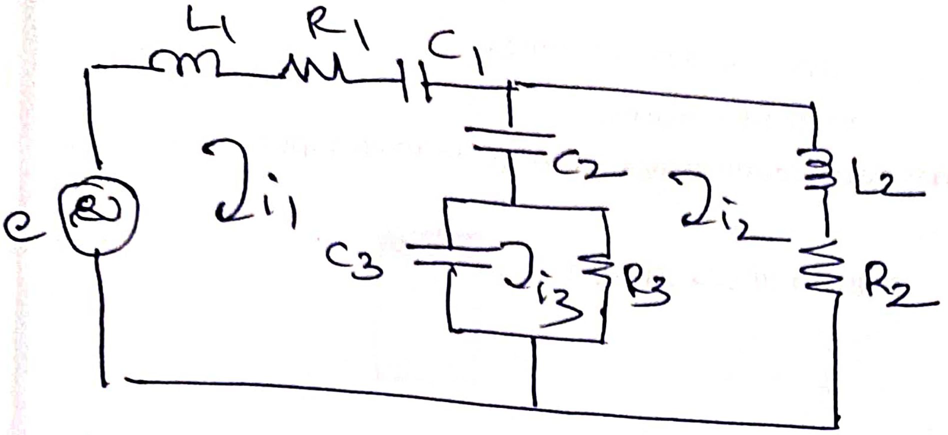
The force voltage analogy of a mechanical translational system is given obtain analogous mechanical system (1)



Applying KVL to the loop i_1, i_2 & i_3

$$e = L_1\frac{di_1}{dt} + R_1 i_1 + \frac{1}{C_1}\int i_1\,dt + \frac{1}{C_2}\int (i_1 - i_2)\,dt + \frac{1}{C_3}\int (i_1 - i_3)\,dt$$

in terms of q

$$e = L_1\frac{d^2q_1}{dt^2} + R_1\frac{dq_1}{dt} + \frac{1}{C_1}q_1 + \frac{1}{C_2}(q_1 - q_2) + \frac{1}{C_3}(q_1 - q_3)$$

$F \to V$

$v \to i$

$x \to q$

$\frac{dx}{dt} \to \frac{dq}{dt}$

$\frac{dx}{dt} \to i$

$x \to \int i\,dt$

$M \to L$

$B \to R$

$k \to \frac{1}{C}$

Corresponding analogous mechanical sys equations

$$f = M_1\frac{d^2x_1}{dt^2} + B_1\frac{dx_1}{dt} + K_1 x_1 + K_2(x_1 - x_2) + K_3(x_1 - x_3) \quad (1)$$

Loop 2

$$0 = \frac{1}{C_2}\int (i_2 - i_1)\,dt + L_2\frac{di_2}{dt} + R_2 i_2 + R_3(i_2 - i_3)$$

$$= \cancel{\frac{1}{C_2}\left(\frac{dq_2}{dt} - \frac{dq_1}{dt}\right)}$$

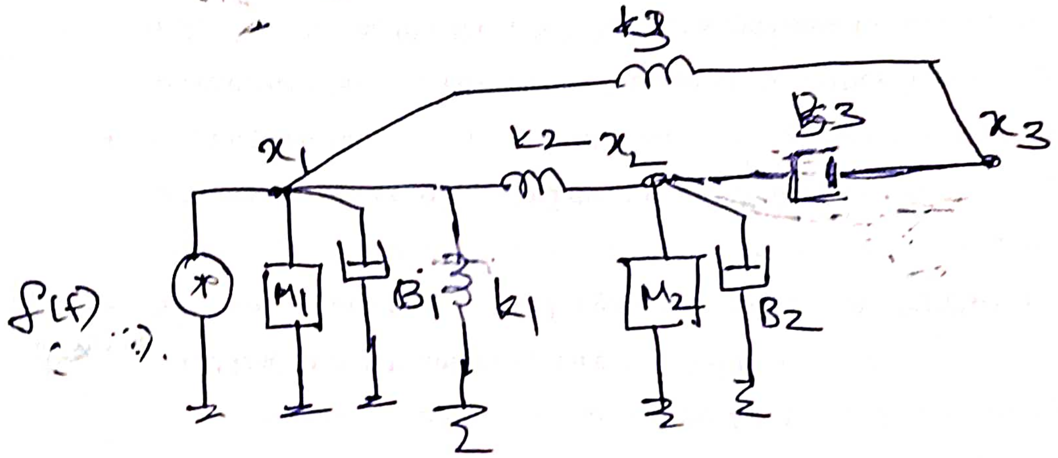
Corresponding mechanical sys differential equation

