CMR
INSTITUTE OF
TECHNOLOGY

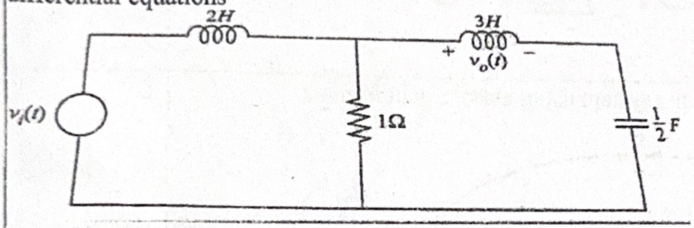
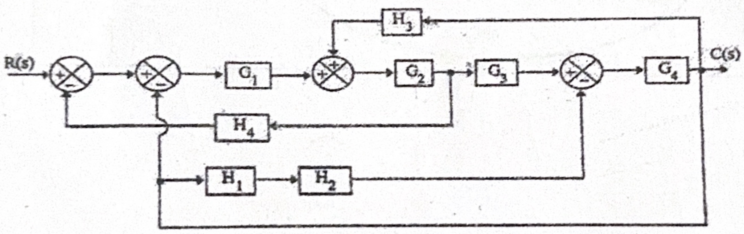
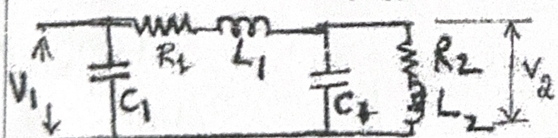
USN

(260)

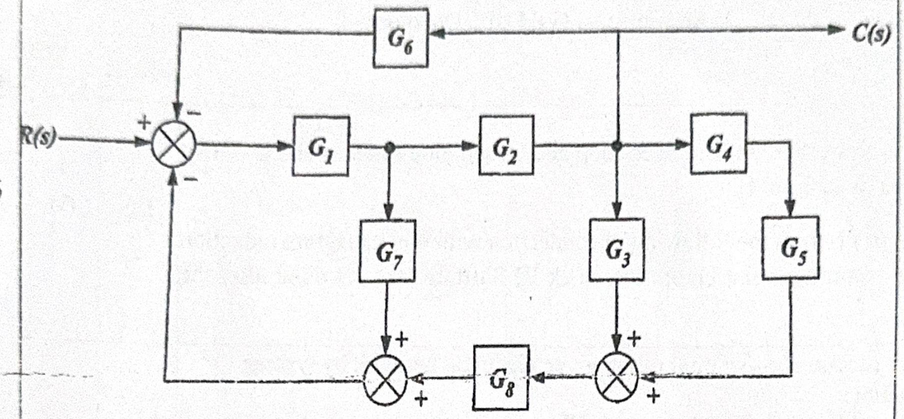
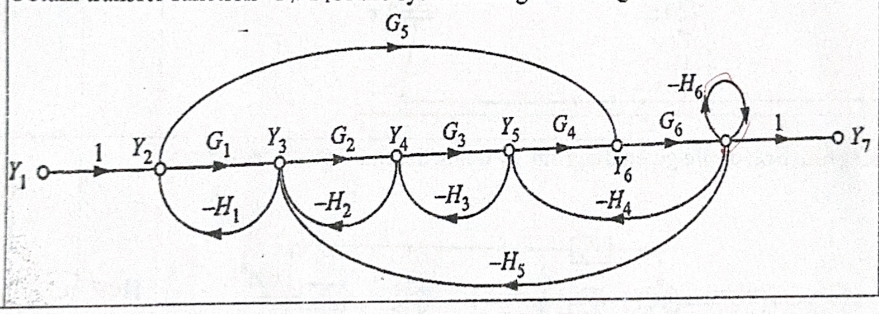
Internal Assesment Test - I

Sub:	Control Systems							Code:	BEC403
Date:	04/ 06/ 2024	Duration:	90 mins	Max Marks:	50	Sem:	4th	Branch:	ECE

Answer Any FIVE FULL Questions

		Marks	OBE CO	OBE RBT
1.	a) Define Control System? Compare open loop and closed loop systems and give two practical example of each.(6M) b) Illustrate how to perform the following in connection with block diagram reduction rules. I) shifting summing point before the block II) Shifting take off point after the block (4M)	[10]	CO1	L2
2.	Find the transfer function Vo(s)/Vi(s) of the given electrical network by writing differential equations 	[10]	CO1	L3
3.	Obtain the transfer function of the given diagram by using Block Diagram reduction rules 	[10]	CO1	L3
4	Obtain transfer function of the system.. 	[10]	CO1	L3
5	The performance equations of a controlled system are given by the following set of linear algebraic equations: (i) Draw the signal flow graph. (ii) Find the overall transfer function X(s) / U(s) using Mason's Gain Formula. $X(s)=X_1(S)+\beta_3 U(S)$ $X_1(S)=\frac{-a1}{s}X_1(S)+\frac{X2(S)}{S}+\frac{\beta 2}{S}U(S)$ $X_2(S)=\frac{-a2}{s}X_1(S)+\frac{\beta 1}{S}U(S)$	[10]	CO1	L3

