single transfer function.

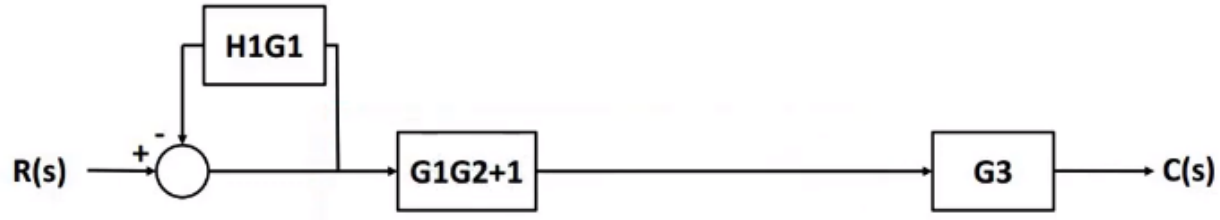


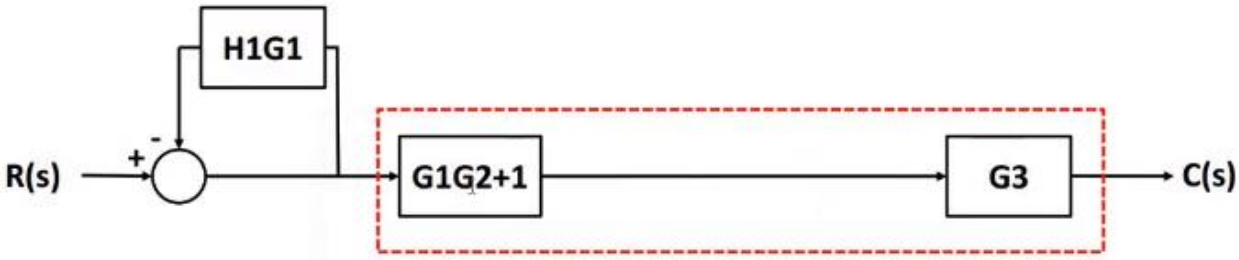


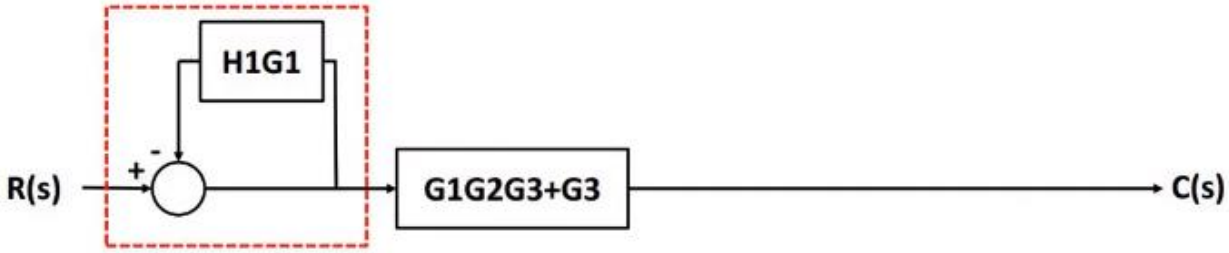


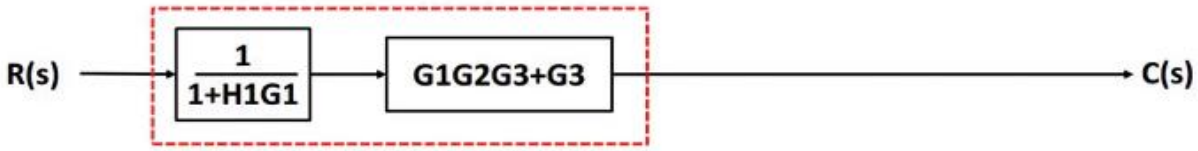
Parallel Form