$$0 = K_2(x_2 - x_1) + M_2\frac{d^2x_2}{dt^2} + B_2\frac{dx_2}{dt} + B_3\frac{d}{dt}(x_2 - x_3)$$

Loop 3

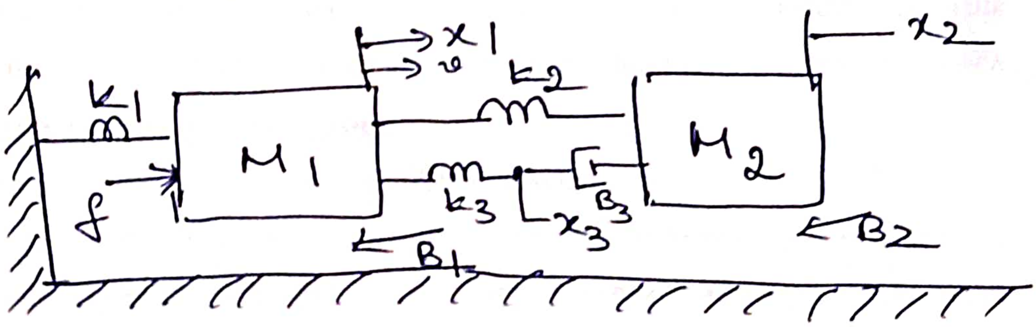
$$\frac{1}{C_3}\int(i_3 - i_1)dt + R_3(i_3 - i_2) = 0$$

