

# Block Diagram Reduction

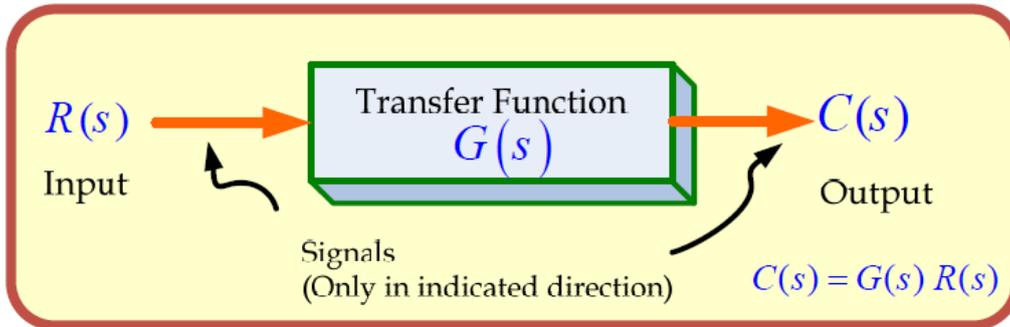


Figure 1: Single block diagram representation

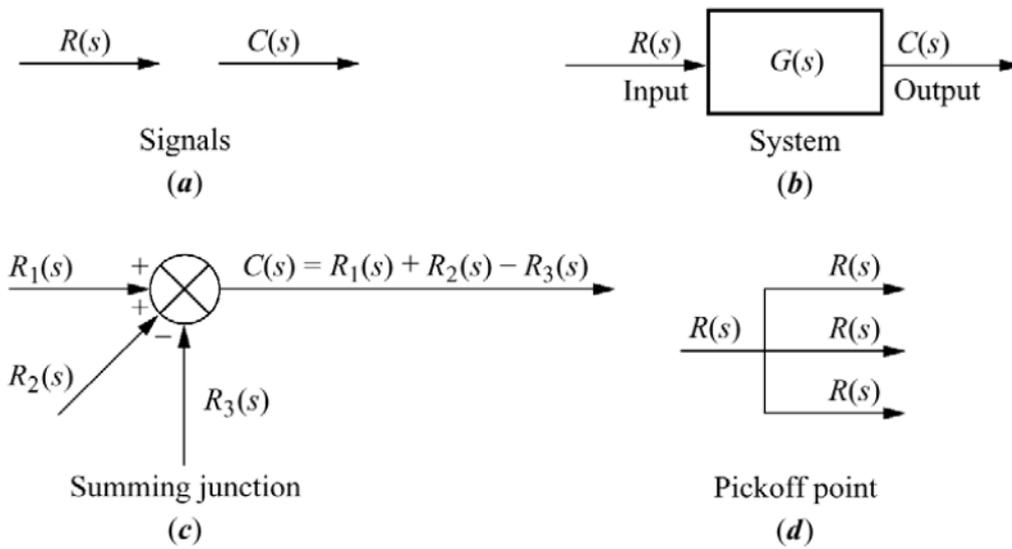


Figure 2: Components of Linear Time Invariant Systems (LTIS)