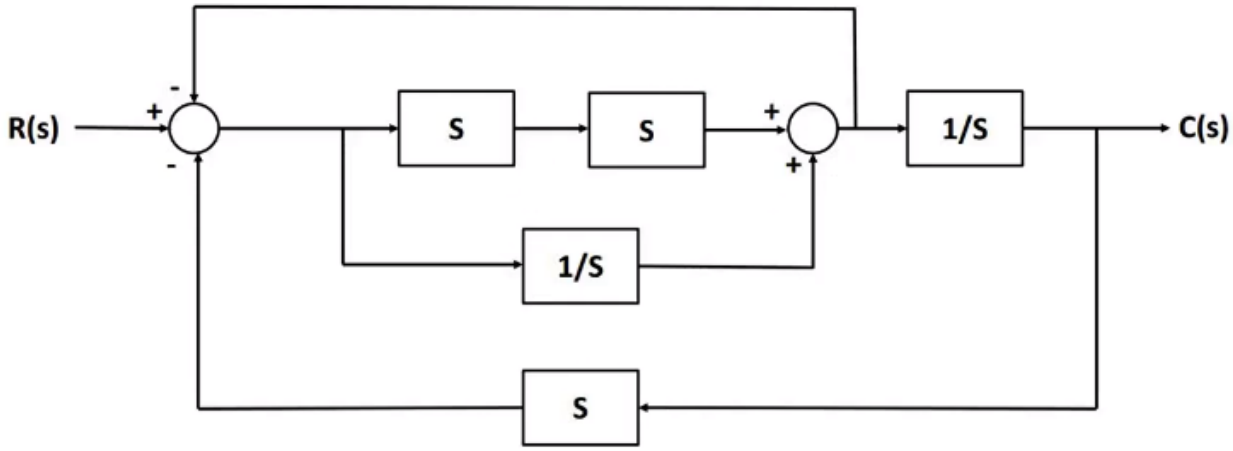


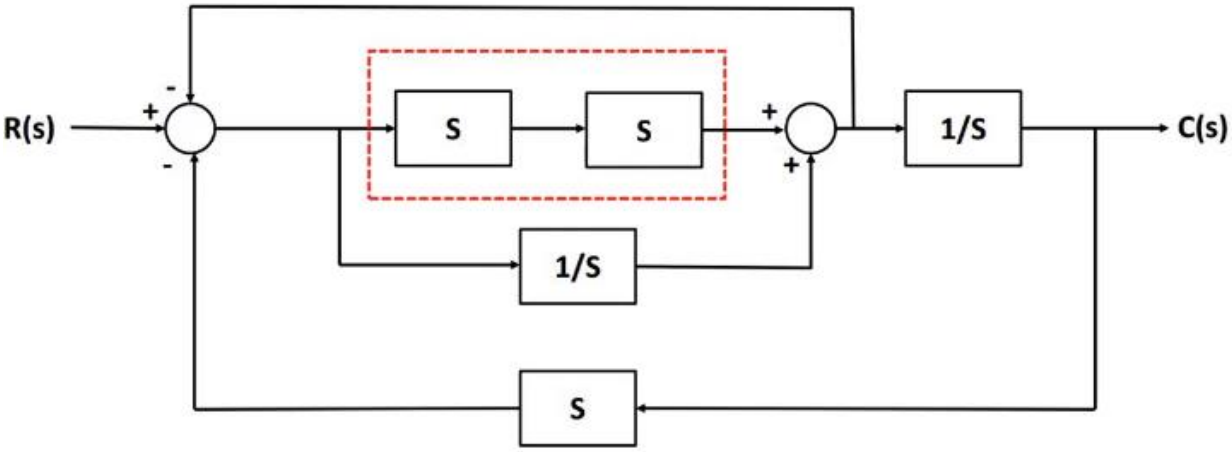


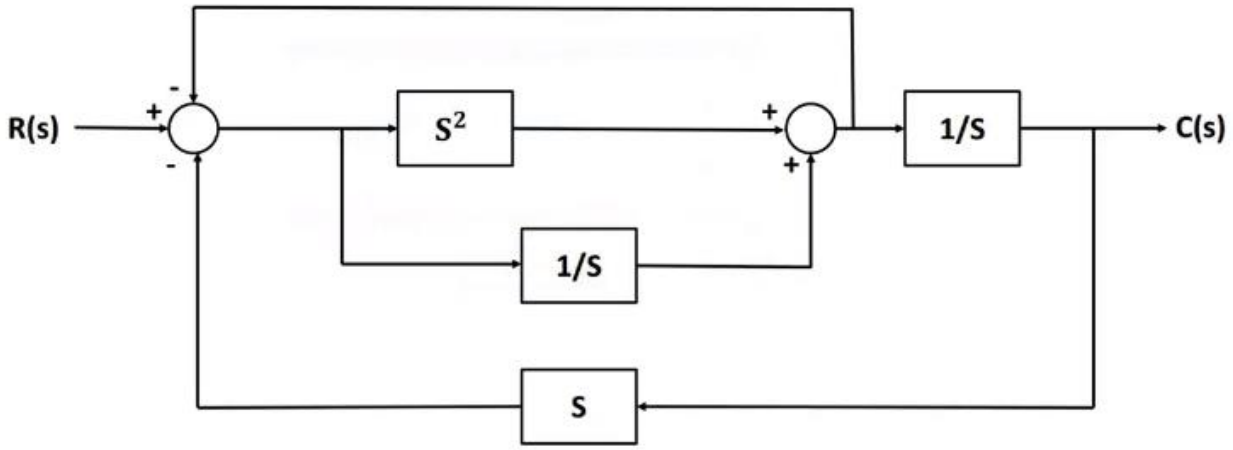


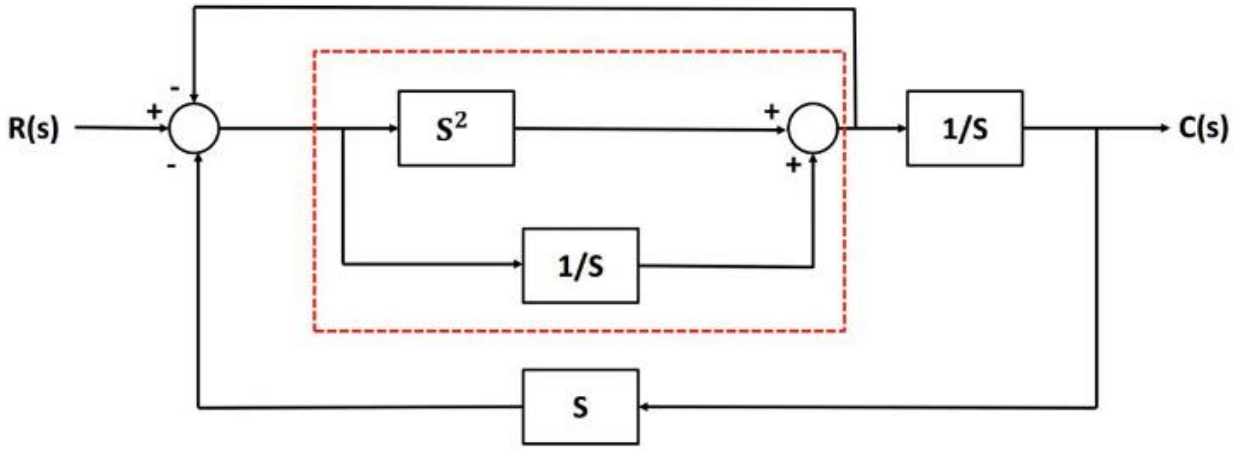
$$G(s) = \frac{C(s)}{R(s)} = \frac{G1G2G3+G3}{1+H1G1}$$

