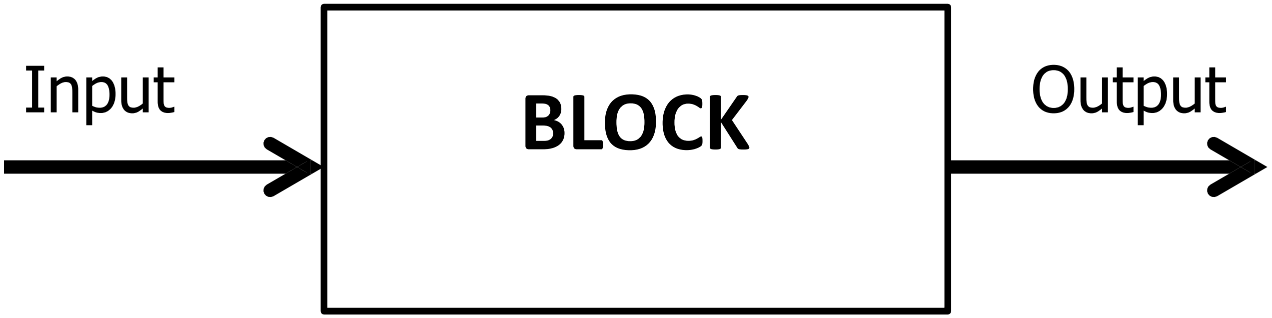
Need of Block Diagram Algebra

- To overcome this problem block diagram representation method is used.
- It is a simple way to represent any practically complicated system. In this each component of the system is represented by a separate block known as functional block.
- These blocks are interconnected in a proper sequence.

https://youtube.com/playlist?list=PLBlnK6fEyqRiiBFXtLOsvoAsPXqC8IBd8&si=2NYQxw8AFee0EjFf

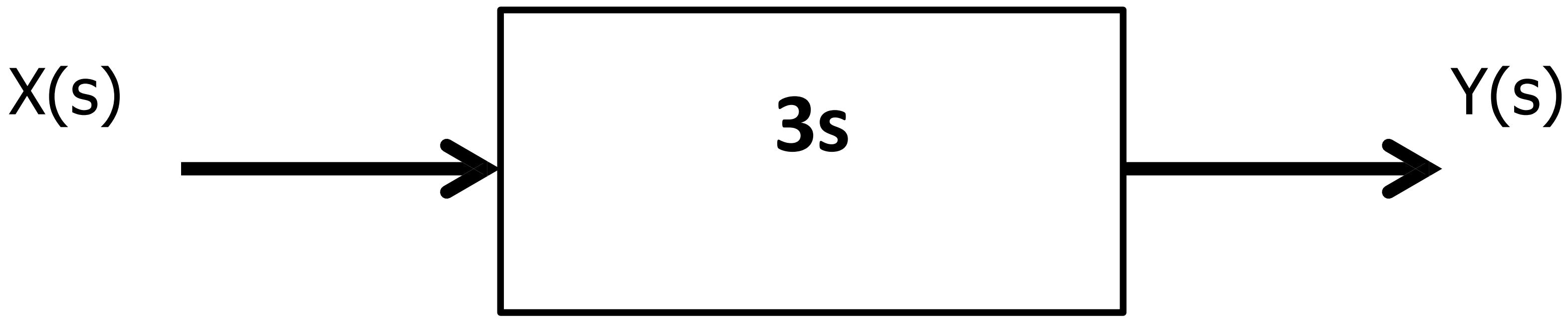
Block Diagram Fundamentals

- **Block Diagram:** It is shorthand, pictorial representation of the cause and effect relationship between input and output of a physical system.



Block Diagram Fundamentals

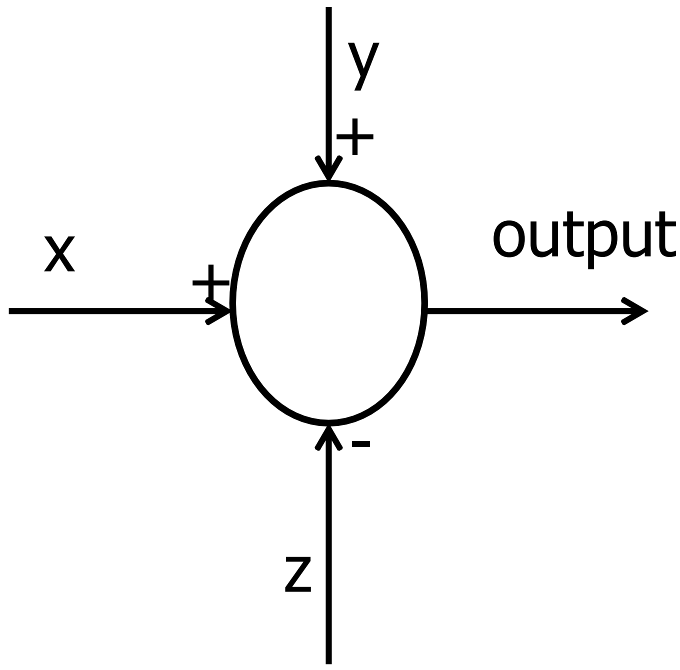
- **Output:** The value of the input is multiplied to the value of block gain to get the output.



Output $Y(s) = 3s. X(s)$

Block Diagram Fundamentals

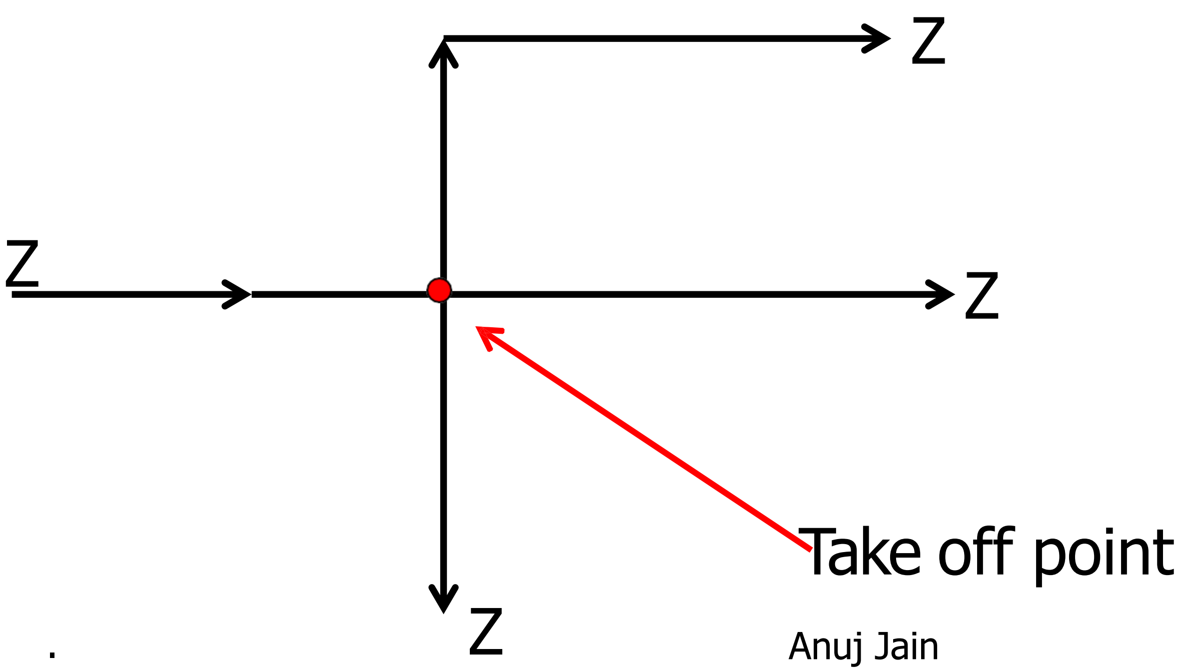
- **Summing Point:** Two or more signals can be added/ substracted at summing point.