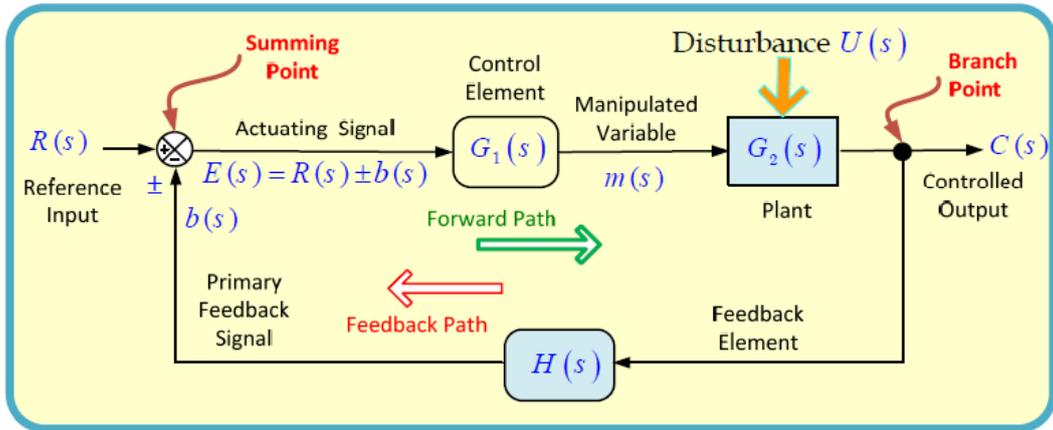


Figure 3: Block diagram components

### Definitions

- $G(s)$   $\equiv$  Direct transfer function = Forward transfer function.
- $H(s)$   $\equiv$  Feedback transfer function.
- $G(s)H(s)$   $\equiv$  Open-loop transfer function.
- $C(s)/R(s)$   $\equiv$  Closed-loop transfer function = Control ratio
- $C(s)/E(s)$   $\equiv$  Feed-forward transfer function.

