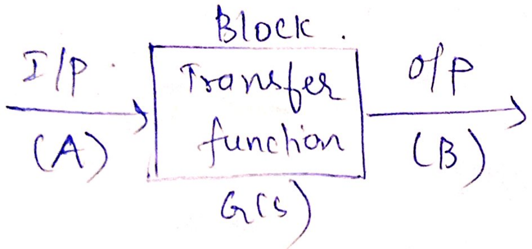
6/9/20

# Block Diagrams.

→ A block diagram of a system is a pictorial representation of the functions performed by each component and the flow of signals.

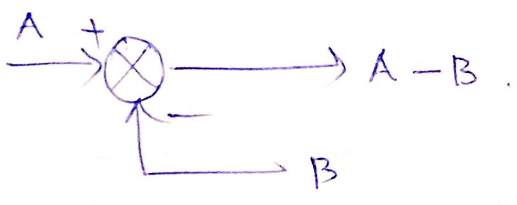
→ The elements of a block diagram are block, branch point and summing point.

→ **Block**

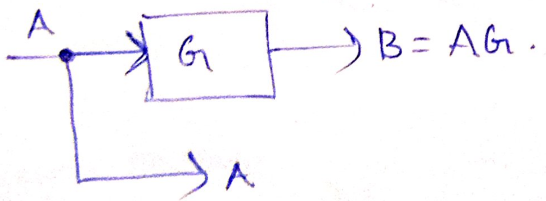



$$B = A(G(s))$$

→ **Summing point** → used to add two or more




→ **Branch point** → the signal from a block goes con-currently to other blocks.



Eg 1) construct the block diagram ~~of~~ for the following differential equation.

$$(1) \rightarrow V_a = i_a R_a + L_a \frac{di_a}{dt} + e_b$$

$$(2) \rightarrow T = K_t i_a$$

$$(3) \rightarrow T = J \frac{\partial w}{dt} + Bw$$

$$(4) \rightarrow e_b = K_b w$$

$$(5) \rightarrow \omega = \frac{d\theta}{dt}$$

Soln Take LT for all equations.

$$V_a(s) = I_a(s) R_a + L_a s I_a(s) + E_b(s) \text{ --- } ①$$

$$T(s) = K_t I_a(s) \text{ --- } ②$$

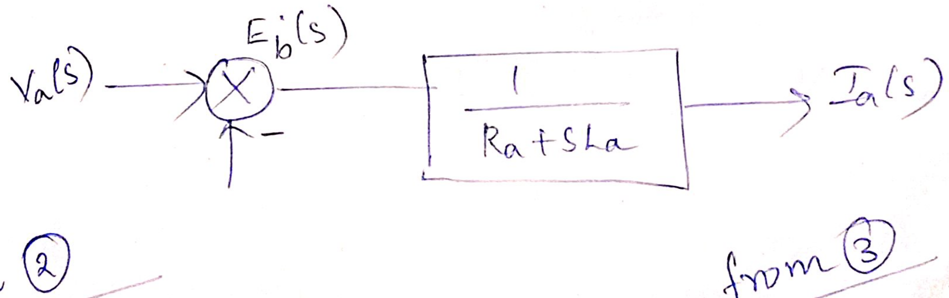
$$T(s) = J s w(s) + B w(s) \text{ --- } ③$$

$$E_b(s) = K_b w(s) \text{ --- } ④$$

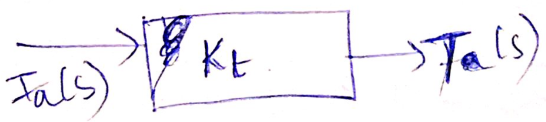
$$w(s) = s\theta(s) \text{ --- } ⑤$$

from ①

$$V_a(s) - E_b(s) = I_a(s)(R_a + sL_a) \Rightarrow I_a(s) = \frac{V_a(s) - E_b(s)}{R_a + sL_a}.$$