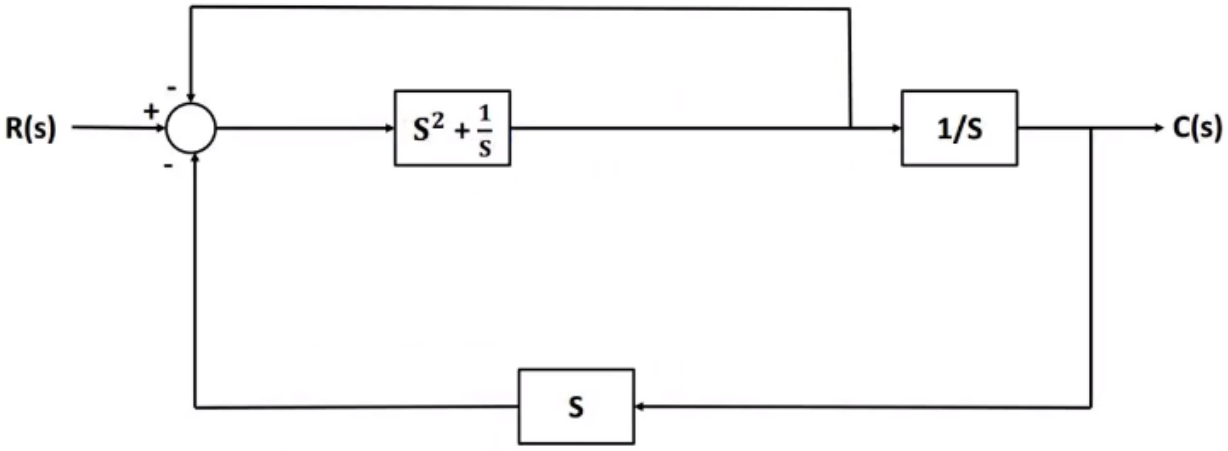
Example #4: Reduce the below block diagram to a single transfer function.

