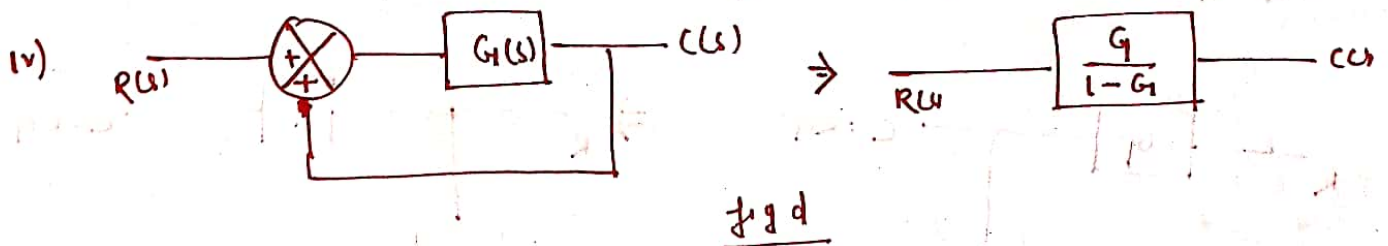
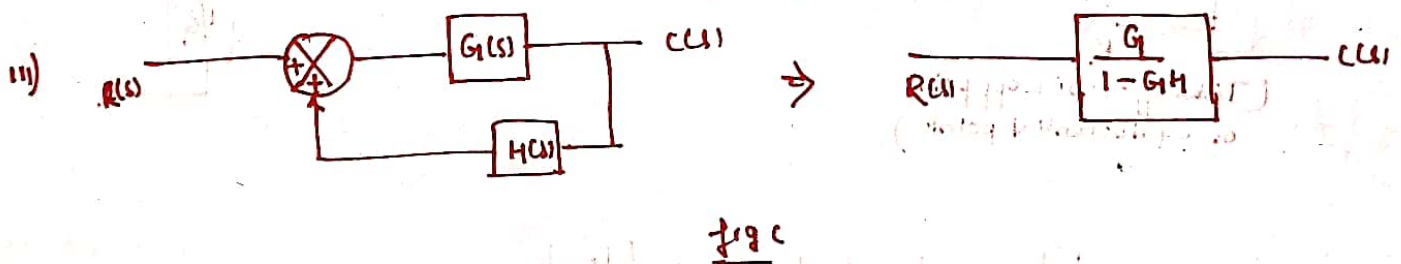
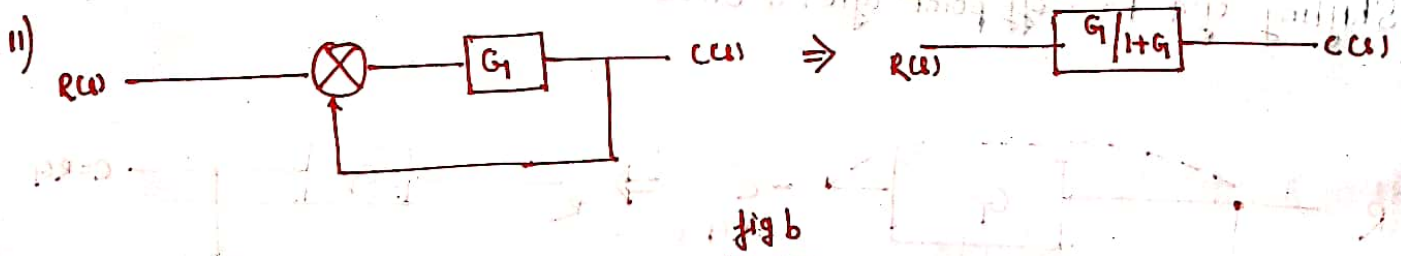
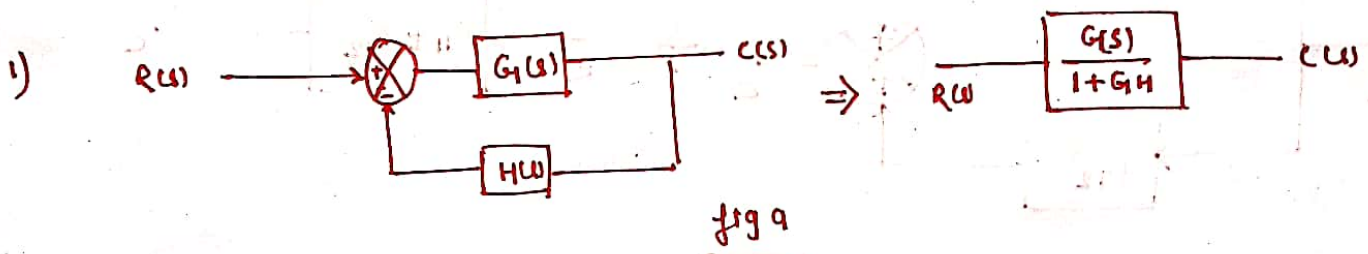


Block Diagram

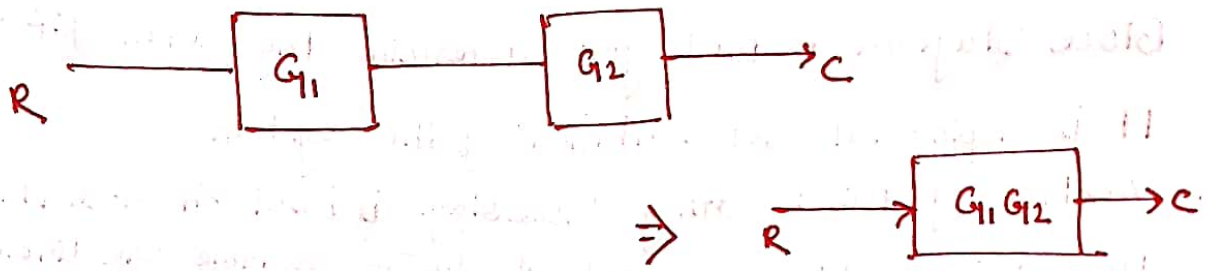
1. Block Diagram is used for determine the overall T.f of the system.
2. It is a pictorial representation of the system.
3. Analysis of T.f by using Block Diag. is based on Block Diag. Reduction rule.
4. In a Block Diag. representⁿ all system Variable are linked to each other through functional block.

* Block Diagram Reduction Rules:-

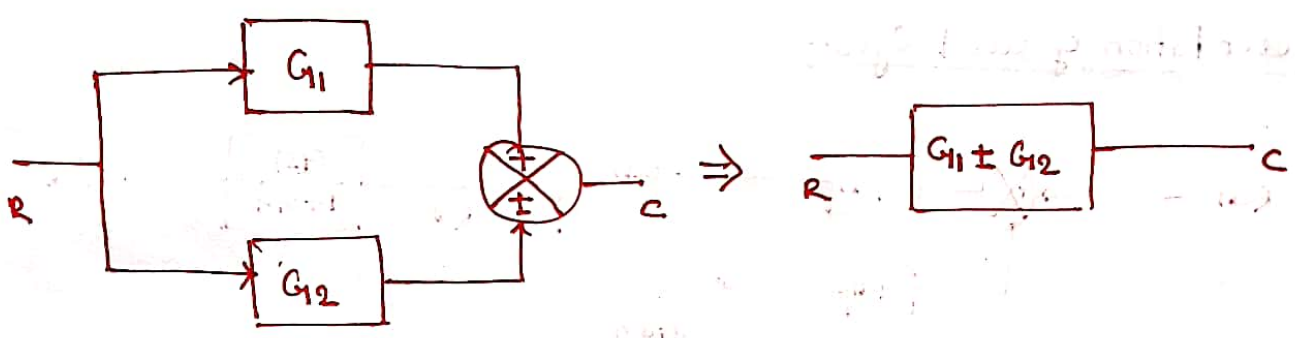
1. Representation of closed system:-



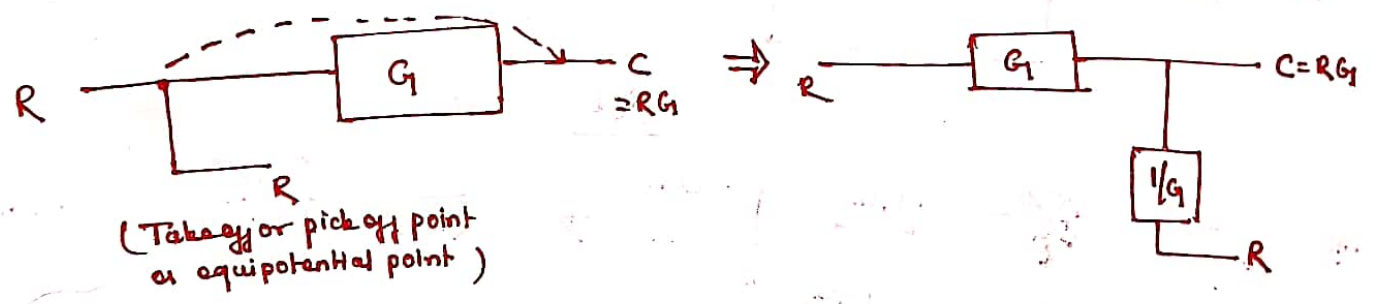
2. Blocks are Connected in Series / Cascade :



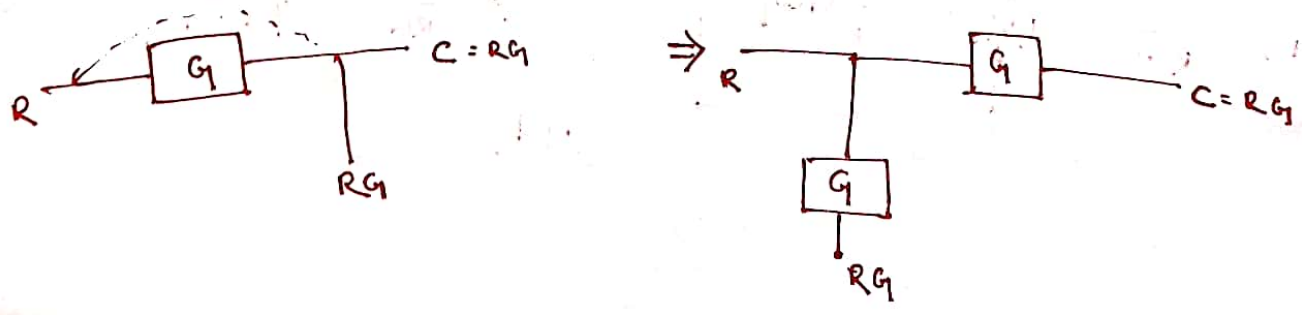
3. Blocks are Connected in parallel :



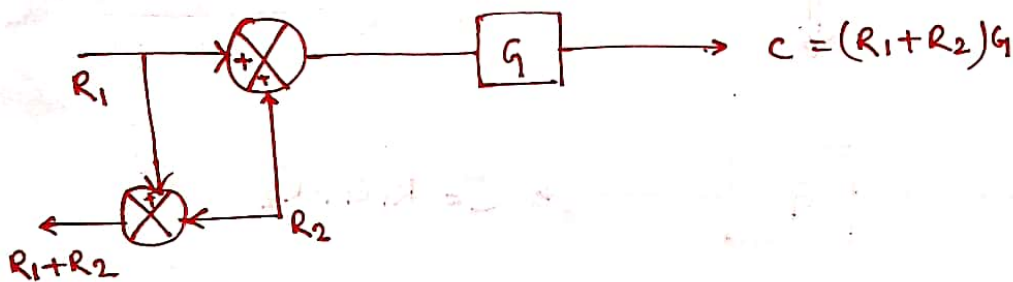
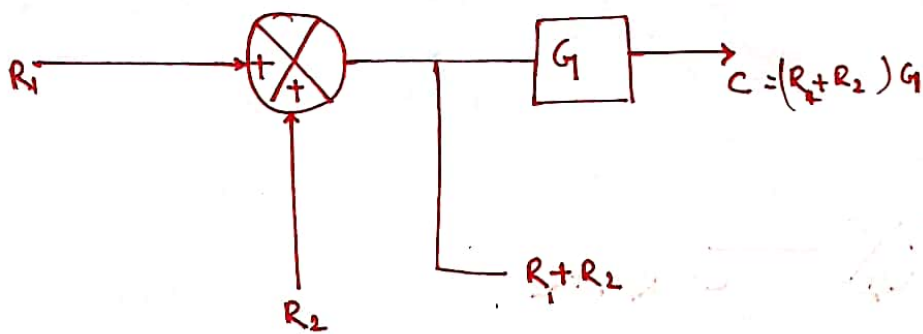
4. Shifting of a take off point after a Block :



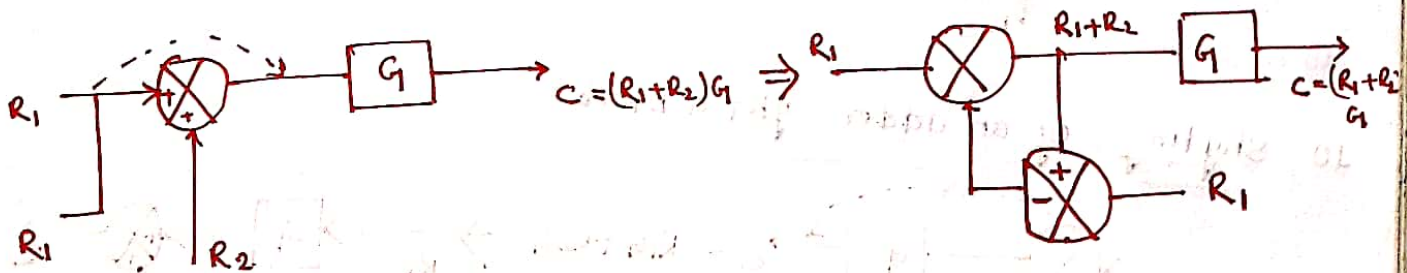
5. Shifting of a take off point before a block



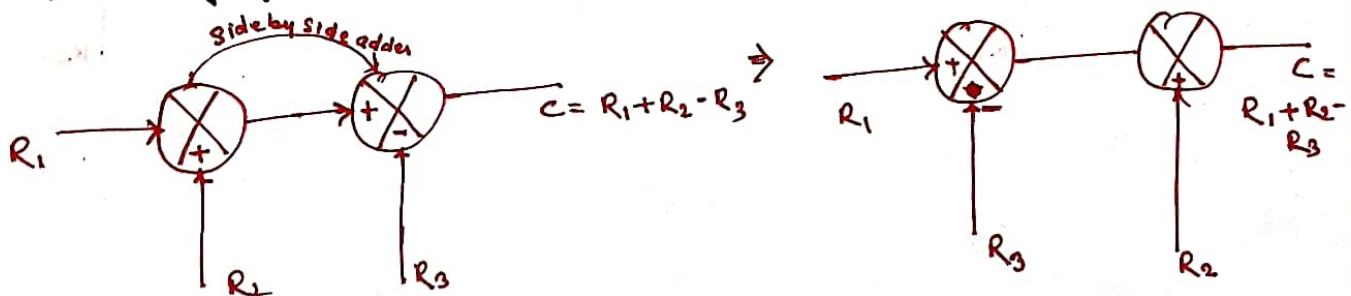
6. Shifting of a takeoff point before an Adder



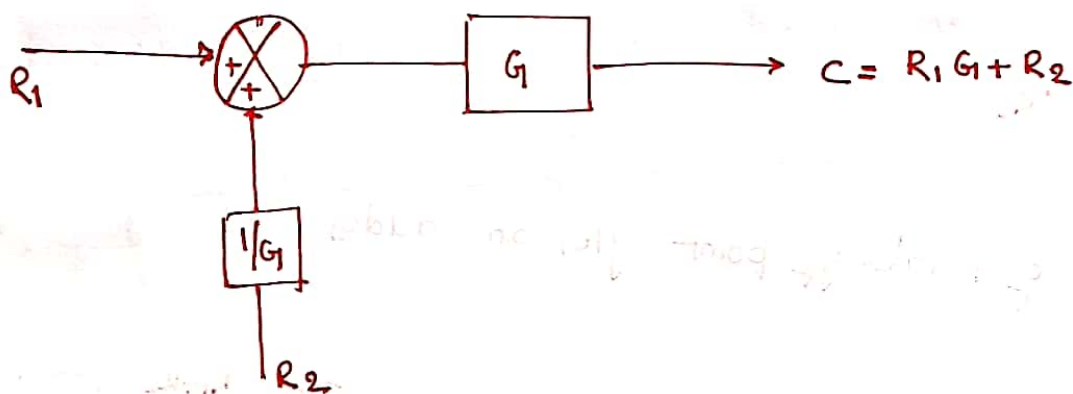
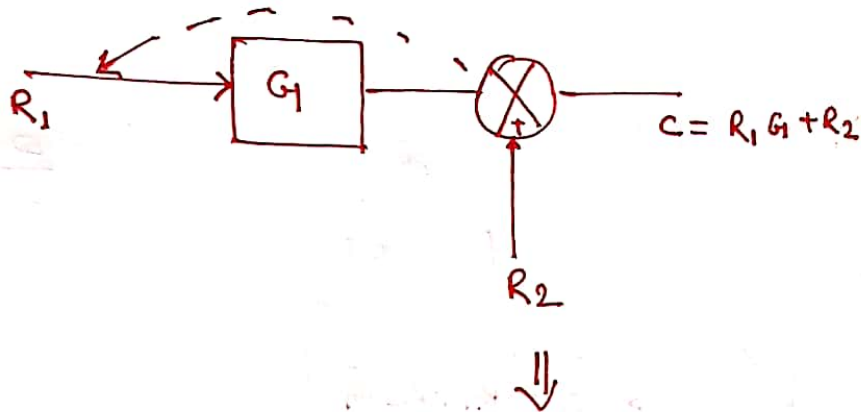
7. Shifting of a takeoff point after an adder