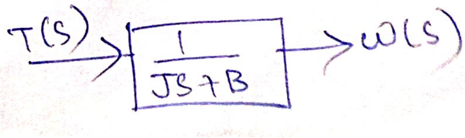



from ②



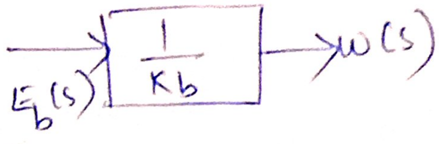

from ③

$$w(s) = \frac{1}{JS + B} T(s)$$



(4) $E_b(s) = K_b\,\omega(s)$

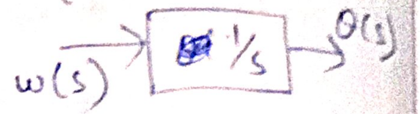
$$\omega(s) = \frac{1}{K_b}\left[E_b(s)\right]$$




(5)

$$\omega(s) = s(\theta(s))$$

$$\theta(s) = \frac{1}{s}\,\omega(s)$$

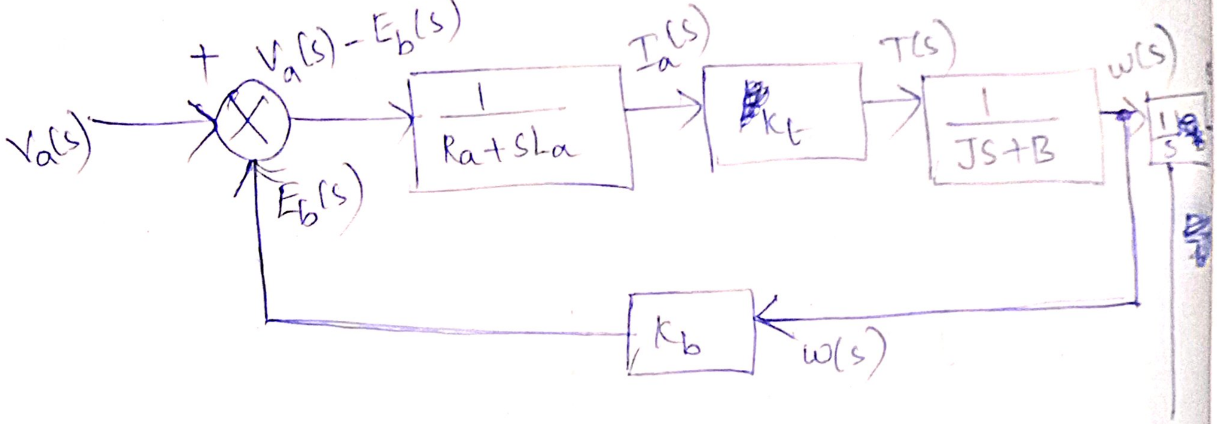



By comparing all the blocks,

$V_a(s) \rightarrow$ i/p

o/p $\rightarrow \theta(s)$

all other blocks are intermediate blocks.

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2) construct the block diagram for the following diff. eqns.

$$V_f = R_f i_f + L_f \frac{di_f}{dt}$$

$$T = K_{tf}\, i_f$$

$$T = J\frac{d^2\theta}{dt^2} + B\frac{d\theta}{dt}.$$

Soln

→ Take L.T for all equations.

① → $V_f(s) = R_f I_f(s) + L_f\, s\, I_f(s)$

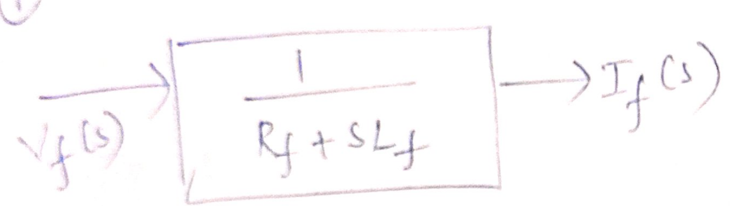
② → $T(s) = K_{tf}\, I_f(s)$

③ → $T(s) = J s^2 \theta(s) + B s \theta(s)$.

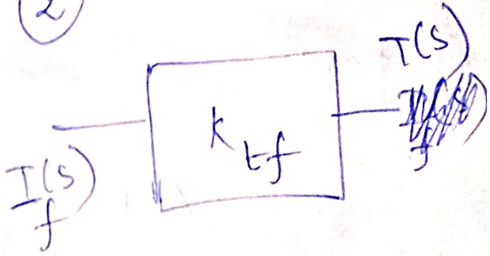
$$T(s) = \theta(s)\left[Js^2 + Bs\right]$$