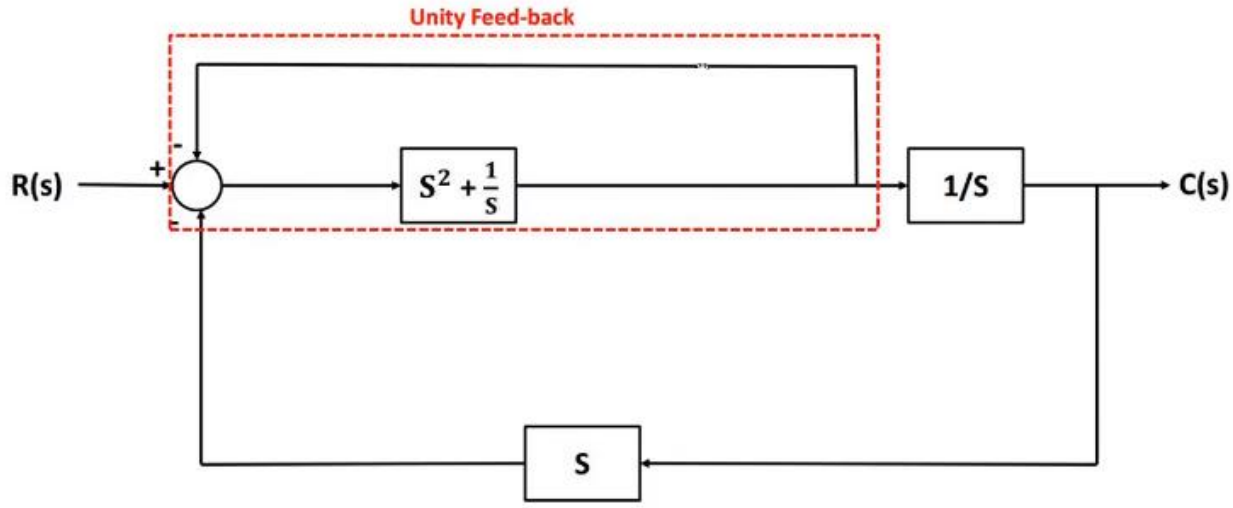


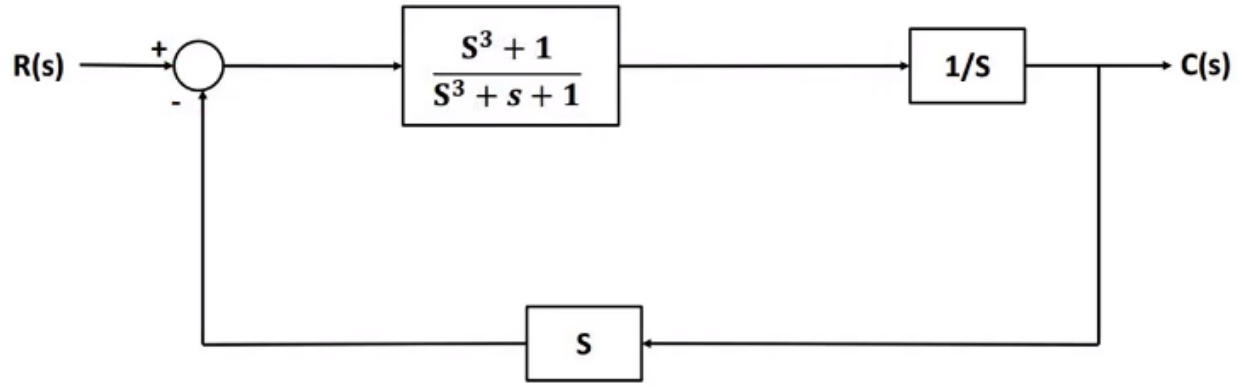


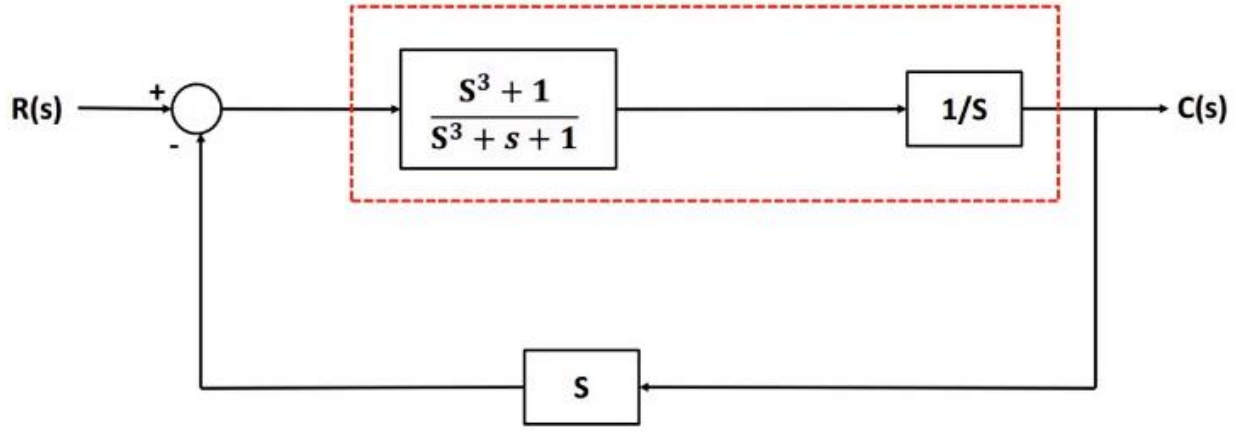


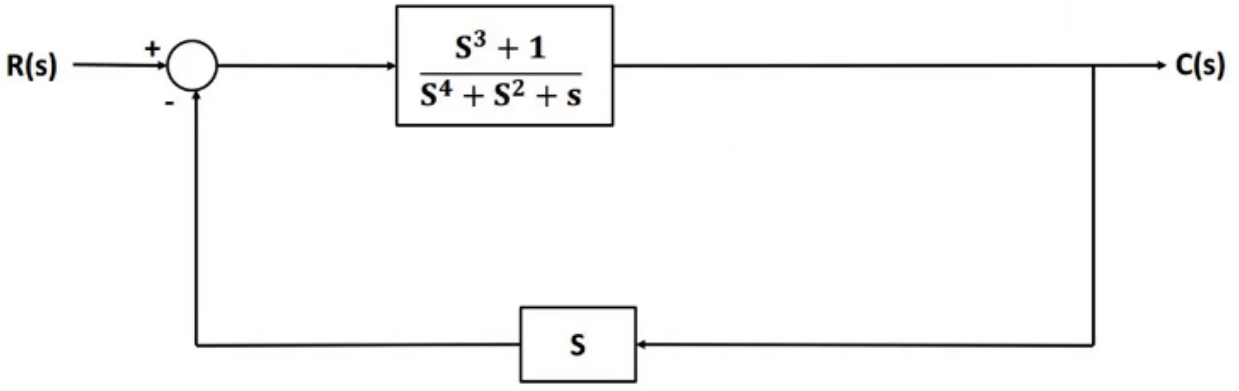

R(s)
+
-
-
S^2
+
+
1/S
C(s)
1/S
S

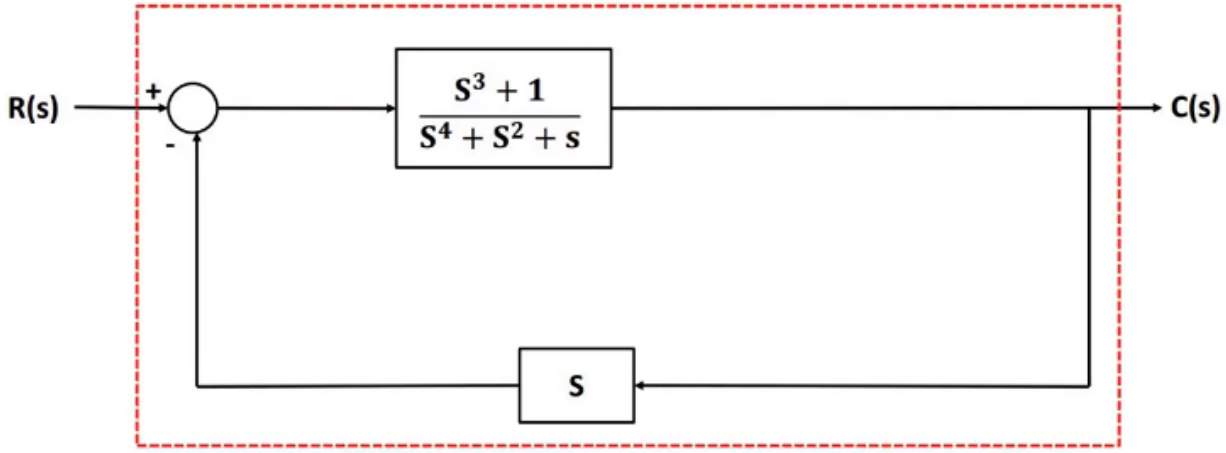

R(s)
+
-
-
$S^2 + \frac{1}{S}$
1/S
C(s)
S

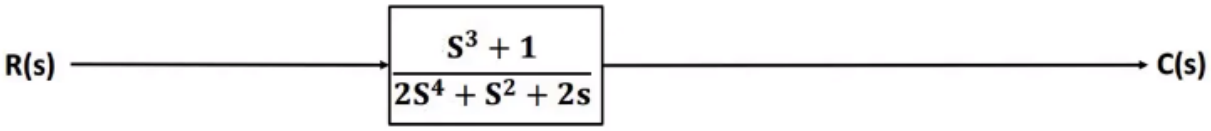

Unity Feed-back
R(s)
+
-
-
$S^2 + \frac{1}{S}$
1/S
C(s)
S


R(s)
+
-
$\frac{S^3+1}{S^3+s+1}$