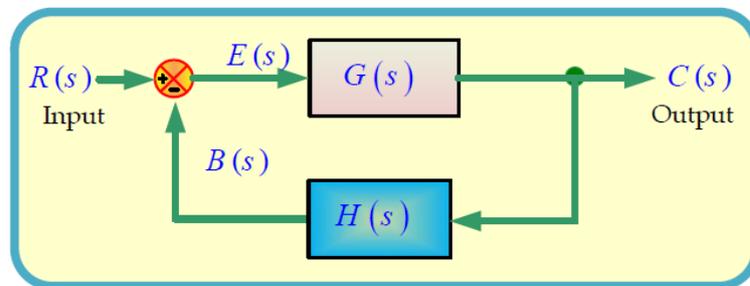


Figure 4: Block diagram of a closed-loop system with a feedback element

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

## BLOCK DIAGRAM SIMPLIFICATIONS

### Cascade (Series) Connections

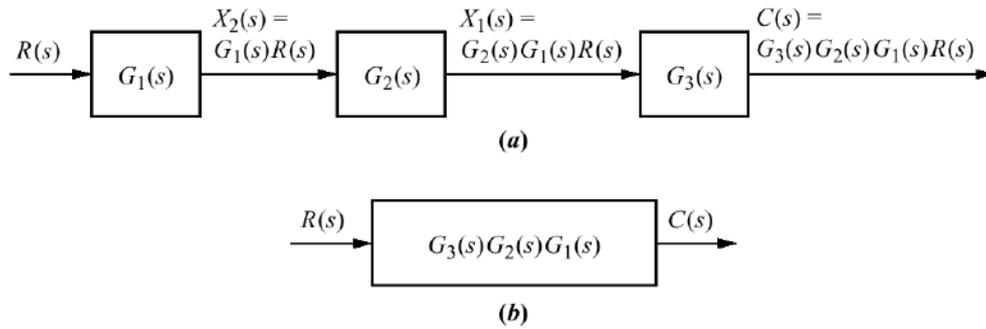


Figure 5: Cascade (Series) Connections

### Parallel Connections

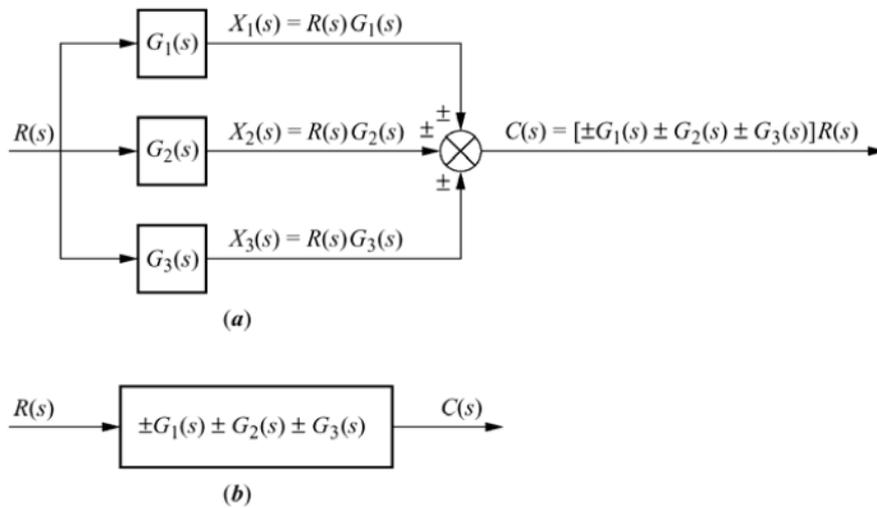


Figure 6: Parallel Connections