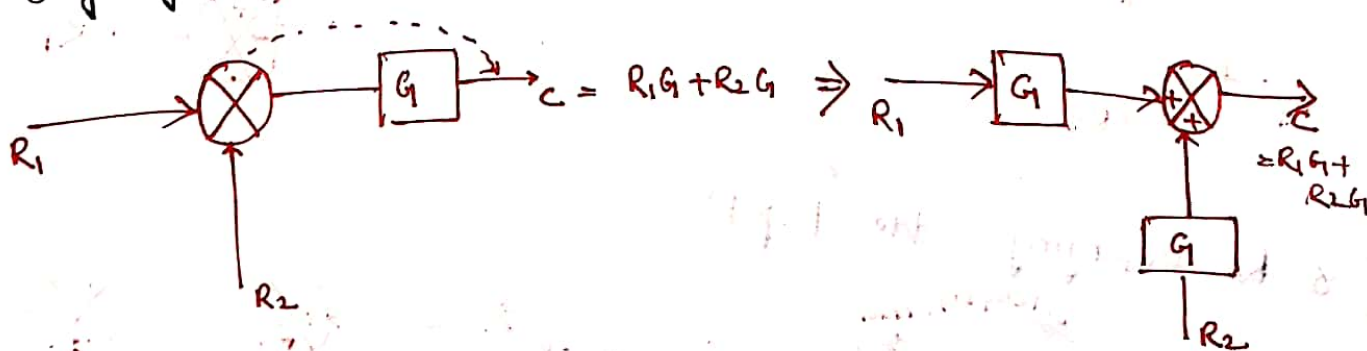
8. Re-arranging adder input



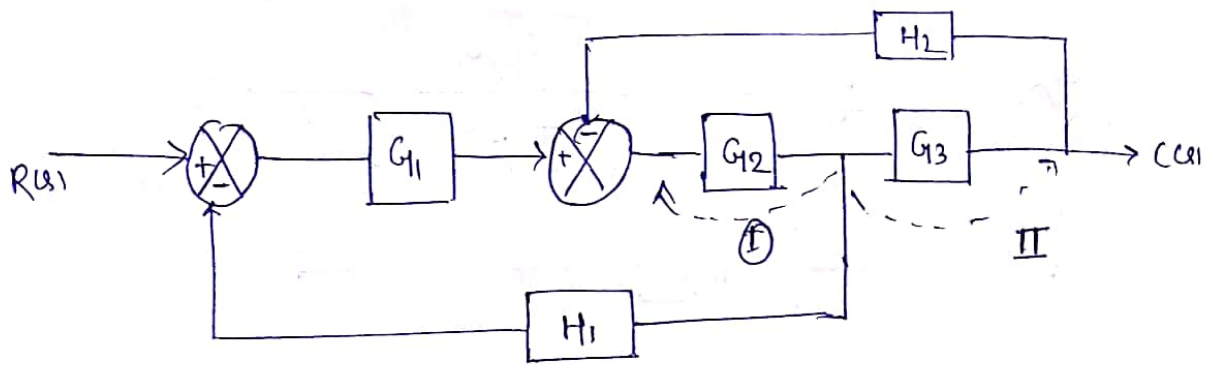
9. Shifting of an adder before a block:



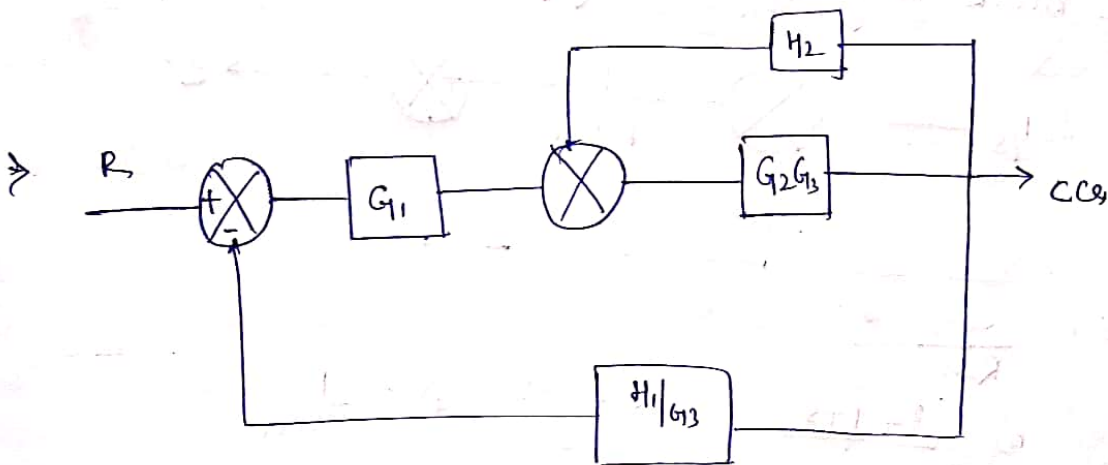
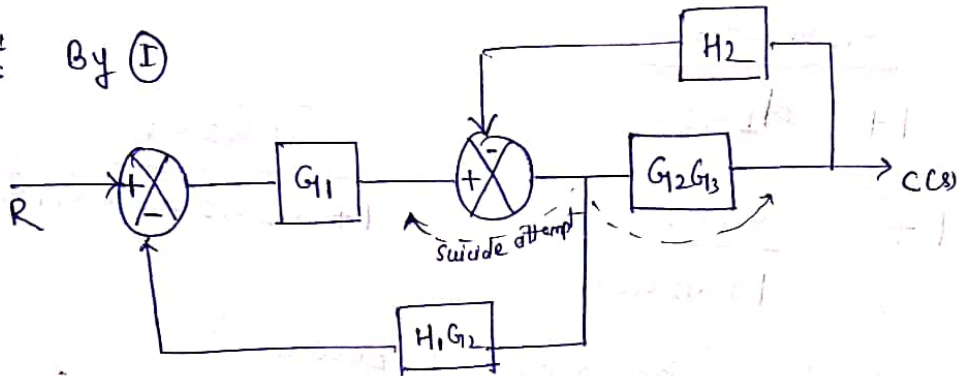
10. Shifting of an adder after a block:



Q1. Find transfer function $C(s)/R(s)$ for a diagram given below:-

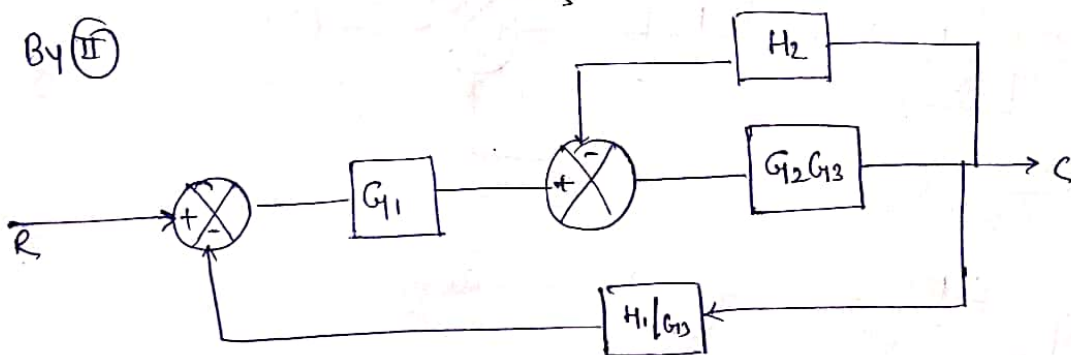


Sol: By (I)



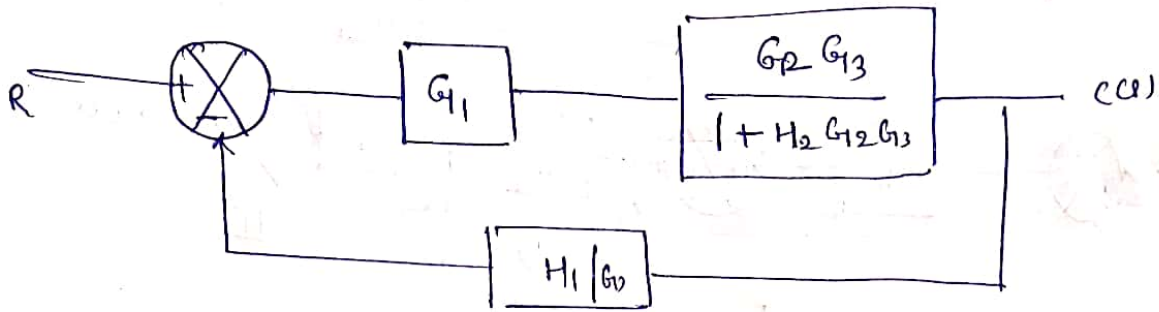
OR

By (II)



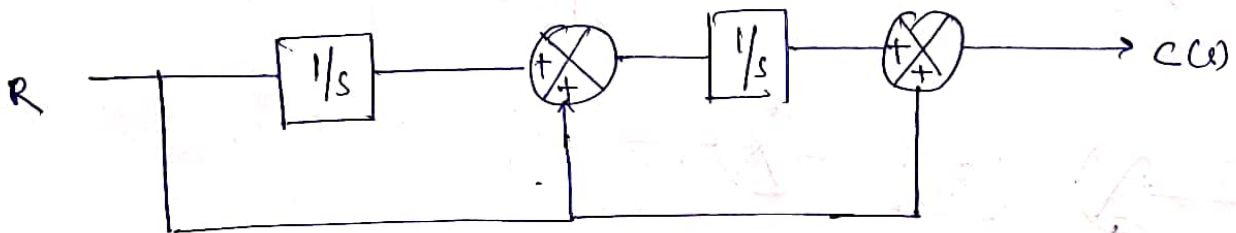
By (I) 2 step

By (II) 1 step



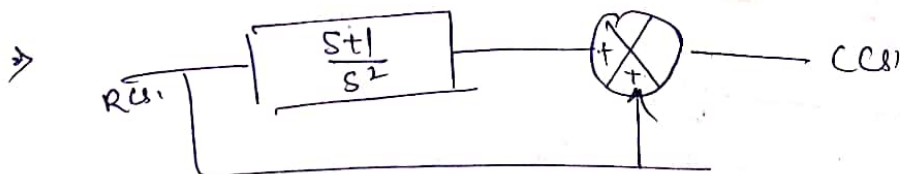
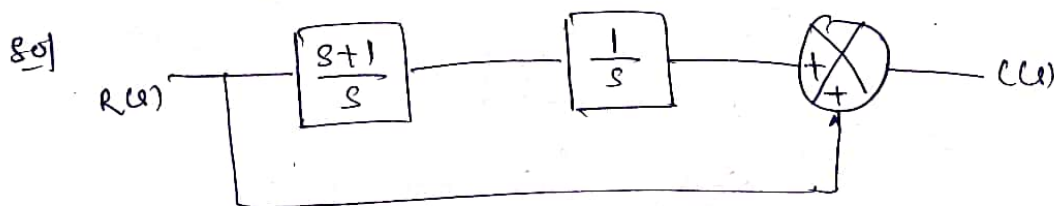
$$\frac{C}{R} = \frac{G_1 G_2 G_3}{1 + H_2 G_2 G_3} = \frac{G_1 G_2 G_3}{1 + \frac{G_1 G_2 G_3}{1 + H_2 G_2 G_3} \cdot H_1} = \frac{G_1 G_2 G_3}{1 + H_2 G_2 G_3 + G_1 G_2 H_1}$$

Q2. For the block diag. shown in fig. below

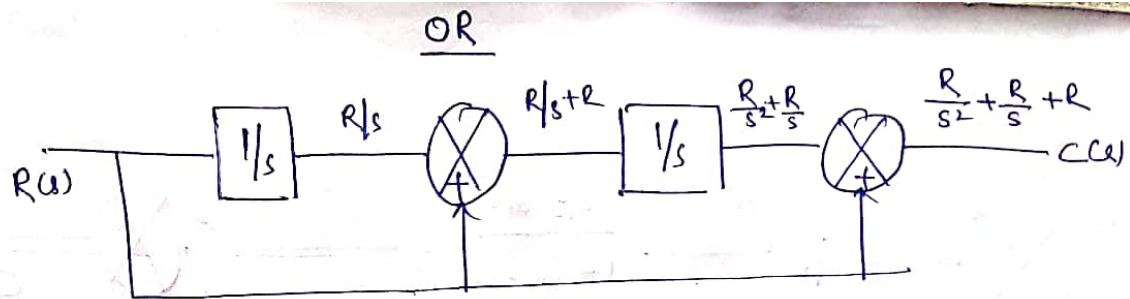


The transfer function $\frac{C(s)}{R(s)} = ?$

- a) $\frac{s^2+1}{s^2}$ b) $\frac{s^2+1+s}{s^2}$ c) $\frac{s^2+s+1}{s}$ d) $\frac{1}{s^2+s+1}$



$$\frac{C}{R} = \frac{\frac{s+1}{s^2} + 1}{1} = \frac{s+1+s^2}{s^2}$$



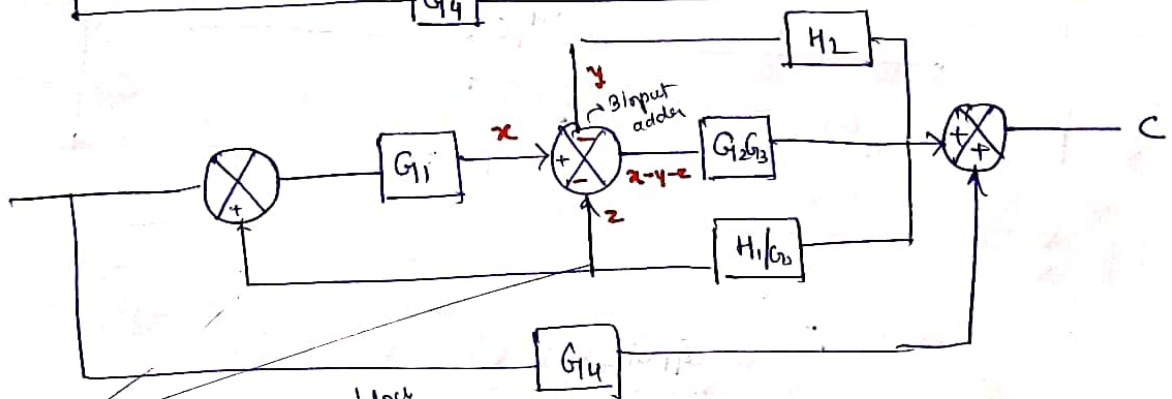
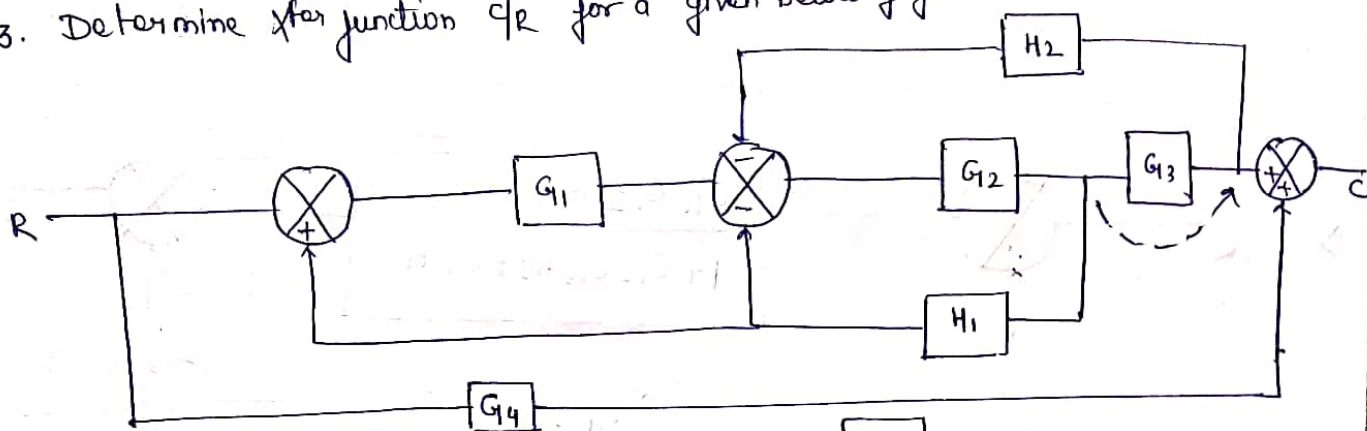
(Other good approach)

$$\Rightarrow E = \frac{R}{s^2} + \frac{R}{s} + R$$

$$\frac{C}{R} = \frac{1}{s^2} + \frac{1}{s} + 1$$

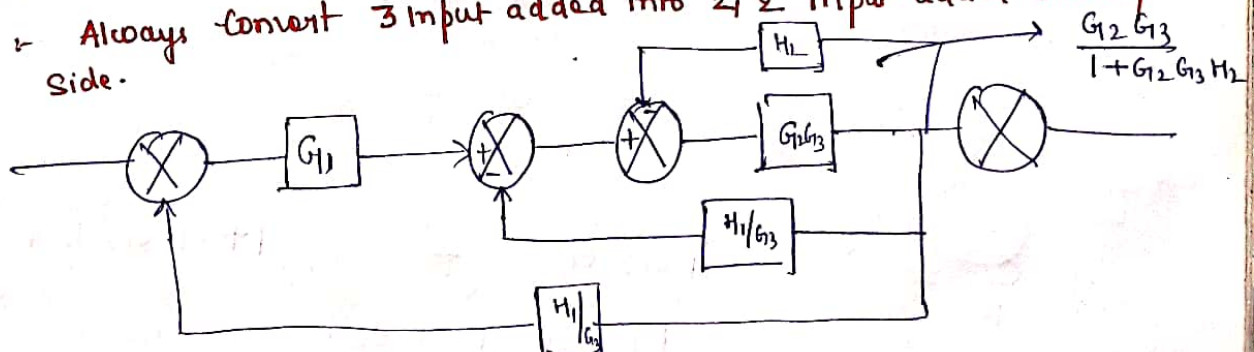
$$\frac{C}{R} = \frac{s^2 + s + 1}{s^2}$$