1/S
C(s)
S


R(s)
+
-
$\frac{S^3+1}{S^3+s+1}$
1/S
C(s)
S

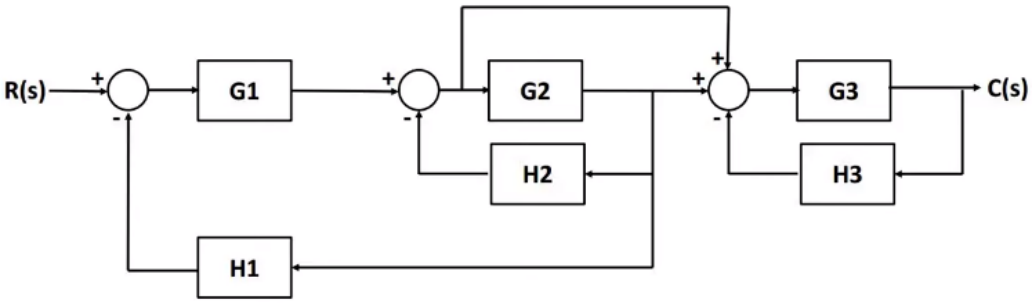

R(s)
+
-
$\frac{S^3+1}{S^4+S^2+s}$
C(s)
S

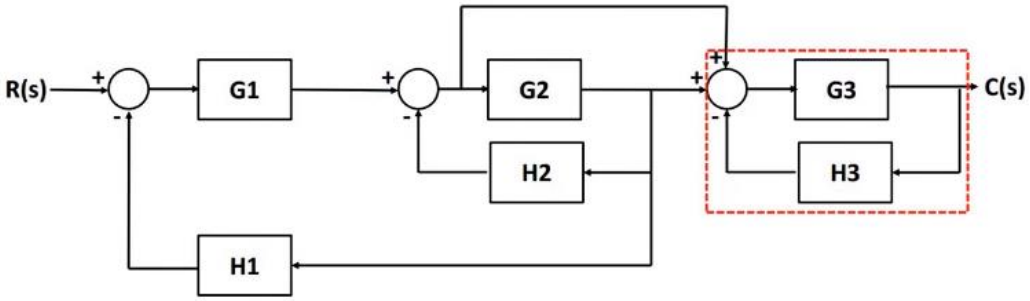


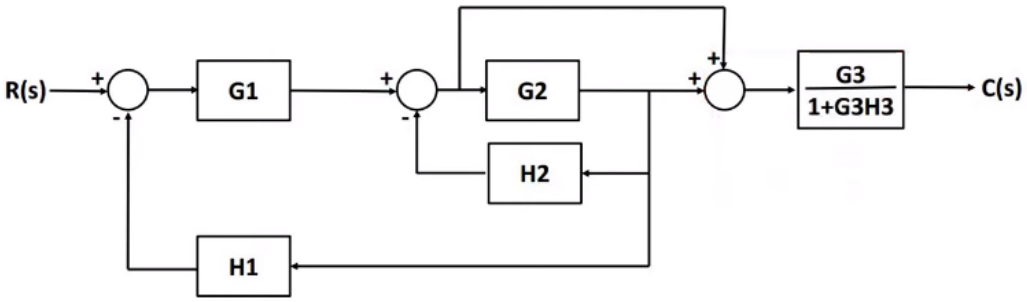


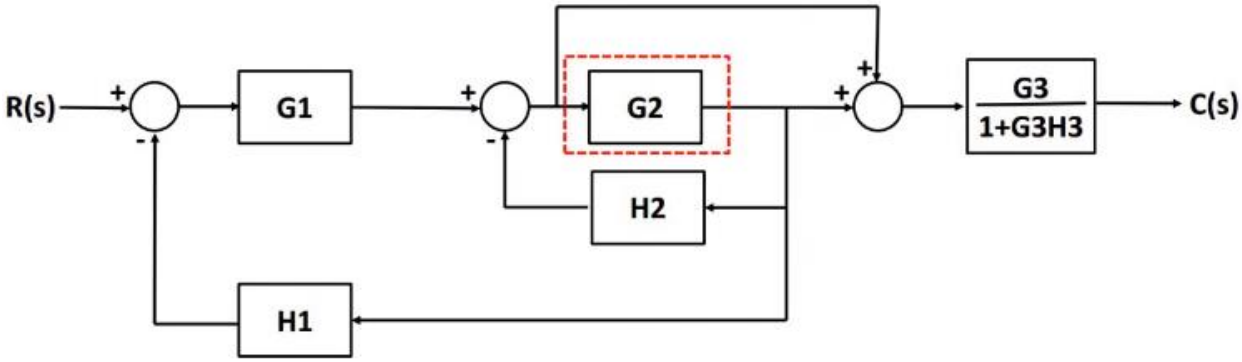
$$G(s) = \frac{C(s)}{R(s)} = \frac{S^3+1}{2S^4+S^2+2s}$$

Example #5: Reduce the below block diagram to a single transfer function.