Output =x+y-z

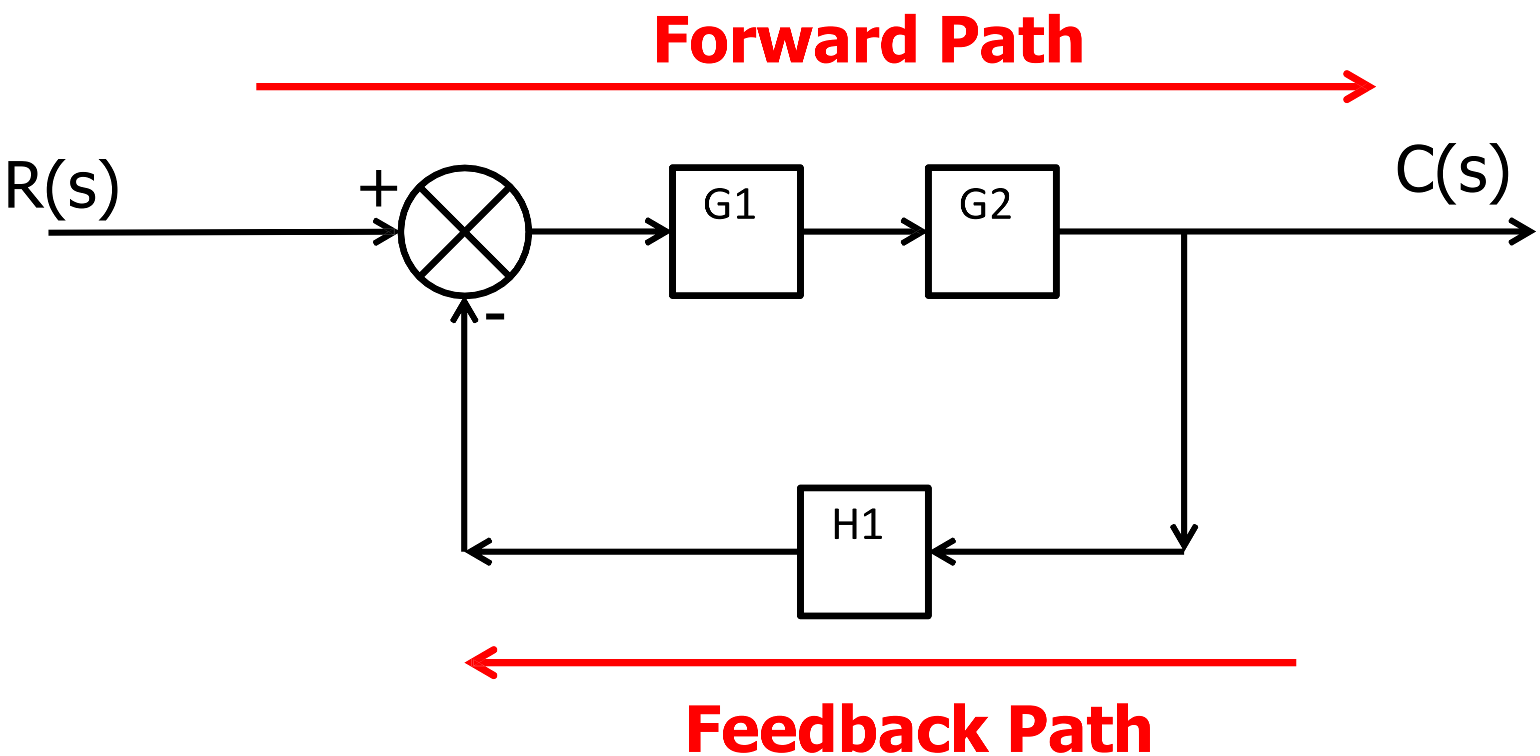
Block Diagram Fundamentals

- **<u>Take off Point:</u>** The output signal can be applied to two or more points from a take off point.



Block Diagram Fundamentals

- **Forward Path:** The direction of flow of signal is from input to output

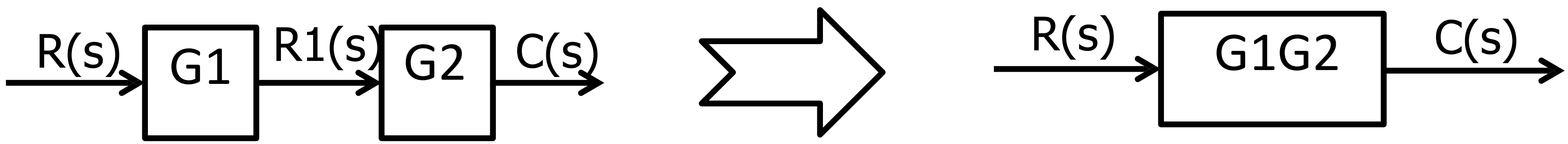


- **Feedback Path:** The direction of flow of signal is from output to input

Block Diagram Reduction Techniques

Rule 1: For blocks in cascade

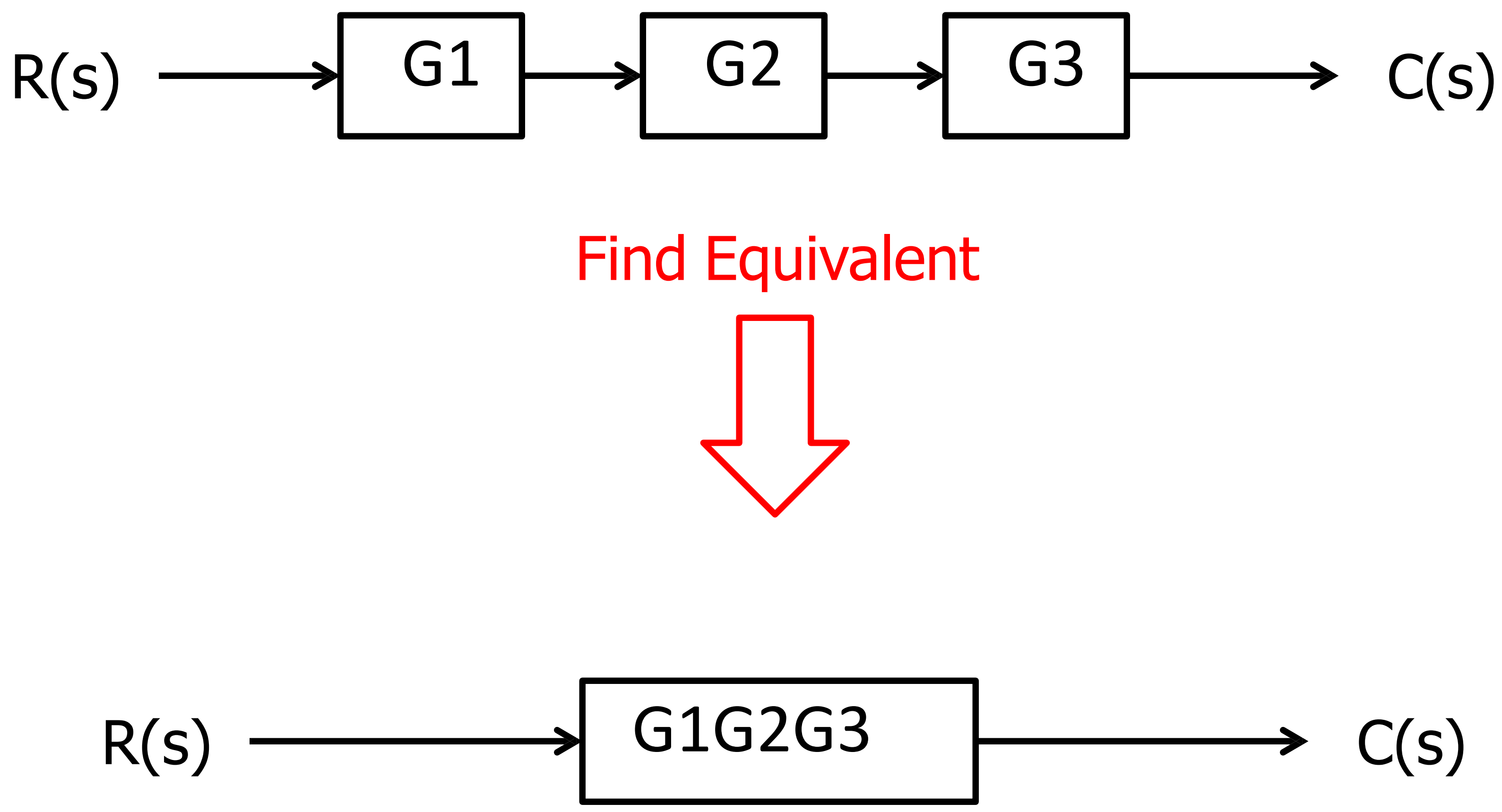
Gain of blocks connected in cascade gets multiplied with each other.