P.T.O

6	Obtain the transfer function of the given diagram by using Block Diagram reduction rules 	[10]	CO1	L3
7.	Obtain transfer function Y_7/Y_1 of the system using masons gain formula 	[10]	CO1	L3

CCI

M. pappa 3/6/2024
HOD

IAT I Control Systems Question Paper Solutions

- Dr. Rasmitha. A

1. a) Def and Comparison with examples. ①

(Refer class notes)

Def – 2M

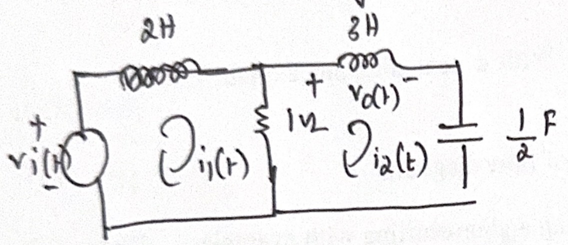
Comparison and Examples – 4M

b) i) shifting summing point before the block — 2M

ii) shifting take off point after the block — 2M

(Refer class notes)

2.



Two loops — so Assume two currents

By writing KVL in the first loop

$$-v_i(t) + 2 \cdot \frac{di(t)}{dt} + 1\,(i_1(t) - i_2(t)) = 0$$

$$v_i(t) = 2 \cdot \frac{di_1(t)}{dt} + i_1(t) - i_2(t)$$

apply L.T on both sides

$$V_i(s) = 2s\, i_1(s) + i_1(s) - i_2(s)$$

$$\boxed{V_i(s) = (2s+1)\, i_1(s) - i_2(s)} \longrightarrow ①$$

By writing KVL in second loop

$$3 \cdot \frac{di_2(t)}{dt} + \frac{1}{\frac{1}{2}}\int i_2(t) + 1\,(i_2(t) - i_1(s)) = 0$$

Apply L.T on both sides

$$3s\, i_2(s) + \frac{2}{s}\, i_2(s) + i_2(s) - i_1(s) = 0$$

$$\left(3s + \frac{2}{s} + 1\right) i_2(s) = i_1(s)$$

By taking LCM

2'

$$\boxed{\left(\frac{3s^2+s+2}{s}\right) i_2(s) = i_1(s)} \longrightarrow 2'$$

$$V_o(t) = 3 \cdot \frac{di_2(t)}{dt}$$

$$\boxed{V_o(s) = 3s\, i_2(s)} \longrightarrow 3$$

Since $V_o(s)$ is interms of $i_2(s)$ let us write 1 equation also in $i_2(s)$ to find the ratio $\frac{V_o(s)}{V_i(s)}$.

From 2 substitute $i_1(s)$ in equ 1

$$\therefore \quad V_i(s) = (2s+1)\, i_1(s) - i_2(s)$$

$$V_i(s) = (2s+1)\left[\left(\frac{3s^2+s+2}{s}\right) i_2(s)\right] - i_2(s)$$

$$V_i(s) = \frac{(6s^3+2s^2+4s+3s^2+s+2)\, i_2(s) - s\, i_2(s)}{s}$$

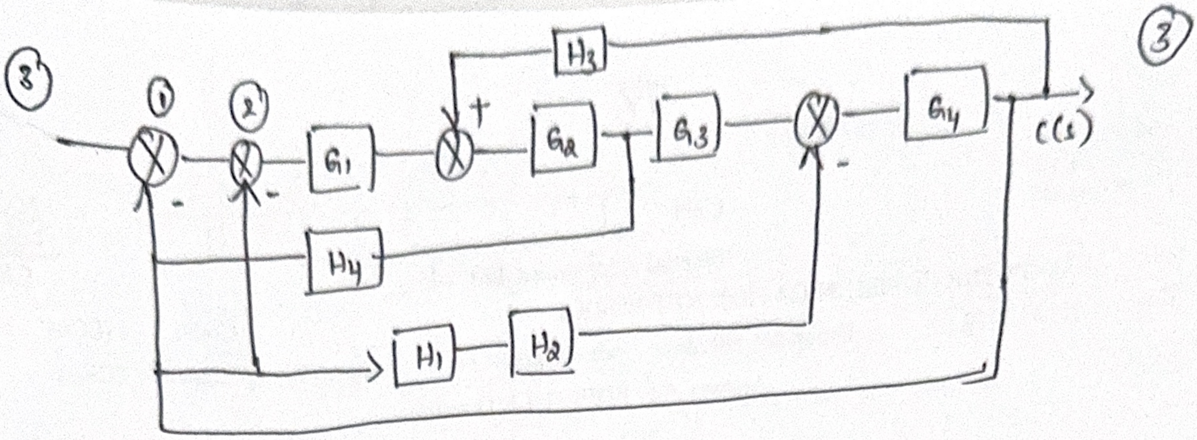
$$V_i(s) = \frac{(6s^3+5s^2+4s+\cancel{s}+2-\cancel{s})\, i_2(s)}{s}$$

$$\boxed{V_i(s) = \frac{(6s^3+5s^2+4s+2)\, i_2(s)}{s}} \longrightarrow 4$$

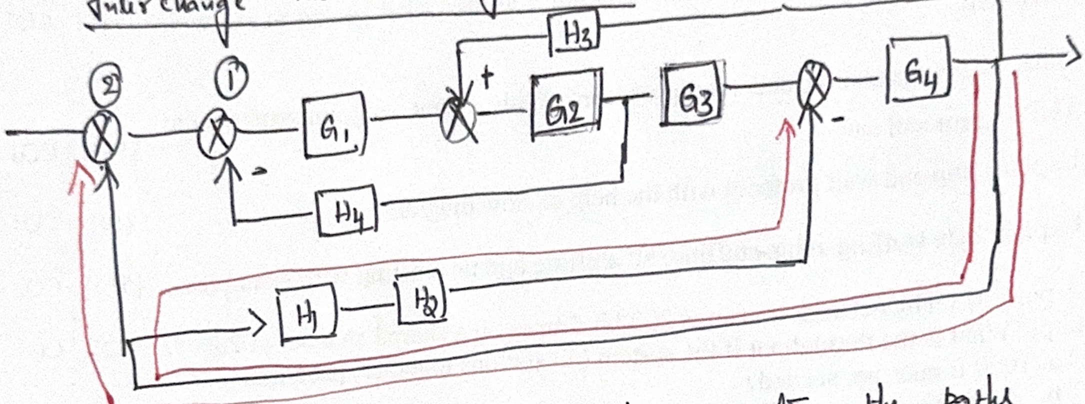
$$\frac{V_o(s)}{V_i(s)} = \frac{3s\, \cancel{i_2(s)}}{\frac{(6s^3+5s^2+4s+2)}{s}\, \cancel{i_2(s)}}$$

$$\boxed{\frac{V_o(s)}{V_i(s)} = \frac{3s^2}{6s^3+5s^2+4s+2}}$$

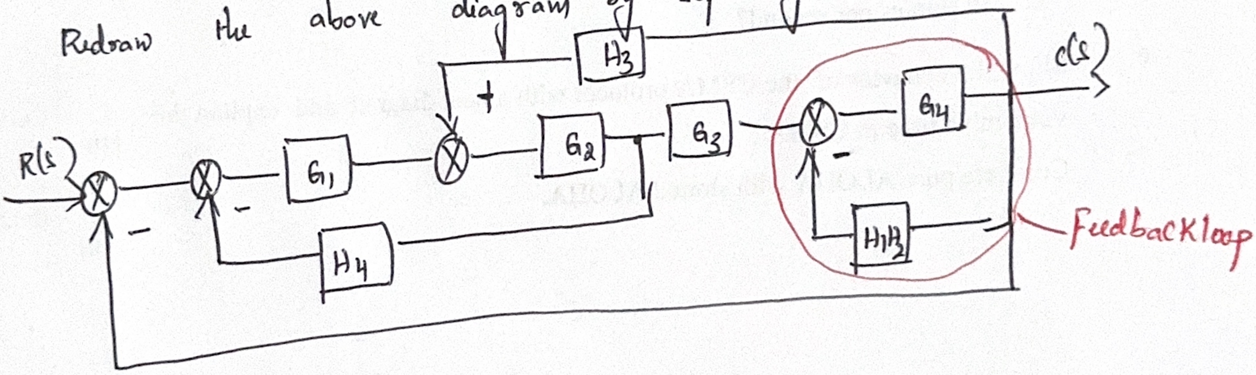
3



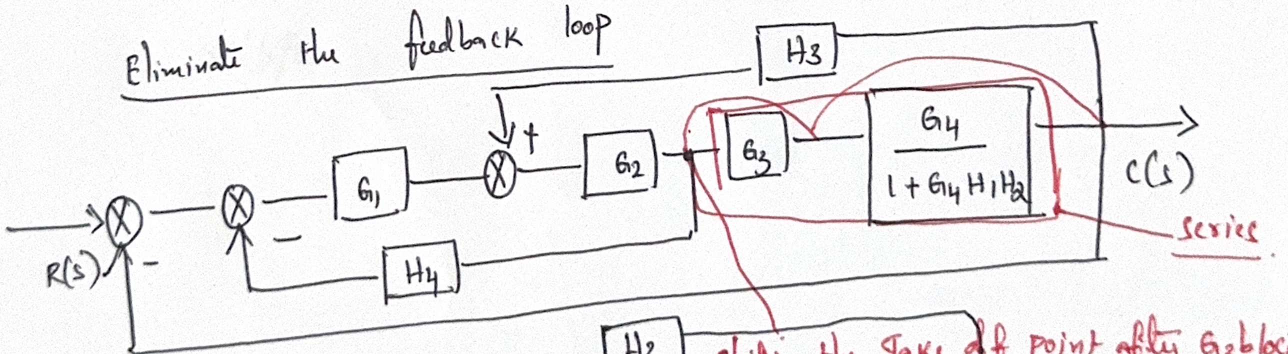
Interchange the summing points



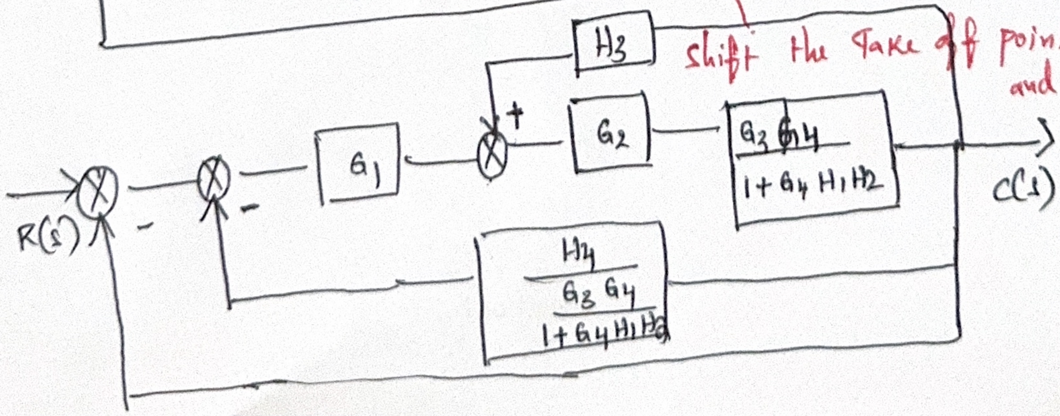
Redraw the above diagram by seperating the paths

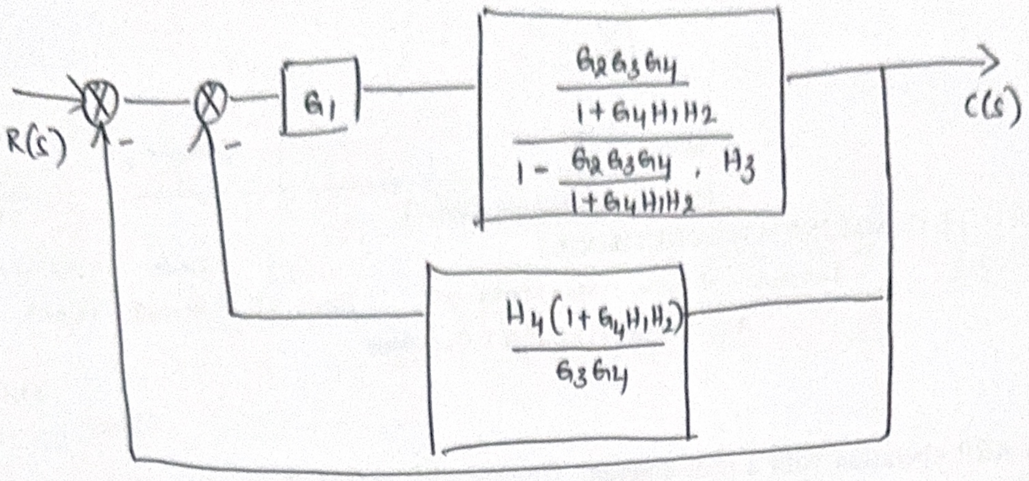


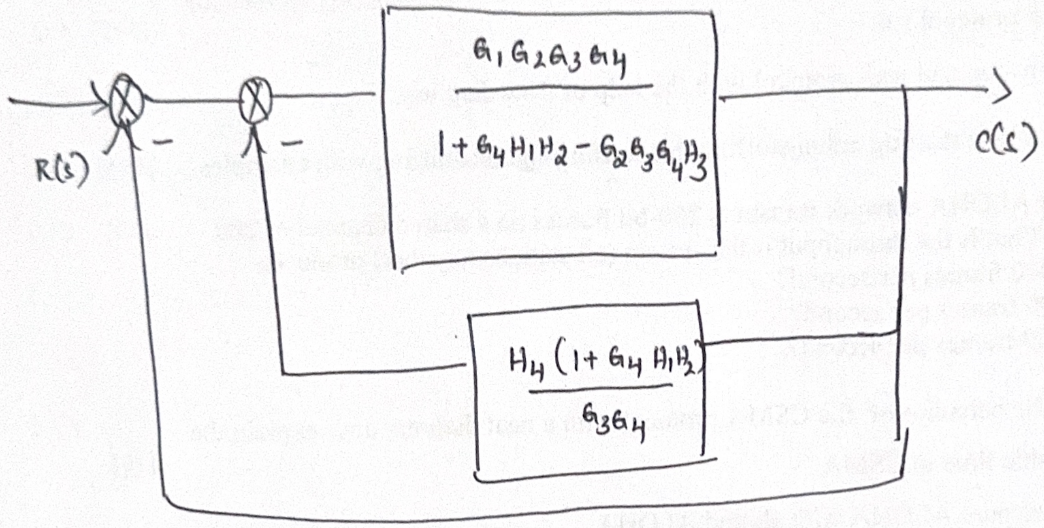
Eliminate the feedback loop

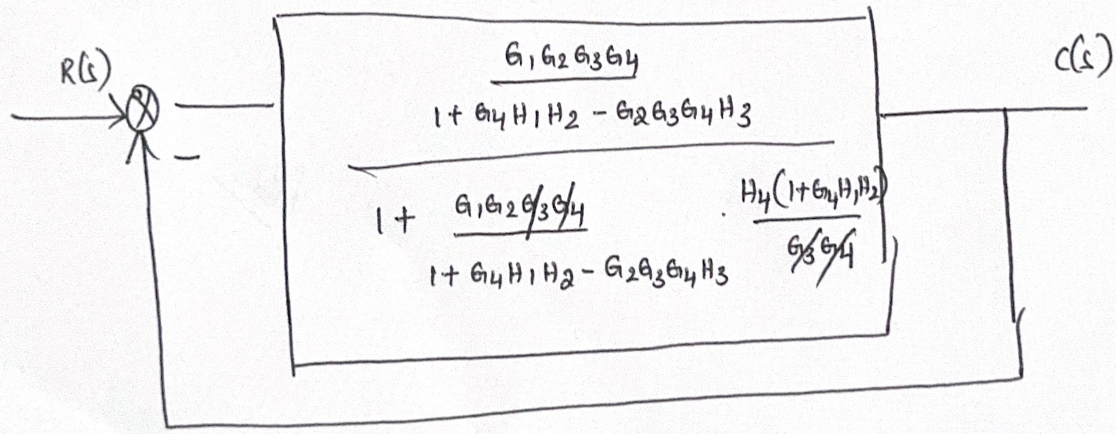


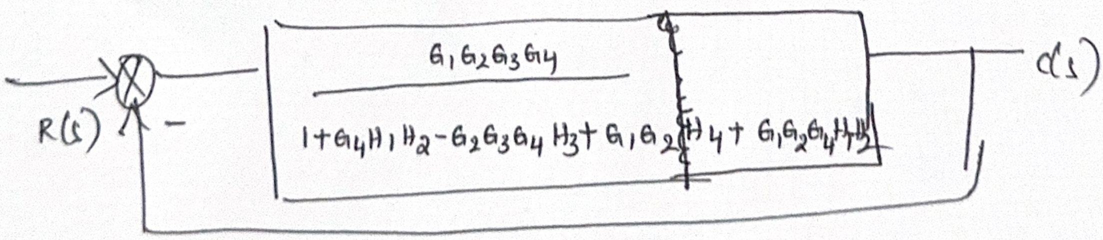
Shift the Take off point after G_3 block and $\frac{G_4}{1+G_4H_2H_1}$ blocks











$$\boxed{\frac{C(s)}{R(s)} = \frac{G_1G_2G_3G_4}{1+G_4H_1H_2-G_2G_3G_4H_3+G_1G_2H_4+G_1G_2G_4H_1H_2+G_1G_2G_3G_4}}$$

5

$$X(s) = X_1(s) + \beta_3 V(s)$$

$$X_1(s) = -\frac{a_1}{s} X_1(s) + \frac{X_2(s)}{s} + \frac{\beta_2}{s} V(s)$$

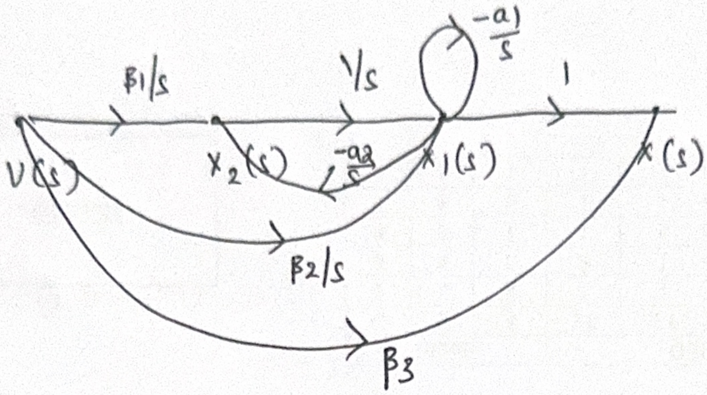
$$X_2(s) = -\frac{a_2}{s} X_1(s) + \frac{\beta_1}{s} V(s)$$

5

Since T.F is

$\frac{X(s)}{V(s)} \rightarrow$ $X(s)$ – o/p

$V(s)$ – i/p.



No of Forward paths = 3

$$P_1 = \frac{\beta_1}{s^2}$$

$$P_2 = \frac{\beta_2}{s}$$

$$P_3 = \beta_3$$

Two individual loops

$$L_1 = -\frac{a_2}{s^2} \qquad L_2 = -\frac{a_1}{s}$$

No non touching loops.

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

$$= 1 + \frac{a_2}{s^2} + \frac{a_1}{s}.$$

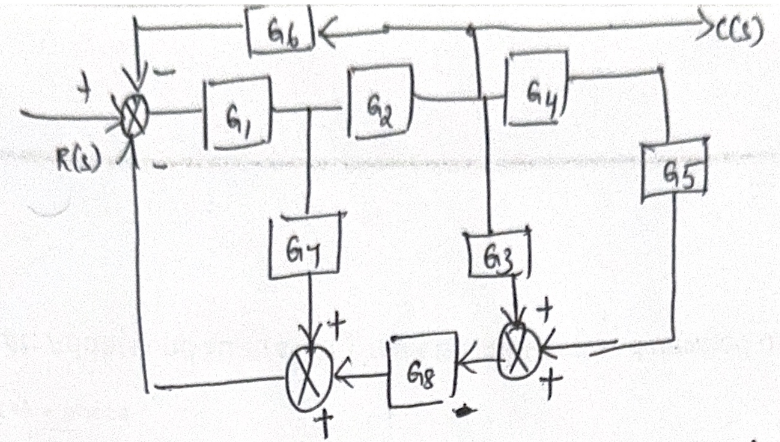
$\Delta_1 = 1$ $\quad \Delta_2 = 1$

$$\Delta_3 = 1 + \frac{a_2}{s^2} + \frac{a_1}{s}.$$

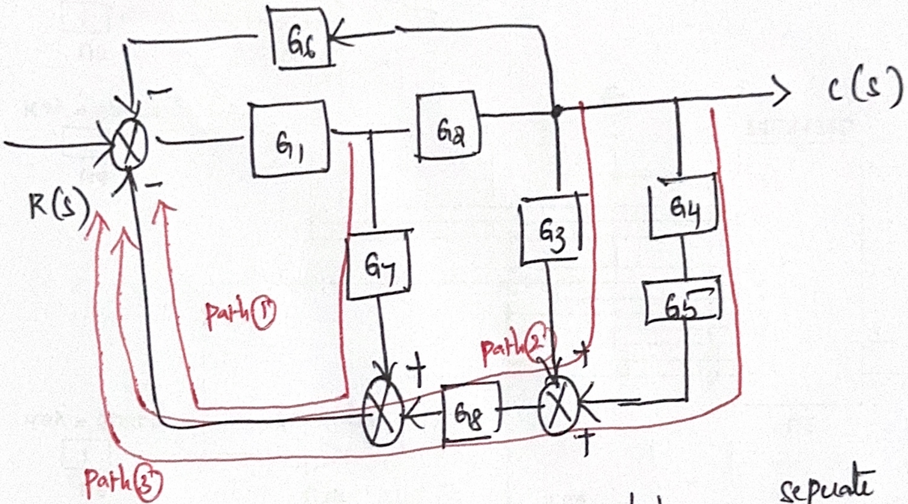
$$T.F = \frac{\Sigma P_K \Delta_K}{\Delta} = \frac{P_1\Delta_1 + P_2\Delta_2 + P_3\Delta_3}{\Delta}$$

$$\boxed{T.F = \frac{\frac{\beta_1}{s^2}\cdot 1 + \frac{\beta_2}{s}\cdot 1 + \beta_3\left(1 + \frac{a_2}{s^2} + \frac{a_1}{s}\right)}{1 + \frac{a_2}{s^2} + \frac{a_1}{s}}.}$$

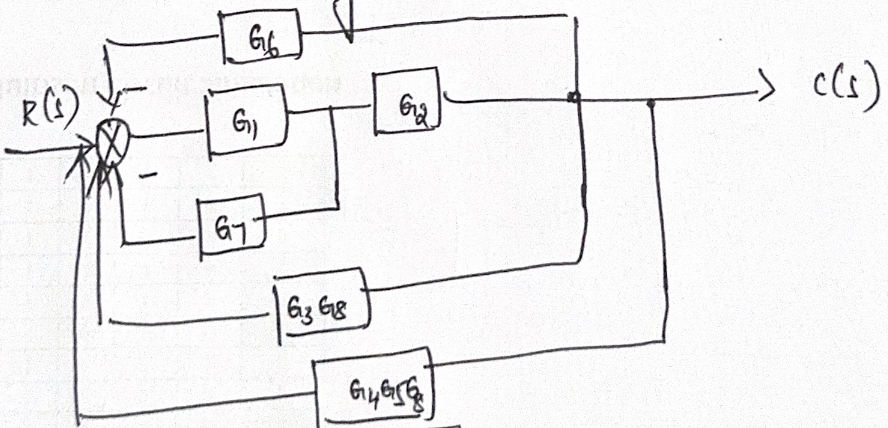
(b)

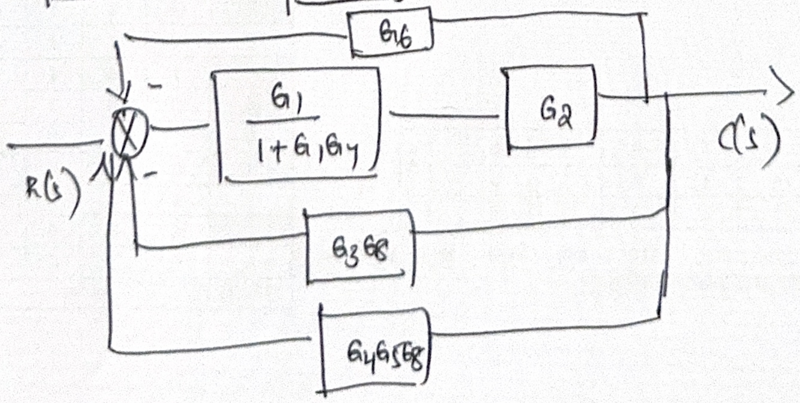


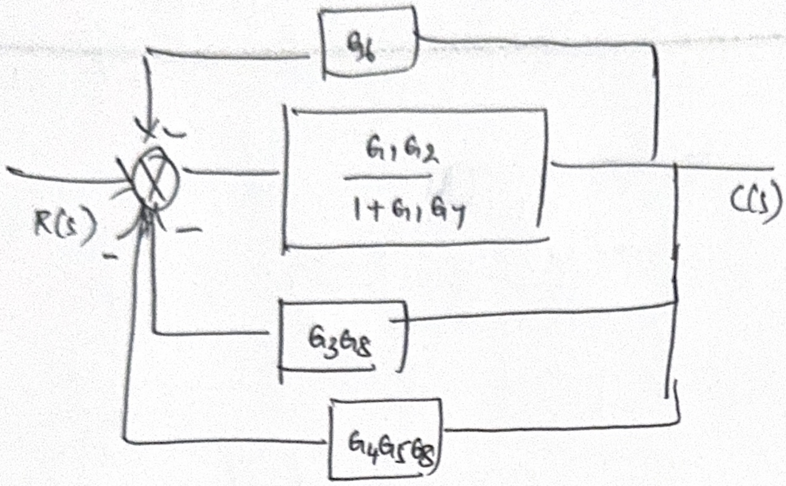
Redraw the diagram (always start from the input to output)

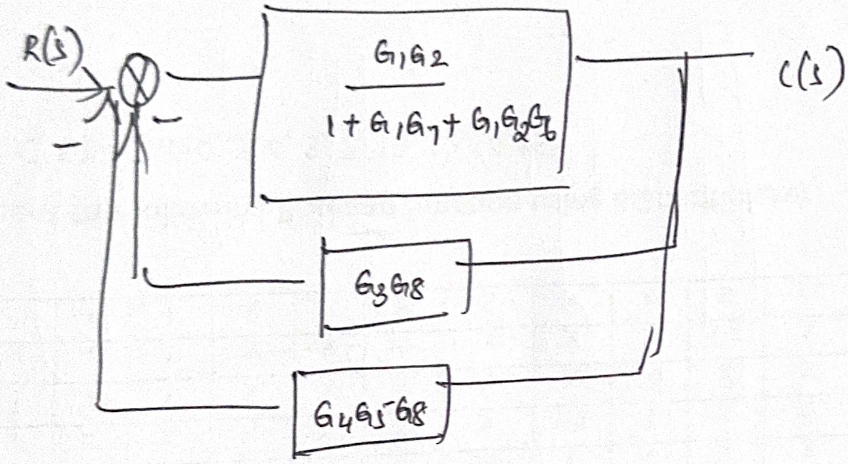


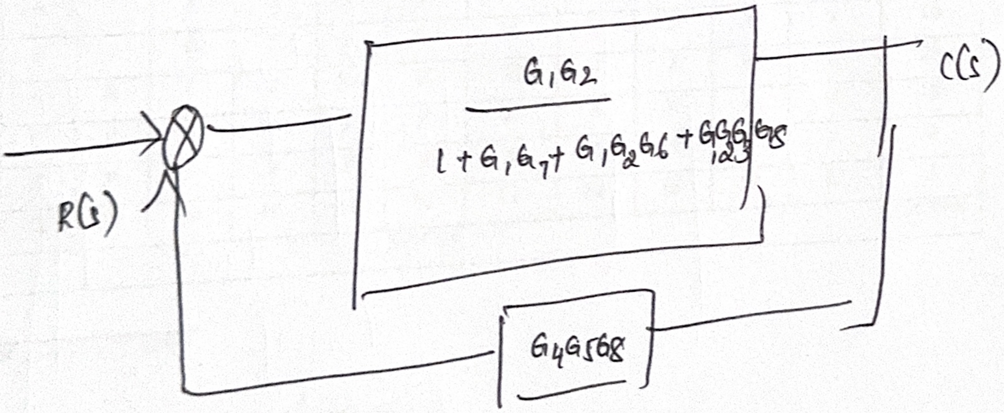
when summing points are below, separate the paths.







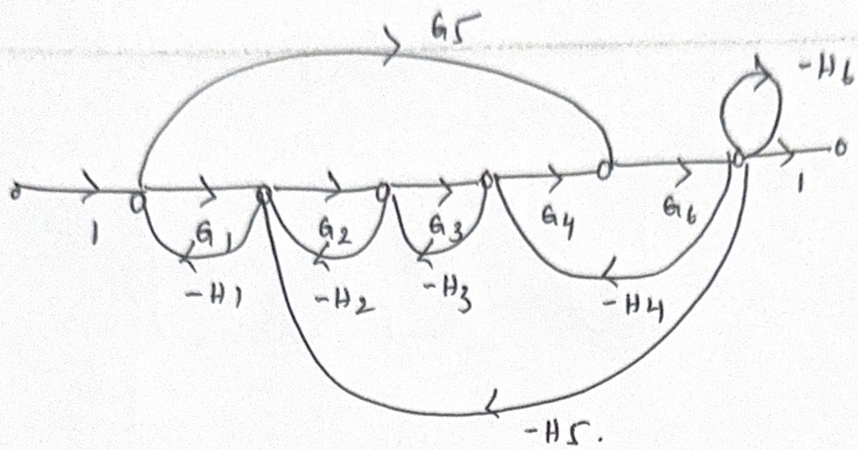




$$\boxed{\frac{C(s)}{R(s)} : \frac{G_1G_2}{1+G_1G_7+G_1G_2G_6+G_1G_2G_3G_8+G_1G_2G_4G_5G_8}}$$

(8)

(7)



K=2 $\quad P_1 = G_1G_2G_3G_4G_6$

$P_2 = G_5G_6$

$L_1 = -G_1H_1$

$L_2 = -G_2H_2$

$L_3 = -G_3H_3$

$L_4 = -G_4G_6H_4$

$L_5 = -H_6$

$L_6 = -G_2G_3G_4G_6H_5$

$L_7 = G_5G_6(-H_5)(-H_1)$

$L_8 : G_5G_6(-H_4)(-H_3)(-H_2)(-H_1)$

Non touching Combinations (two)

(1) $L_1 \,\&\, L_3 : G_1G_3H_1H_3$

(2) $L_1L_4 : G_1G_4G_6H_1H_4$

(3) $L_1 \,\&\, L_5 : G_1H_1H_6$

(4) $L_2 \,\&\, L_4 : G_2G_4G_6H_2H_4$

(5) $L_2 \,\&\, L_5 : G_2H_2H_6$

(6) $L_3 \,\&\, L_5 : G_3H_3H_6$

(7) $L_3 \,\&\, L_7 = -(G_3H_3)(G_5G_6H_1H_5)$

Three non touching

(1) $L_1L_3L_5$

$= (-G_1H_1)(-G_3H_3)(-H_6)$

$\Delta_1 = 1$

$\Delta_2 = 1 + G_2H_2 + G_3H_3$

$\Delta = 1 - (L_1 + L_2 + L_3 + L_4 + L_5 + L_6 + L_7 + L_8) + L_1L_3 + L_1L_4$
$+ L_1L_5 + L_2L_4 + L_2L_5 + L_3L_5 + L_3L_7 - L_1L_2L_3$

$$T.F = \frac{P_1\Delta_1 + P_2\Delta_2}{\Delta}$$

$$= \frac{G_1G_2G_3G_4G_6 + G_5G_6(1 + G_2H_2 + G_3H_3)}{\Delta}.$$