$$\theta(s) = \frac{1}{Js^2+Bs}\, T(s)$$

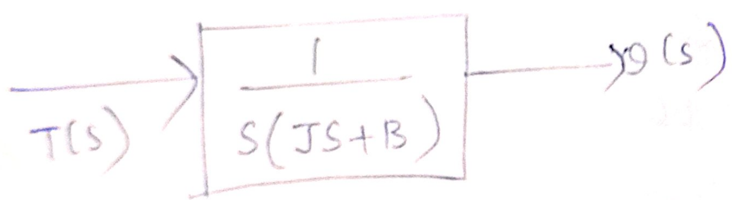
①

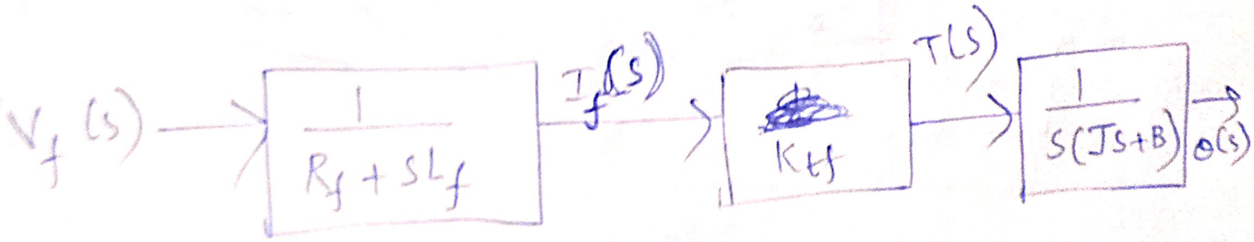



②




③

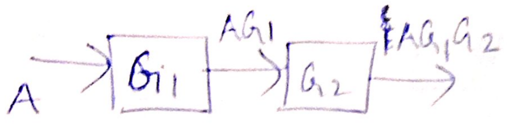


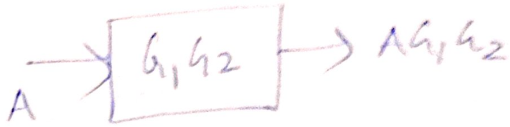



# Rules of Block diagram Alagebra :-

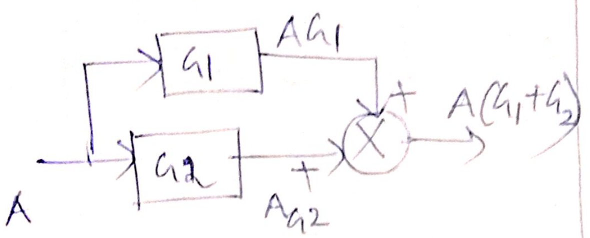
Rules — Blocks | Reduced/modified Blocks