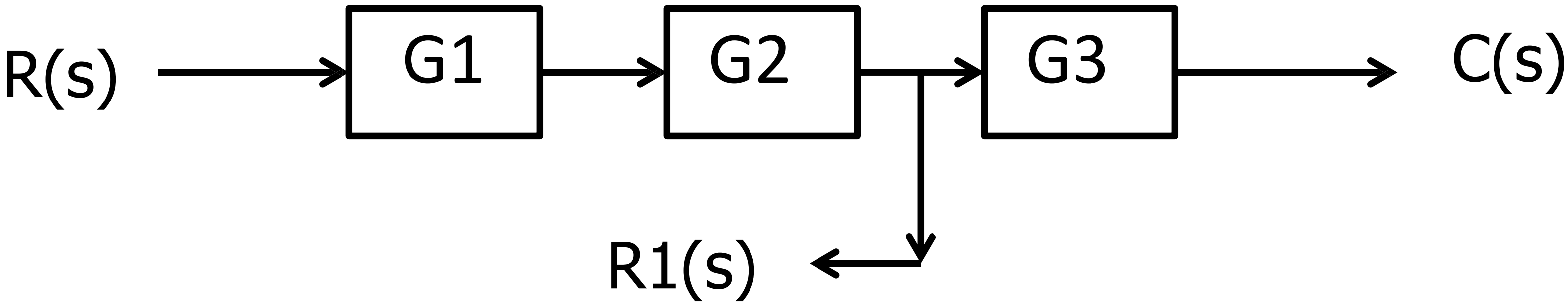


R1(s)=G1R(s)

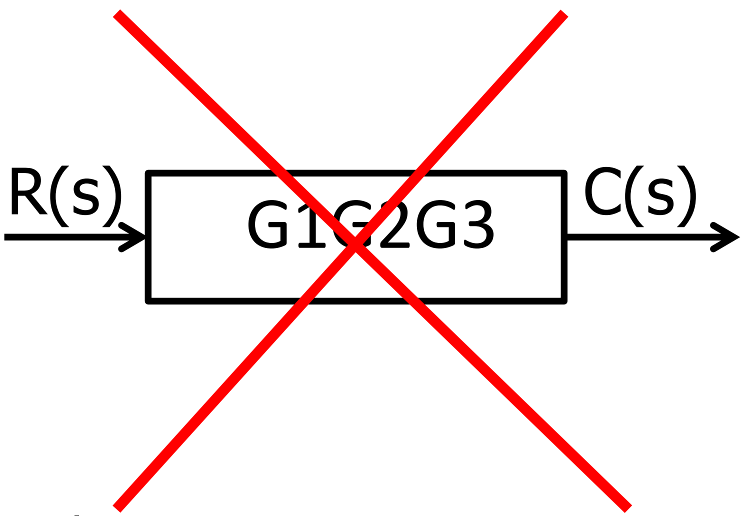
C(s) =G2R1(s)
=G1G2R(s)

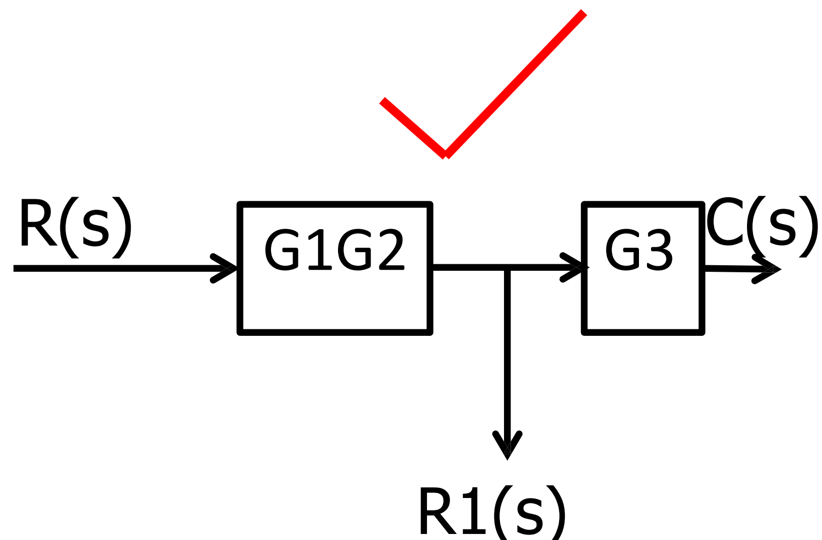
C(s)= G1G2R(s)


R(s)
G1
G2
G3
C(s)
Find Equivalent
R(s)
G1G2G3
C(s)



Find Equivalent

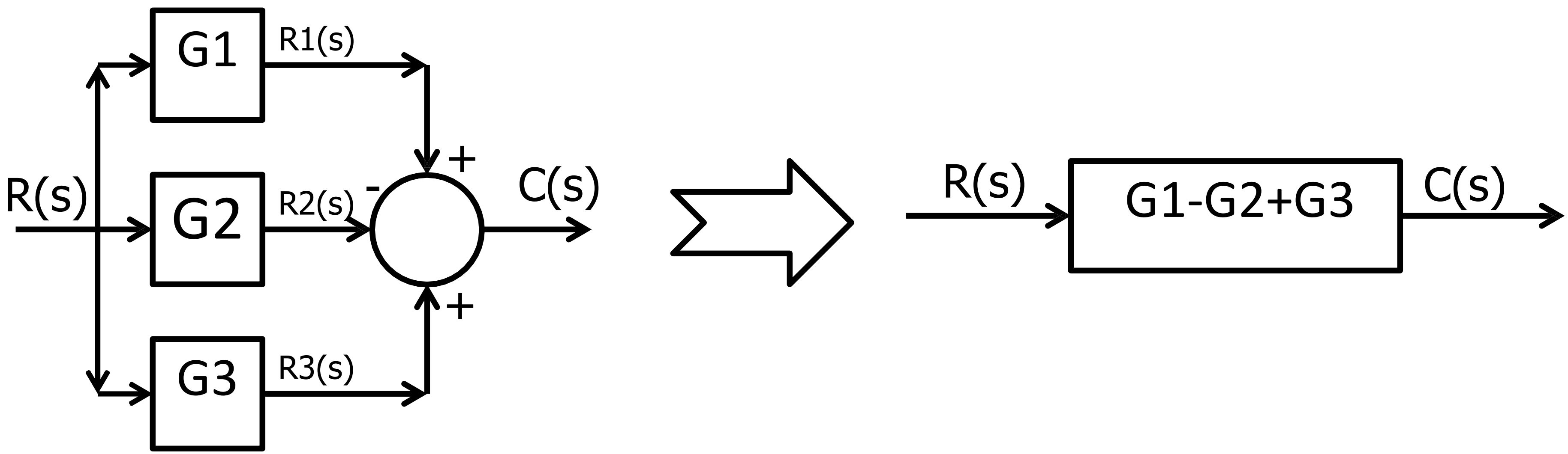




Block Diagram Reduction Techniques

Rule 2: For blocks in Parallel

Gain of blocks connected in parallel gets added algebraically.



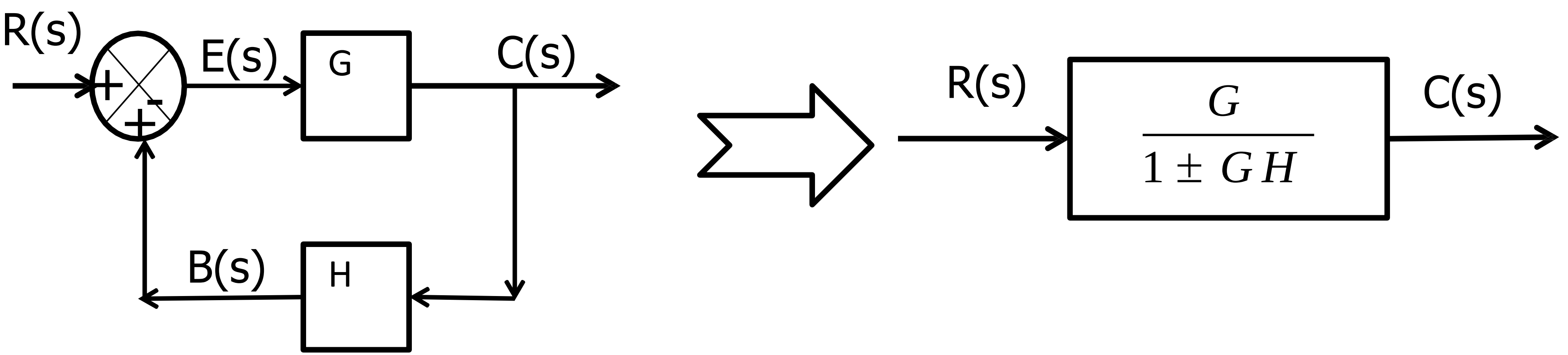
C(s)= R1(s)-R2(s)+R3(s)
= G1R(s)-G2R(s)+G3R(s)

C(s)=(G1-G2+G3) R(s)

C(s)= (G1-G2+G3) R(s)