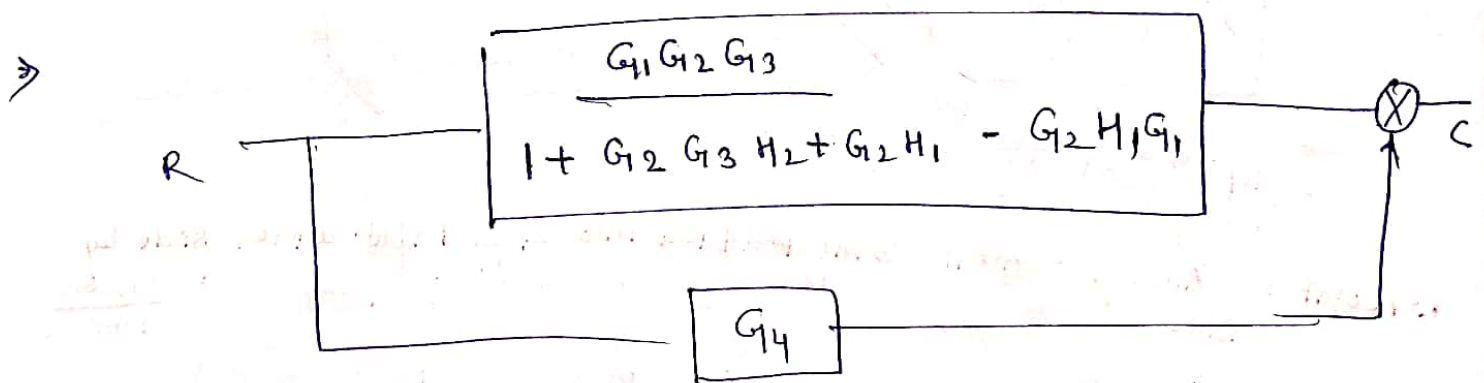
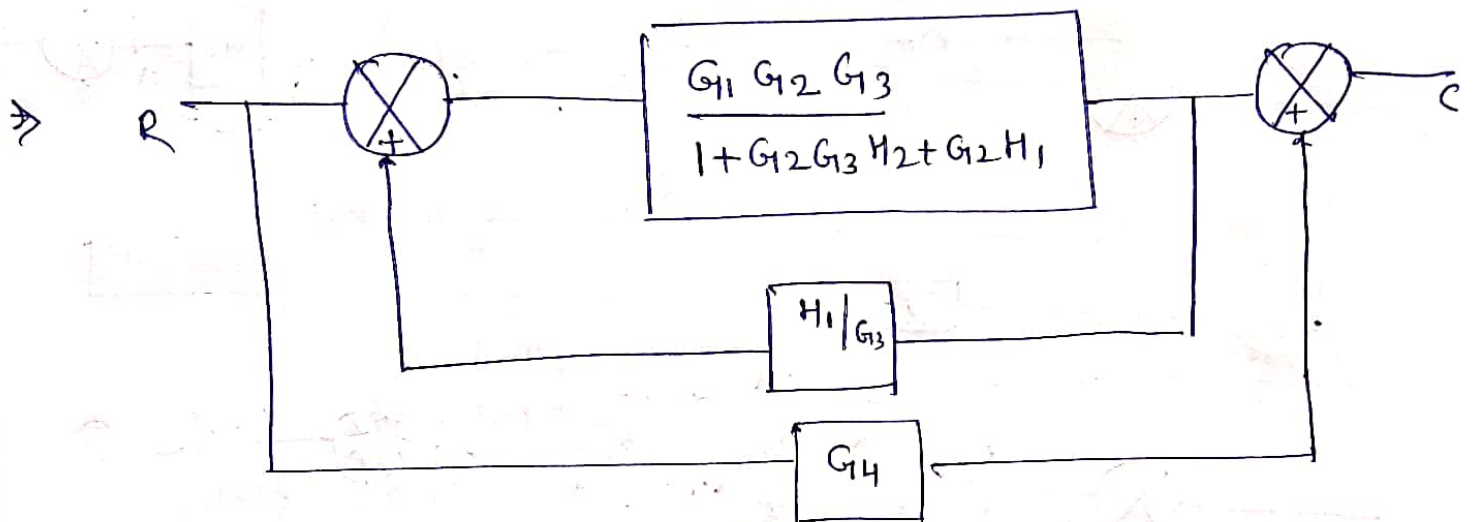
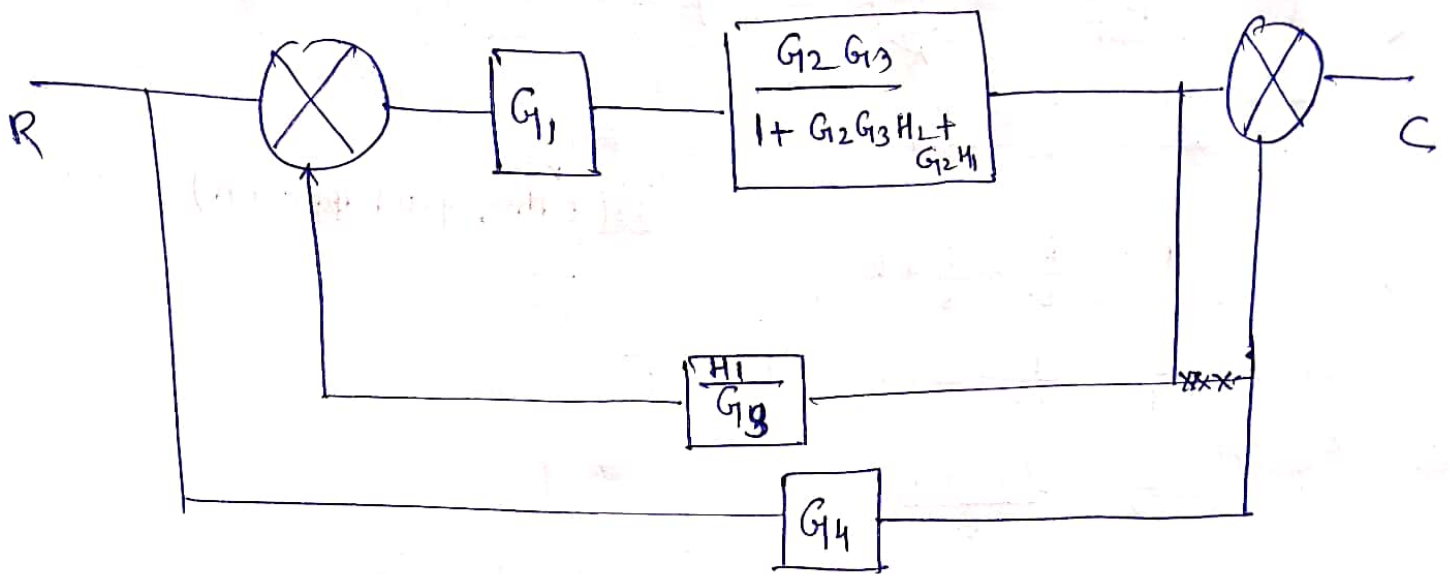
Q3. Determine transfer function C/R for a given below figure.



equi potential
Can be replaced by two block $\frac{H_1}{G_3}$

Key point = Always convert 3 input added into 2, 2 input adder side by side.





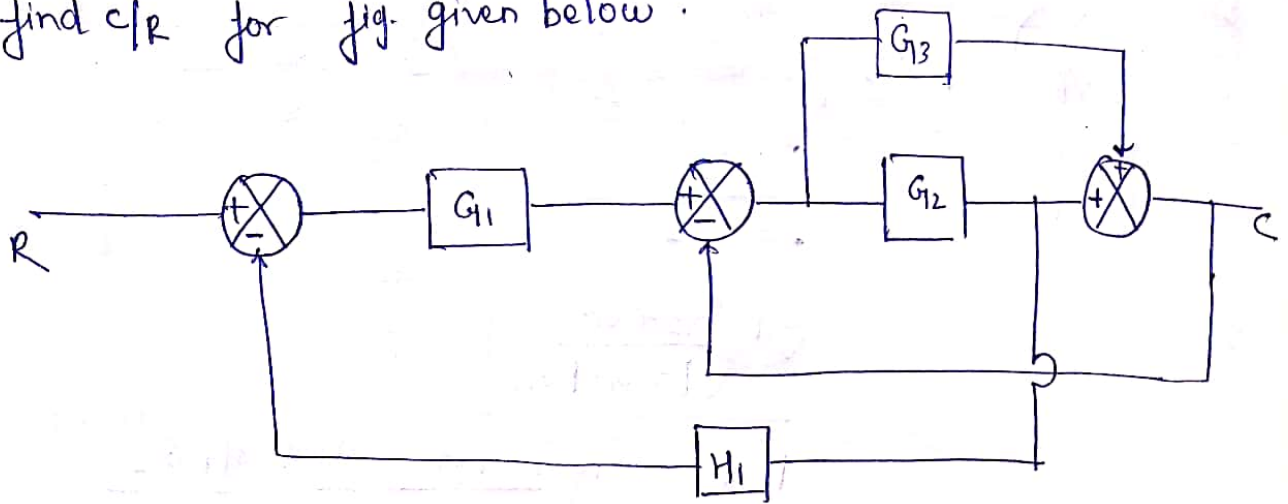
$$\frac{C}{R} = \frac{G_1 G_2 G_3 + G_4 (1 + G_2 G_3 H_2 + G_2 H_1 - G_2 H_1 G_1)}{1 + G_2 G_3 H_2 + G_2 H_1 - G_2 H_1 G_1}$$

//

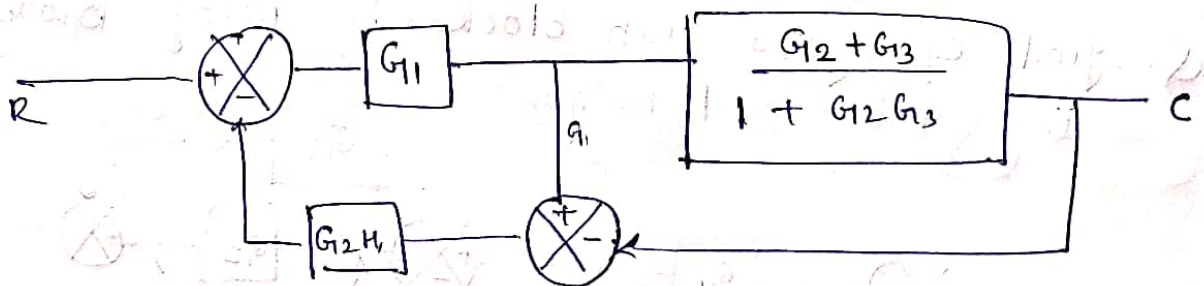
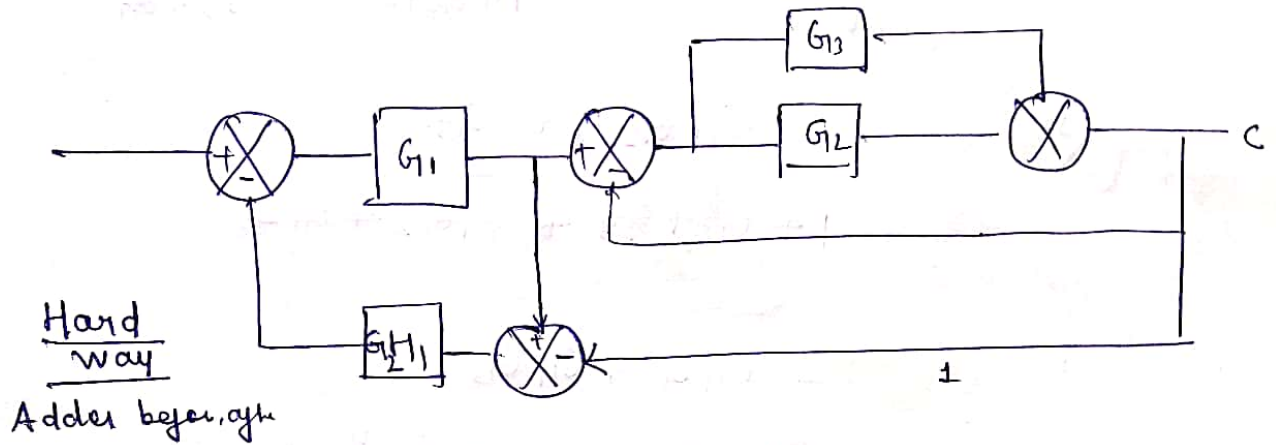
H.W

without converting 3 input adder in 2,2 input adder and check Ans.

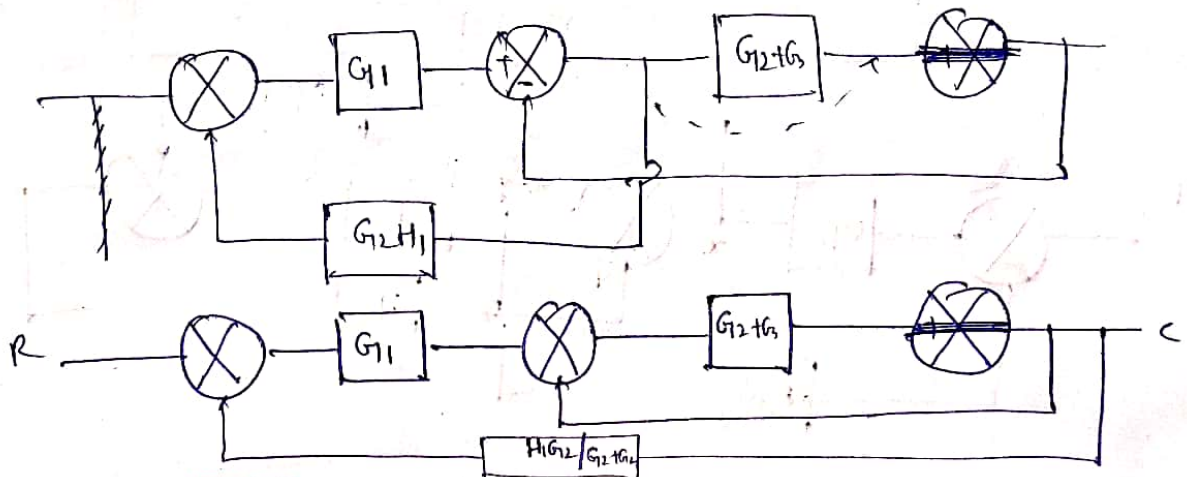
Q. find c/r for fig. given below.

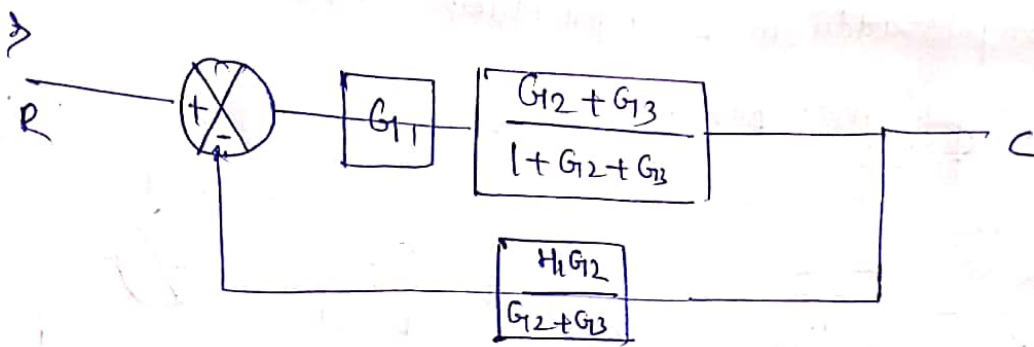


Sol



(Simple)
Other Method



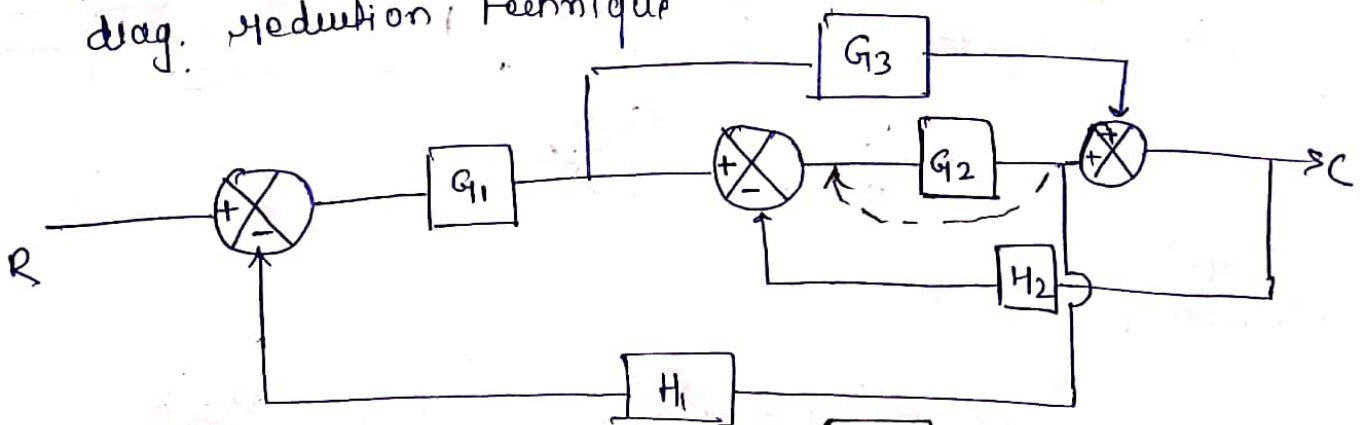


$$\frac{G_1 \left(\frac{G_2 + G_3}{1 + G_2 + G_3} \right)}{1 + \left(\frac{G_1 (G_2 + G_3)}{1 + G_2 + G_3} \right) \times \frac{H_1 G_2}{G_2 + G_3}}$$