## Block Diagram Algebra for Summing Junctions

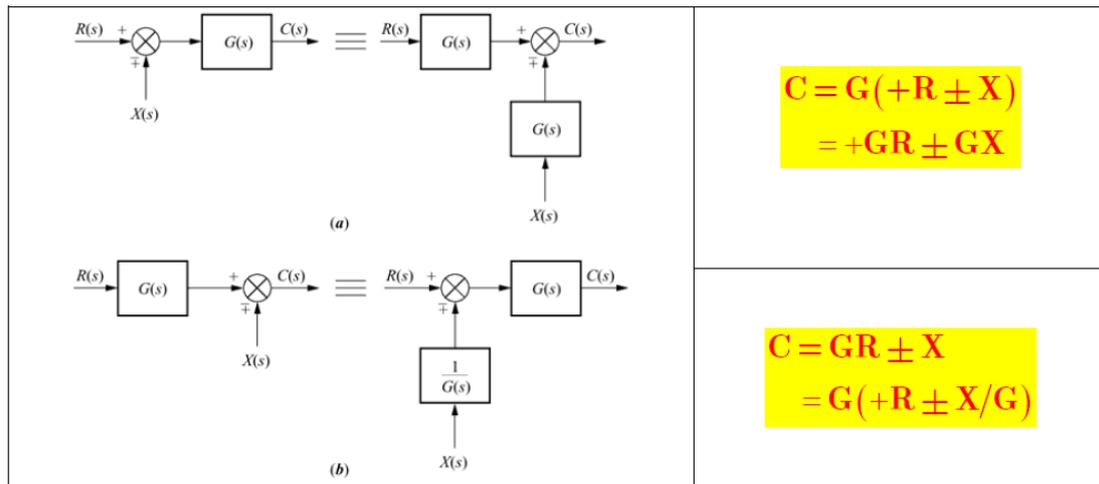


Figure 7: Summing Junctions

## Block Diagram Algebra for Branch Point

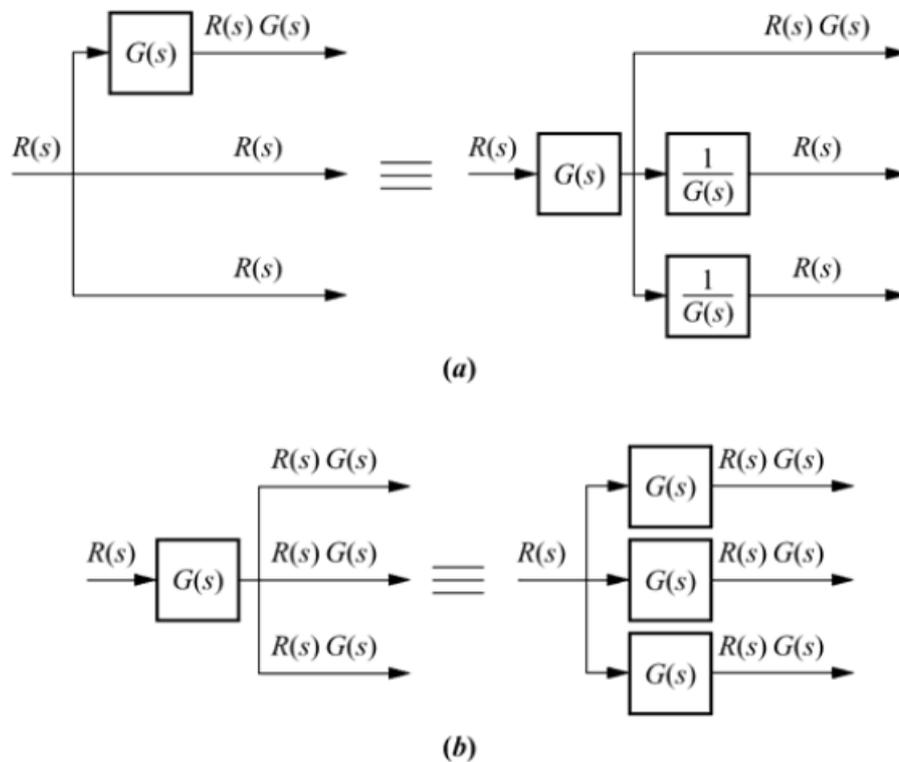


Figure 8: Branch Points

# Block Diagram Reduction Rules

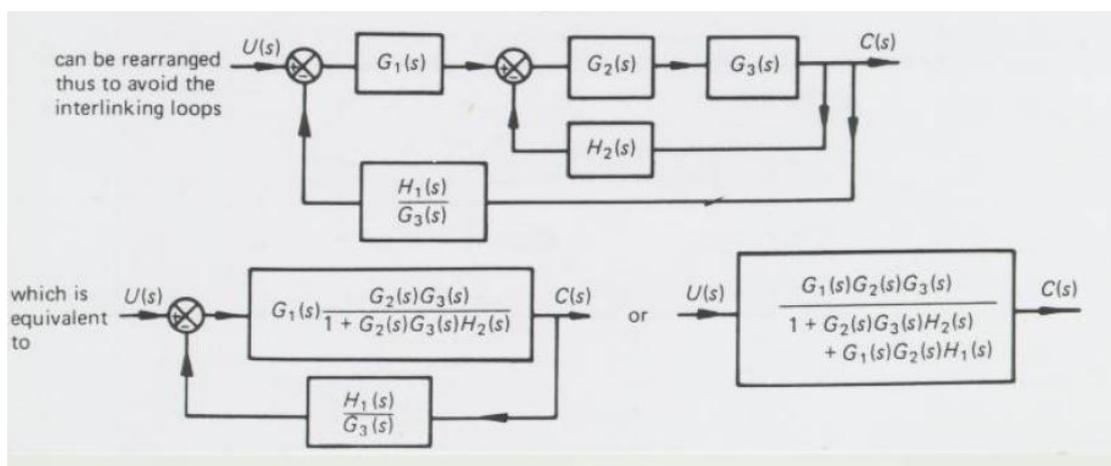
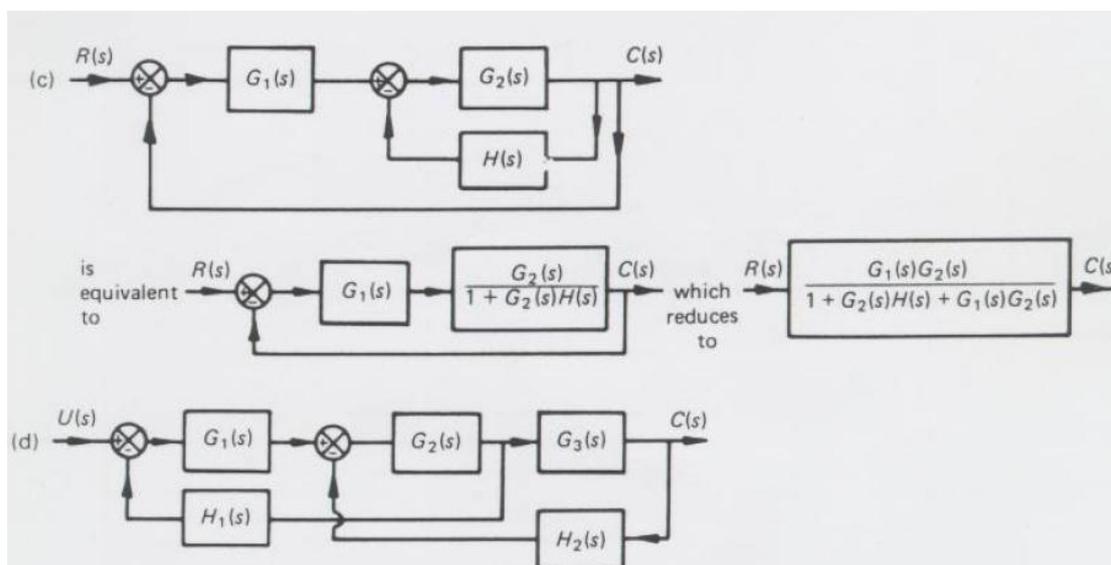
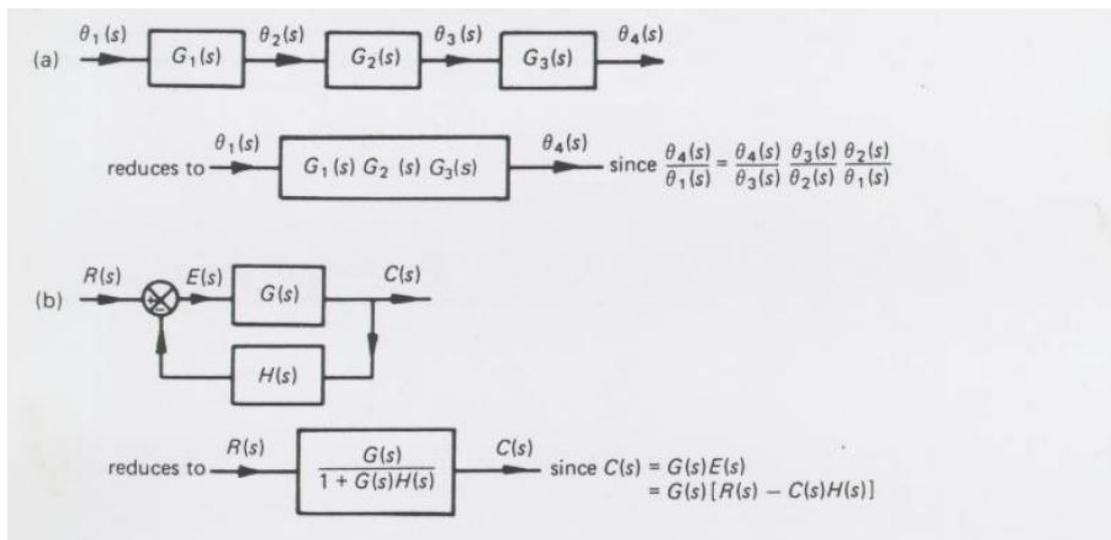
Table 1: Block Diagram Reduction Rules