Block Diagram Reduction Techniques

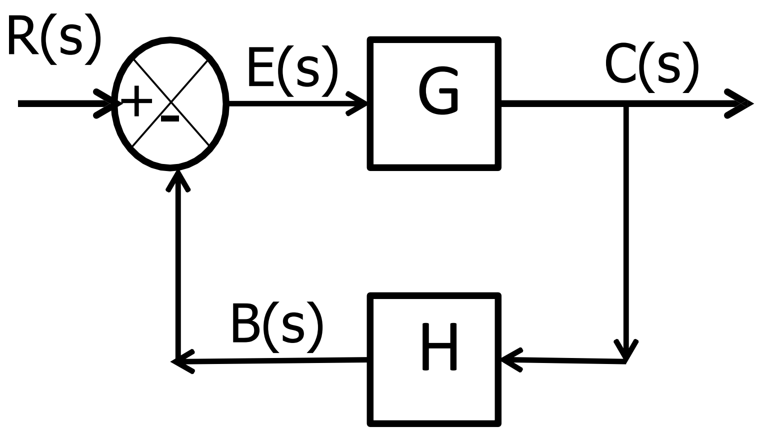
Rule 3: Eliminate Feedback Loop



$$\frac{C(s)}{R(s)} = \frac{G}{1 \pm GH}$$

In General

From Shown Figure,



$$E(s) = R(\mathrm{s}) - \mathrm{B(s)}$$

and

$$C(s) = G.E(s)$$
$$= G[\mathrm{R(s)} - \mathrm{B(s)}]$$
$$= GR(\mathrm{s}) - \mathrm{GB(s)}$$

But

$$B(s) = H.C(s)$$

$$\therefore C(s) = G.R(s) - \mathrm{G.H.C(s)}$$

$$C(s) + \mathrm{G.H} = \mathrm{GR(s)}$$

$$\therefore C(s)\{1 + \mathrm{G.H}\} = \mathrm{G.R(s)}$$

For Negative Feedback

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

From Shown Figure,

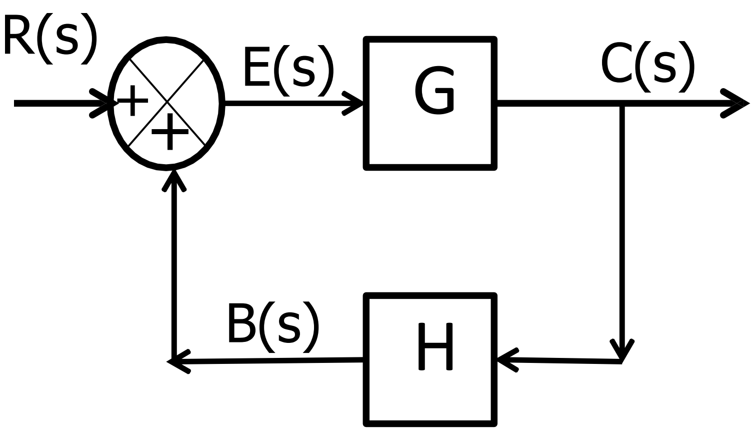
$$E(s) = R(s) + B(s)$$

and

$$C(s) = G.E(s)$$

$$= G[R(s) + B(s)]$$

$$= GR(s) + GB(s)$$



But

$$B(s) = H.C(s)$$

$$\therefore C(s) = G.R(s) + G.H.C(s)$$

$$C(s) - G.H = GR(s)$$

$$\therefore C(s)\{1 - G.H\} = G.R(s)$$

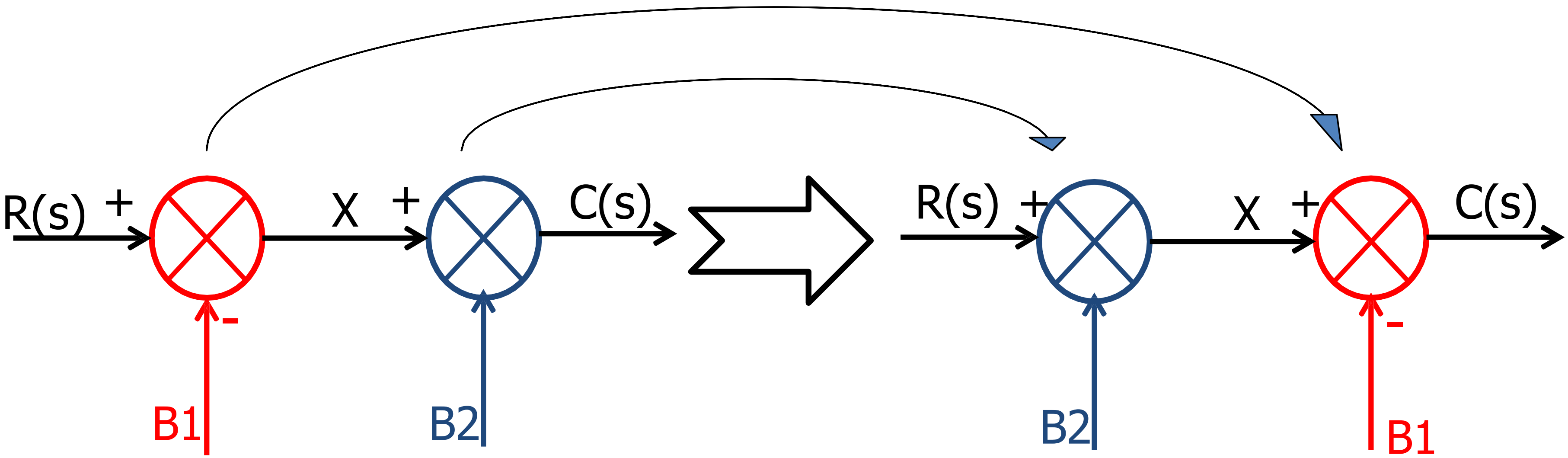
$$\therefore \frac{C(s)}{R(s)} = \frac{G}{1 - GH}$$

For Positive Feedback

Block Diagram Reduction Techniques

Rule 4: Associative Law for Summing Points

The order of summing points can be changed if two or more summing points are in series