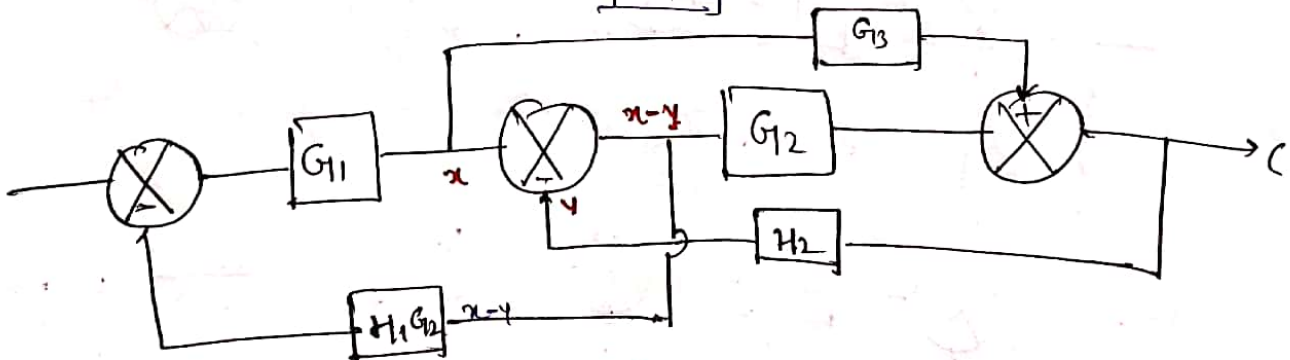
$$\frac{G_1 G_2 + G_1 G_3}{1 + G_2 + G_3 + G_1 G_2 + G_1 G_3}$$

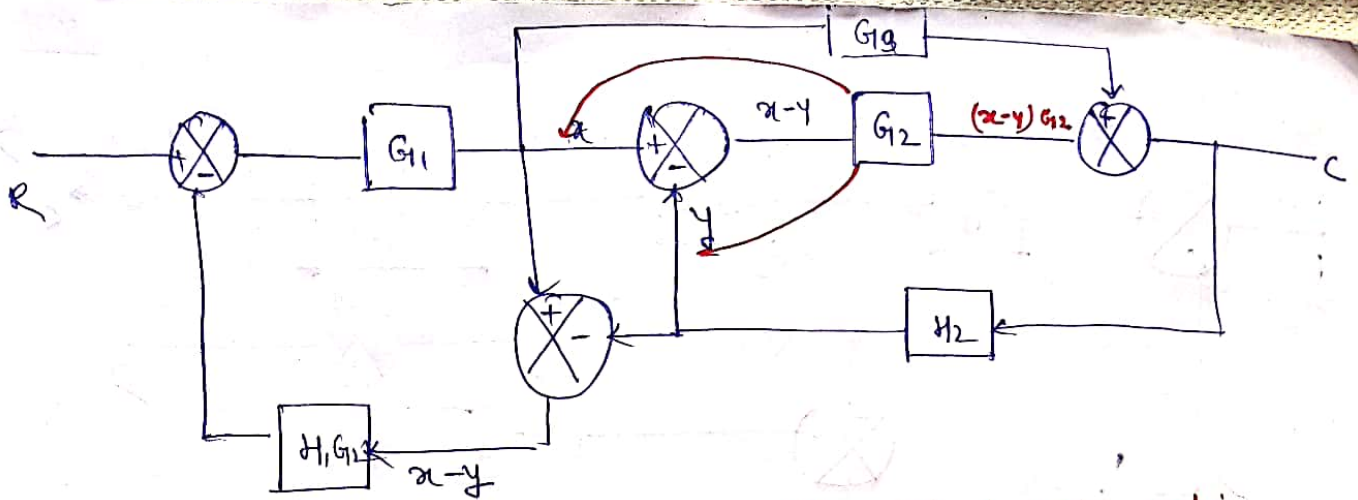
$$\frac{G_1 G_2 + G_1 G_3}{1 + G_2 + G_3 + G_1 G_2 H_1} //$$

Q. find c/r for a given block by using Block diag. reduction technique

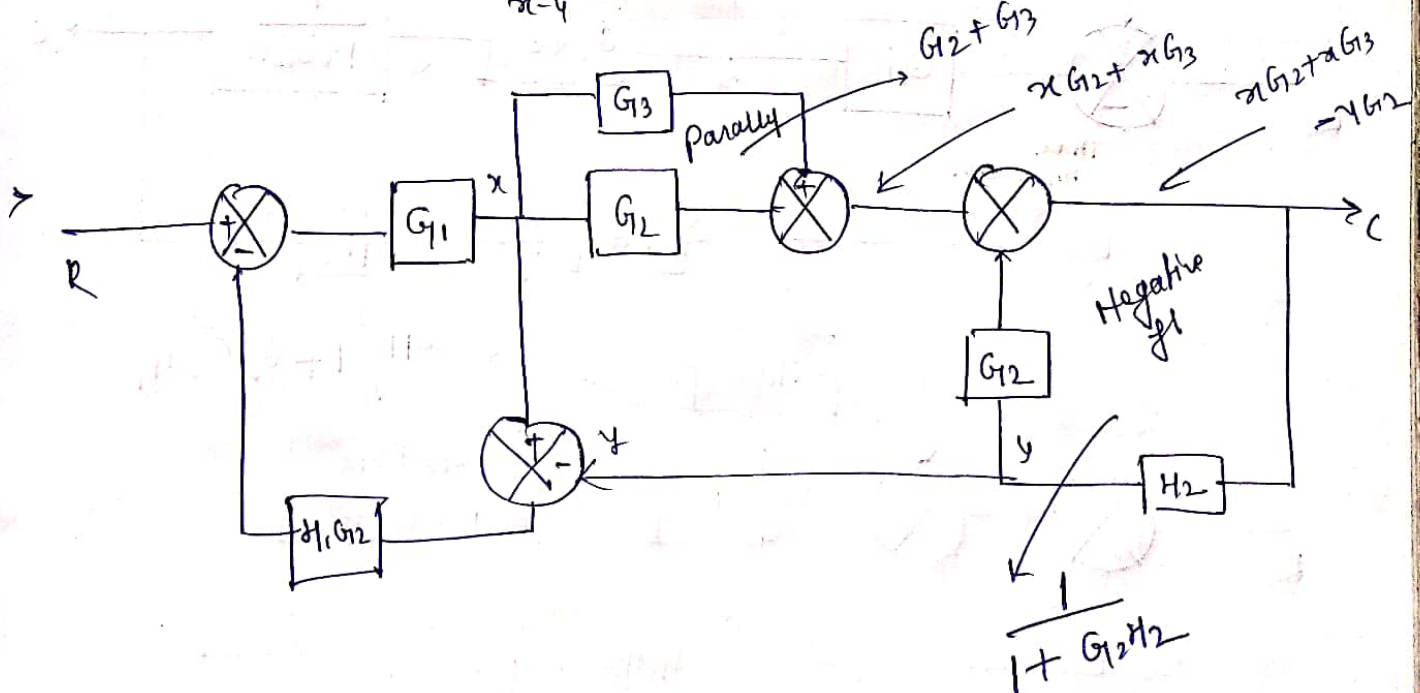
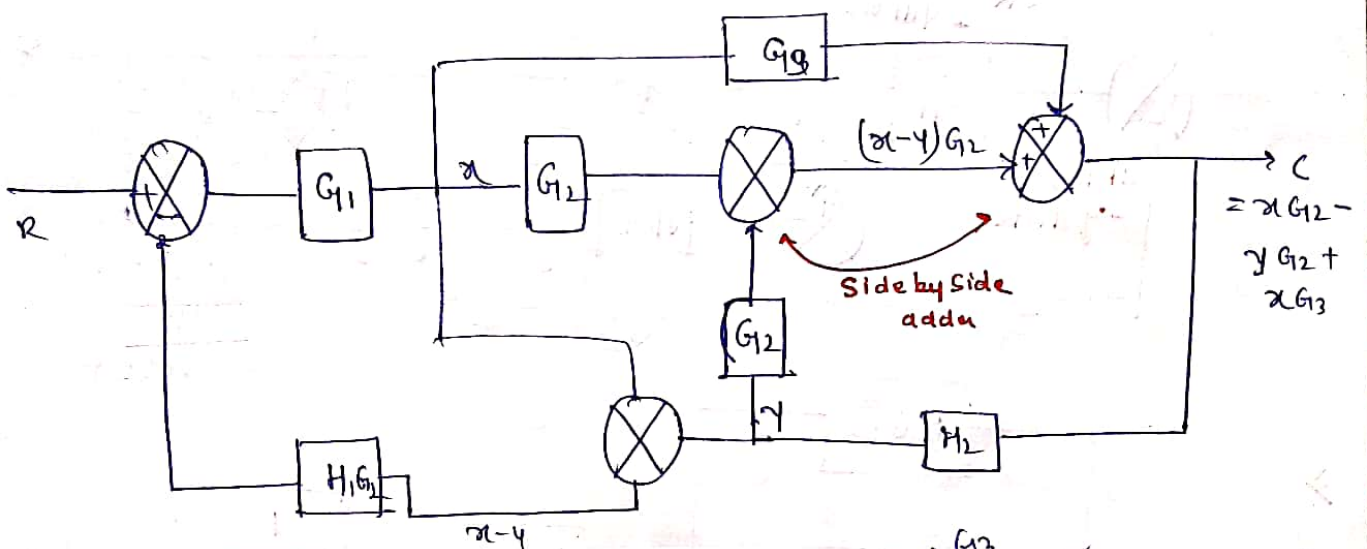


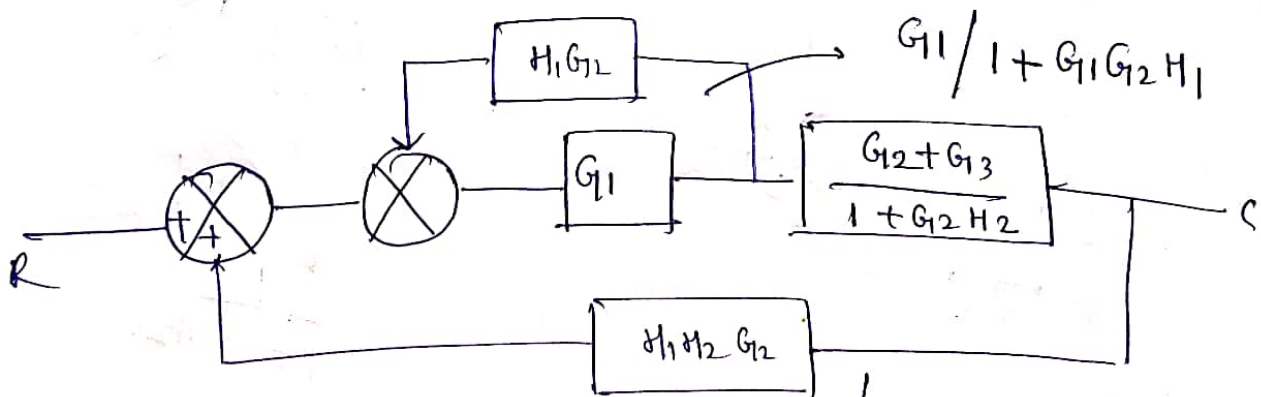
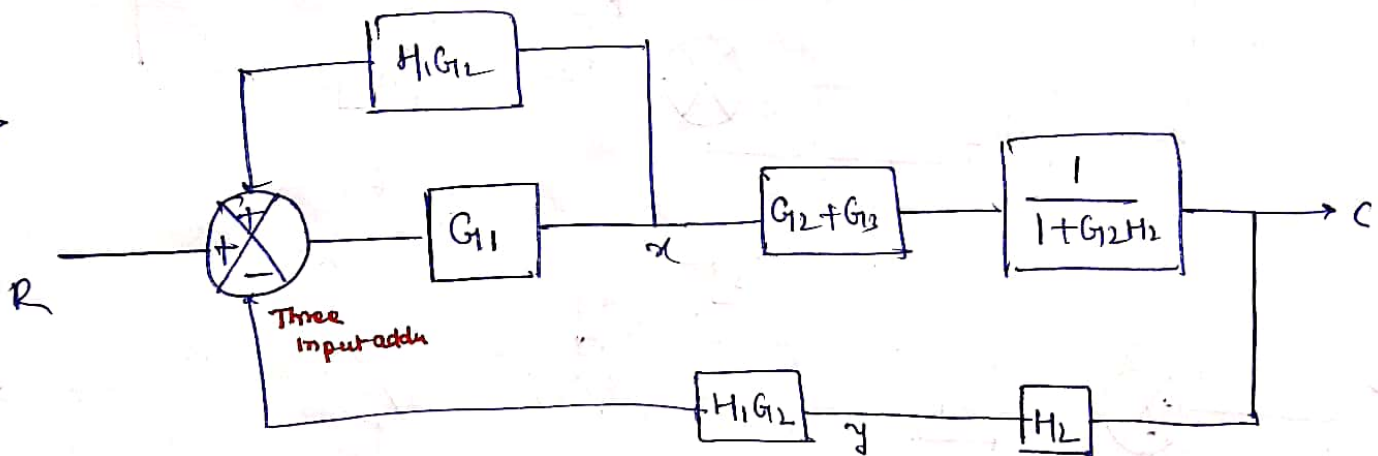
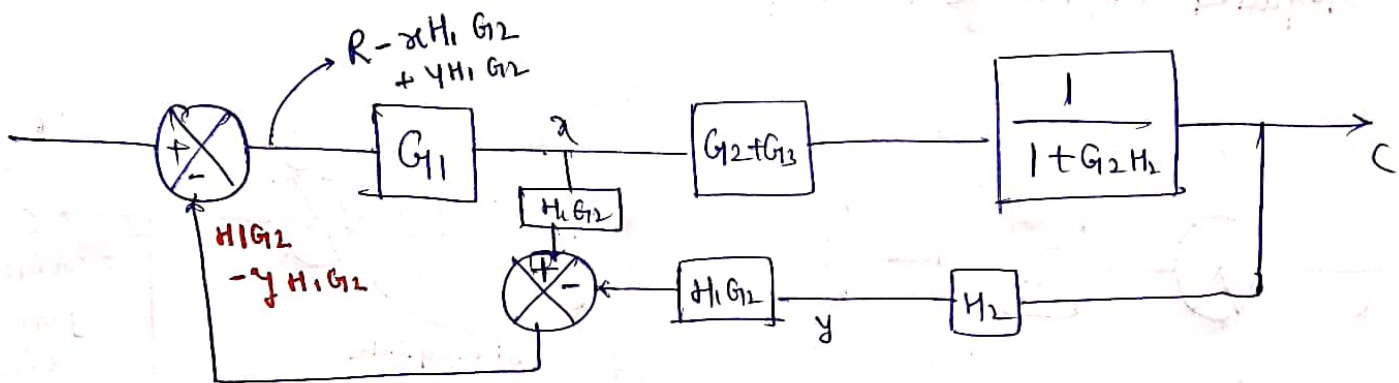
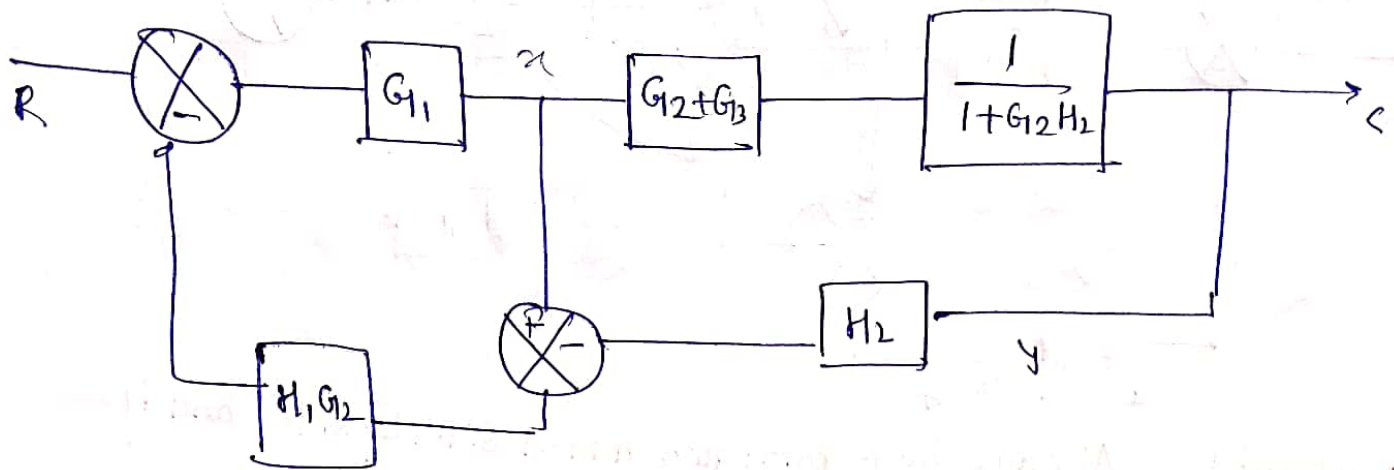
Sol





Key point! Always try to bring two adder side by side and if required interchange the respective input.





$$\frac{C}{R} = \frac{G_1}{1 + G_1 G_2 H_1} \times \frac{G_2 + G_3}{1 + G_2 H_2} \left(1 - \frac{(G_1)(H_1 H_2 G_2)(G_2 + G_3)}{1 + G_1 G_2 H_1 \cdot 1 + G_2 H_2} \right)$$

$$\rightarrow \frac{G_1 (G_2 + G_3)}{(1 + G_1 G_2 H_1)(1 + G_2 H_2) - G_1 (G_2 + G_3) (H_1 H_2 G_2)}$$

$$\rightarrow \frac{G_1 G_2 + G_1 G_3}{1 + G_2 H_2 + G_1 G_2 H_1 + G_1 G_2 G_2 H_2 H_1 - G_1 G_2 - G_1 G_3}$$

$$\rightarrow \frac{C}{R} = \frac{G_1 G_2 + G_1 G_3}{1 + G_1 G_2 H_1 + G_2 H_2 - G_1 G_2 G_3 H_1 H_2}$$

II. SIGNAL FLOW GRAPH

1. SFG is a graphical representation of block diag. system.
2. SFG is used for determine the xfer function between any two node.
3. SFG is an easier way to determining xfer function compared to block diag. reduction technique.
4. SFG is based on distribution of parameter in which gain is distributed across the line betn two node where as block diag is based on lumped parameters in which gain exist at a point.
5. In SFG we determine xfer functn directly by using Mason's Gain formula
6. Mason's Gain formula is given by —

$$T(s) = \sum_{k=1}^n \frac{P_k \Delta_k}{\Delta}$$

n = no. of forward path (path from Input node to output node without Repetition of any node)

P_k = forward path gain of k^{th} path

Δ = determinant of SFG

Δ_k = associated path factor depends on forward path and isolated loop gain.