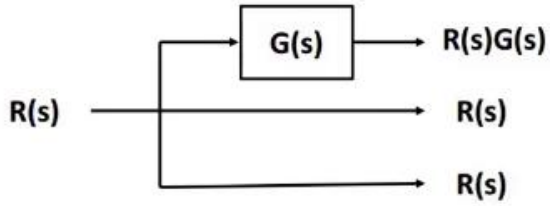


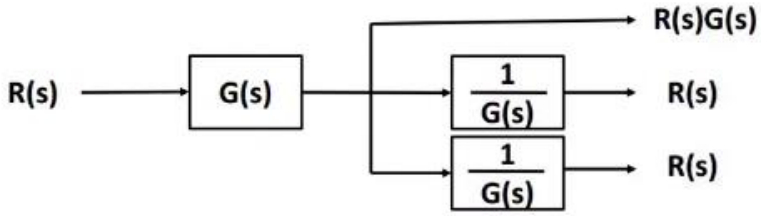


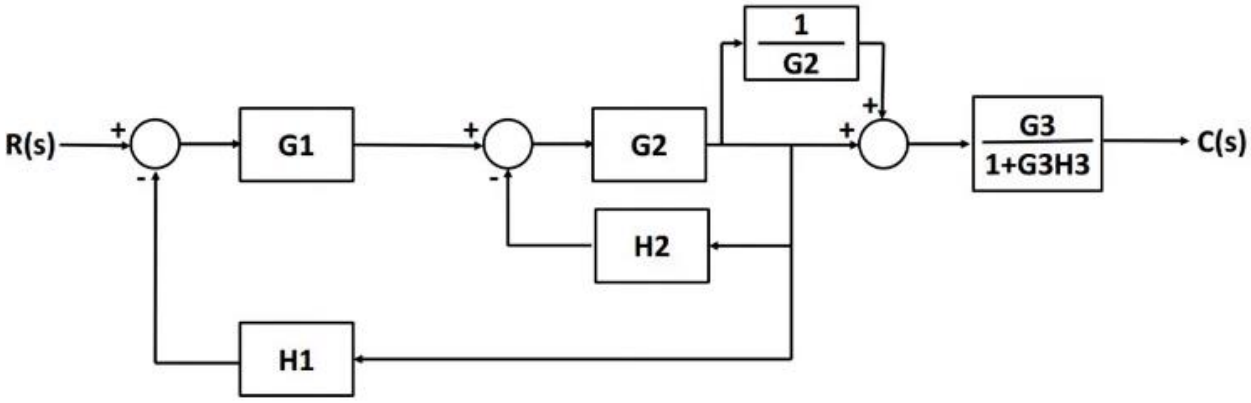


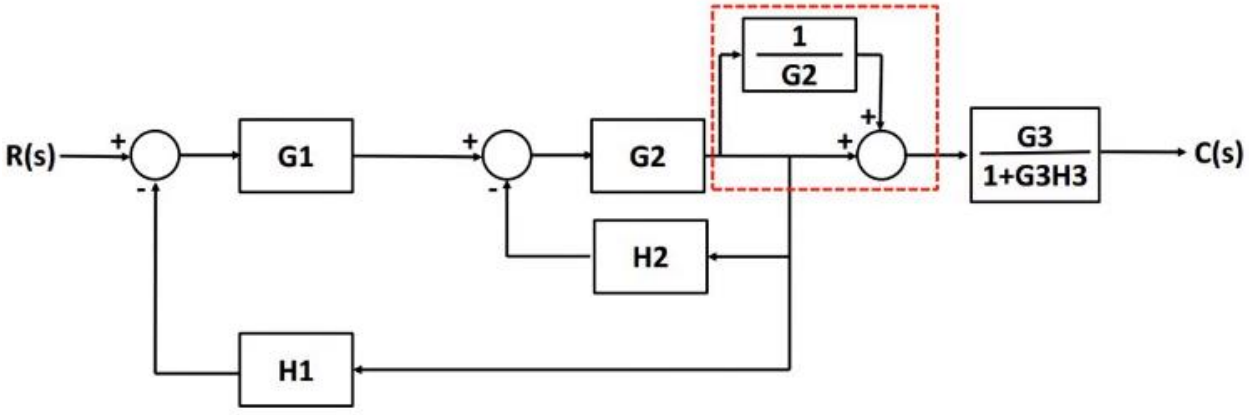
Moving Blocks

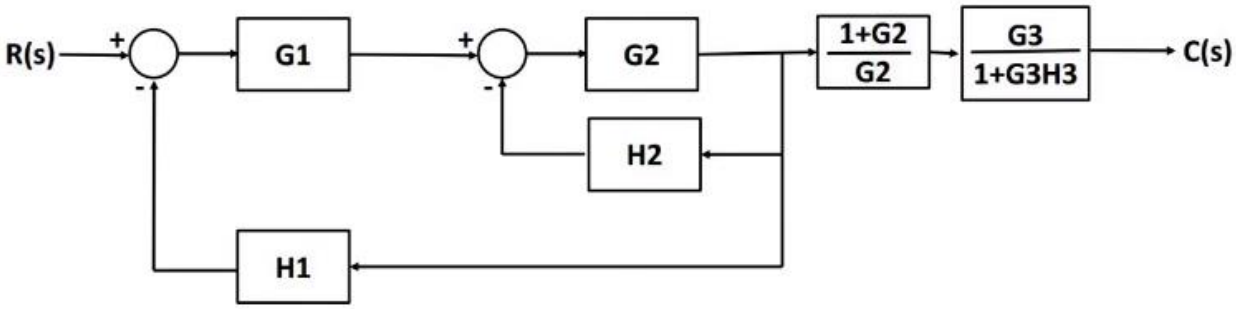
Case (3)