$$0 = k_3(x_3 - x_1) + B_3\frac{d}{dt}(x_3 - x_2)$$

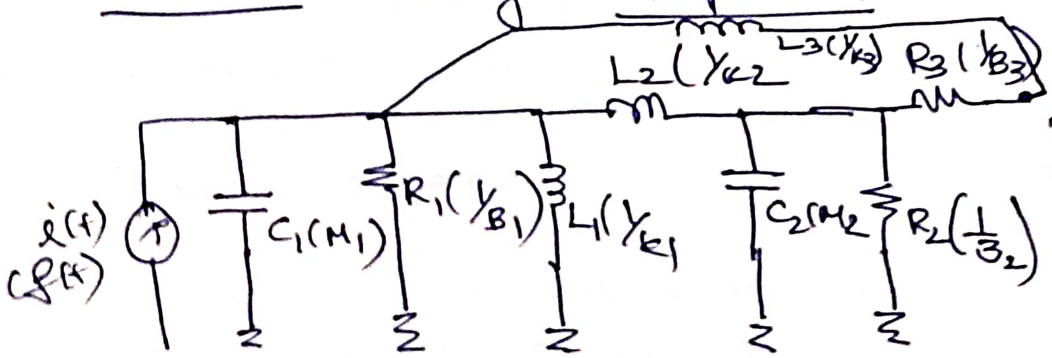


Mechanical n/w

Mechanical system



F-I analogous system



F → I

v → V

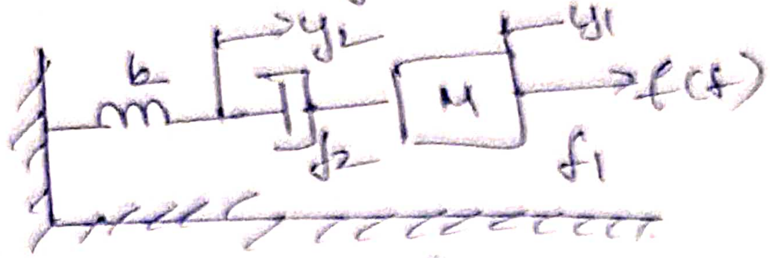
x → Φ

M → C

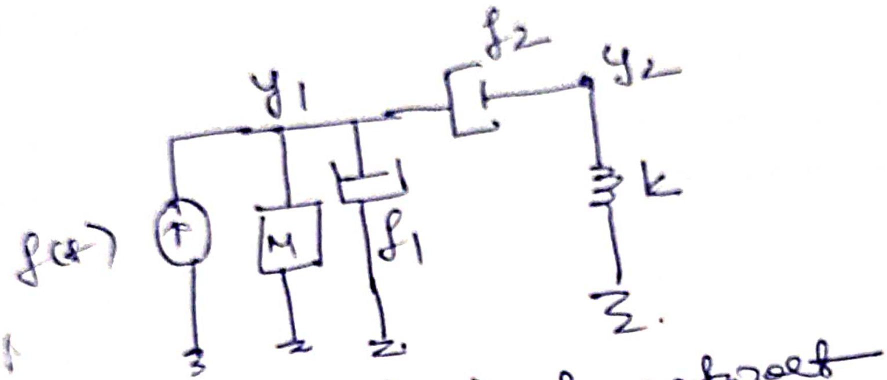
B → 1/R

K — 1/L

Consider mechanical system
Draw Mechanical network
F-I analogue network
F-V analogue network.

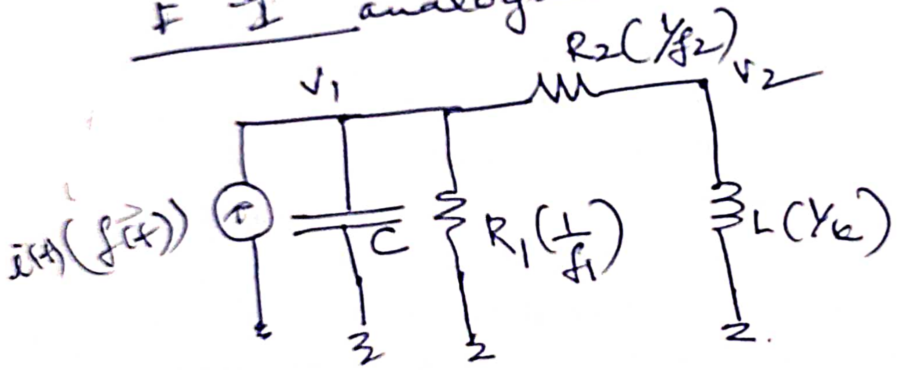


Mechanical system.