1.	Combine all cascade blocks
2.	Combine all parallel blocks
3.	Eliminate all minor (interior) feedback loops
4.	Shift summing points to left
5.	Shift takeoff points to the right
6.	Repeat Steps 1 to 5 until the canonical form is obtained

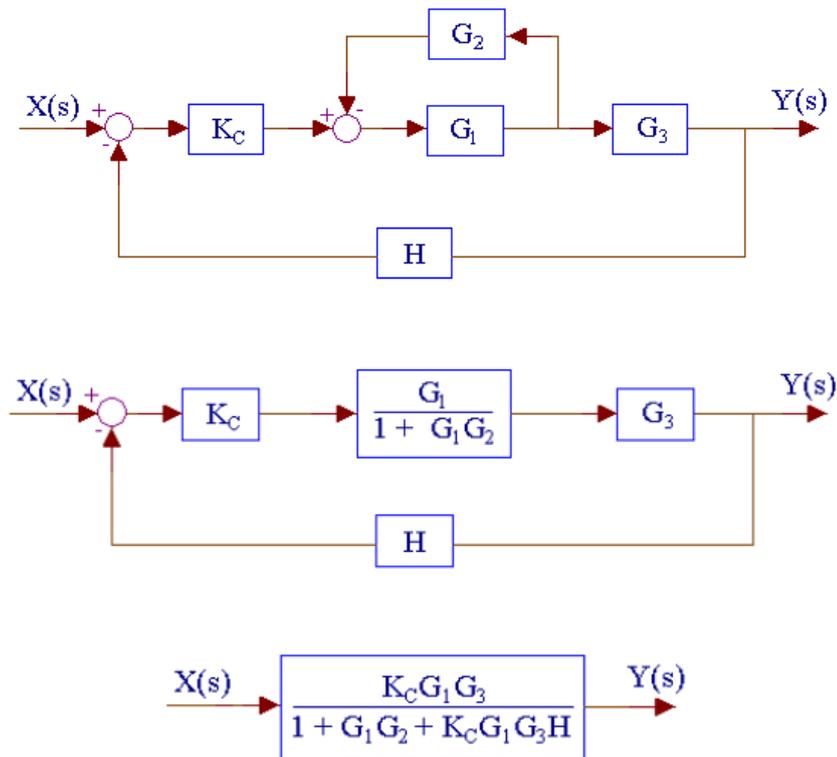
Table 2: Basic rules with block diagram transformation