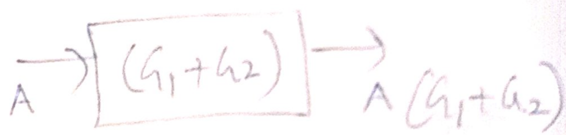
1) cascade blocks



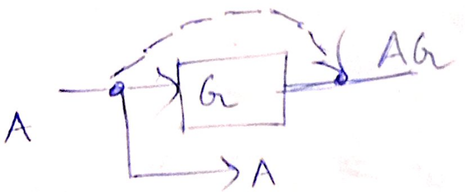



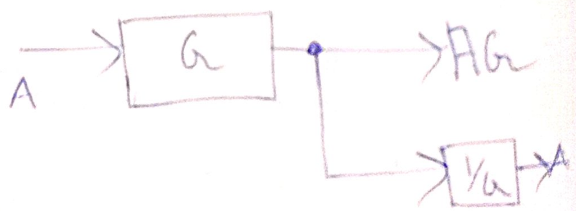

2) parallel blocks



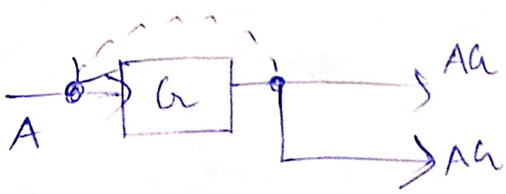



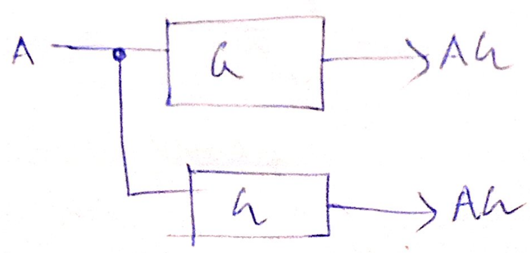

3) Moving branch point ahead of the block



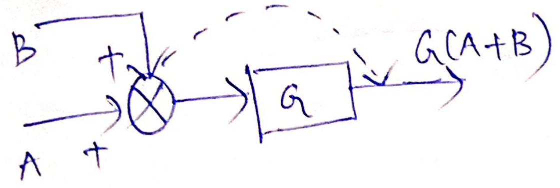



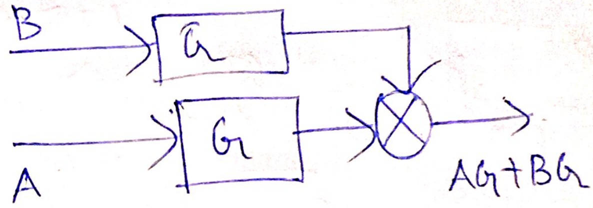

4) Moving the branch point before the block



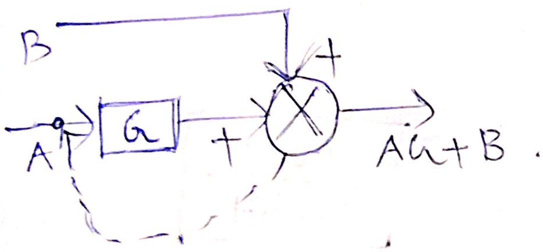



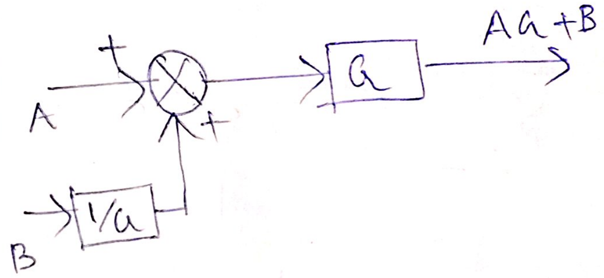
5) Moving the summing point ahead of the block



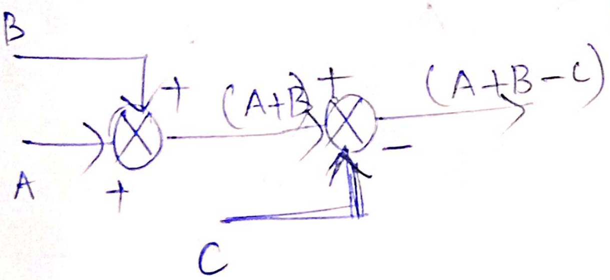



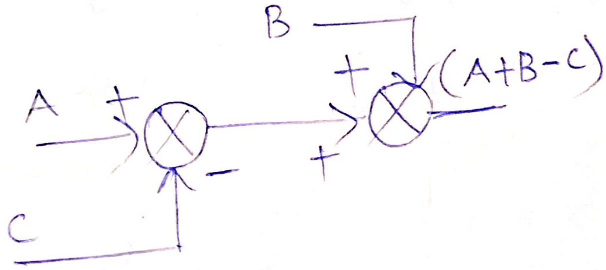

6) Moving the summing point before the block



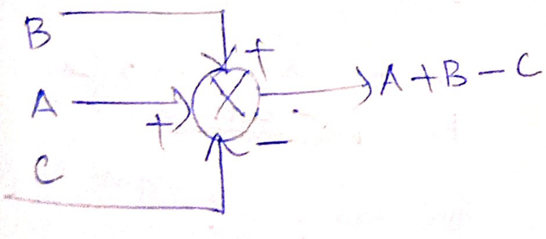



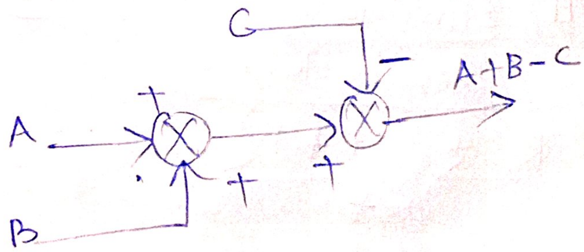

7) Interchanging summing point



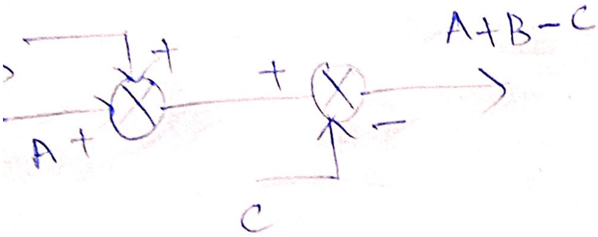



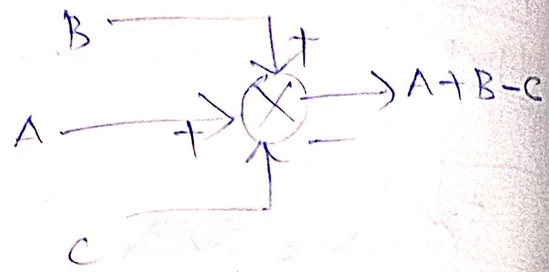

8) splitting summing points



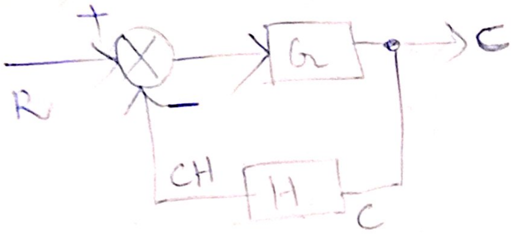



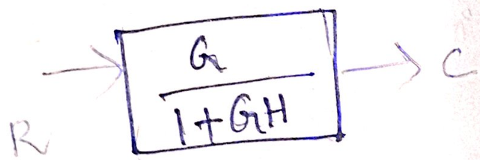
9) combining summing points




10) Eliminating - negative feedback loop




$$(R - CH)G = C$$

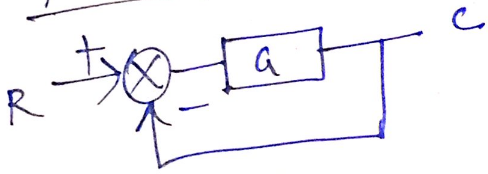
$$RG - CHG = C$$

$$RG = C + CHG$$

$$RG = C(1 + HG)$$

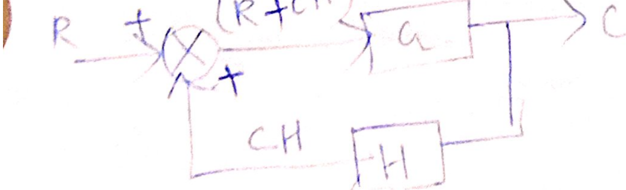
$$C = R\left(\frac{G}{1+GH}\right)$$

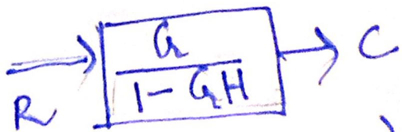
for unity fb (−ve)



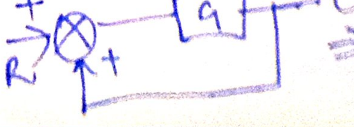

$$C/R = \frac{G}{1+G}$$

11) Eliminating - positive feedback loop



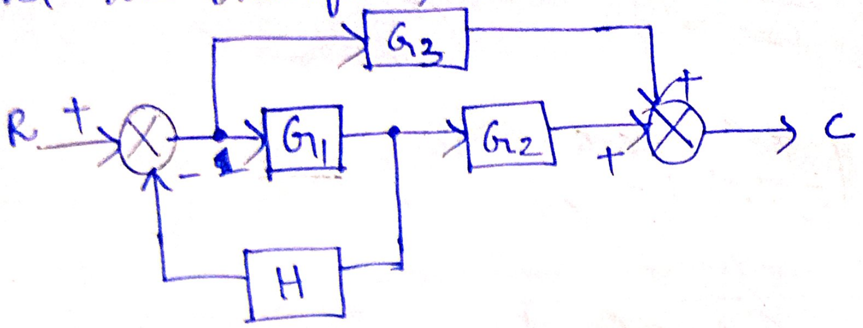




for unity fb (+ve)




$$\Rightarrow \frac{C}{R} = \frac{G}{1-G}$$

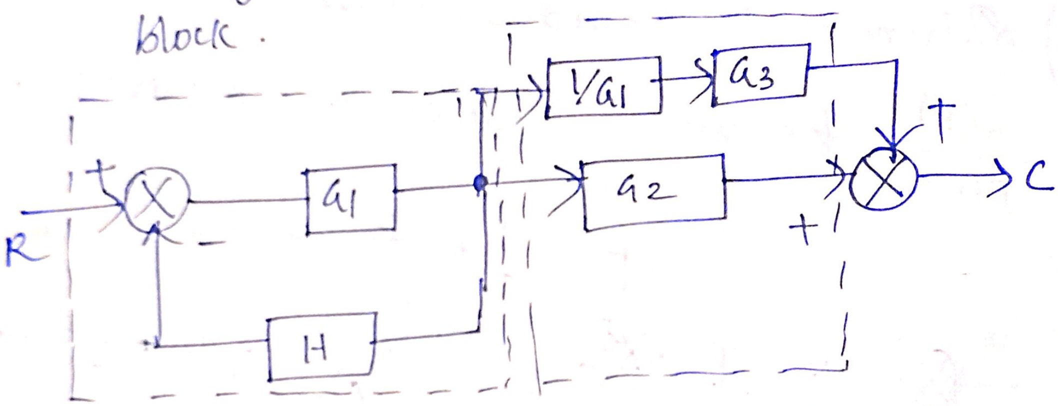
Q1) Reduce the block diagram shown in figure & find the transfer function.

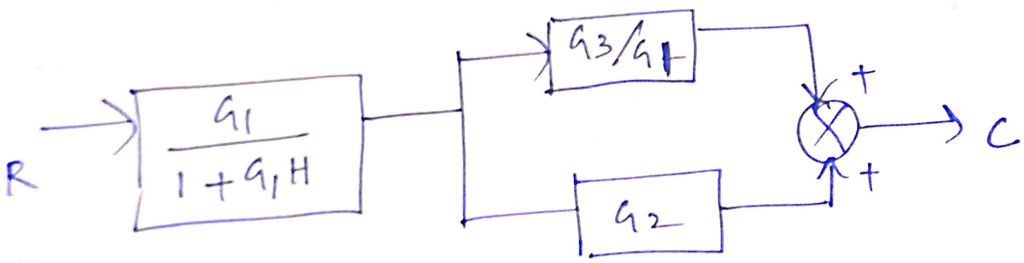


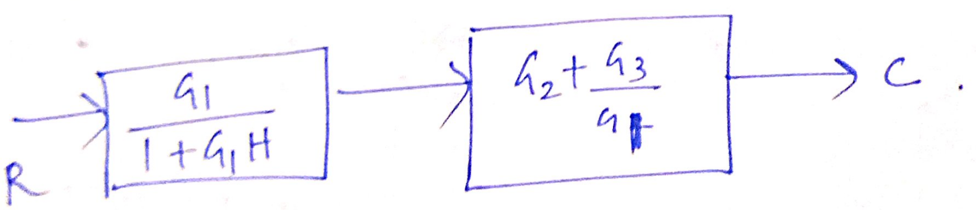

Soln:-

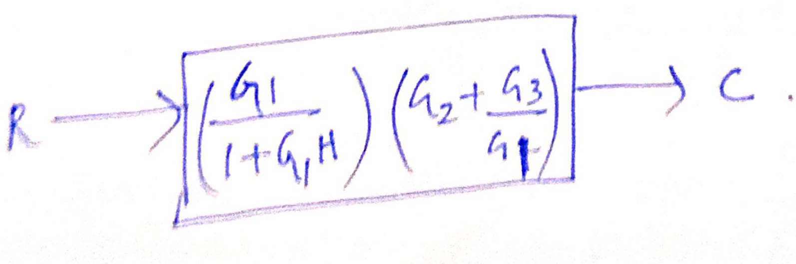
Step 1

Moving the branch point ahead of the block.