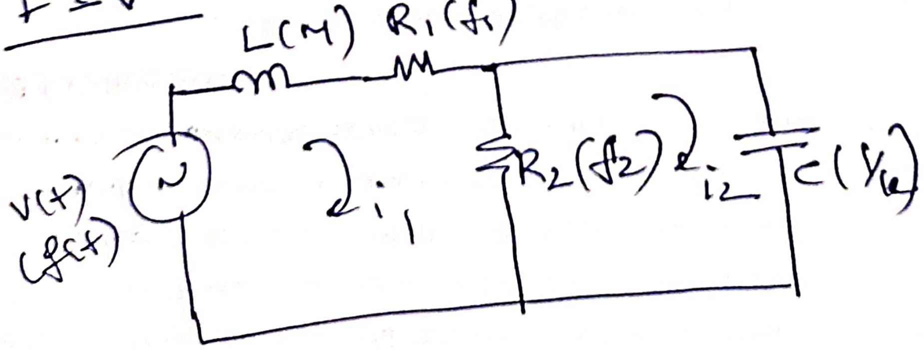
Mechanical network

F I analogue network



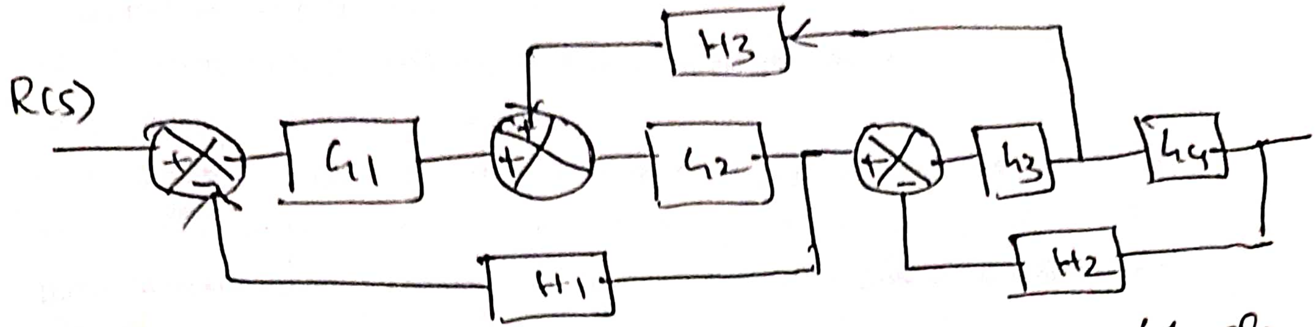
$F \to I$
$v \to V$
$x \to \phi$
$M \to C$
$B \to 1/R$
$K \to 1/L$