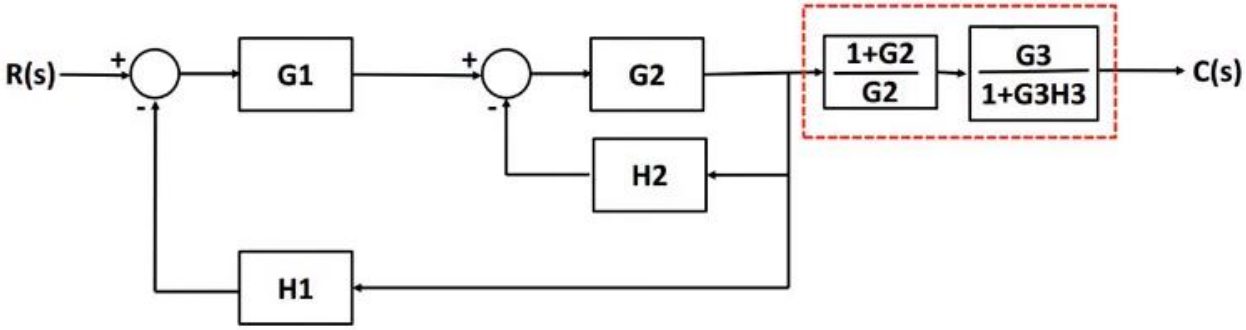


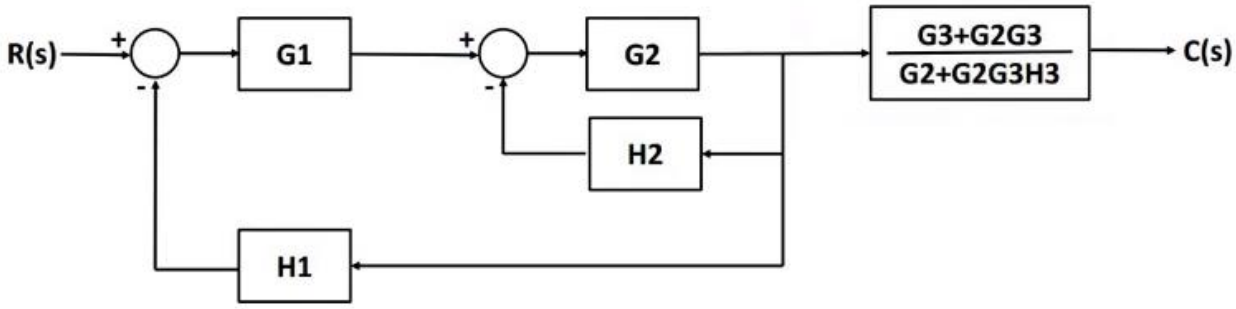


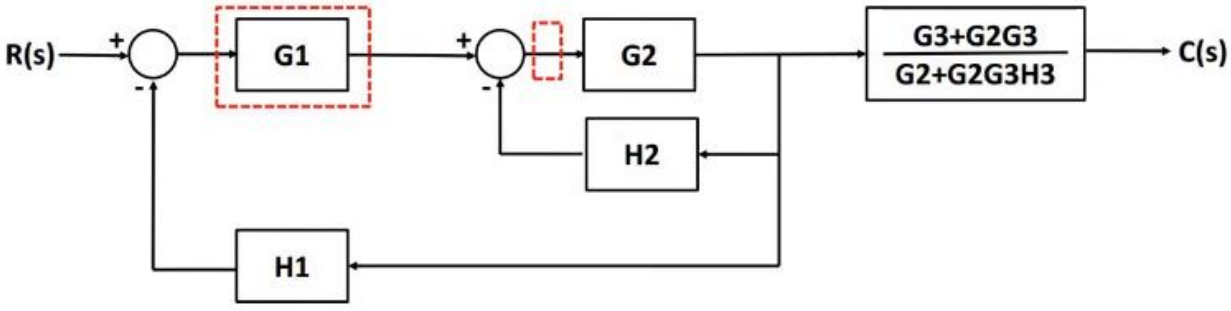


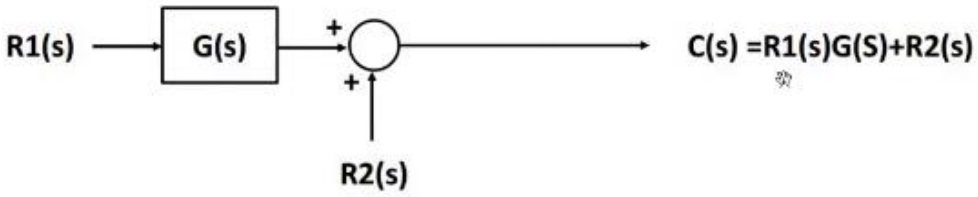


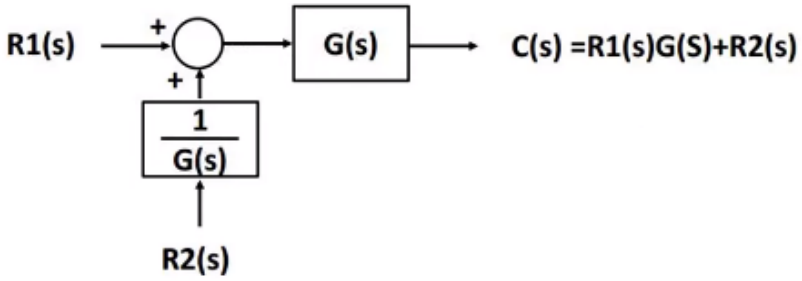

R(s)
+
-
G1
+
-
G2
1+G2
G2
G3
1+G3H3
C(s)
H2
H1

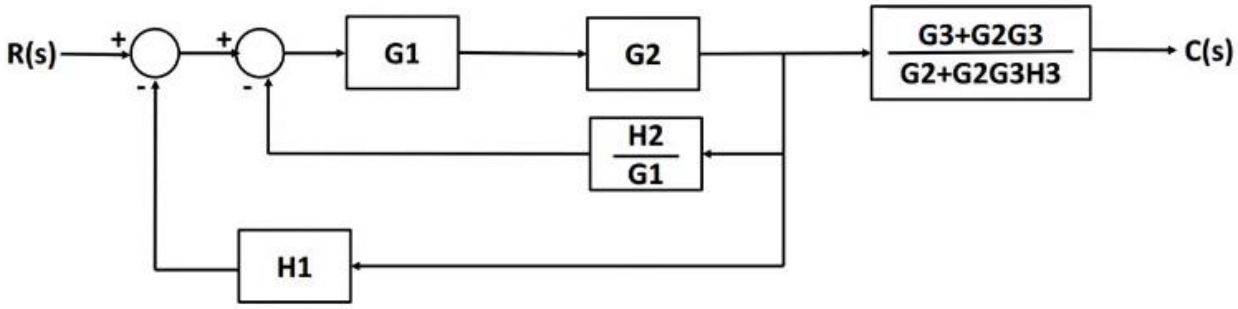

R(s)
+
-
G1
+
-
G2
1+G2
G2
G3
1+G3H3
C(s)
H2
H1

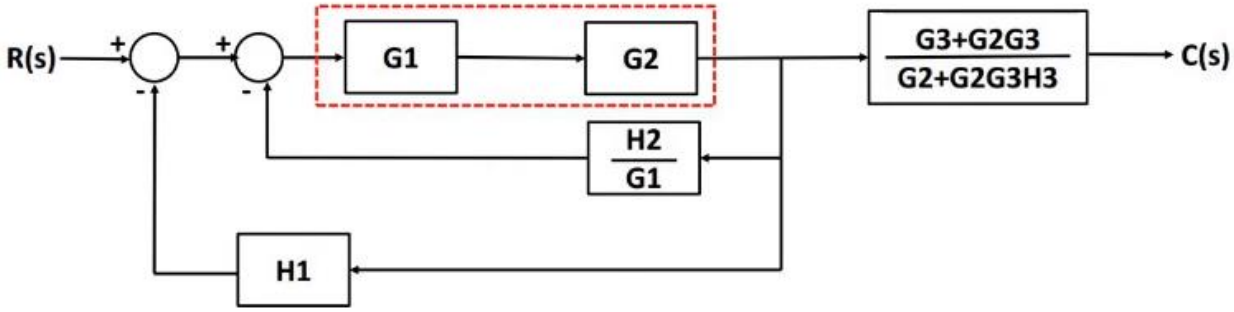

R(s)
+
-
G1
+
-
G2
G3+G2G3
G2+G2G3H3
C(s)
H2
H1

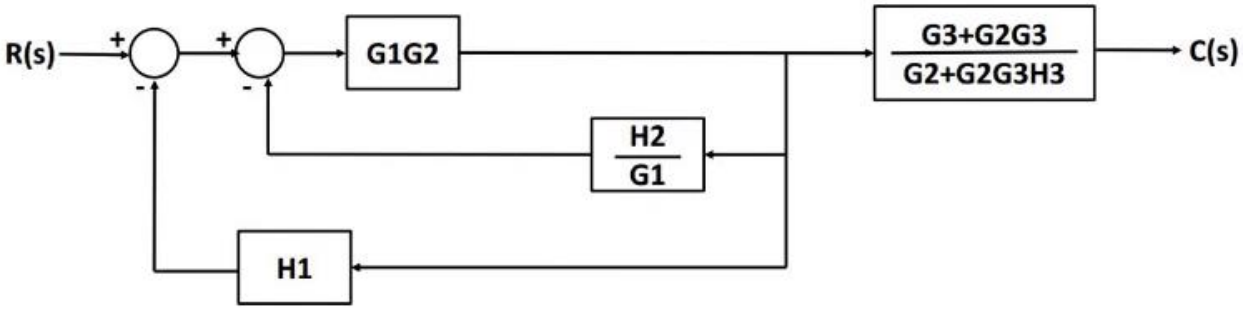

R(s)
+
-
G1
+
-
G2
G3+G2G3
G2+G2G3H3