$$\frac{C}{R} = \left(\frac{G_1}{1+G_1 H}\right)\left(G_2 + \frac{G_3}{G_1}\right)$$

$$= \left(\frac{\cancel{G_1}}{1+G_1 H}\right)\left(\frac{G_1 G_2 + G_3}{\cancel{G_1}}\right)$$

$$\boxed{\frac{C}{R} = \frac{G_1 G_2 + G_3}{1 + G_1 H}}$$

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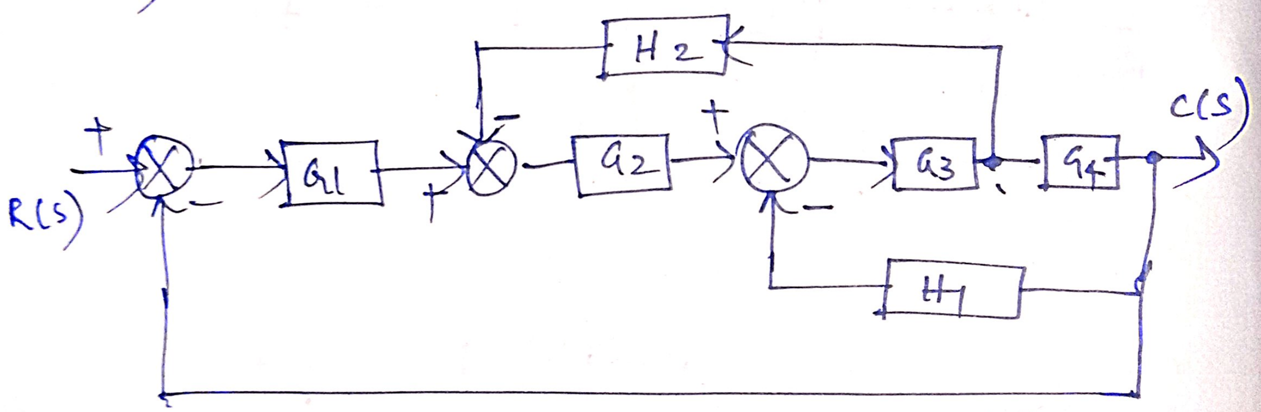
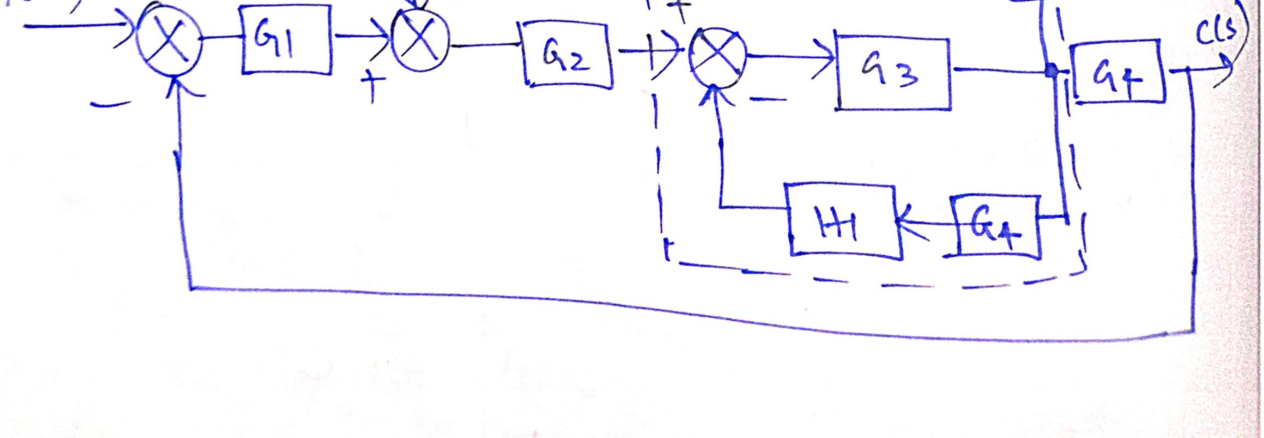
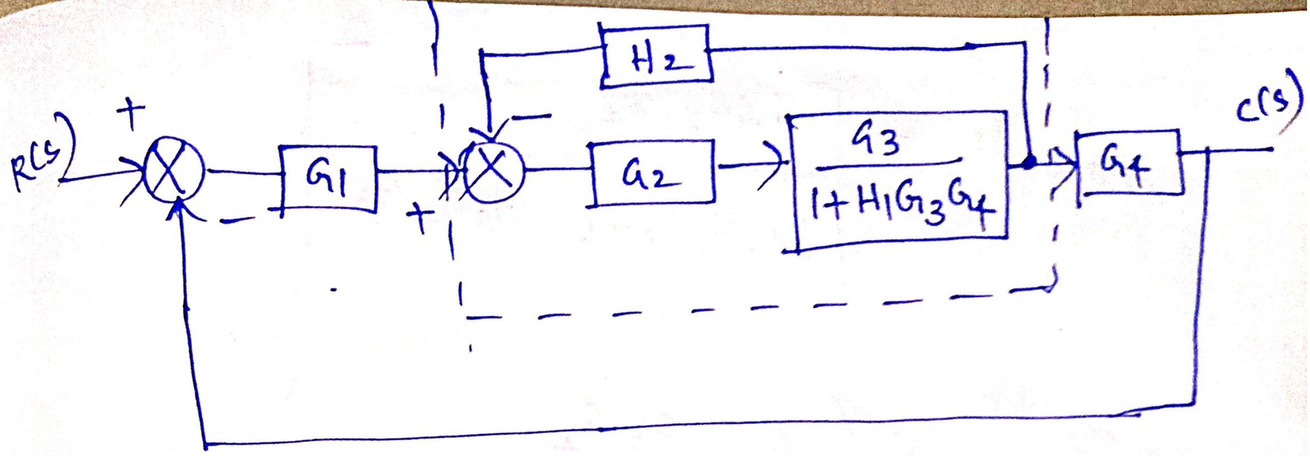
2) Determine the overall transfer function $\frac{C(s)}{R(s)}$ for the S/m shown in the figure