F - V

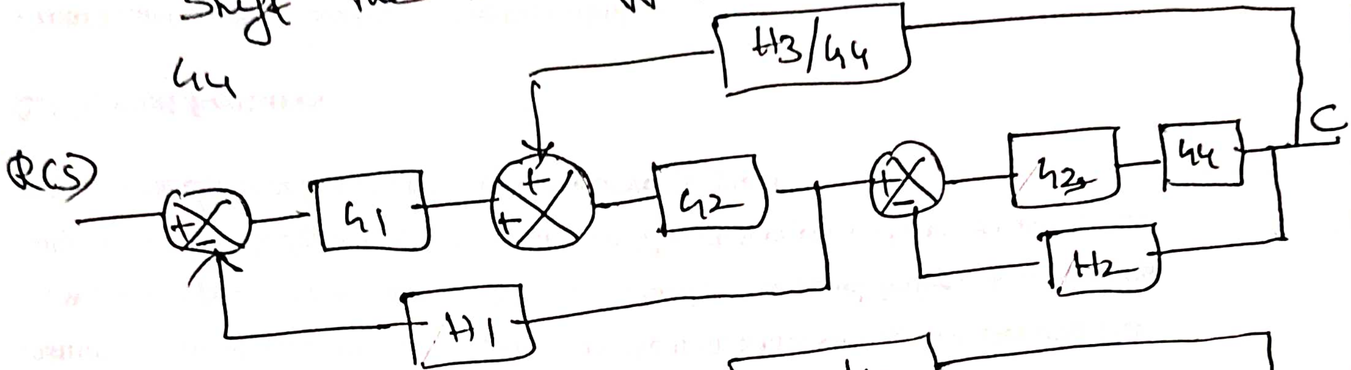


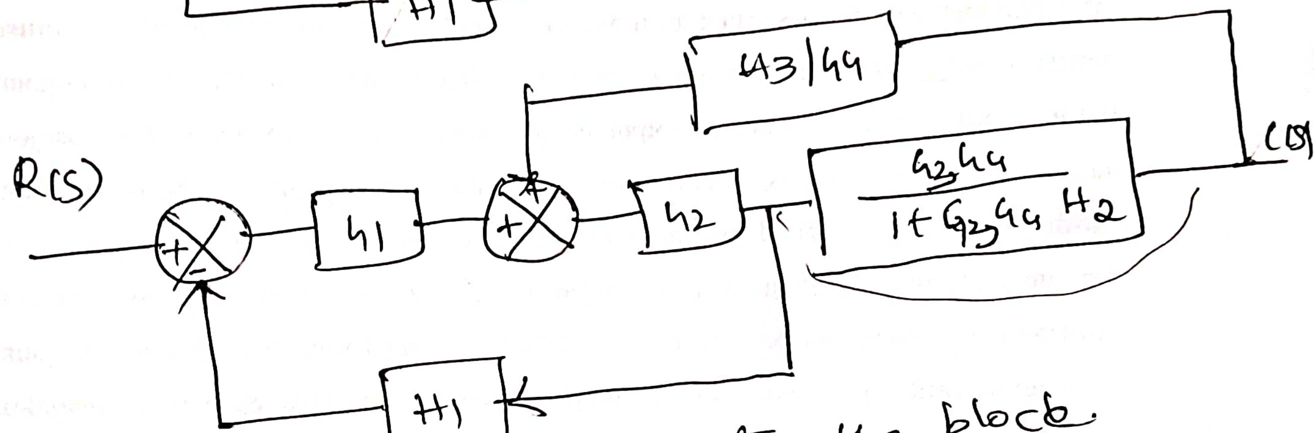
$F \to V$
$v - i$
$x - q$
$x - \int i dt$
$M - L$
$B \to R$
$k - 1/C$

1) Determine transfer function by reducing the block diagram shown in fig

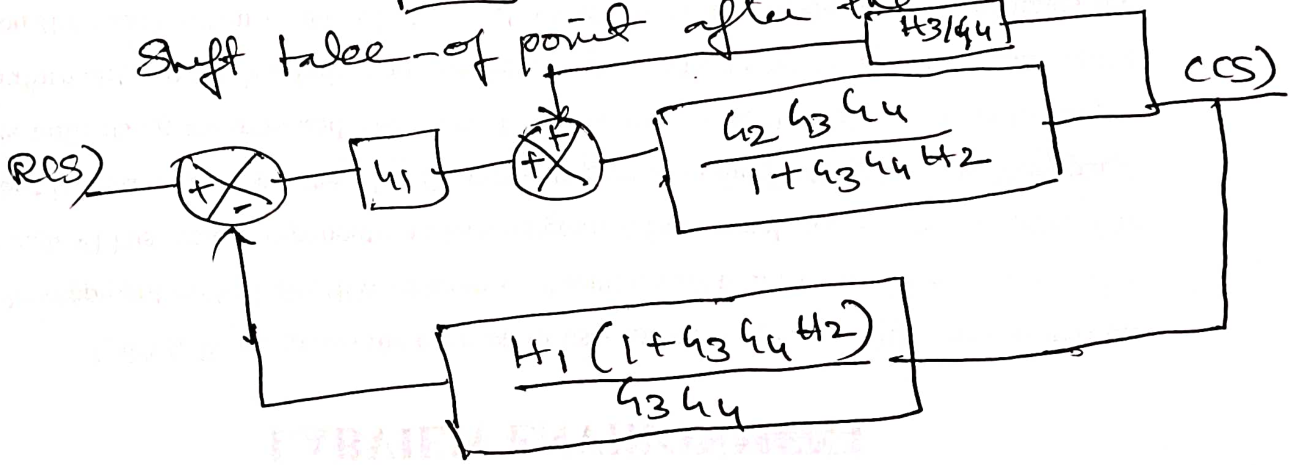


Shift the take off point after the block G4





Shift take-of point after the block.