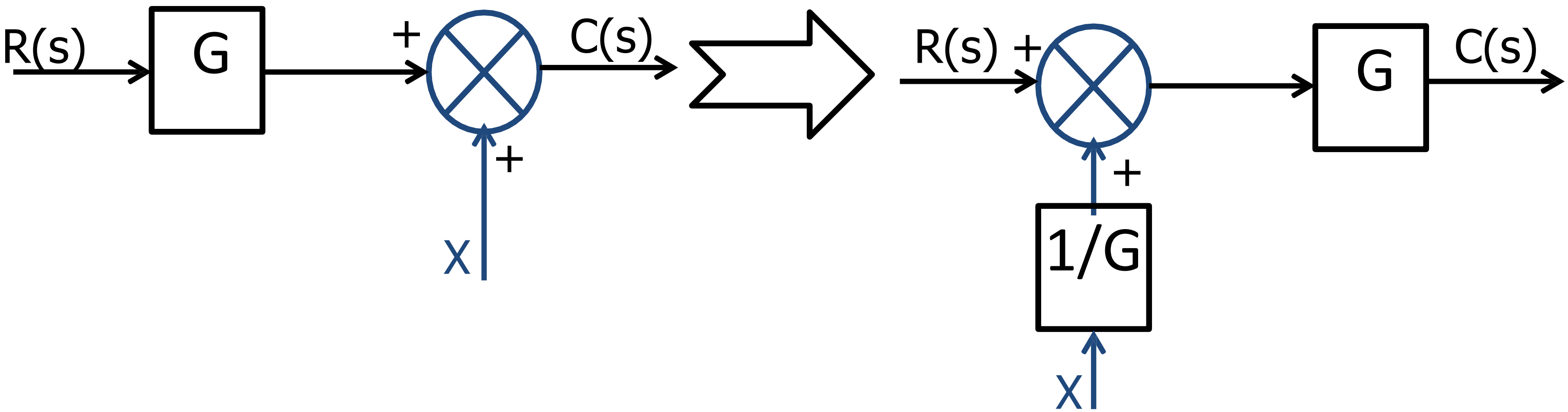


X=R(s)-B1
C(s)=X-B2
C(s)=R(s)-B1-B2

X=R(s)-B2
C(s)=X-B1
C(s)=R(s)-B2-B1

Block Diagram Reduction Techniques

Rule 5: Shift summing point before block

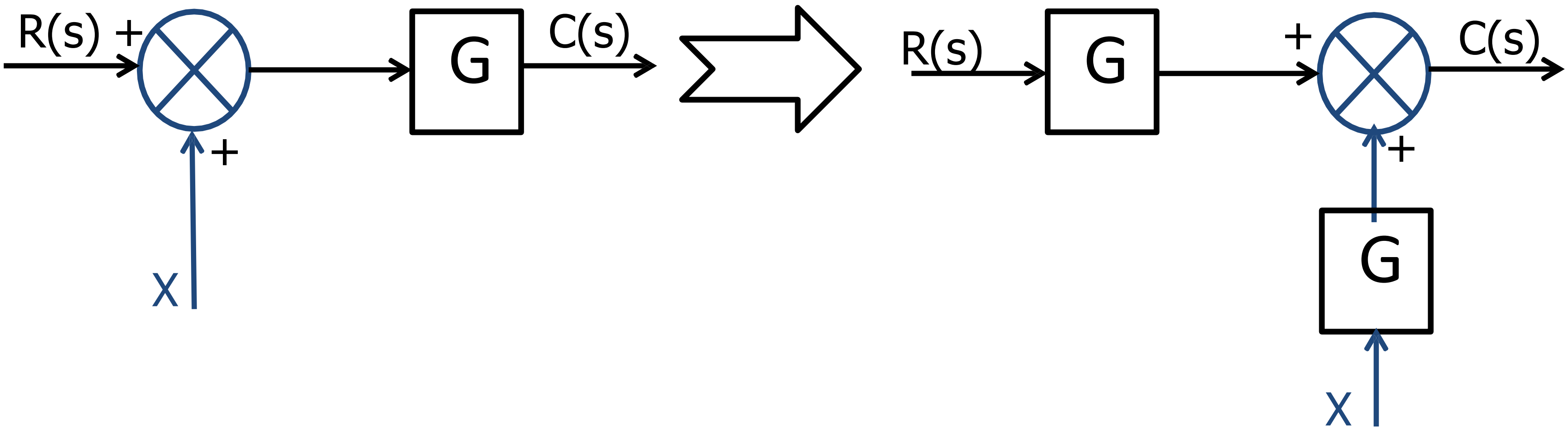


$C(s) = R(s)G + X$

$$C(s) = G\{R(s) + X/G\}$$
$$= GR(s) + X$$

Block Diagram Reduction Techniques

Rule 6: Shift summing point after block

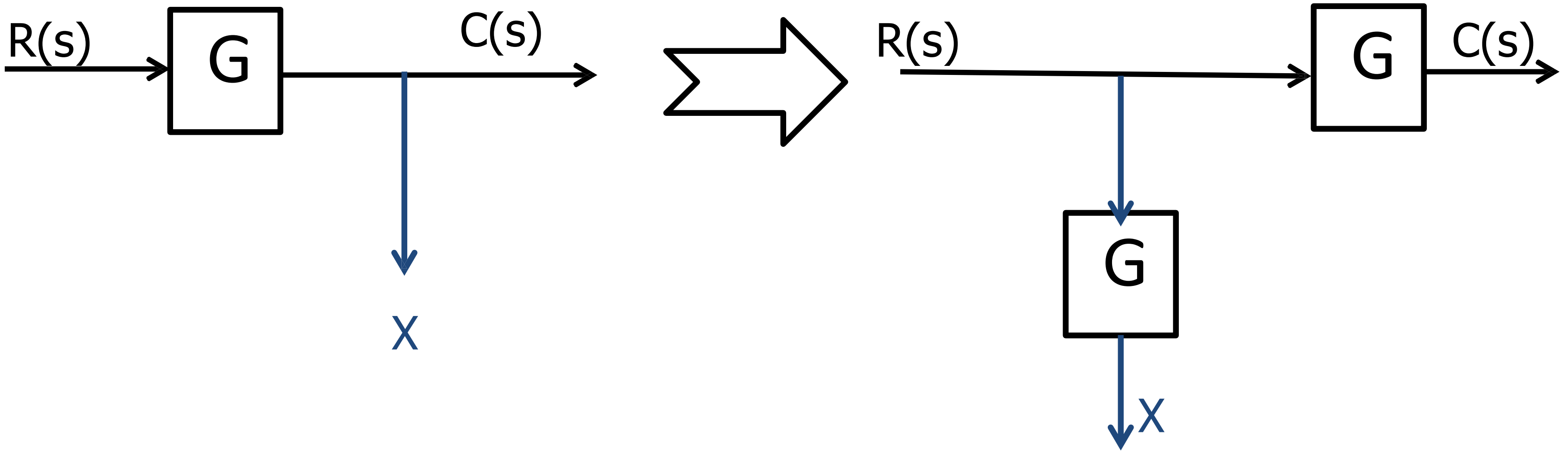


C(s)=G{R(s)+X}
=GR(s)+GX

C(s)=GR(s)+XG
=GR(s)+XG

Block Diagram Reduction Techniques

Rule 7: Shift a take off point before block

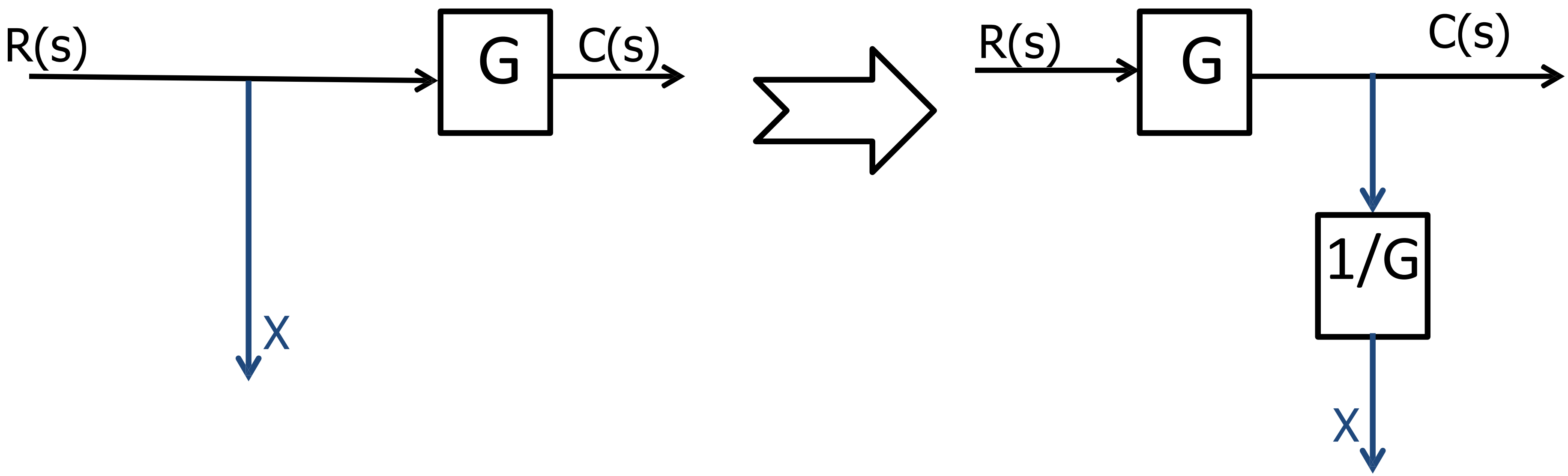


C(s)=GR(s)
and
X=C(s)=GR(s)

C(s)=GR(s)
and
X=GR(s)

Block Diagram Reduction Techniques

Rule 8: Shift a take off point after block



C(s)=GR(s)

and

X=R(s)

C(s)=GR(s)

and

X=C(s).{1/G}

=GR(s).{1/G}

= R(s)

Block Diagram Reduction Techniques

- While solving block diagram for getting single block equivalent, the said rules need to be applied. After each simplification a decision needs to be taken. For each decision we suggest preferences as

Block Diagram Reduction Techniques

First Choice

First Preference: Rule 1 (For series)

Second Preference: Rule 2 (For parallel)

Third Preference: Rule 3 (For FB loop)

Second Choice

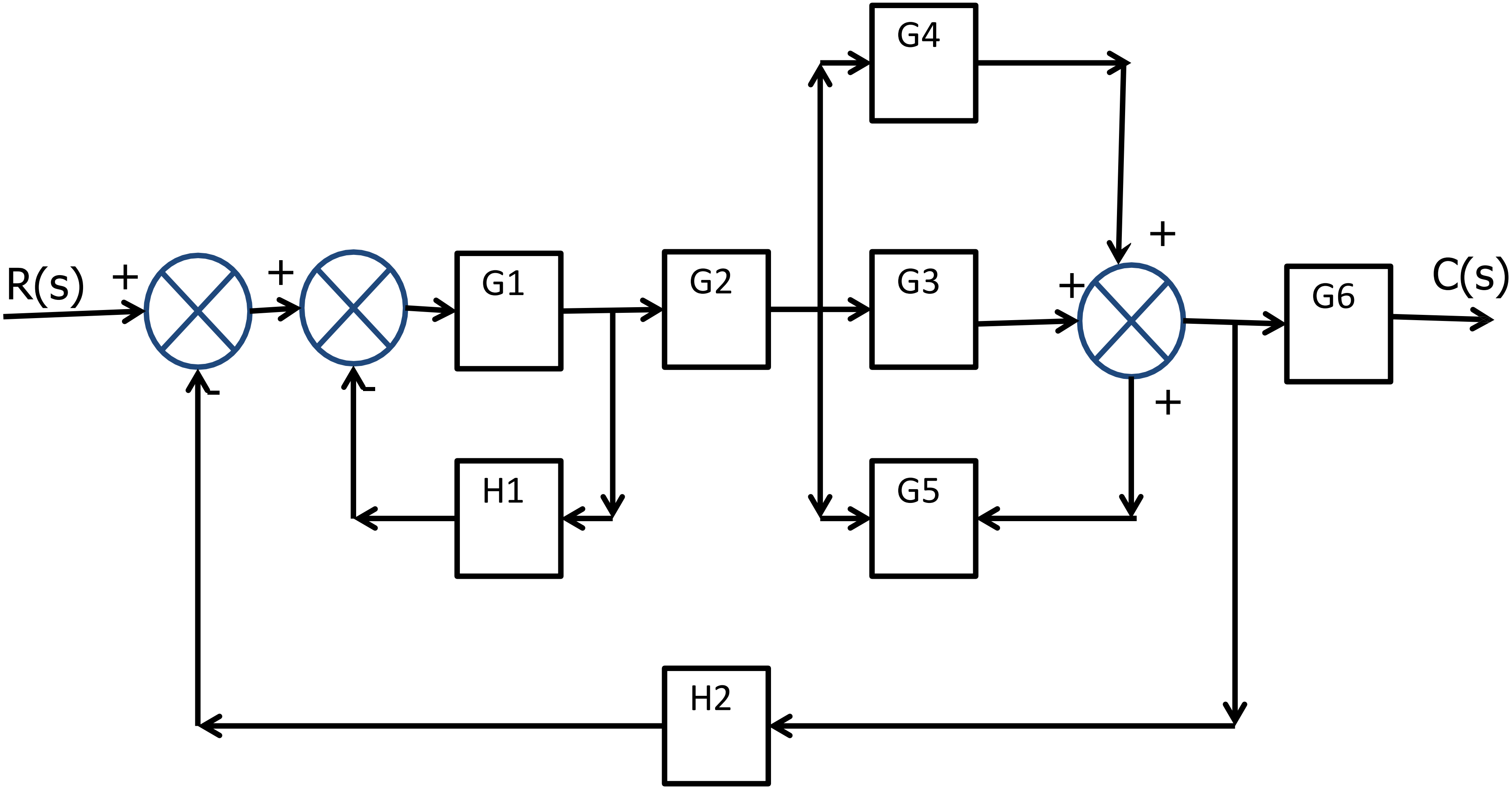
(Equal Preference)

Rule 4 Adjusting summing order

Rule 5/6 Shifting summing point before/after block

Rule7/8 Shifting take off point before/after block

Example 1

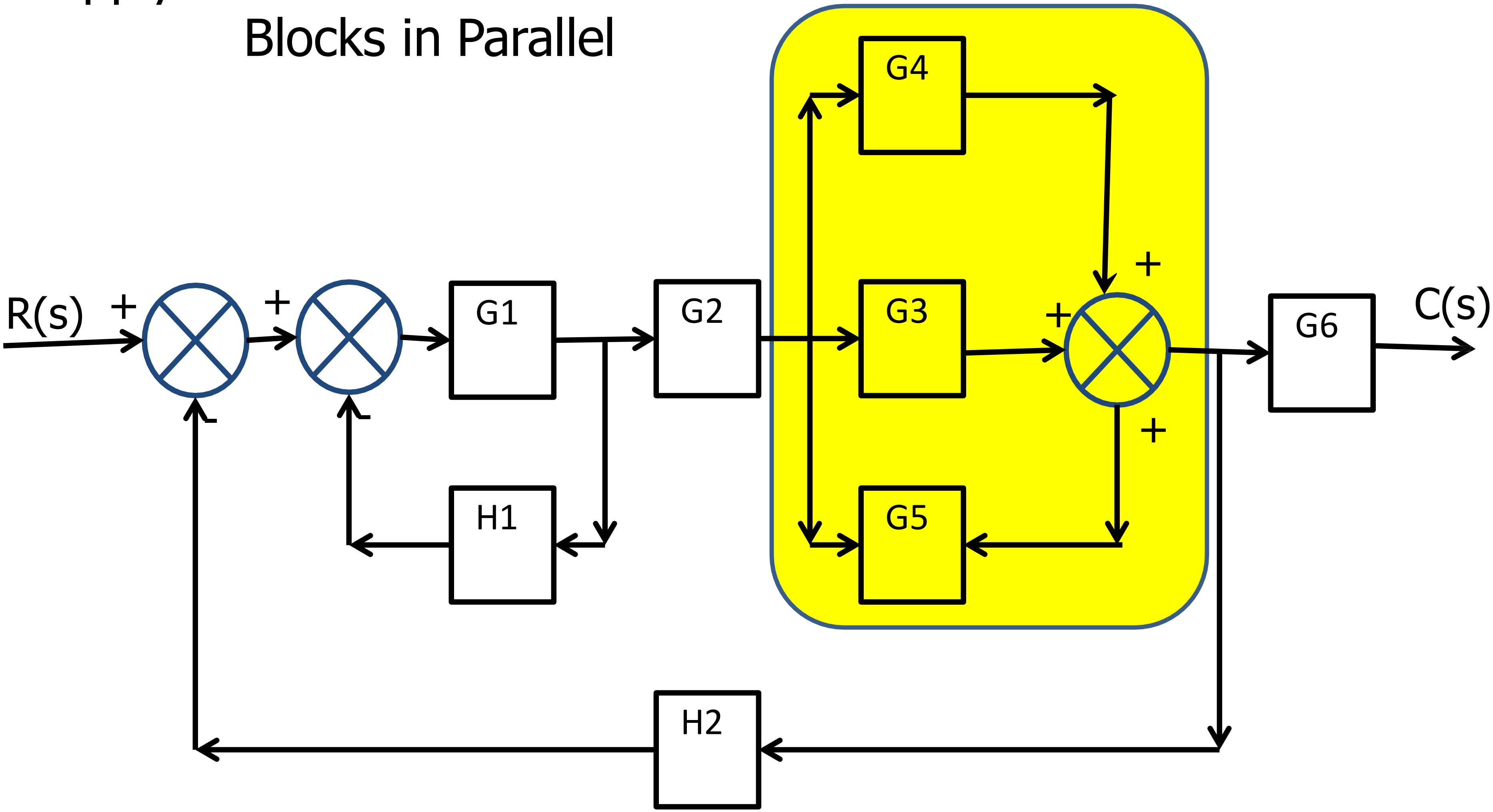


- Rule 1 cannot be used as there are no immediate series blocks.
- Hence Rule 2 can be applied to G4, G3, G5 in parallel to get an equivalent of G3+G4+G5

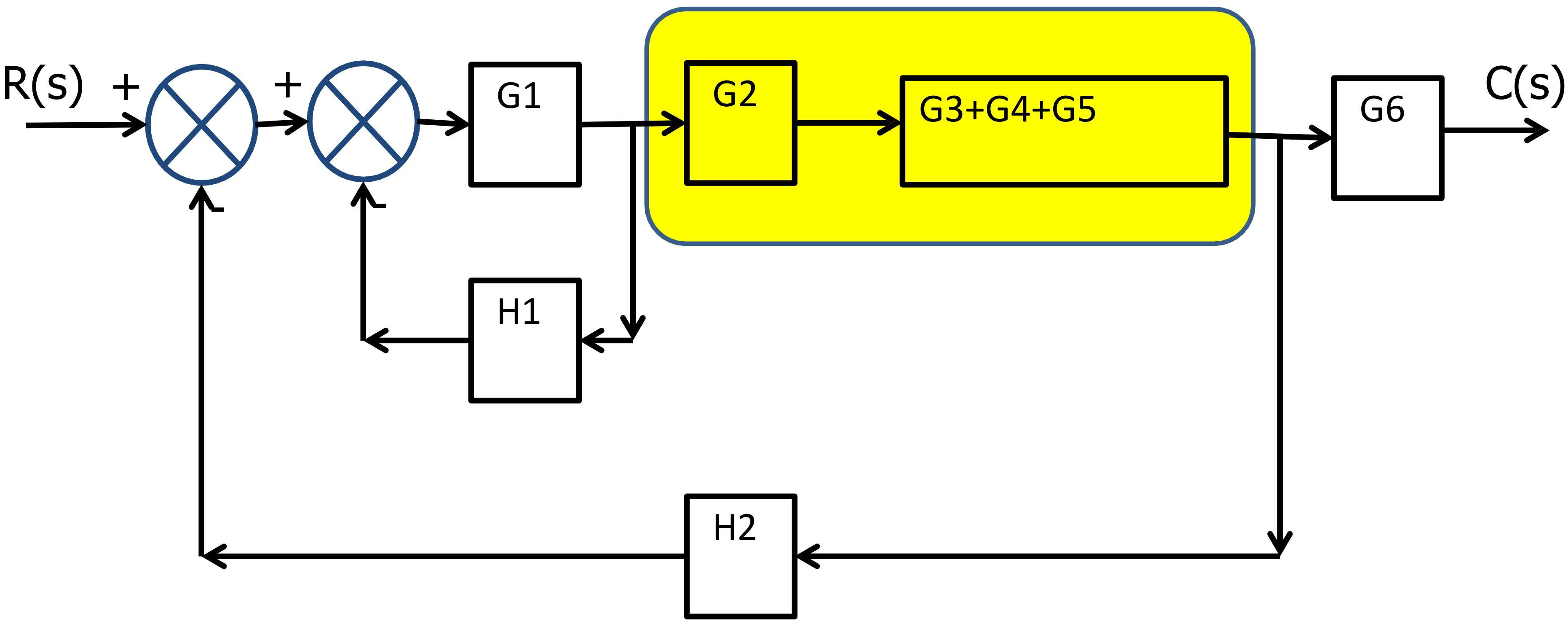
Example 1 cont….

Apply Rule 2

Blocks in Parallel

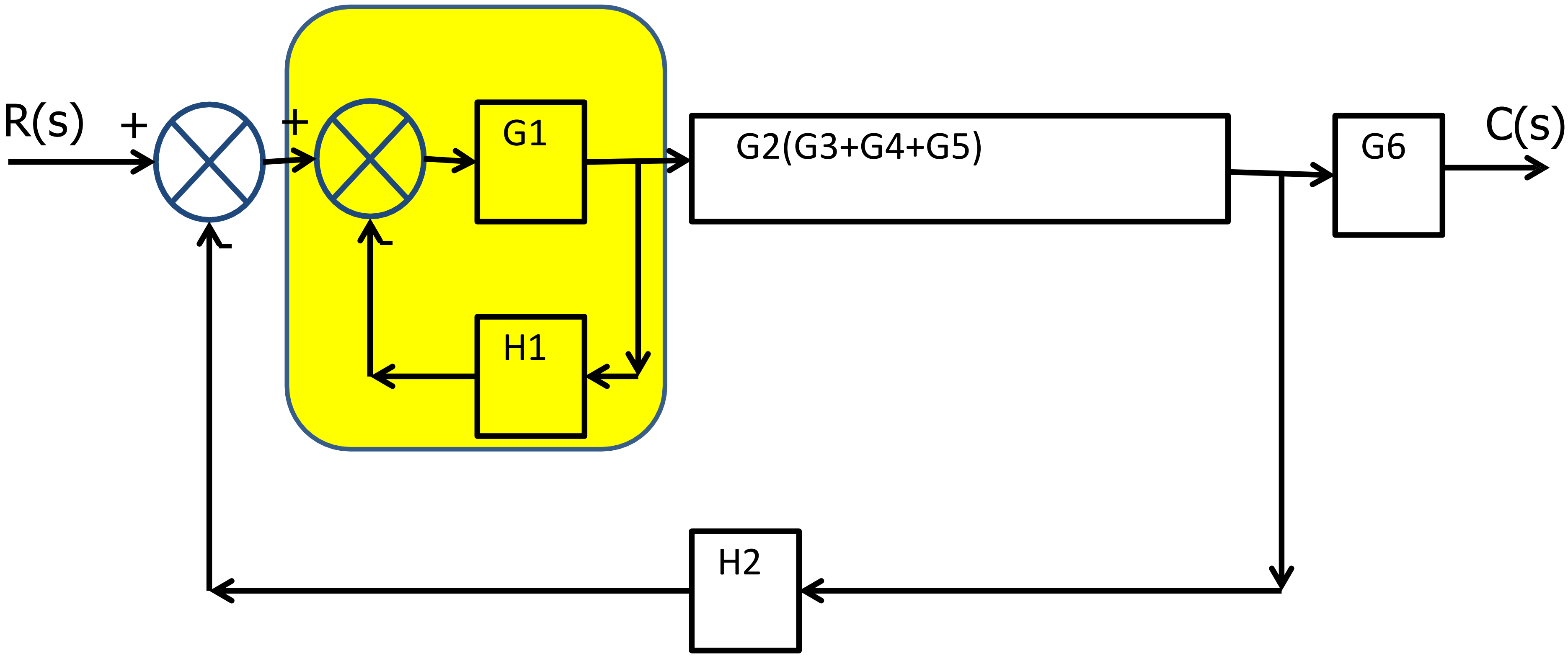


Apply Rule 1 Blocks in series



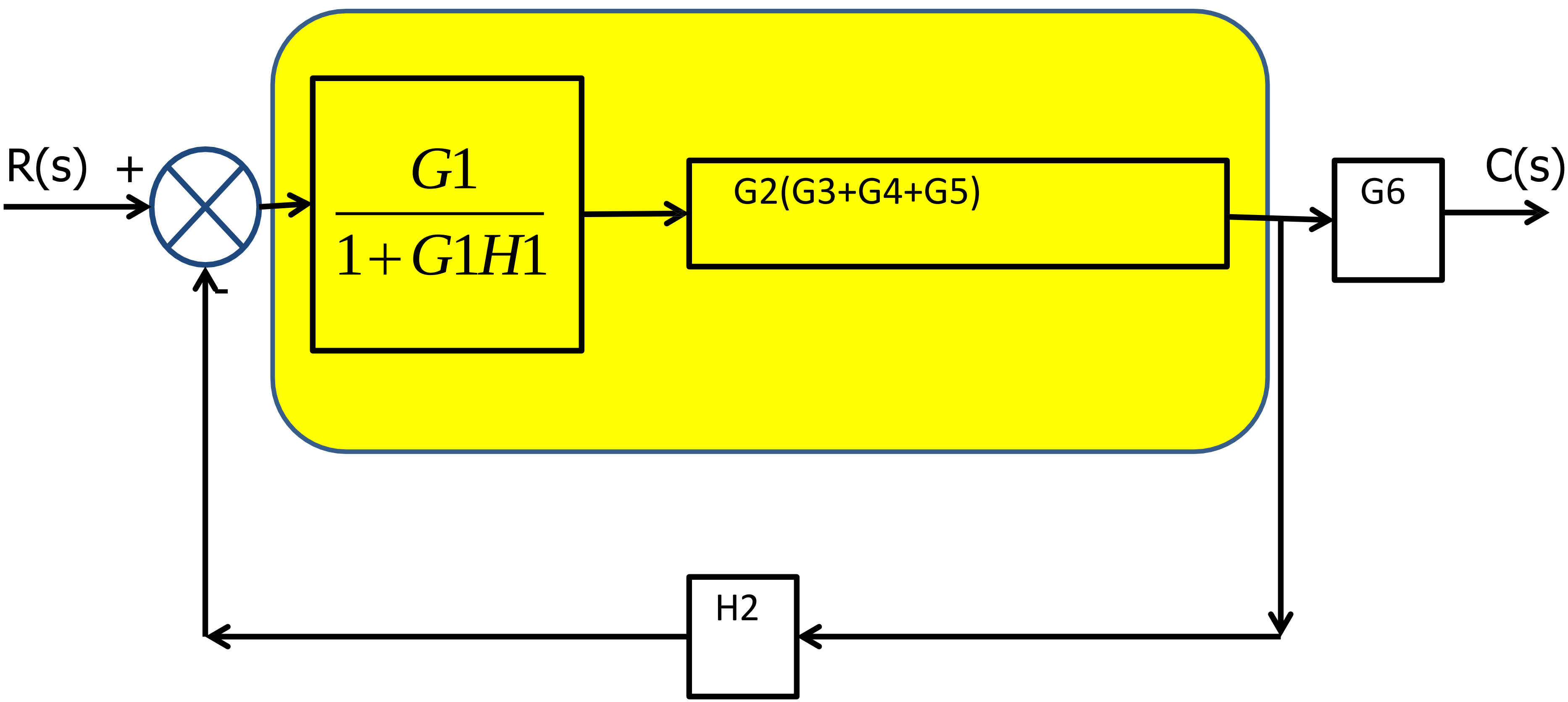
Example 1 cont….