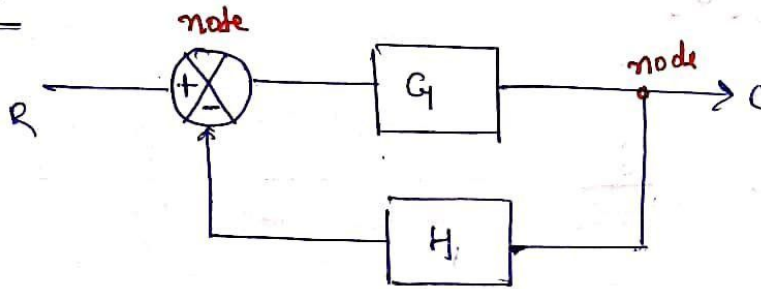
$$\Delta = 1 - \left[\text{Sum of all individual loop gain} \right] + \left[\text{Sum of product of all two non-touching loop gain} \right] - \left[\text{Sum of product of all three non-touching loop gain} \right] + \dots$$

$$\Delta_k = 1 - [\text{Sum of all individual isolated loop gain}]$$

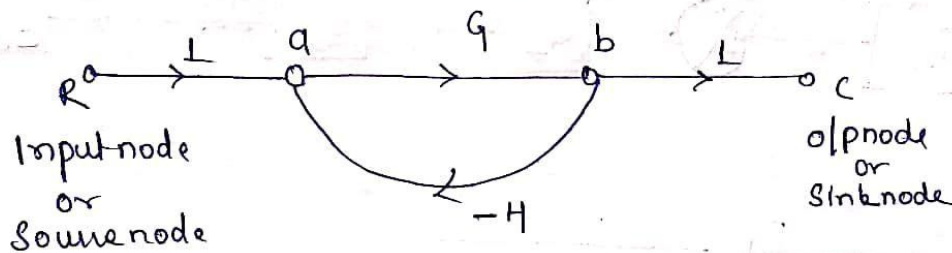
$$+ [\text{Sum of product of all two non-touching isolated loop gain}]$$

$$- [\text{Sum of product of all three non-touching isolated gain}]$$

eg ①



adder & takeoff point
as node



forward path = $R \rightarrow a \rightarrow b \rightarrow c$

forward path gain = $1 \times G \times 1 = G$

$\eta = 1$

$$T(s) = \sum_{k=1}^n \frac{P_k \Delta_k}{\Delta} = \frac{P_1 \Delta_1}{\Delta}$$

$$P_1 = 1 \times G \times 1 = G$$

Individual loop = $a - b - a$

Loop gain = $-G_1 H$

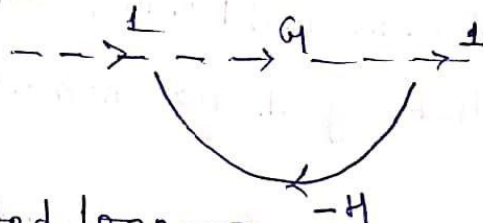
$$\Delta = 1 - (-G_1 H)$$

$$= 1 + G_1 H$$

$$T(s) =$$

Loop start & End on same
point
Direction must end at start
point

Calculation of Δ



node branch are vanished

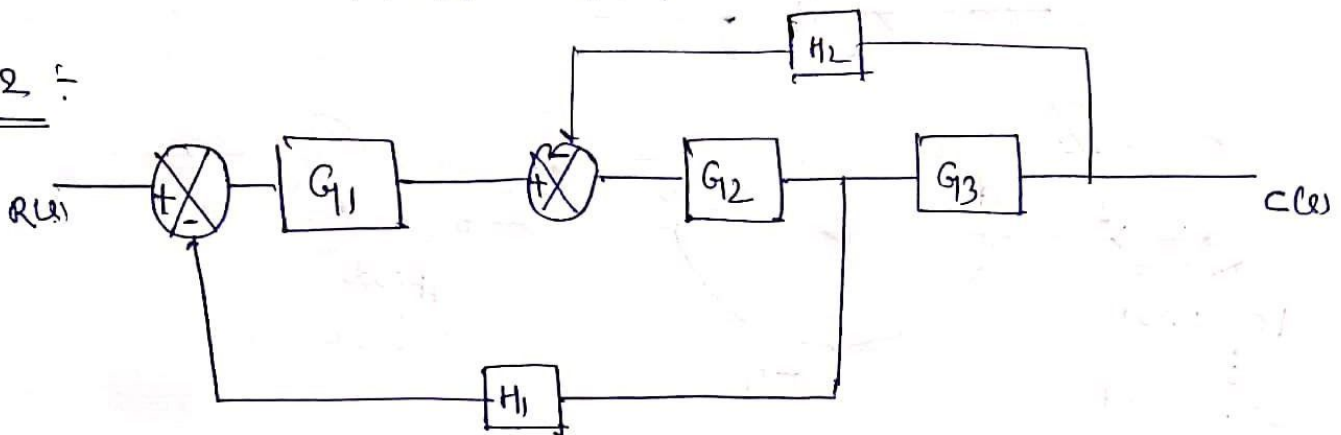
no. of isolated loop = 0

Isolated loop gain = 0

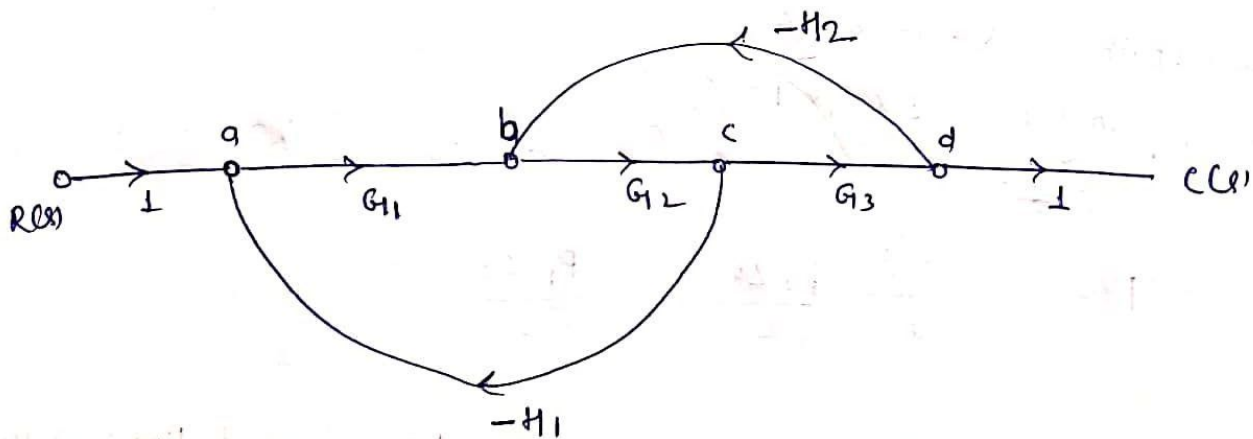
$$\Delta = 1 - [0] = 1$$

$$T(s) = \frac{G \times 1}{1 + GH} = \frac{G}{1 + G}$$

eg:2 :



Sol



$n=1$ from fig.

$$\frac{C}{R} = \frac{P_1 \Delta_1}{\Delta}$$

$$P_1 = 1 \times G_1 \times G_2 \times G_3 \times 1 = G_1 G_2 G_3$$

$$\Delta = 1 - [-G_1 G_2 H_1 - G_2 G_3 H_2]$$

Individual loop

$$L_1 = a - b - c - a$$

$$L_1 \text{ gain} = G_1 G_2 \times -H_1$$

$$= -G_1 G_2 H_1$$

$$L_2 = -G_2 G_3 H_2$$

no. of two non touching loop = 0

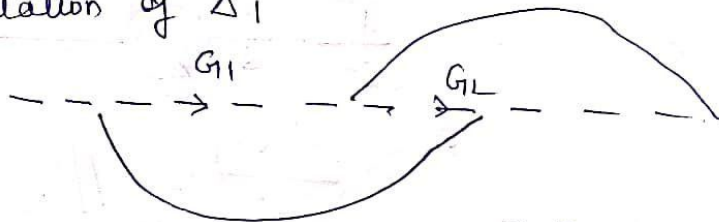
$$\Delta = 1 - [L_1 + L_2] + [0]$$

$$= 1 - [G_1 G_2 H_1 + G_2 G_3 H_2]$$

$$= 1 + G_1 G_2 H_1 + G_2 G_3 H_2$$

~~T(s)~~ =

Calculation of Δ_1

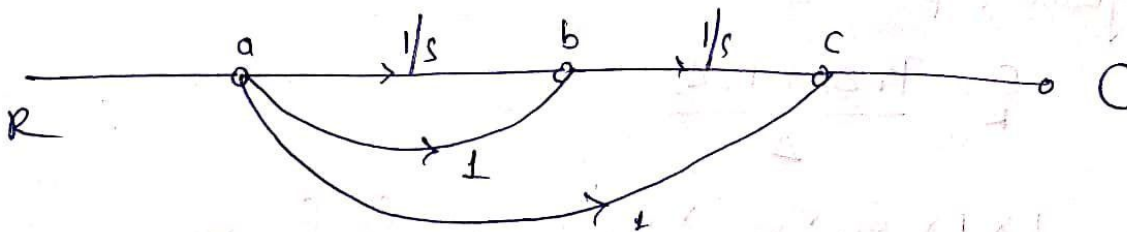
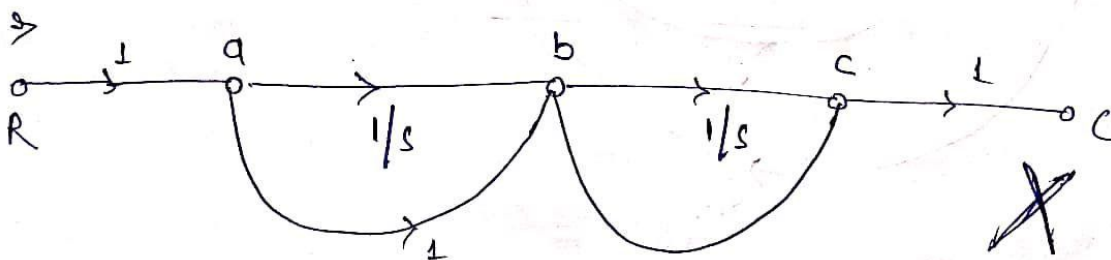
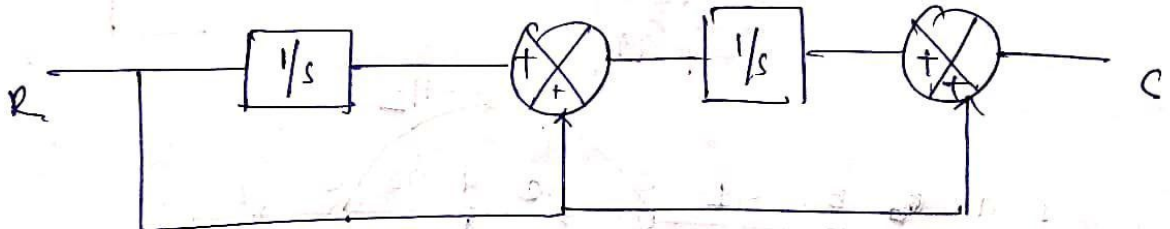


$$\Delta_1 = 1 - [0]$$

$$= 1$$

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

ex 3



$$P_1 = 1 \times \frac{1}{s} \times \frac{1}{s} \times 1 = \frac{1}{s^2} \quad \eta = 3$$

$$P_2 = 1 \times 1 \times \frac{1}{s} \times 1 = \frac{1}{s}$$

$$P_3 = 1 \times 1 \times 1 = 1$$

$$\frac{C}{R} = \frac{P_1 \Delta_1 + P_2 \Delta_2 + P_3 \Delta_3}{\Delta}$$

$$\frac{C}{R} = \frac{\frac{1}{s^2} \times 1 + \frac{1}{s} \times 1 + 1 \times 1}{1 - 0}$$

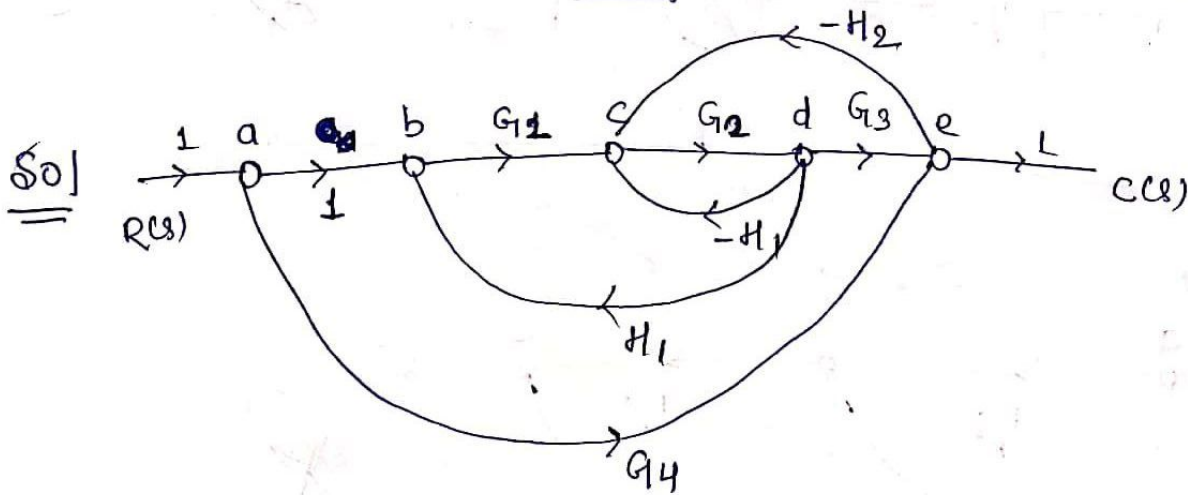
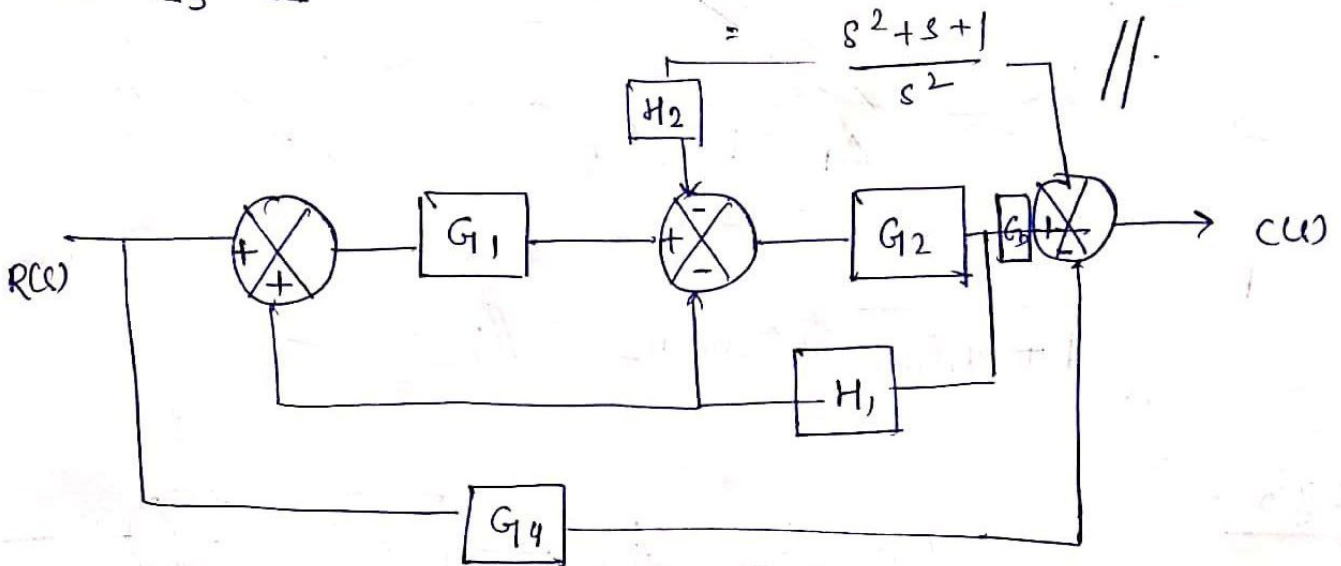
$$= \frac{1}{s^2} + \frac{1}{s} + 1$$

no. of individual loop = 0

no. of isolated loop = 0

$$\Delta_1 = \Delta_2 = \Delta_3 = 1$$

eg4



no. of forward path = 2

$$\frac{C}{R} = \frac{P_1 \Delta_1 + P_2 \Delta_2}{\Delta}$$

$$P_1 = 1 \times 1 \times G_1 \times G_2 \times G_3 \times 1 = G_1 G_2 G_3$$

$$P_2 = 1 \times G_4 \times 1 = G_4$$

Individual loop gain

$$\frac{P}{R} = L_1 = -G_2 H_1$$

$$L_2 = G_1 G_2 H_1$$

$$L_3 = -G_2 G_3 H_2$$

no. of two non touching loop = 0

no. of three non touching loop = 0

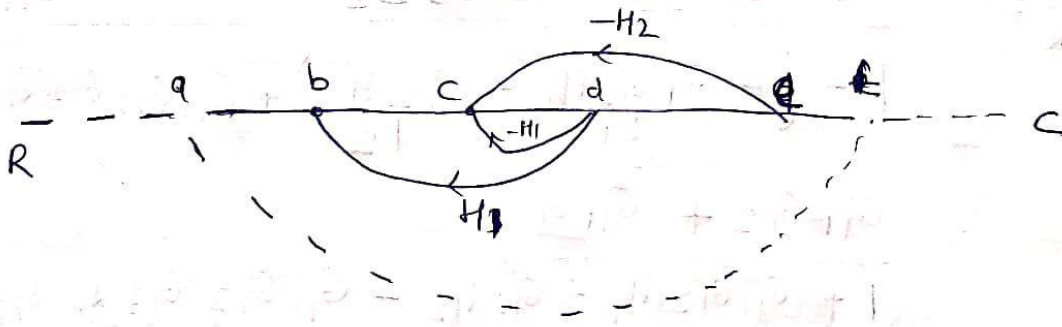
$$\Delta = 1 - (L_1 + L_2 + L_3)$$

$$= 1 - (-G_2 H_1 + G_1 G_2 H_1 - G_2 G_3 H_2)$$

$$\Delta = 1 + G_2 H_1 - G_1 G_2 H_1 + G_2 G_3 H_2$$

from figure $\Delta_1 = 1 - 0$

Calculation of Δ_2 :