	Manipulation	Original Block Diagram	Equivalent Block Diagram	Equation
1	Combining Blocks in Cascade			$Y = (G_1 G_2) X$
2	Combining Blocks in Parallel; or Eliminating a Forward Loop			$Y = (G_1 \pm G_2) X$
3	Moving a pickoff point behind a block			$y = G u$ $u = \frac{1}{G} y$
4	Moving a pickoff point ahead of a block			$y = G u$
5	Moving a summing point behind a block			$e_2 = G(u_1 - u_2)$
6	Moving a summing point ahead of a block			$y = G u_1 - u_2$
				$y = (G_1 - G_2) u$

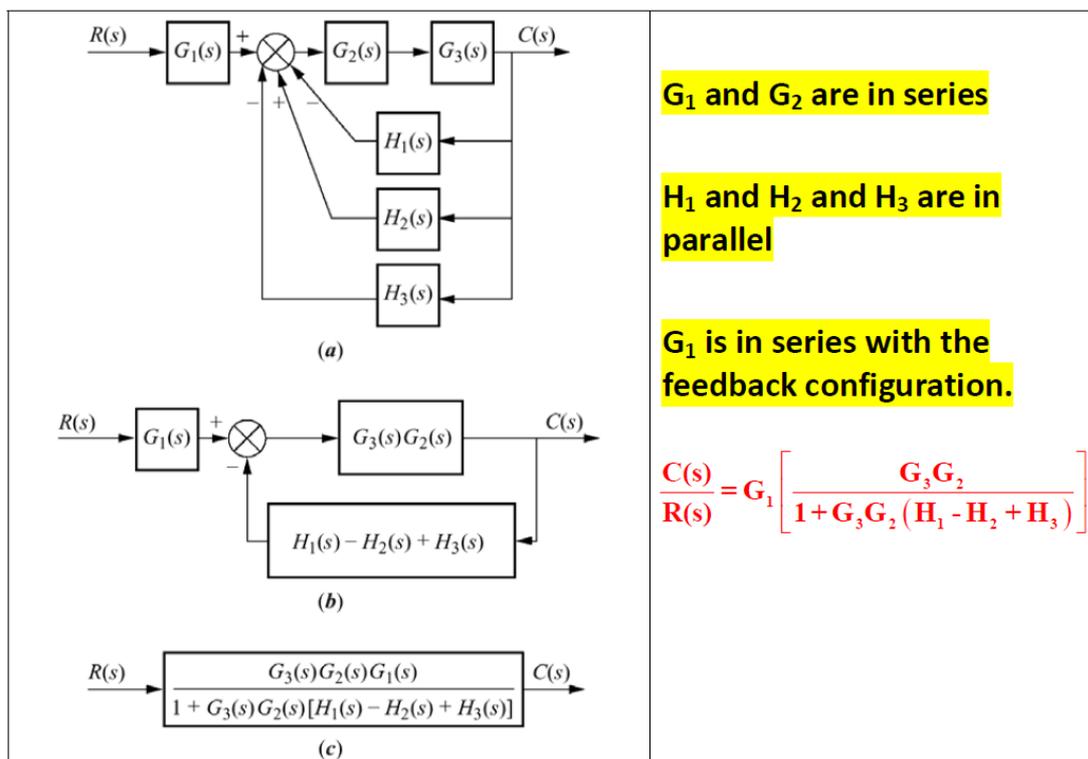
Example 1:



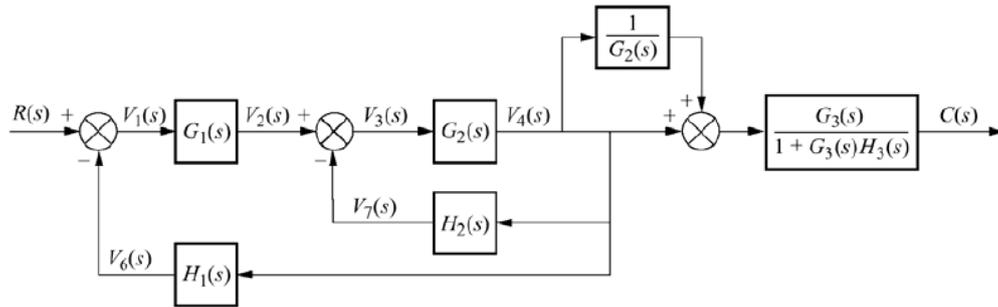
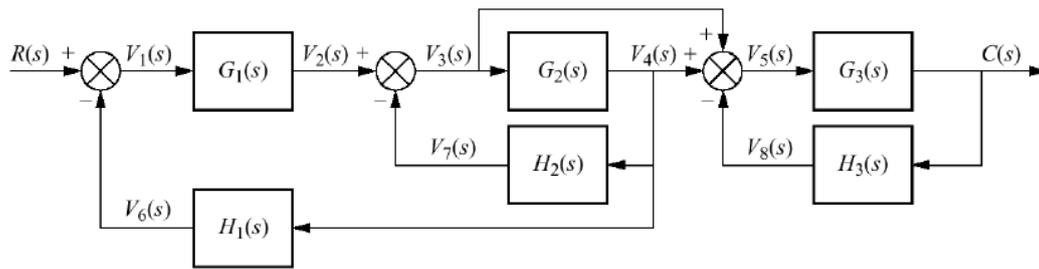
Example 2:



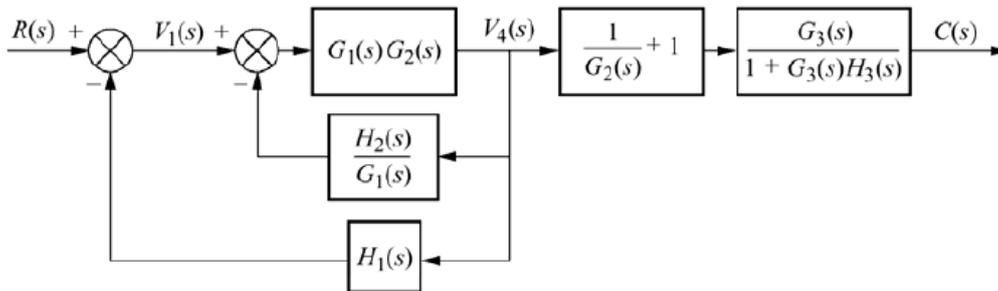
Example 3:



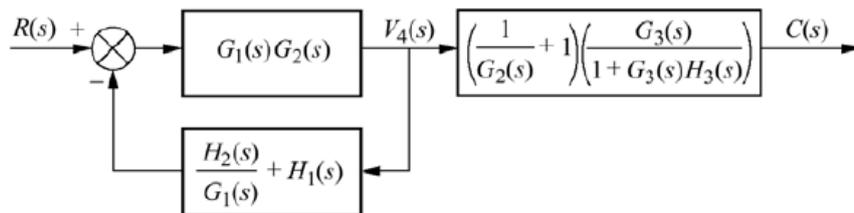
Example 4:



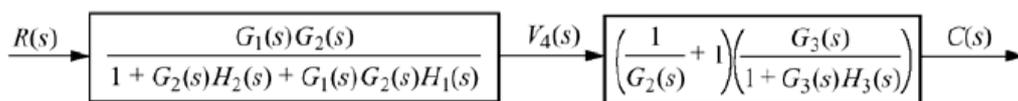
(a)



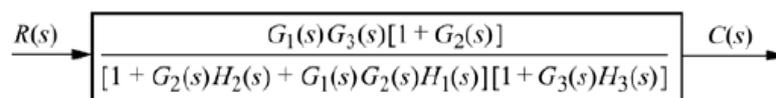
(b)



(c)



(d)



(e)

Example5:

