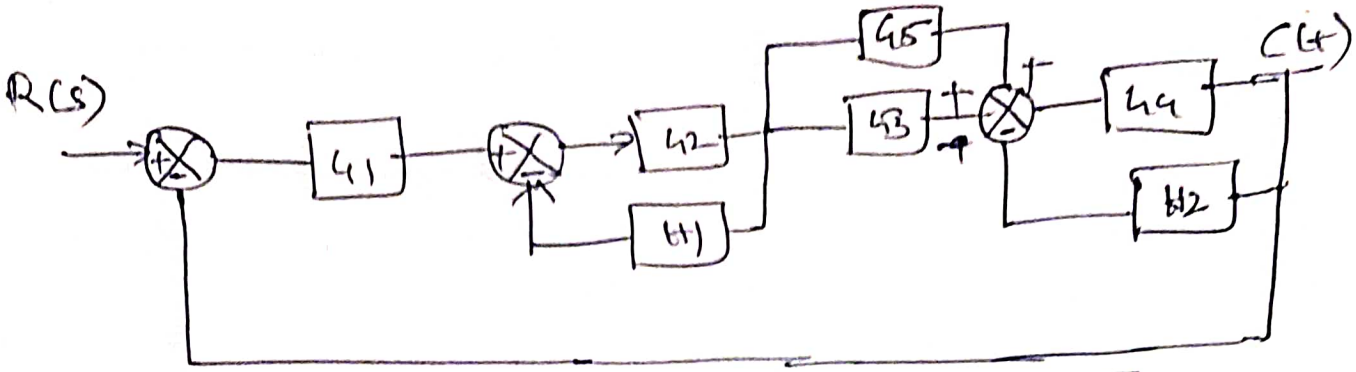
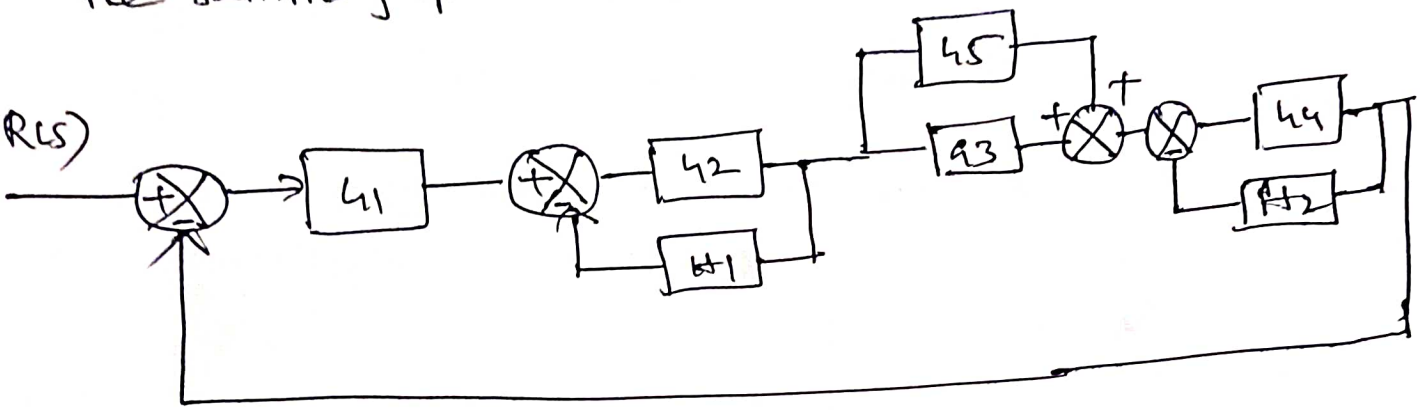
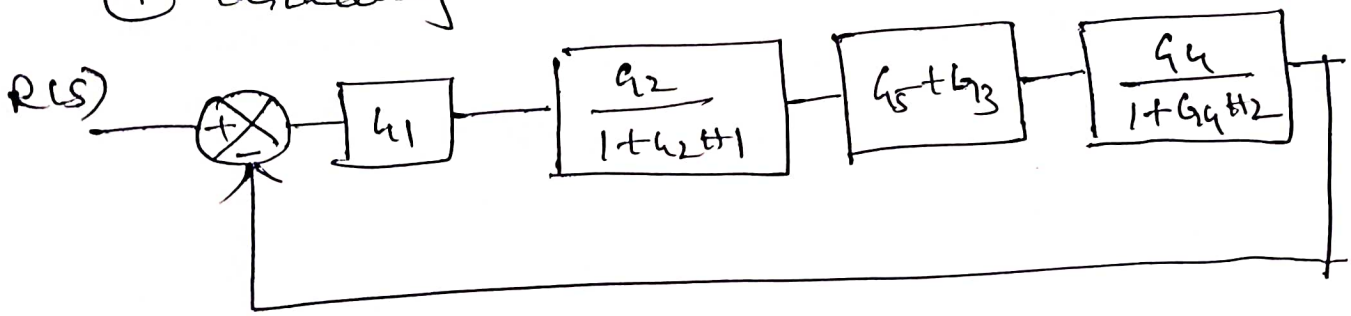
Exercise 2.13 Find C/R using Mason's gain formula

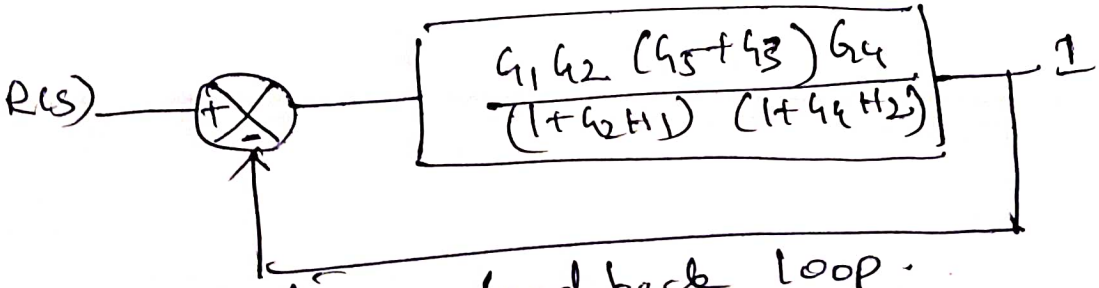


Removing the block diagram & splitting the summing point



(1) Eliminating feed back.
(2) Combing blocks G_3 & G_5
(3) Eliminating the feedback
(4) cascading





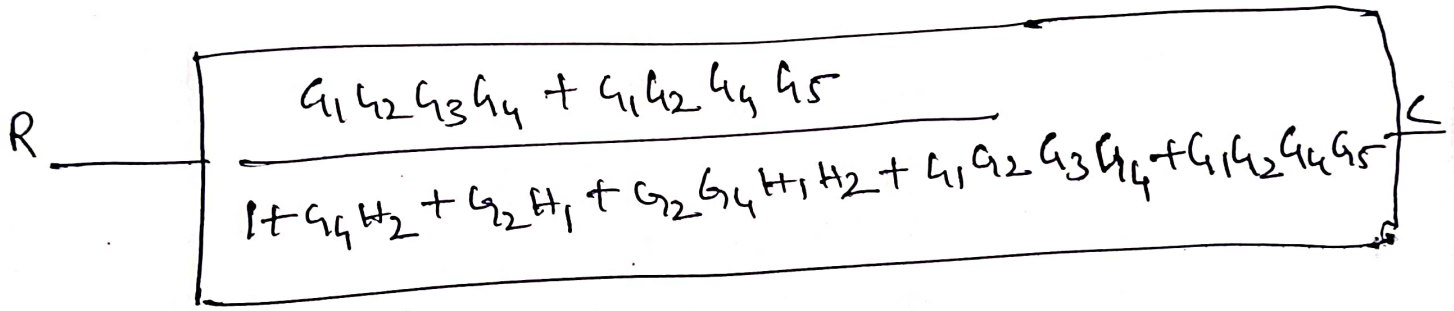
Eliminating feedback loop.

$$TF = \frac{G_1G_2G_3G_4 + G_1G_2G_4G_5/(1+G_2H_1)(1+G_4H_2)}{1 + \frac{G_1G_2G_3G_4 + G_1G_2G_4G_5}{(1+G_2H_1)(1+G_4H_2)}}$$

$$= \frac{G_1G_2G_3G_4 + G_1G_2G_4G_5 / (1+G_2H_1)(1+G_4H_2)}{\left(\frac{(1+G_2H_1)(1+G_4H_2) + G_1G_2G_3G_4 + G_1G_2G_4G_5}{(1+G_2H_1)(1+G_4H_2)}\right)}$$

$$= \frac{G_1G_2G_3G_4 + G_1G_2G_4G_5}{1 + G_4H_2 + G_2H_1 + G_2G_4H_1H_2 + G_1G_2G_3G_4 + G_1G_2G_4G_5}$$

$\therefore$



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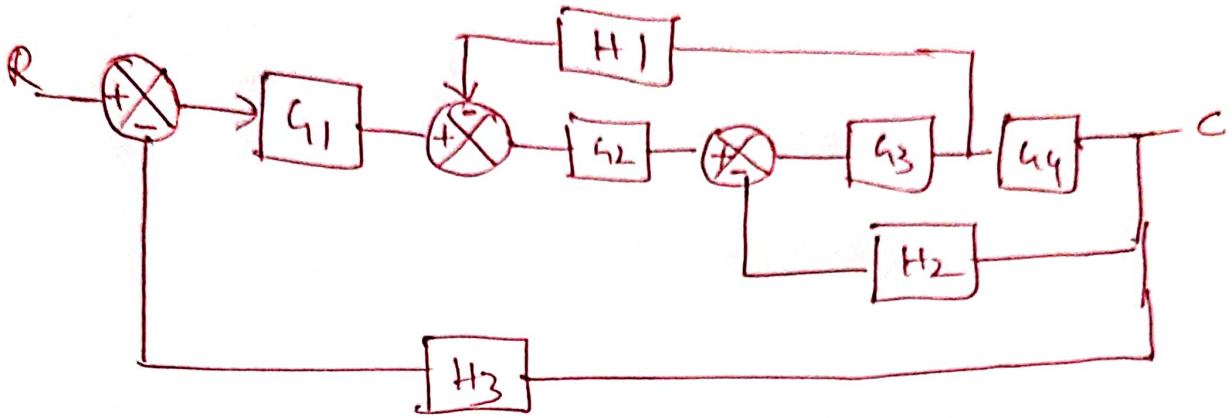
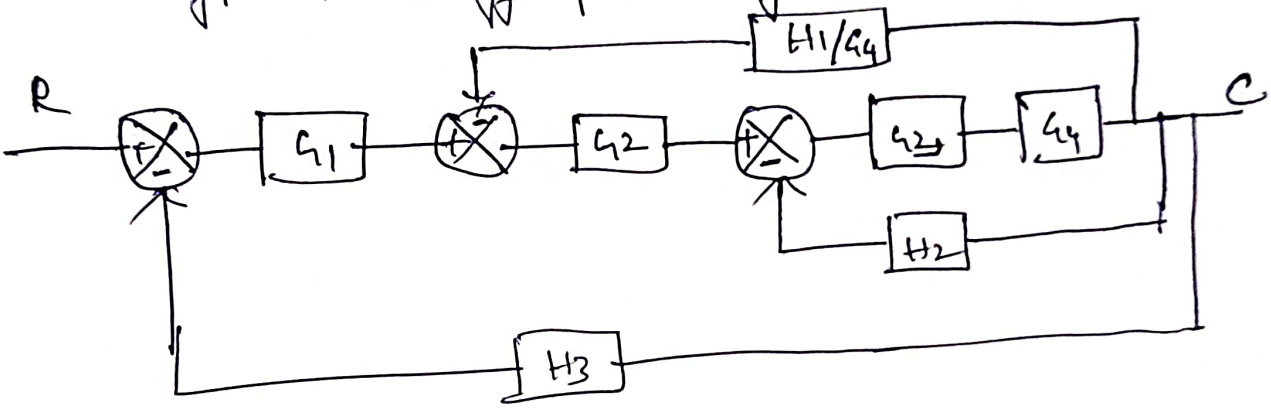
(3)

The system block diagram is shown find C(s)/R(s)

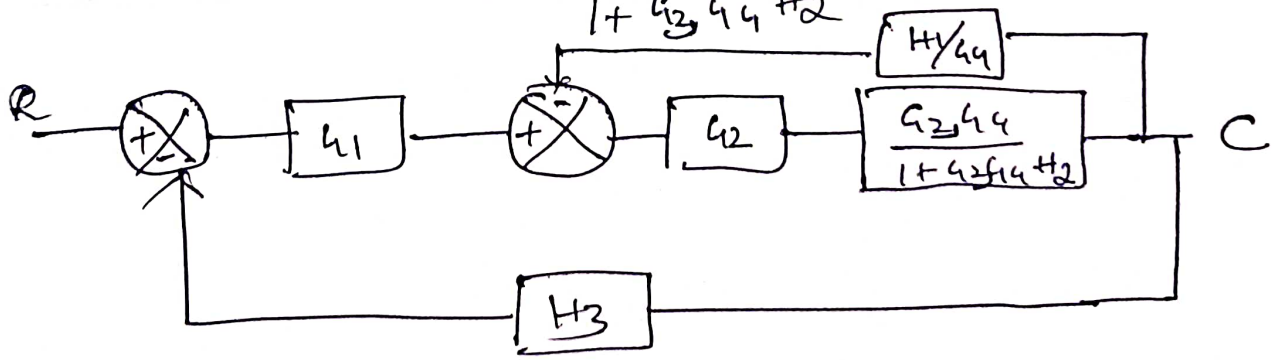


Shift take off point after G4.



Eliminate feedback loop

$$TF = \frac{G_2 G_4}{1 + G_3 G_4 H_2} = \frac{G_3 G_4}{1 + G_3 G_4 H_2}$$

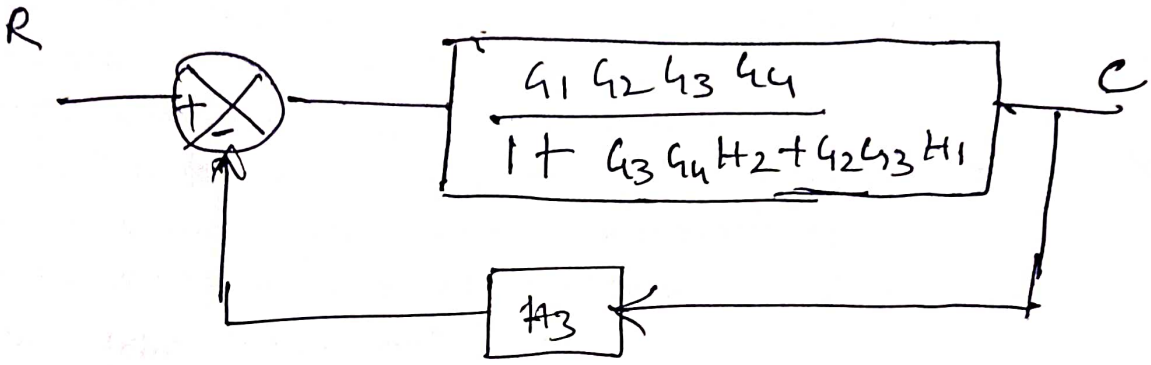


Eliminating feedback loop

$$T.F \quad \frac{\frac{G_2 G_3 G_4}{1 + G_3 G_4 H_2}}{1 + \frac{G_2 G_3 G_4}{1 + G_3 G_4 H_2} \times \frac{H_1}{G_4}}$$

$$TF = \frac{\frac{G_2G_3G_4}{1+G_3G_4H_2}}{\frac{1+G_3G_4H_2+G_2G_3H_1}{1+G_3G_4H_2}}$$

Cascading the blocks



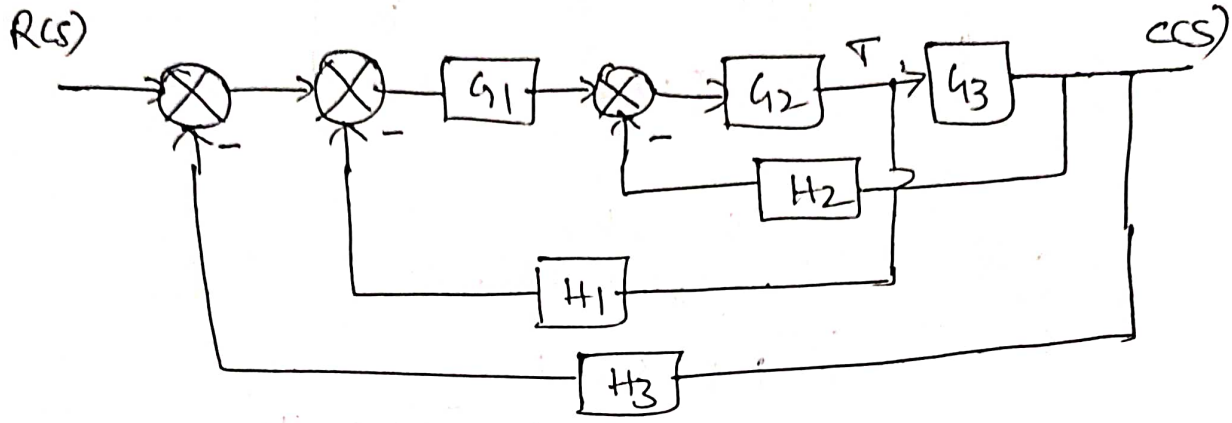
Eliminating feedback loop

$$TF = \frac{G_1G_2G_3G_4 / (1+G_3G_4H_2+G_2G_3H_1)}{1+\frac{G_1G_2G_3G_4}{1+G_3G_4H_2+G_2G_3H_1} \times H_3}$$

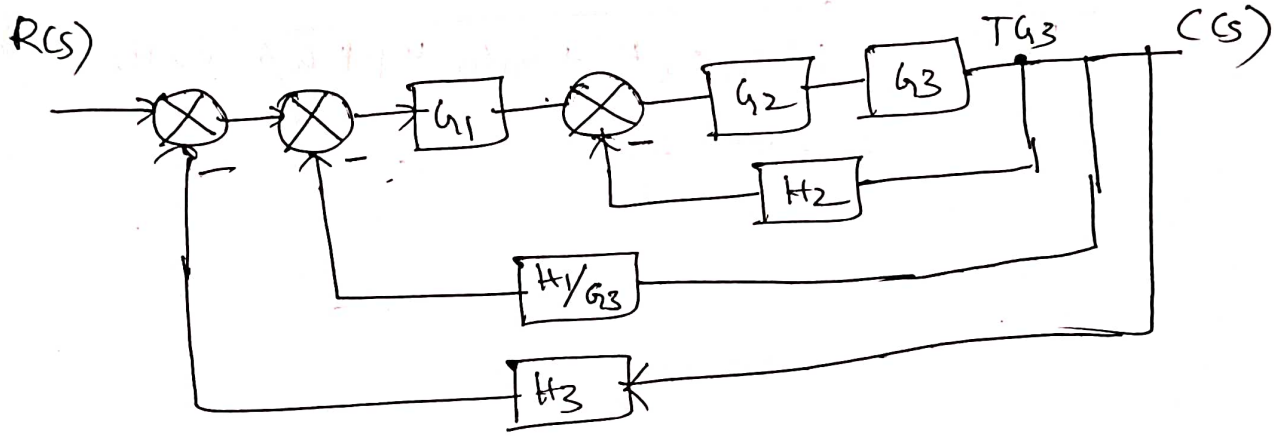
$$= \frac{G_1G_2G_3G_4 / (1+G_3G_4H_2+G_2G_3H_1)}{\frac{1+G_3G_4H_2+G_2G_3H_1+G_1G_2G_3G_4H_3}{1+G_3G_4H_2+G_2G_3H_1}}$$

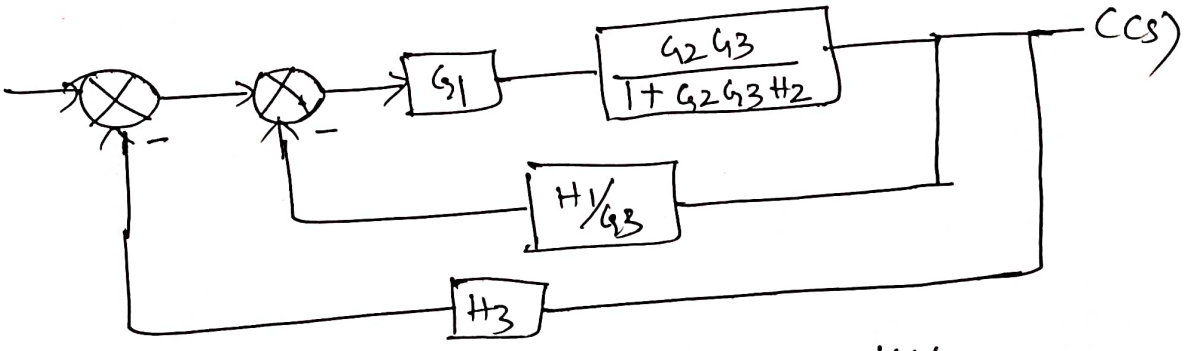
$$TF \text{ is } \frac{R(s)}{} \boxed{\frac{G_1G_2G_3G_4}{1+G_3G_4H_2+G_2G_3H_1+G_1G_2G_3G_4H_3}}$$

1(b) Find overall transfer function C(s)/R(s) using block diagram reduction technique.



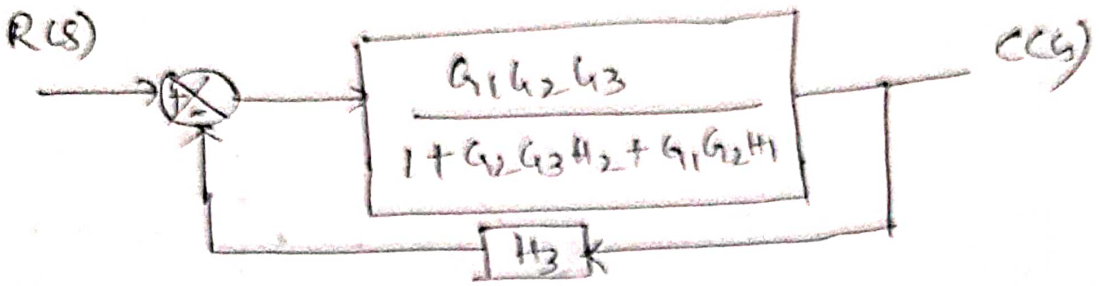
Shift take off point T after G3





$$G(s) = \frac{G_1 G_2 G_3}{1+G_2 G_3 H_2} \qquad H(s) = H_1/G_3$$

$$TR = \frac{G_1 G_2 G_3 / 1+G_2 G_3 H_2}{1 + \frac{G_1 G_2 G_3}{1+G_2 G_3 H_2} \cdot \frac{H_1}{G_3}} = \frac{G_1 G_2 G_3}{1+G_2 G_3 H_2 + G_1 G_2 H_1}$$

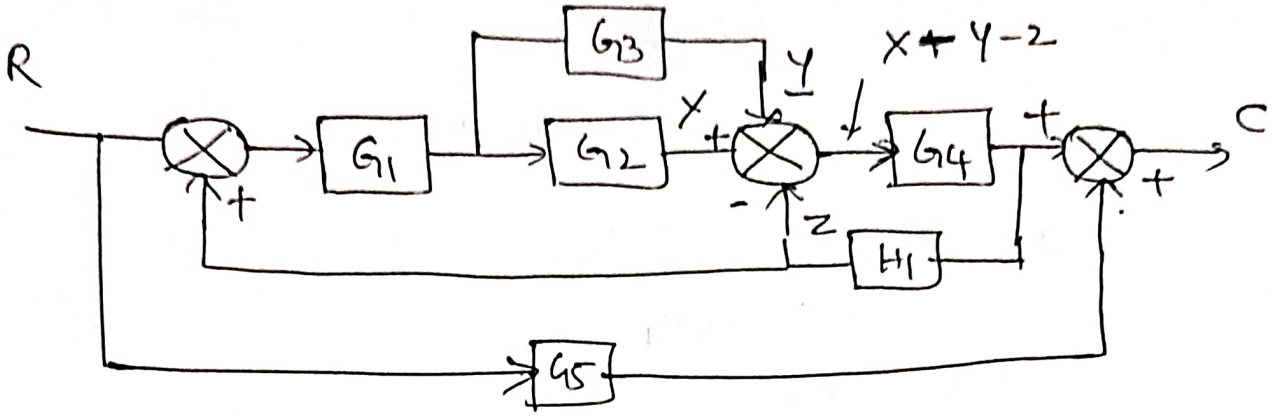


$$\frac{C(s)}{R(s)} = \frac{\dfrac{G_1G_2G_3}{1+G_2G_3H_2+G_1G_2H_1}}{1+\dfrac{G_1G_2G_3}{1+G_2G_3H_2+G_1G_2H_1}H_3}$$

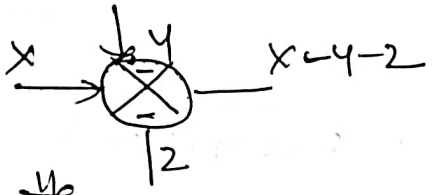
$$\frac{C(s)}{R(s)} = \frac{G_1G_2G_3}{1+G_2G_3H_2+G_1G_2H_1+G_1G_2G_3H_3}$$

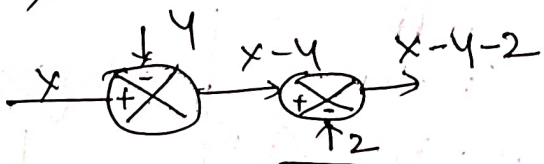
Solution to Assignment :-2

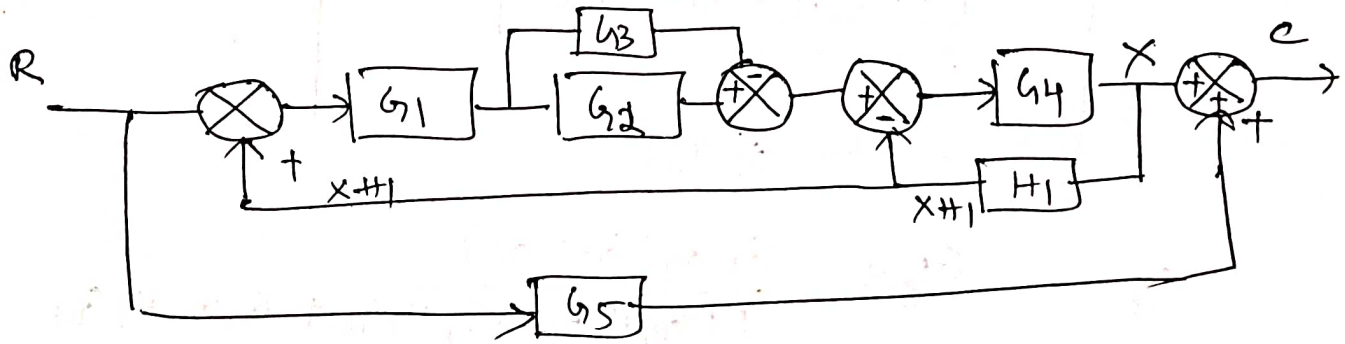
12) Obtain C/R for the given block deagram using block deagram reduction techniques

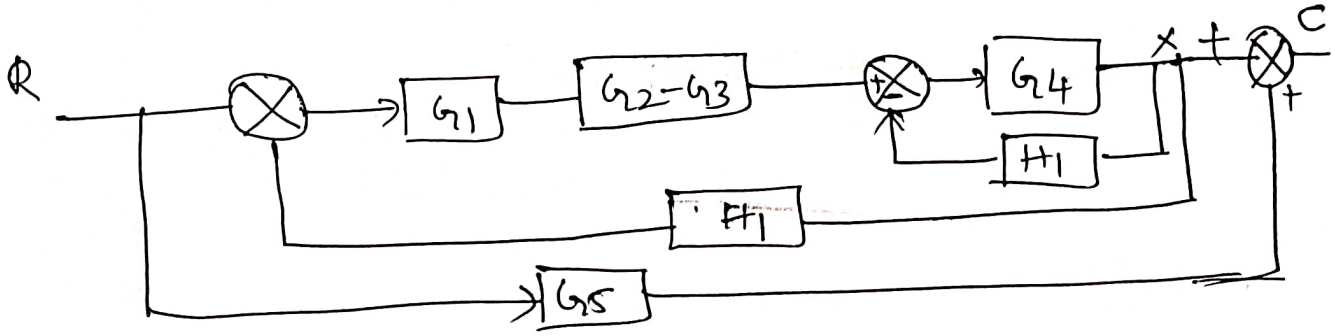


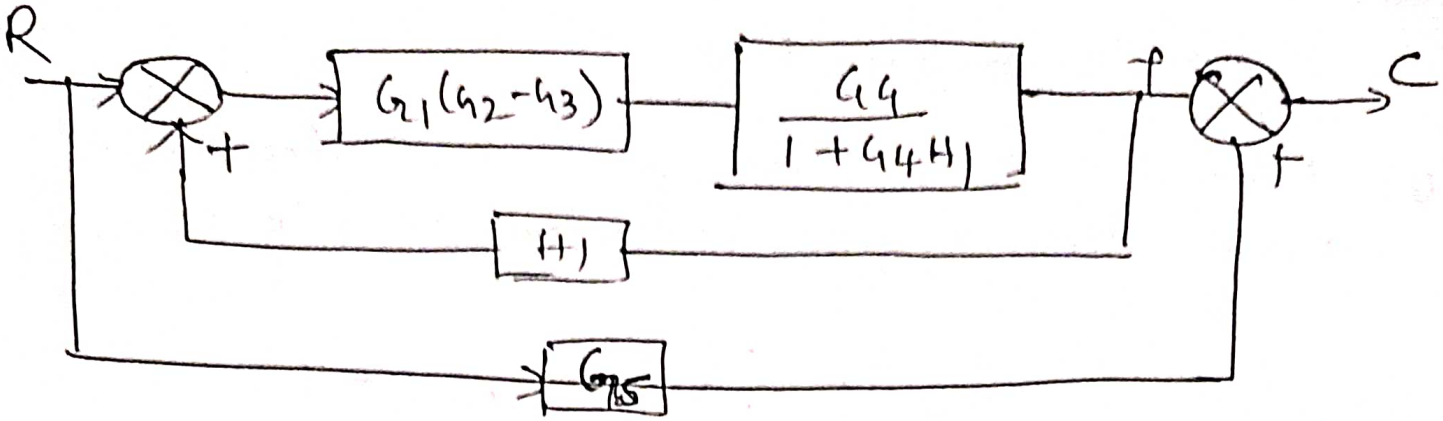
Splitting the summing point











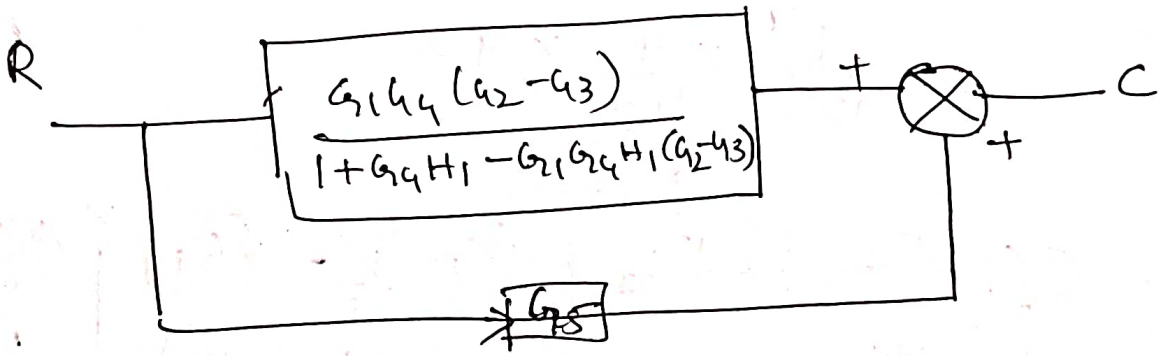
To eliminate feedback loop

$$G(s) = \frac{G_1(G_2-G_3)G_4}{1+G_4H_1}$$

$$H(s) = H_1$$

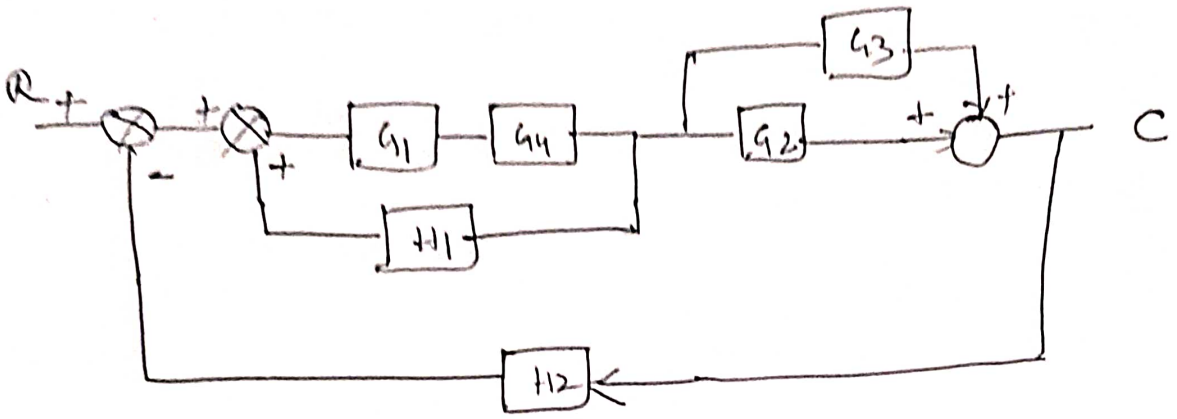
$$\therefore \quad C/R = \frac{G}{1-GH} = \frac{\dfrac{G_1G_4(G_2-G_3)}{1+G_4H_1}}{1-\dfrac{G_1G_4(G_2-G_3)}{1+G_4H_1}H_1}$$

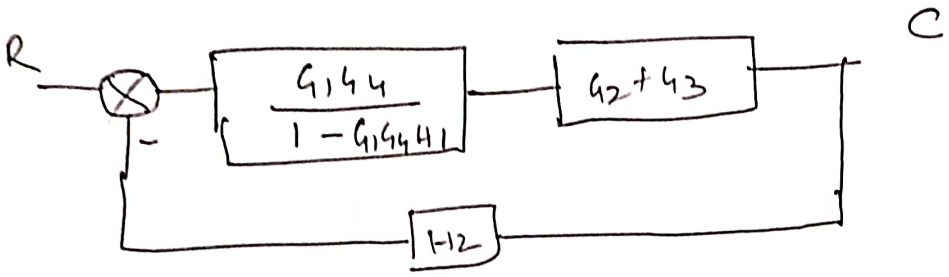
$$= \frac{G_1G_4(G_2-G_3)}{1+G_4H_1-G_1G_4H_1(G_2-G_3)}$$

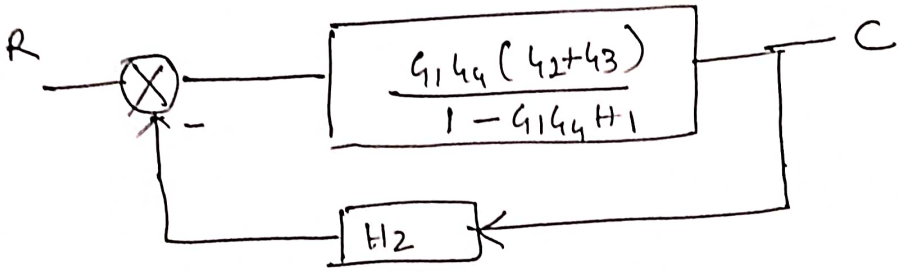


$$C/R = G_5 + \frac{G_1G_4(G_2-G_3)}{1+G_4H_1-G_1G_4H_1G_2+G_1G_4H_1G_3}$$

4 Find overall transfer function of the system using block diagram reduction technique



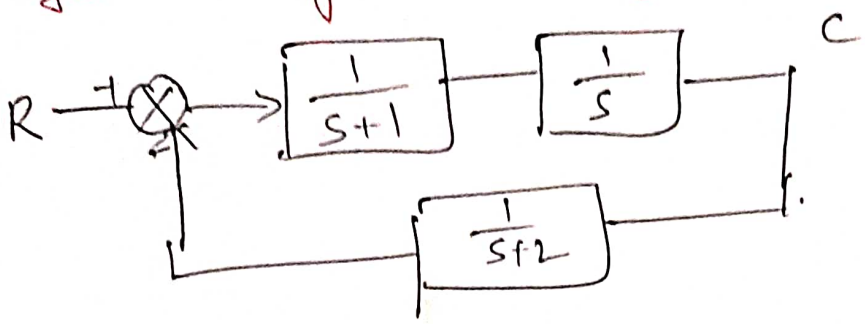


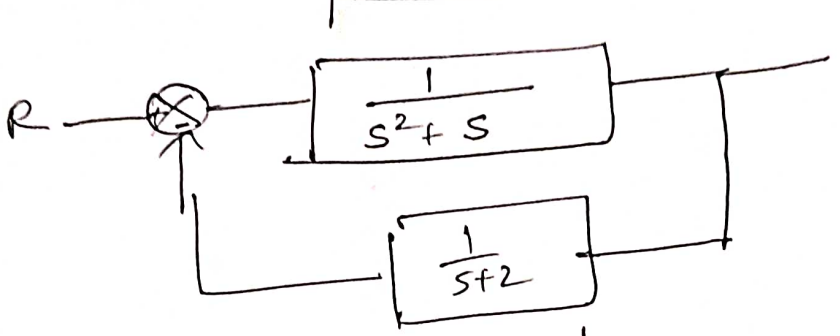


$$\frac{\frac{G_1G_4(G_2+G_3)}{1-G_1G_4H_1}}{1+\frac{G_1G_4(G_2+G_3)}{1-G_1G_4H_1}\cdot H_2}$$

$$\frac{G_1G_4(G_2+G_3)}{1-G_1G_4H_1+G_1G_4(G_2+G_3)H_2}$$

5) % write a matlab program to implement block diagram reduction technique to obtain transfer function of a control system.



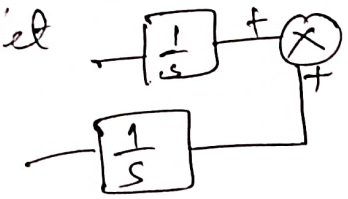


$$T.F = \frac{\frac{1}{s^2+s}}{1 + \frac{1}{(s^2+s)}\frac{1}{(s+2)}}$$

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

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

Let



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