Apply Rule 3 Elimination of feedback loop



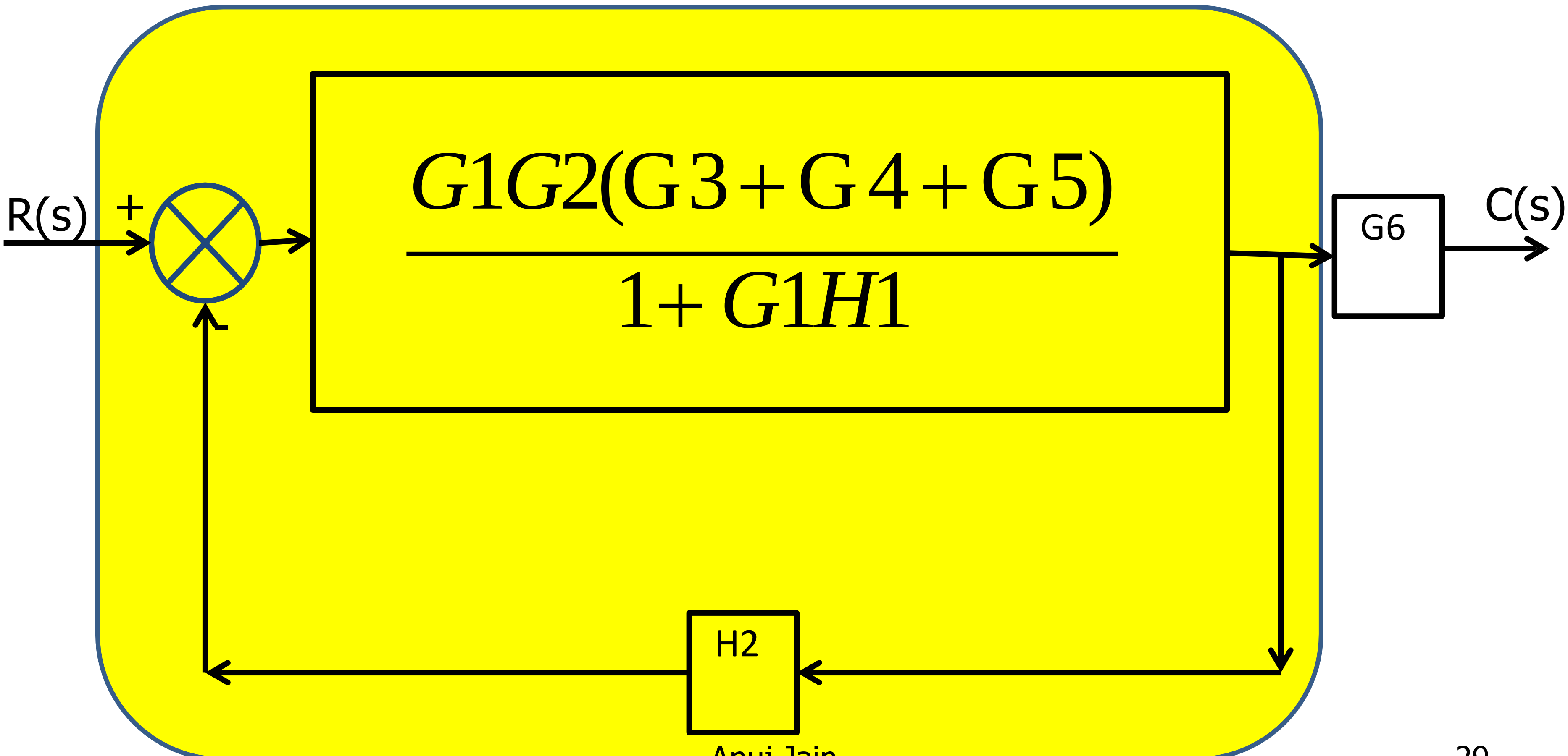
Example 1 cont….

Apply Rule 1 Blocks in series



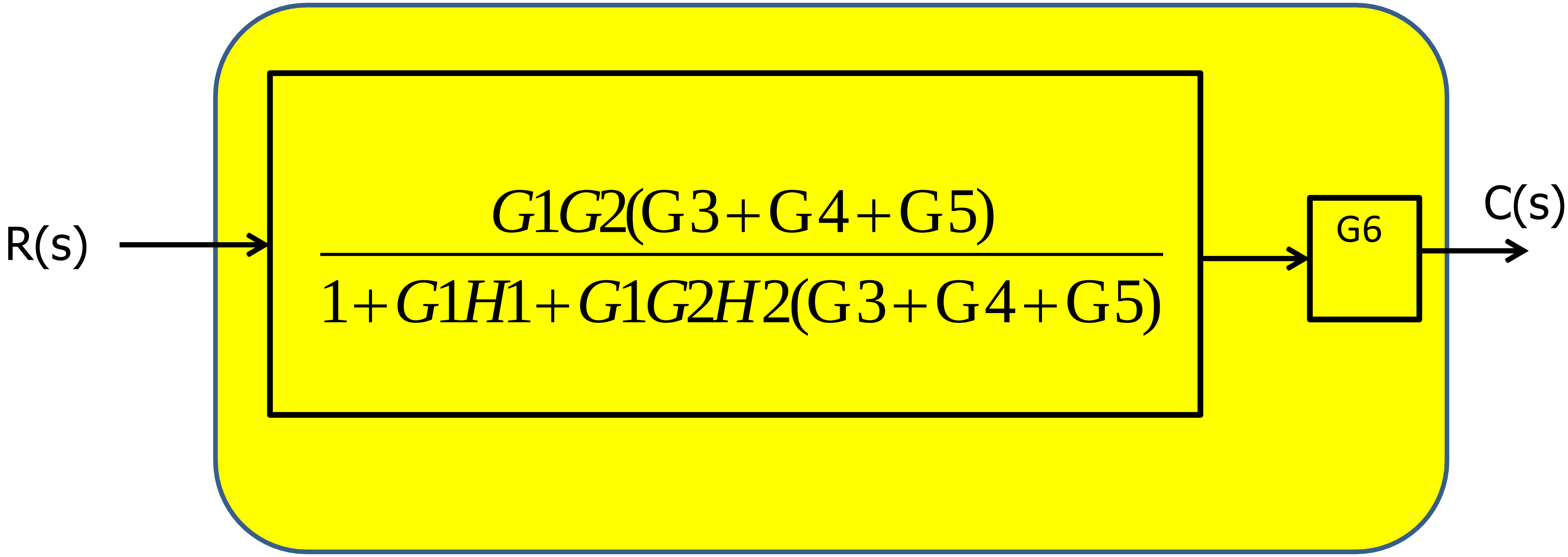
Example 1 cont….

Apply Rule 3 Elimination of feedback loop

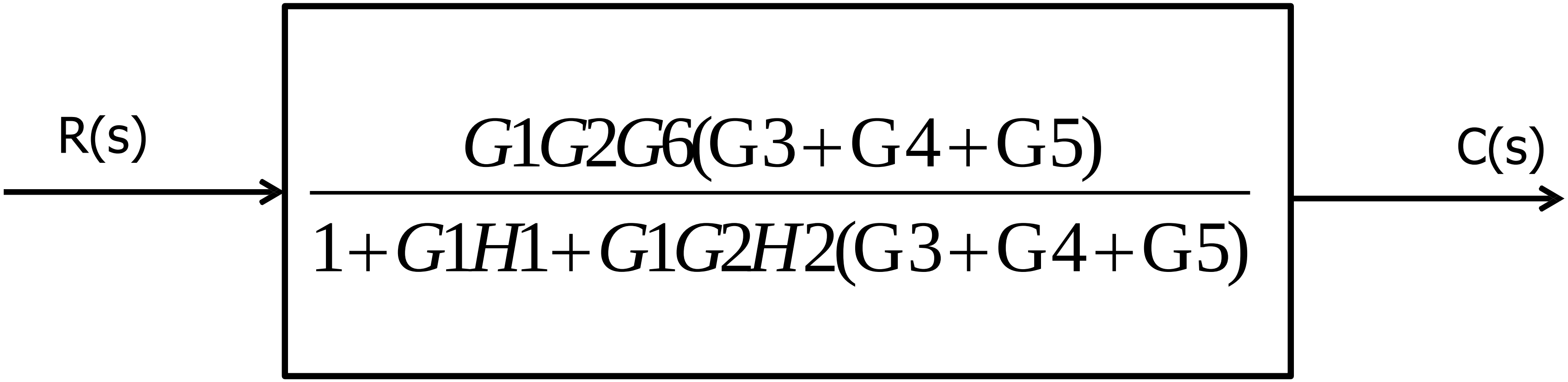


Example 1 cont….

Apply Rule 1 Blocks in series



Example 1 cont….



Example 1 cont….

$$\frac{C(s)}{R(s)} = \frac{G1G2G6(G3+G4+G5)}{1+G1H1+G1G2H2(G3+G4+G5)}$$