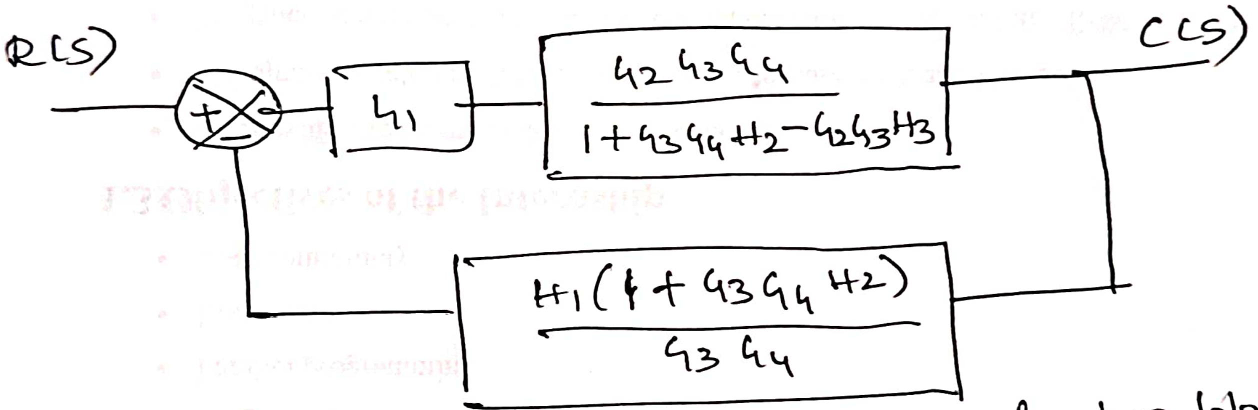
Eliminating feedback loop (+ve)

$$TF = \frac{G}{1 - GH}$$

$$= \frac{\dfrac{G_2 G_3 G_4}{1 + G_3 G_4 H_2}}{1 - \dfrac{G_2 G_3 \cancel{G_4}}{1 + G_3 G_4 H_2} \times \dfrac{H_3}{\cancel{G_4}}}$$

$$= \frac{\dfrac{G_2 G_3 G_4}{\cancel{1 + G_3 G_4 H_2}}}{\dfrac{1 + G_3 G_4 H_2 - G_2 G_3 H_3}{\cancel{1 + G_3 G_4 H_2}}}$$

$$= \frac{G_2 G_3 G_4}{1 + G_3 G_4 H_2 - G_2 G_3 H_3}$$



Cascade two block

$$TF = \frac{G}{1 + GH}$$

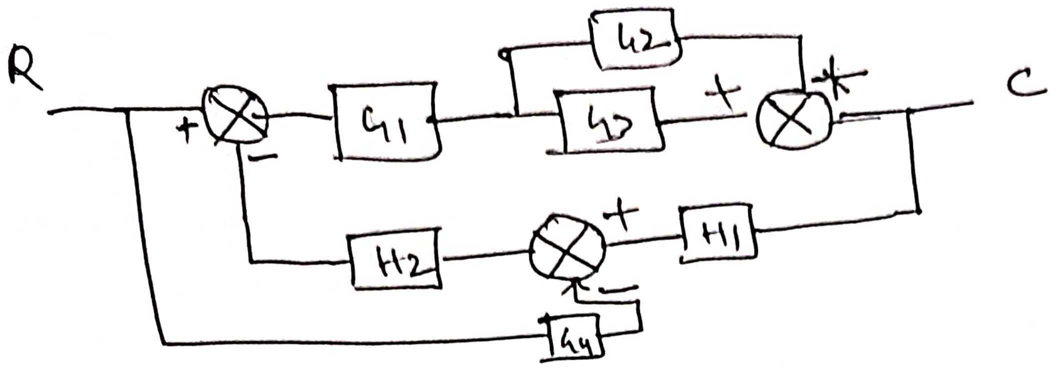
$$TF = \frac{\dfrac{G_1 G_2 G_3 G_4}{1+G_3G_4H_2-G_2G_3H_3}}{1+\dfrac{G_1G_2\cancel{G_3G_4}}{1+G_3G_4H_2-G_2G_3H_3}\times\dfrac{H_1(1+G_3G_4H_2)}{\cancel{G_3G_4}}}$$