C(s)
H2
H1

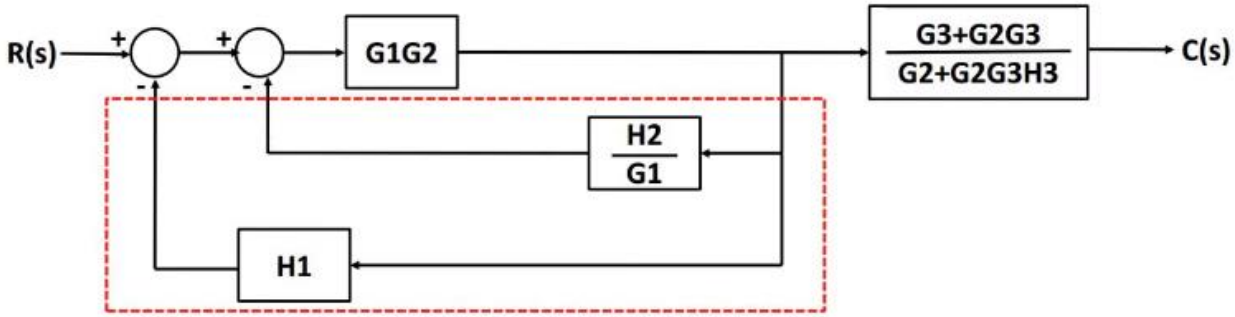

R1(s)
G(s)
+
+
R2(s)
C(s) =R1(s)G(S)+R2(s)

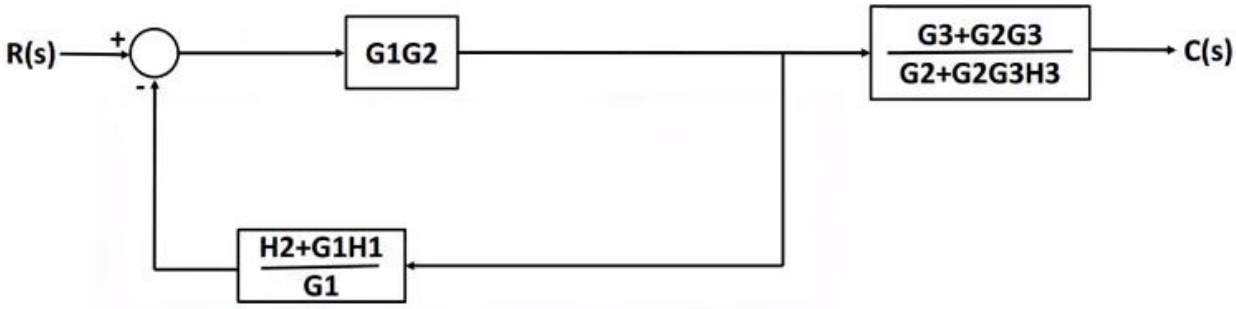

R1(s)
+
+
G(s)
C(s) =R1(s)G(S)+R2(s)
1
G(s)
R2(s)

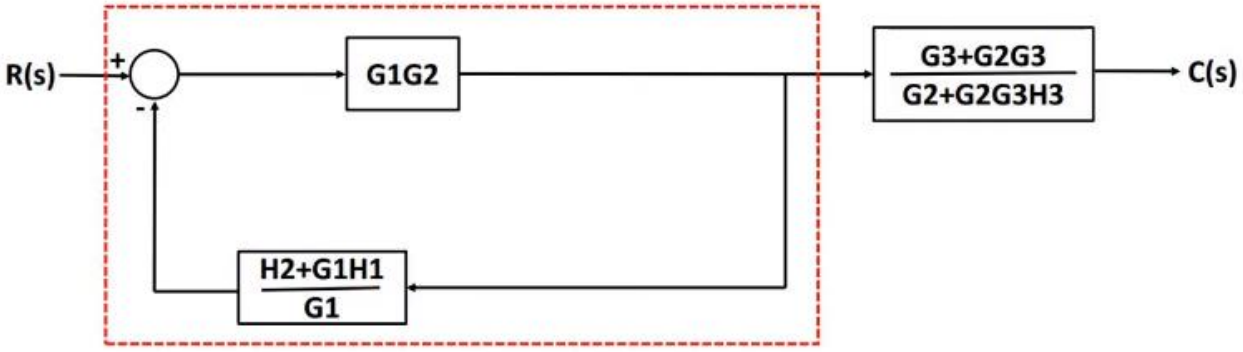

R(s)
+
-
+
-
G1
G2
G3+G2G3
G2+G2G3H3
C(s)
H2
G1
H1

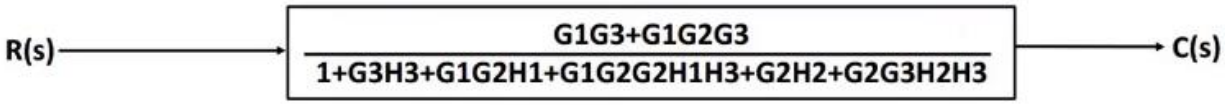

R(s)
+
-
+
-
G1
G2
G3+G2G3
G2+G2G3H3
C(s)
H2
G1
H1


R(s)
+
-
+
-
G1G2
G3+G2G3
G2+G2G3H3
C(s)
H2
G1
H1









$$G(s) = \frac{C(s)}{R(s)} = \frac{G1G3+G1G2G3}{1+G3H3+G1G2H1+G1G2G2H1H3+G2H2+G2G3H2H3}$$