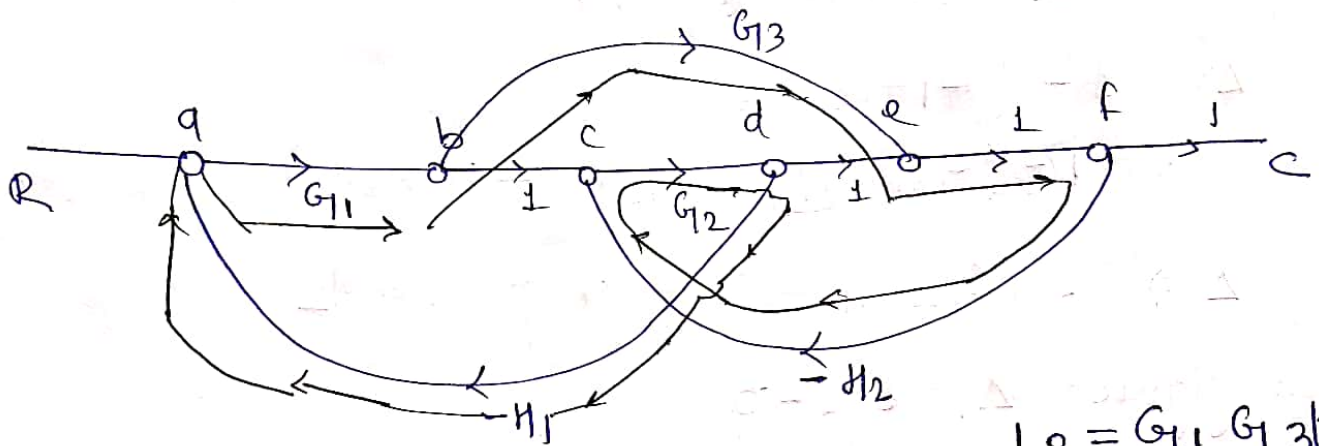
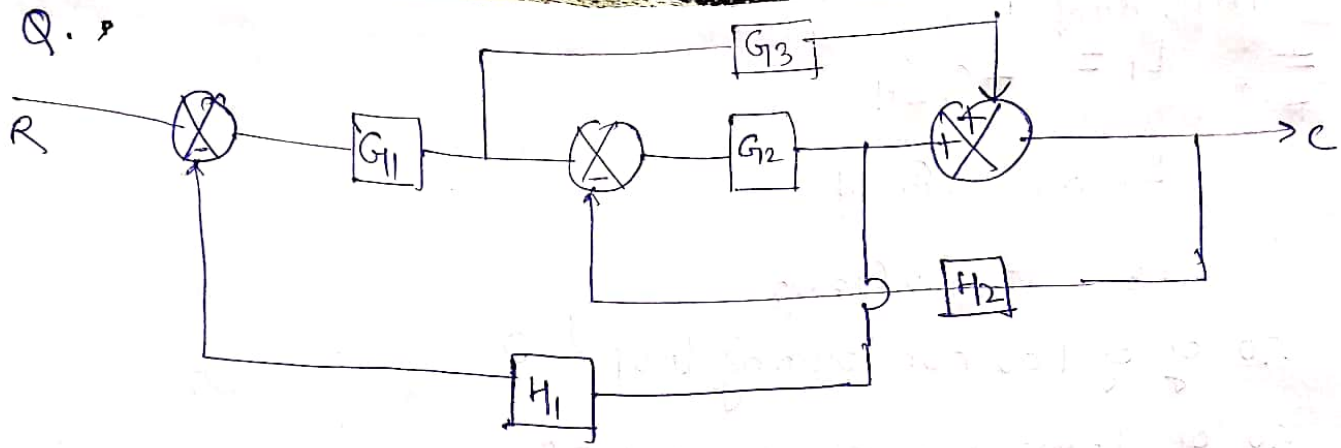
No. of isolated loop = 3

$$\Delta_2 = 1 - (L_1^* + L_2^* + L_3^*)$$

$$= 1 + G_2 H_1 - G_1 G_2 H_1 + G_2 G_3 H_2$$

$$\frac{C}{R} = \frac{G_1 G_2 G_3 + G_4 (1 + G_2 H_1 - G_1 G_2 H_1 + G_2 G_3 H_2)}{1 + G_2 H_1 - G_1 G_2 H_1 + G_2 G_3 H_2}$$

Q. 8



$$L_3 = G_1 G_3 (-H_2) \\ G_2 (-H_1)$$

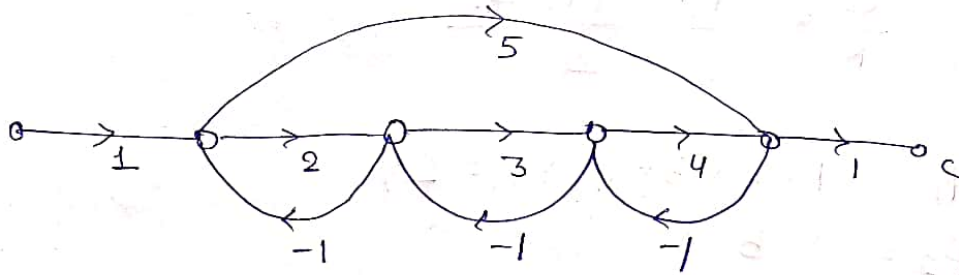
$$\Rightarrow \frac{C}{R} = \frac{G_1 G_2 \Delta_1 + G_1 G_3 \Delta_2}{1 - \left(-G_1 G_2 H_1 - G_2 H_2 \right) + G_1 G_2 G_3 H_1 H_2}$$

$$\frac{C}{R} = \frac{G_1 G_2 + G_1 G_3}{1 + G_1 G_2 H_1 + G_2 H_2 - G_1 G_2 G_3 H_1 H_2} //$$

from fig. $\Delta_1 = 1 - 0 = 1$

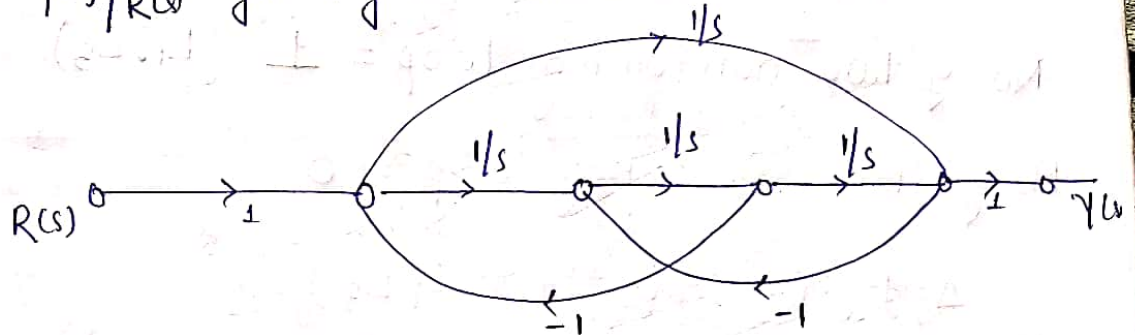
$$\Delta_2 = 1 - 0 = 1$$

Q1. find $\frac{C}{R}$ for a given below figure.



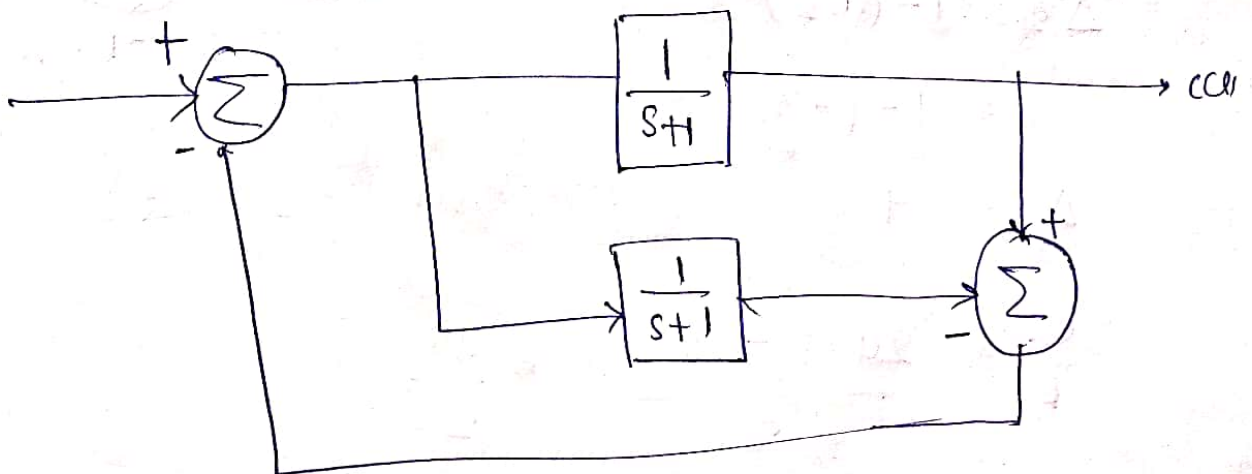
- A. $11/9$ B. $22/15$ C. $24/23$ d. $44/23$

Q2. find $\frac{Y(s)}{R(s)}$ for a given below SFG



- A. $1/s$ B. $\frac{s^2+1}{s(s^2+2)}$ C. $\frac{s(s^2+1)}{s^2+2}$ d. $\frac{1-1/s}{1}$

Q3. The transfer function Y/R of system shown in fig is



- a) 0 b) $1/s+1$ c) $2/s+1$ d) $2/s+3$

Sol 1 : $n = 2$

$$\frac{C}{R} = \frac{P_1 \Delta_1 + P_2 \Delta_2}{\Delta}$$

$$P_1 = 1 \times 2 \times 3 \times 4 \times 1 = 24$$

$$P_2 = 5$$

$$L_1 = -2$$

$$L_2 = -3$$

$$L_3 = -4$$

$$L_4 = 5 \times 1 \times 1 \times 1 = 5$$

No. of two non touching loop = 1 (L_1, L_3)

No. of three non touching loop = 0

$$\Delta = 1 - (L_1 + L_2 + L_3 + L_4 + 4L_3)$$

$$= 1 - (-2 - 3 - 4 + 5) + (-2 \times -4)$$

$$= 1 + 2 + 3 + 4 + 5 + 8$$

$$\Delta = 23$$

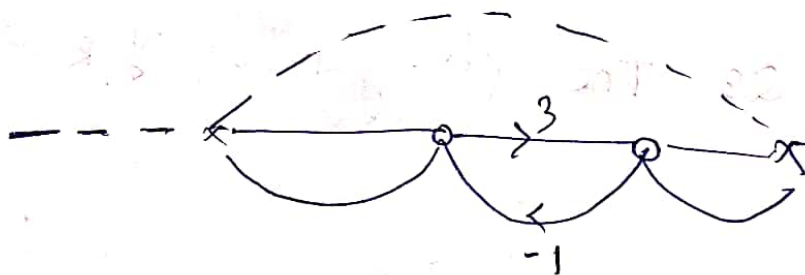
for fig $\Delta_1 = 1 \times 1 = 1$

$$\Delta_2 = 1 - (L_2)$$

$$= 1 - (-3)$$

$$\Delta_2 = 4$$

$$\frac{C}{R} = \frac{24 \times 1 + 5 \times 4}{23} = \frac{44}{23}$$



Sol 2: $n = 2$

$$P_1 = 1 \times 1/s \times 1/s \times 1/s \times 1 = 1/s^3$$

$$P_2 = 1 \times 1/s \times 1 = 1/s$$

$$\frac{Y}{R} = \frac{P_1 \Delta_1 + P_2 \Delta_2}{\Delta}$$

$$L_1 = 1/s \times 1/s \times -1 = -1/s^2$$

$$L_2 = -1/s \times 1/s = -1/s^2$$

$$L_3 = 1/s \times -1 \times 1/s \times -1 = 1/s^2$$

no. of two non touching loop = 0

$$\Delta = 1 - [L_1 + L_2 + L_3]$$

$$= 1 + \frac{1}{s^2} + \frac{1}{s^2} - \frac{1}{s^2}$$

$$\Delta = \frac{1 + s^2}{s^2}$$

from fig

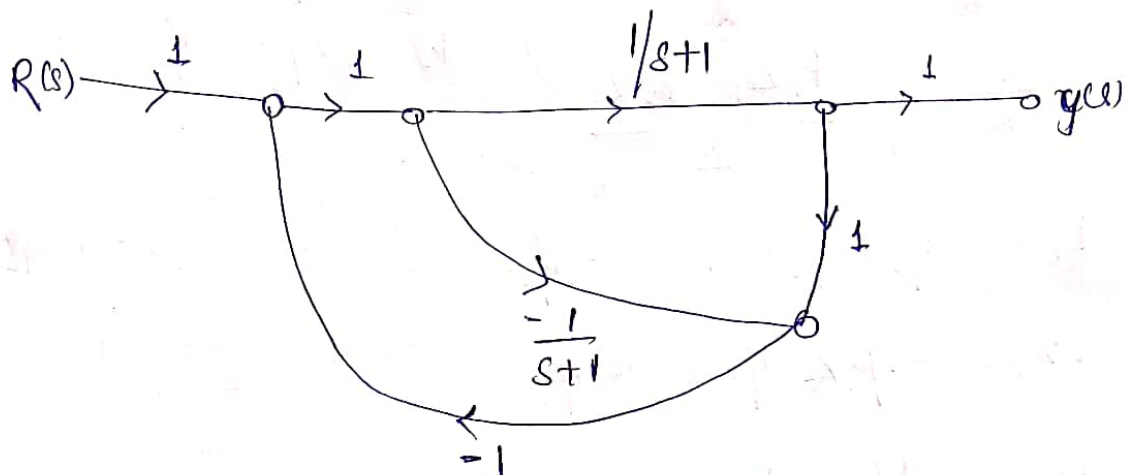
$$\Delta_1 = 1 - 0 = 1$$

$$\Delta_2 = 1 - 0 = 1$$

$$\frac{Y}{R} = \frac{1/s^3 + 1/s}{\frac{1 + s^2}{s^2}}$$

$$= \frac{1 + s^2}{s^3} \times \frac{s^2}{1 + s^2} = 1/s$$

Sol 3 :



$$\gamma = 1$$

$$\frac{C}{R} = -1 \frac{P_1 \Delta_1}{\Delta}$$

$$\Delta = 1 - \left[\frac{1}{s+1} - \frac{1}{s+1} \right]$$

$$\Delta = 1$$

$$L_1 = 1 \times \frac{-1}{s+1} \times -1$$

$$= \frac{1}{s+1}$$

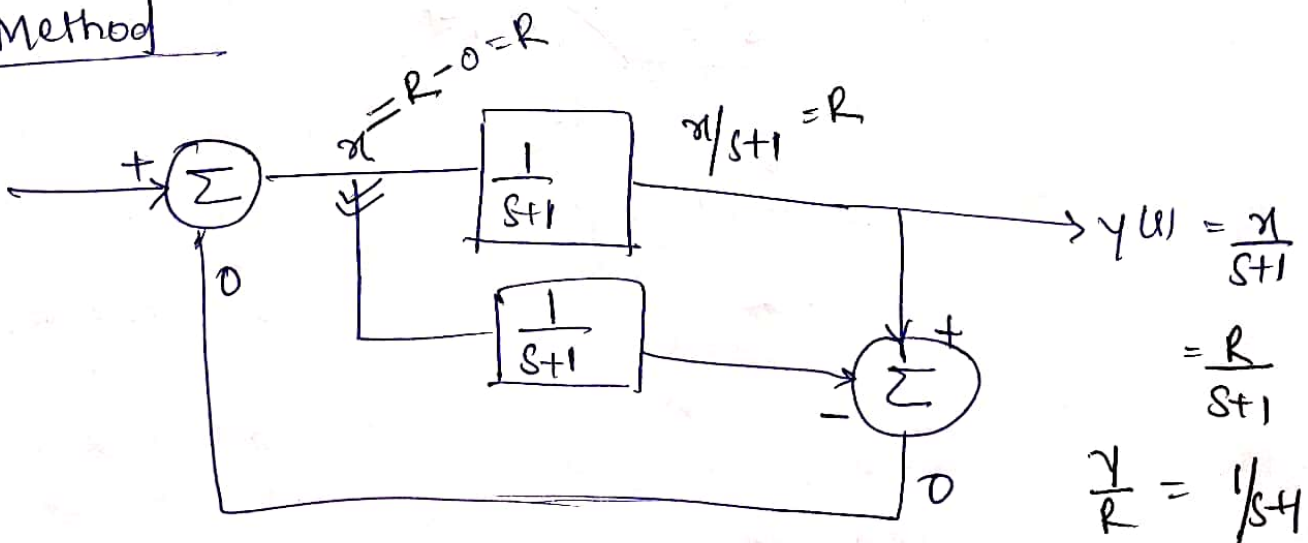
$$L_2 = 1 \times \frac{1}{s+1} \times 1 \times -1$$

$$L_2 = -\frac{1}{s+1}$$

from figure 1- $\Delta_1 = 1 - 0 = 1$

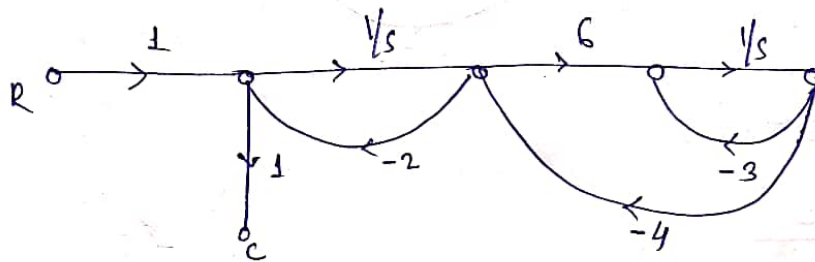
$$\frac{Y}{R} = \frac{1}{s+1} //$$

2nd Method



$$\frac{Y}{R} = \frac{1}{s+1}$$

Q4. Determine X_{for} function C/R for a given below SFG.



a) $6/s^2 + 29s + 6$

c) $\frac{6s}{s^2 + 29s + 6}$

b) $\frac{s(s+2)}{s^2 + 29s + 6}$

d) $\frac{s(s+27)}{s^2 + 29s + 6}$

So no. of forward path = 1

$P_1 = 1$

$L_1 = 1/s \times -2 = -2/s$

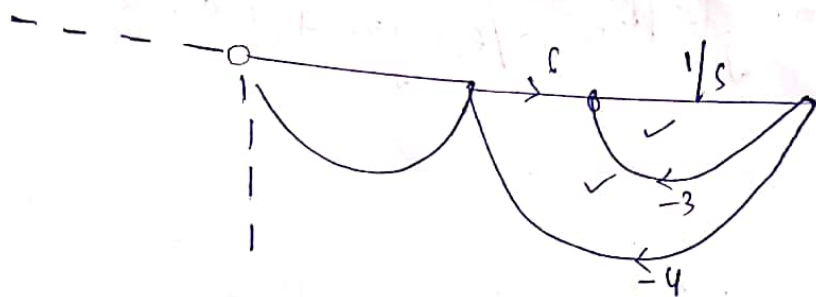
$L_2 = -3/s$

$L_3 = -24/s$

$L_1 L_2 = 6/s^2$

$\Delta = 1 + \frac{2}{s} + \frac{3}{s} + \frac{24}{s} + \frac{6}{s^2}$

$= \frac{s^2 + 29s + 6}{s^2}$



$$\Delta_1 = 1 - (L_2^* + L_3^*)$$

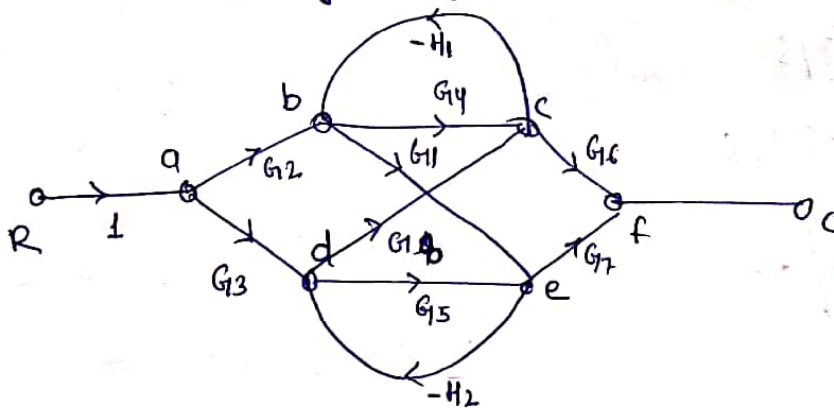
$$= 1 + \frac{27}{s}$$

$$= \frac{s+27}{s}$$

$$\frac{C}{R} = \frac{1 \left(\frac{s+27}{s} \right)}{\frac{s^2 + 29s + 6}{s^2}}$$

$$\frac{C}{R} = \frac{s(s+27)}{s^2 + 29s + 6} \quad //$$

Q. Determine T.F = C/R for a given SFG.



Sol

forward path

R-a-b-c-f-c

R-a-d-e-f-c

R-a-b-e-f-c

R-a-d-c-f-c

R-a-d-c-b-e-f-c

R-a-b-e-d-c-f-c

forward path gain

$$P_1 = G_2 G_4 G_6$$

$$P_2 = G_3 G_5 G_7$$

$$P_3 = G_2 G_1 G_7$$

$$P_4 = G_3 G_8 G_6$$

$$P_5 = G_3 G_8 (-H_1) G_1 G_2 = -G_1 G_3 G_7 G_8 H_1$$

$$P_6 = -G_1 G_2 G_6 G_8 H_2$$

Individual loop

b-c-b

d-e-d

c-b-e-d-c

Loop gain

$-G_4 H_1$

$-G_5 H_2$

$G_1 G_8 H_1 H_2$

No. of two non touching loop = 1 ($L_1 L_2$)

$$\Delta = 1 - [L_1 + L_2 + L_3] + [L_1 L_2]$$

$$= 1 - [-G_4 H_1 - G_5 H_2 + G_1 G_8 H_1 H_2] + [G_4 G_5 H_1 H_2]$$

$$\Delta = 1 + G_4 H_1 + G_5 H_2 - G_1 G_8 H_1 H_2 + G_4 G_5 H_1 H_2$$

$$\Delta_1 = 1 - [L_2^*] = 1 + G_5 H_2$$

$$\Delta_2 = 1 - [L_1^*] = 1 + G_4 H_1$$

$$\Delta_3 = 1 - [0] = 1$$

$$\Delta_4 = 1 - [0] = 1$$

$$\Delta_5 = 1 - [0] = 1$$

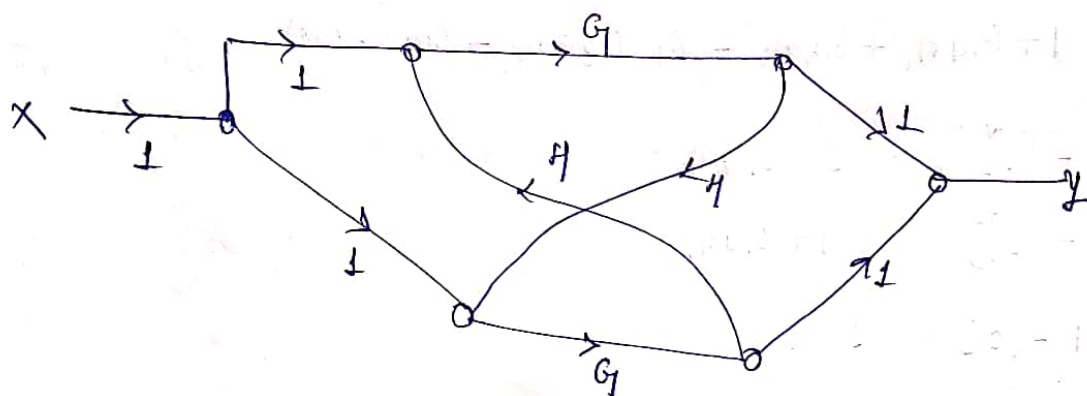
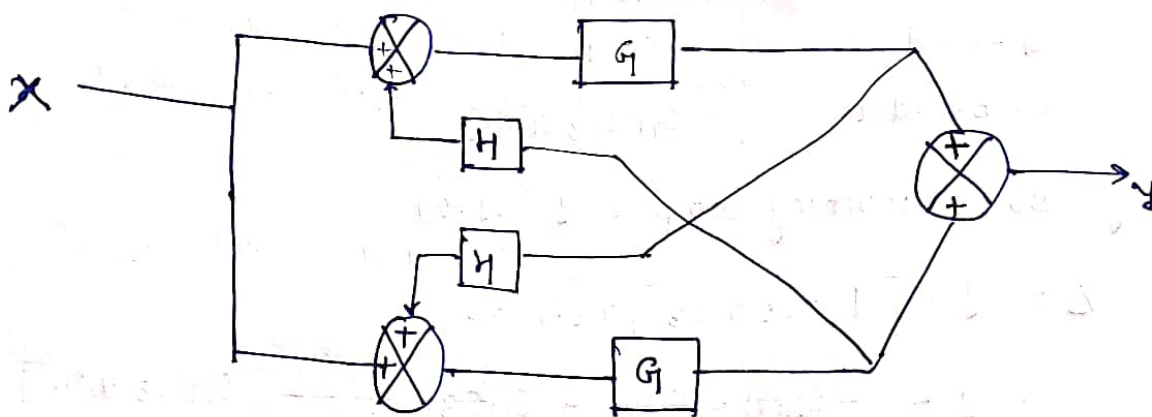
$$\Delta_6 = 1 - 0 = 1$$

$$\frac{C}{R} = \frac{G_2 G_4 G_6 (1 + G_5 H_2) + G_3 G_5 G_7 (1 + G_4 H_1) + G_2 G_1 G_7 + G_3 G_8 G_6 - G_1 G_3 G_7 G_8 H_1 - G_1 G_2 G_6 G_8 H_2}{1 + G_4 H_1 + G_5 H_2 - G_1 G_8 H_1 H_2 + G_4 G_5 H_1 H_2}$$

$$= \frac{G_2 G_4 G_6 + G_2 G_4 G_6 G_5 H_2 + G_3 G_5 G_7 + G_3 G_5 G_7 G_4 H_1 + G_2 G_1 G_7 + G_3 G_8 G_6 - G_1 G_3 G_7 G_8 H_1 - G_1 G_2 G_6 G_8 H_2}{1 + G_4 H_1 + G_5 H_2 - G_1 G_8 H_1 H_2 + G_4 G_5 H_1 H_2}$$

//

Q. Find the overall xfer function of system shown in below figure.



forward paths:

$$P_1 = G$$

$$P_2 = G$$

$$P_3 = G^2 H$$

$$P_4 = G^2 H$$

Individual loop gain

$$L_1 = G H G H$$

$$= G^2 H^2$$

no. of two non touching loop $\Rightarrow 0$

$$\Delta = 1 - L_1 = 1 - G^2 H^2$$

$$\Delta_1 = \Delta_2 = \Delta_3 = \Delta_4 = 1 - 0 = 1$$

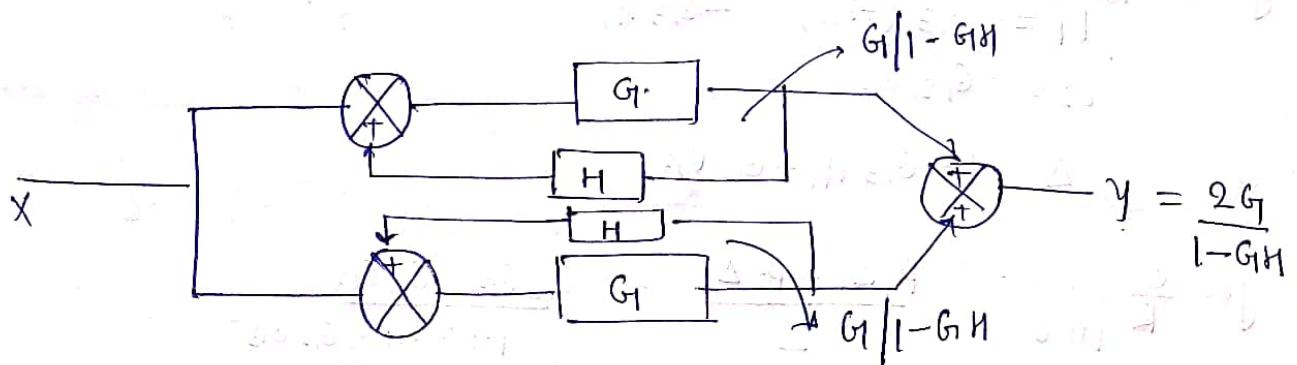
$$\frac{C}{R} = \frac{P_1 \Delta_1 + P_2 \Delta_2 + P_3 \Delta_3 + P_4 \Delta_4}{\Delta}$$

$$= \frac{G + G + G^2 H + G^2 H}{1 - G^2 H^2}$$

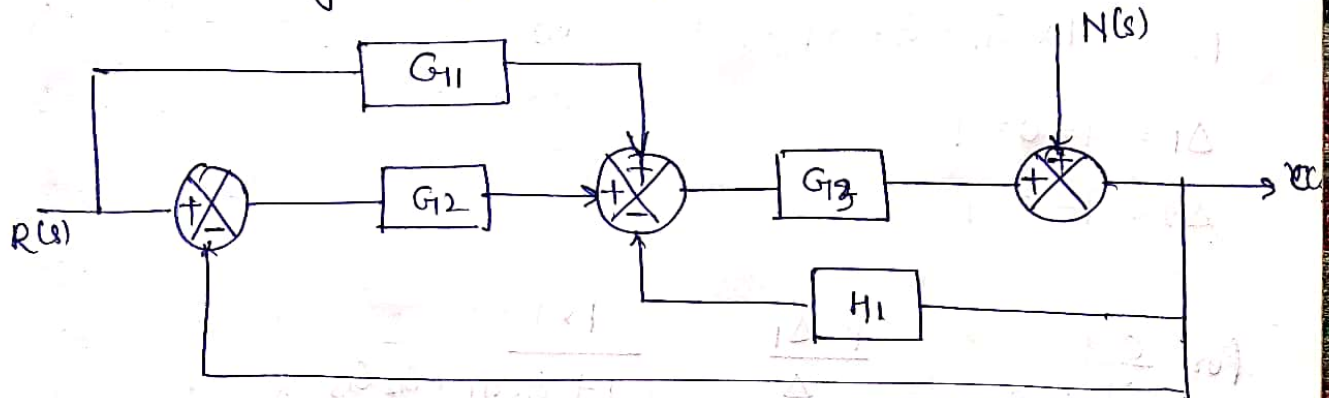
$$= \frac{2G + 2G^2 H}{1 - G^2 H^2}$$

$$= \frac{2G(1 + GH)}{(1 - GH)(1 + GH)} = \frac{2G}{1 - GH}$$

Key point:- Due to Symmetric block diagram we can Interchange the take off point across the Input of adder at the output side



Q. The block diagram of Control System is shown in figure



- i) Draw SFG of block diagram
- ii) Obtain TF $\frac{C}{R}$ when $N=0$ & $\frac{C}{N}$ when $R=0$

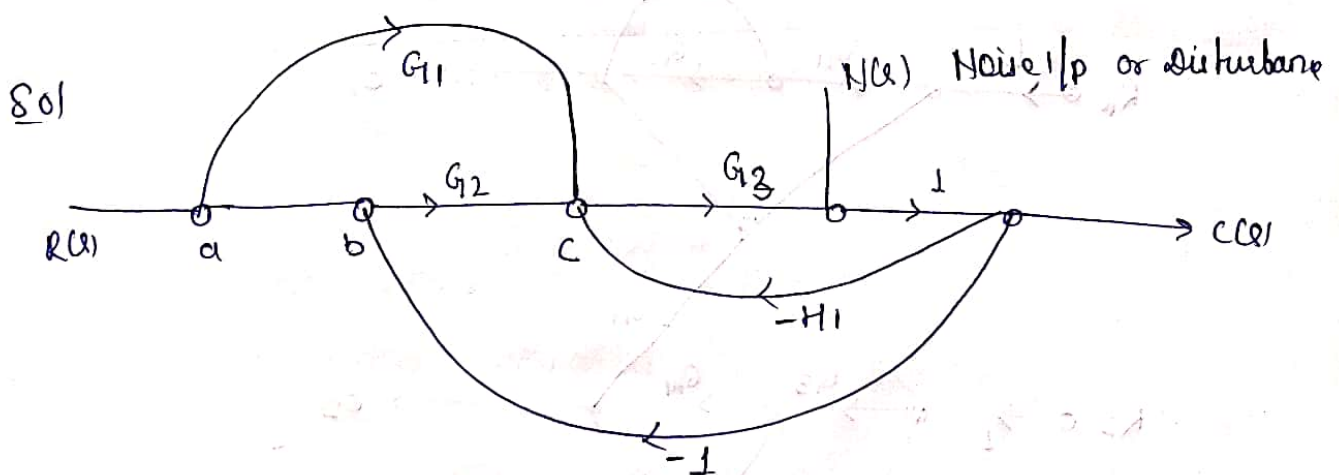


fig. Multiple I/p Multiple Single o/p

$$1) \left. \frac{C}{R} \right|_{N=0} = ?$$

$$11) \left. \frac{C}{N} \right|_{R=0} = ?$$

given SFG, Δ is unique

$$L_1 = G_{13}(-H_1) = -G_{13}H_1$$

$$L_2 = -G_{12}G_{13}$$

$$\Delta = 1 + G_{13}H_1 + G_{12}G_{13}$$

$$\text{for } \left. \frac{C}{R} \right|_{H=0} = \frac{P_1 \Delta_1 + P_2 \Delta_2}{\Delta} = \frac{G_{12}G_{13} + G_{11}G_{13}}{1 + G_{13}H_1 + G_{12}G_{13}}$$

$$P_1 = 1 \times 1 \times G_{12} \times G_{13} \times 1 \times 1 = G_{12}G_{13}$$

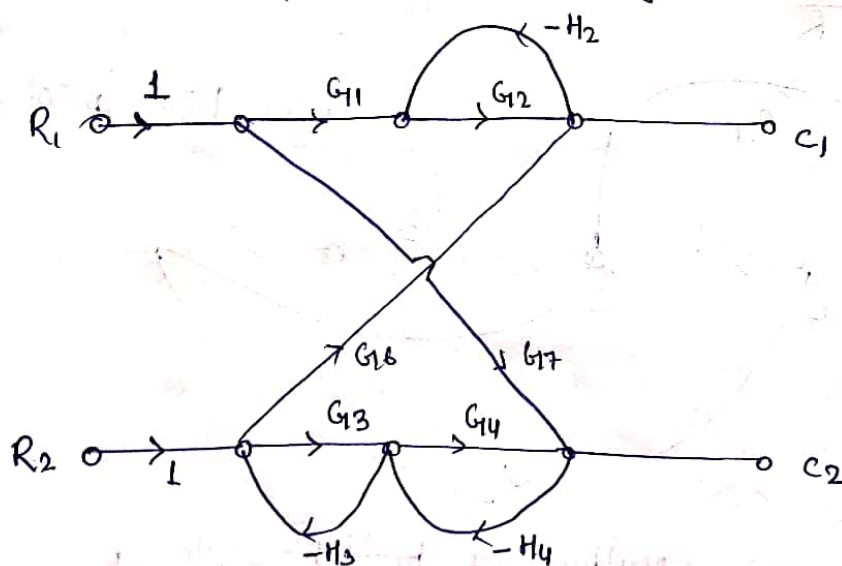
$$P_2 = 1 \times G_{11} \times G_{13} \times 1 \times 1 = G_{11}G_{13}$$

$$\Delta_1 = 1 - 0 = 1$$

$$\Delta_2 = 1 - 0 = 1$$

$$\text{for } \left. \frac{C}{N} \right|_{R=0} = \frac{P_1 \Delta_1}{\Delta} = \frac{1 \times 1}{1 + G_{13}H_1 + G_{12}G_{13}}$$