$$= \frac{\dfrac{G_1G_2G_3G_4}{\cancel{1+G_3G_4H_2-G_2G_3H_3}}}{\dfrac{1+G_3G_4H_2-G_2G_3H_3+G_1G_2H_1(1+G_3G_4H_2)}{\cancel{1+G_3G_4H_2-G_2G_3H_3}}}$$

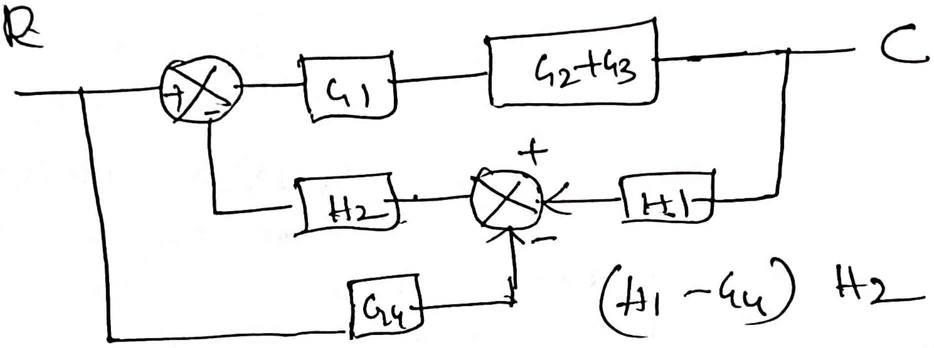
$$\frac{C(s)}{R(s)}\,TF = \frac{G_1G_2G_3G_4}{1+G_3G_4H_2-G_2G_3H_3+G_1G_2H_1+G_1G_2H_1H_2G_3G_4}$$

$$R(s) \longrightarrow \boxed{\frac{G_1G_2G_3G_4}{1+G_3G_4H_2-G_2G_3H_3+G_1G_2H_1+G_1G_2H_1H_2G_3G_4}} \longrightarrow$$

Determine transfer function

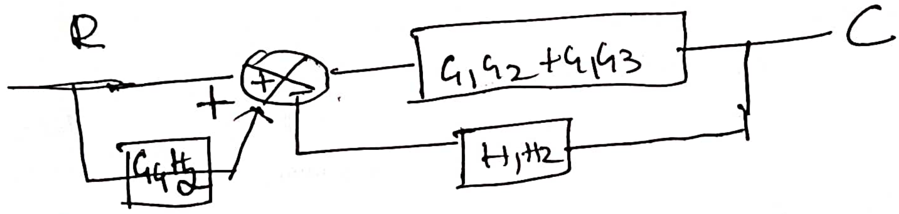


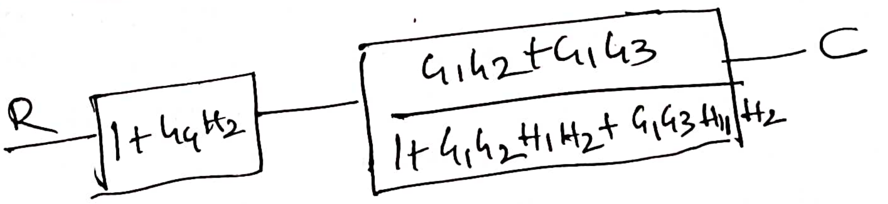
G_2 & G_3 are in parallel



$(H_1 - G_4)\,H_2$

$-\,(H_1H_2 - G_4H_2)$





$$TF = \frac{G_1G_2 + G_1G_3}{1 + (G_1G_2 + G_1G_3)H_1H_2}$$