Soln.



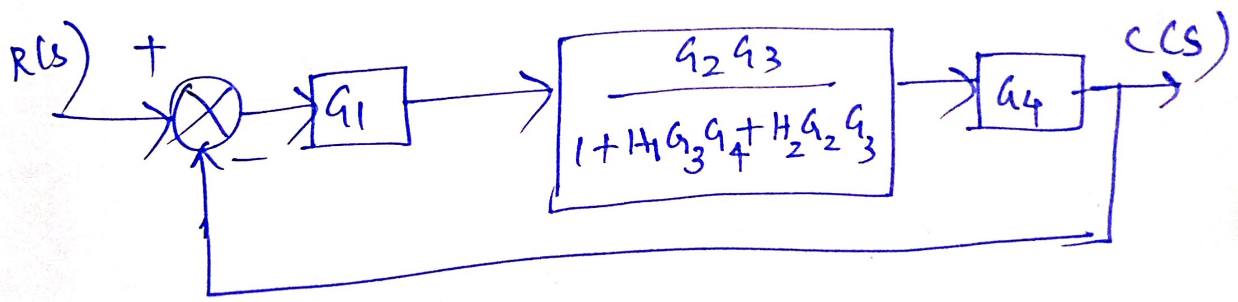



$$\text{cascade} \Rightarrow G_2\left(\frac{G_3}{1+H_1G_3G_4}\right)$$

$$\text{n/w fb} \Rightarrow \frac{\dfrac{G_2G_3}{1+H_1G_3G_4}}{1+H_2\left(\dfrac{G_2G_3}{1+H_1G_3G_4}\right)}$$

$$\Rightarrow \frac{\dfrac{G_2G_3}{\cancel{(1+H_1G_3G_4)}}}{\dfrac{(1+H_1G_3G_4)+H_2G_2G_3}{\cancel{(1+H_1G_3G_4)}}}$$

$$\Rightarrow \frac{G_2G_3}{1+H_1G_3G_4+H_2G_2G_3}$$



cascade $\Rightarrow \left[ \dfrac{G_1G_2G_3G_4}{1+H_1G_3G_4+H_2G_2G_3} \right]$

unity fb $\Rightarrow \dfrac{\left( \dfrac{G_1G_2G_3G_4}{1+H_1G_3G_4+H_2G_2G_3} \right)}{1+\left( \dfrac{G_1G_2G_3G_4}{1+H_1G_3G_4+H_2G_2G_3} \right)}$

$$\therefore \frac{C(s)}{R(s)} = \frac{G_1G_2G_3G_4}{1+H_1G_3G_4+H_2G_2G_3+G_1G_2G_3G_4}.$$

$$R(s) \longrightarrow \boxed{\dfrac{G_1G_2G_3G_4}{1+H_1G_3G_4+H_2G_2G_3+G_1G_2G_3G_4}} \longrightarrow C(s)$$