Q. Consider Multiinput Multioutput System



$$L_1 = -G_2 H_2$$

$$L_2 = -G_3 H_3$$

$$L_3 = -G_4 H_4$$

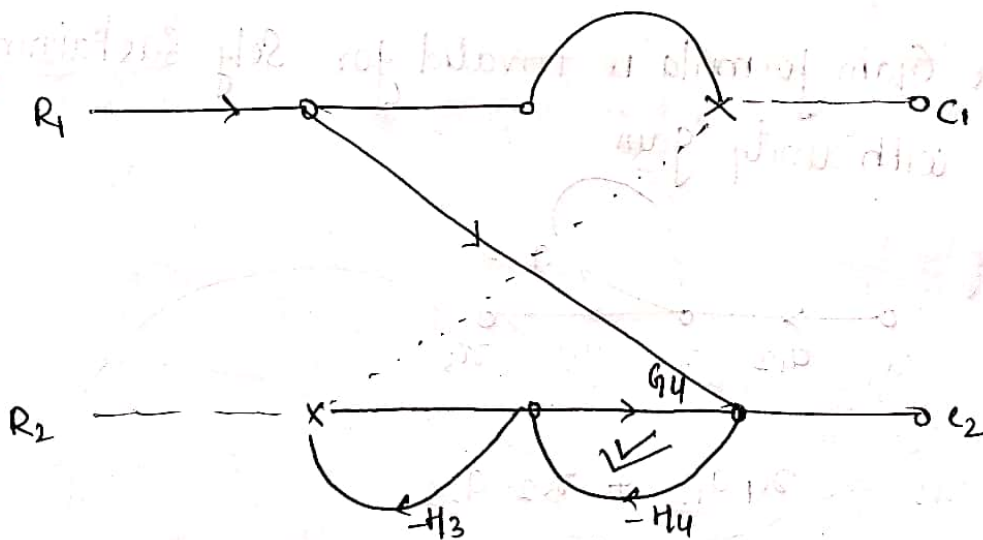
No. of two non touching loop = 2 ($L_1 L_2, L_1 L_3$)

$$\Delta = 1 - [L_1 + L_2 + L_3] + [L_1 L_2 + L_1 L_3]$$

$$= 1 + G_2 H_2 + G_3 H_3 + G_4 H_4 + G_2 G_3 H_2 H_3 + G_2 G_4 H_2 H_4$$

$$\begin{aligned} \text{i) } \left. \frac{C_1}{R_1} \right|_{\substack{R_2=0 \\ C_2=0}} &= \frac{P_1 \Delta_1 + P_2 \Delta_2}{\Delta} \\ &= \frac{G_1 G_2 (1 + G_3 H_3 + G_4 H_4) + G_1 G_7 H_3 H_4}{1 + G_2 H_2 + G_4 H_4 + G_3 H_3 + G_2 G_3 H_2 H_3 + G_2 G_4 H_2 H_4} \end{aligned}$$

$$\text{ii) } \left. \frac{C_1}{R_2} \right|_{R_1=0} = \frac{P_1 \Delta_1}{\Delta} = \frac{G_6 (1 + G_4 H_4)}{\Delta}$$



$$\Delta_1 = 1 - [L_3^*] = 1 + G_4 H_4$$

iii)

$$\left. \frac{C_2}{R_1} \right|_{R_2=0} = \frac{G_7 (1 + G_2 H_2 + G_3 H_3 + G_2 H_2 H_3 G_3)}{\Delta}$$

iv)

$$\left. \frac{C_2}{R_2} \right|_{R_1=0} = \frac{P_1 \Delta_1}{\Delta}$$

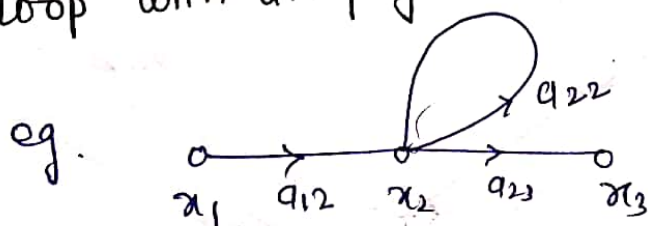
$$P_1 = 1 \times G_3 \times G_4 \times 1 = G_3 G_4$$

$$\Delta_1 = 1 - [L_1^*] = 1 + G_2 H_2$$

$$\frac{C_2}{R_2} = \frac{G_3 G_4 (1 + G_2 H_2)}{\Delta} //$$

* Limitation of Mason's Gain formula:

- ① Mason's Gain formula is invalid for self sustaining loop with unity gain



$$x_2 = x_1 a_{12} + x_2 a_{22}$$

$$x_2 [1 - a_{22}] = x_1 a_{12}$$

$$\frac{x_2}{x_1} = \frac{a_{12}}{1 - a_{22}} \quad \text{--- (1)}$$

By Mason's gain formula

$$\frac{x_2}{x_1} = \frac{a_{12}x_1}{1 - a_{22}} \quad \checkmark$$

$$\frac{x_3}{x_1} :-$$

$$x_3 = x_2 a_{23}$$

$$x_3 = a_{23}x_1 + a_{12} + x_2 a_{22} a_{23}$$

$$\frac{x_3}{x_1} =$$

$$x_3 = \frac{x_1 a_{12}}{1 - a_{22}} a_{23}$$

$$\frac{x_3}{x_1} = \frac{a_{23} a_{12}}{1 - a_{22}}$$

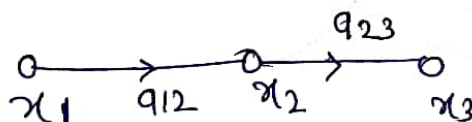
By M.G.F $\frac{x_3}{x_1} = \frac{a_{12} a_{23}}{1 - a_{22}}$

If $a_{22} = 1$

from eq ① $\frac{x_2}{x_1} = \frac{a_{12}}{1 - 1} = \infty$ (not possible)

also, $x_2 = x_1 a_{12} + x_2$ (invalid equation)

So modified SFG will be



eg.



~~only 1st not valid~~

Sol from MBTF

$$\frac{C}{R} = \frac{10}{1 - 0.5} = 20$$

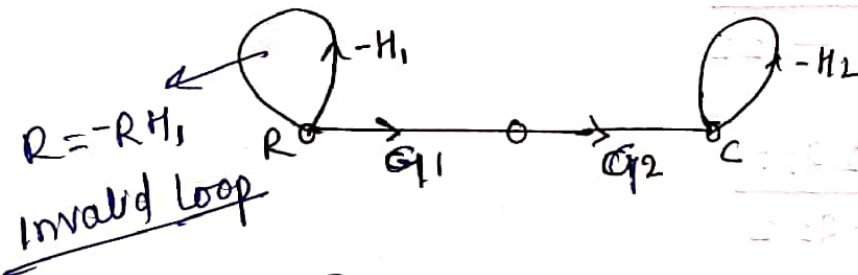
from eqn

$$C = 10R + 0.5C$$

$$0.5C = 10R$$

$$\frac{C}{R} = 20 //$$

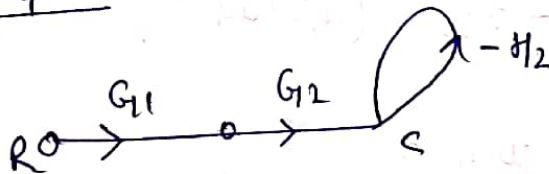
Q. find $\frac{C}{R}$ from given below figure



$$\frac{C}{R} = \frac{P_1 \Delta_1}{\Delta} = \frac{G_1 G_2 \times 1}{1 + H_1 + H_2 + H_1 H_2}$$

X ~~Wrong~~

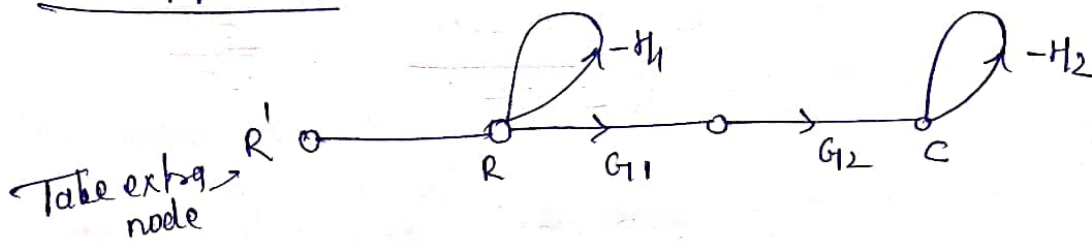
Modified figure:-



$$\frac{C}{R} = \frac{G_1 G_2}{1 + H_2}$$

Key point: If a self loop with any gain exist at input node then this self loop will be invalid

2nd approach :-



$$\frac{C}{R} = \frac{C/R'}{R/R'}$$

$$\frac{C}{R'} = \frac{G_1 G_2}{1 + H_1 + H_2 + H_1 H_2}$$

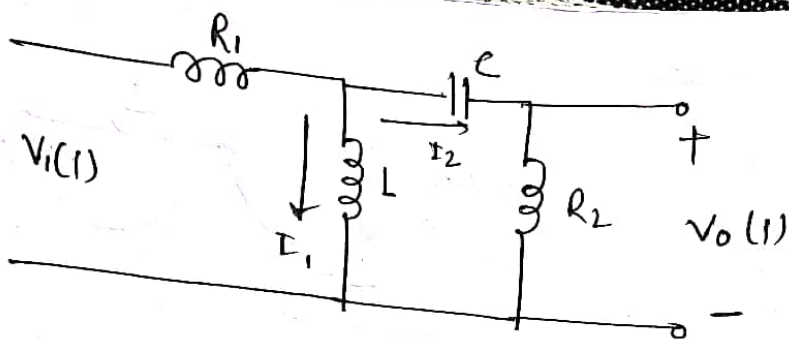
and

$$\frac{R}{R'} = \frac{P_1 \Delta_1}{\Delta} = \frac{1 \times (1 - (-H_1))}{1 + H_1 + H_2 + H_1 H_2}$$

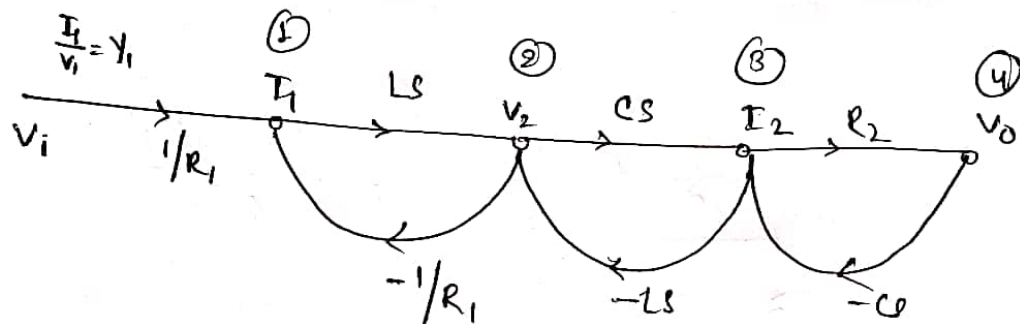
$$= \frac{1 + H_2}{1 + H_1 + H_2 + H_1 H_2}$$

$$\frac{C}{R} = \frac{G_1 G_2}{1 + H_2} //$$

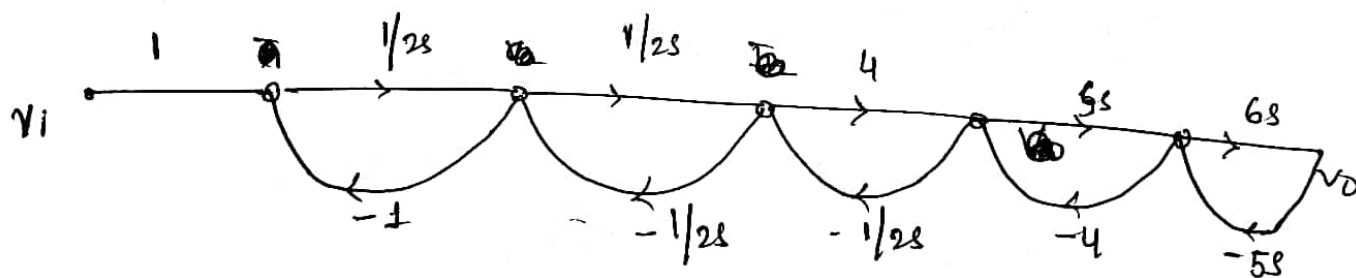
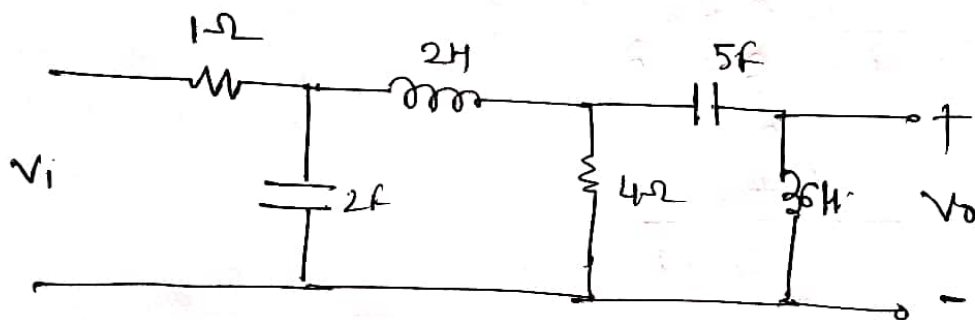
Q1.



Sol



Q2



$$Z[R] = R$$

$$Y[R] = 1/R$$

$$Z[L] = sL$$

$$Y[L] = 1/sL$$

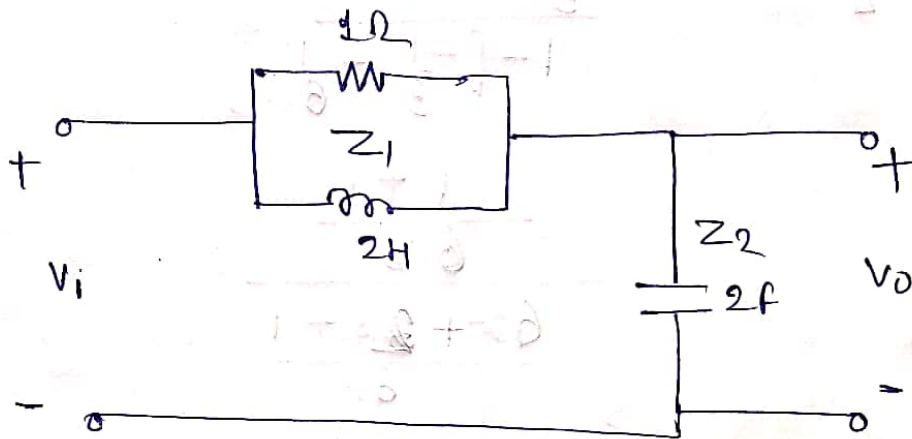
$$Z[C] = 1/sC$$

$$Y[C] = sC$$

key

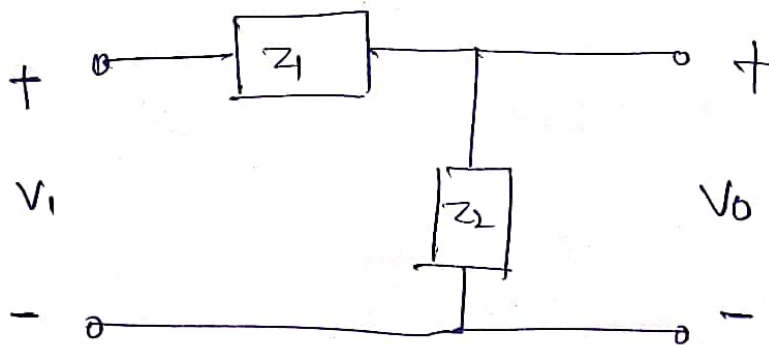
- 1) for formation of SFG from electrical n/w, all n/w element one forward path and one negative feed back path except last element where we take o/p (last element represent one forward path)
- 2) In SFG, All branch gain (or transmittance) represents either impedance or admittance in alternate form.

eg(3)

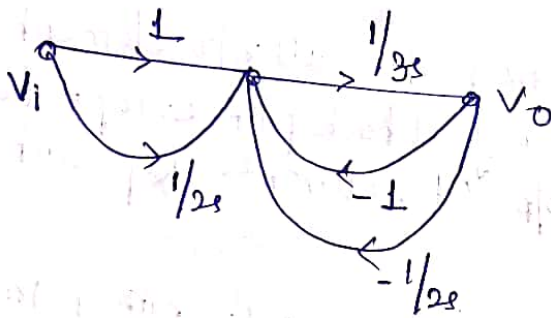


$$Z_1 = 1 \parallel 2s = \frac{1 \times 2s}{1 + 2s} = \frac{2s}{1 + 2s}$$

$$Z_2 = \frac{1}{3s}$$



$$\frac{V_o}{V_i} = \frac{Z_2}{Z_1 + Z_2} = \frac{\frac{1}{3s}}{\frac{2s}{2s+1} + \frac{1}{3s}} = \frac{1+2s}{6s^2 + 1+2s} //$$



$$\frac{V_o}{V_i} = \frac{P_1 \Delta_1 + P_2 \Delta_2}{\Delta} = \frac{\frac{1}{2s} + \frac{1}{6s^2}}{1 - \left[-\frac{1}{3s} - \frac{1}{6s^2} \right]}$$

$$= \frac{\frac{2s + 1}{6s^2}}{\frac{6s^2 + 2s + 1}{6s^2}}$$

$$= \frac{2s + 1}{6s^2 + 2s + 1}$$

//