

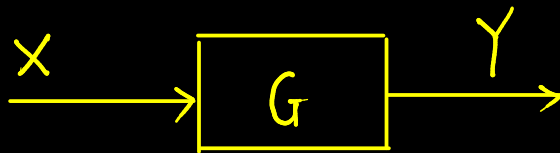
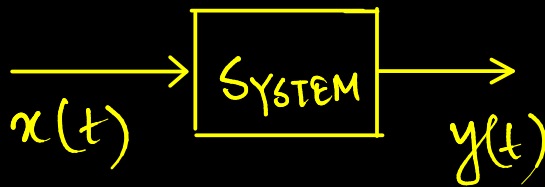
# CONTROL SYSTEMS ENGINEERING

TDG

DAY - 2:

- ① Block diagram algebra
- ① Signal flow graphs

$G$  = transfer functions/  
freq. response functions/  
complex gains

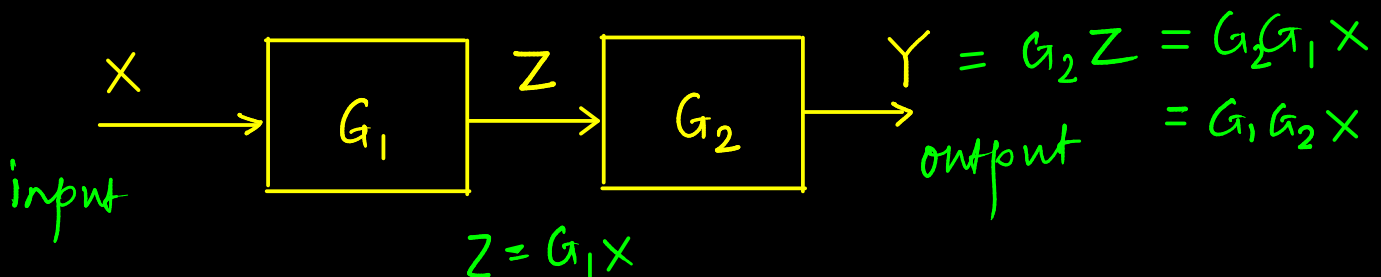


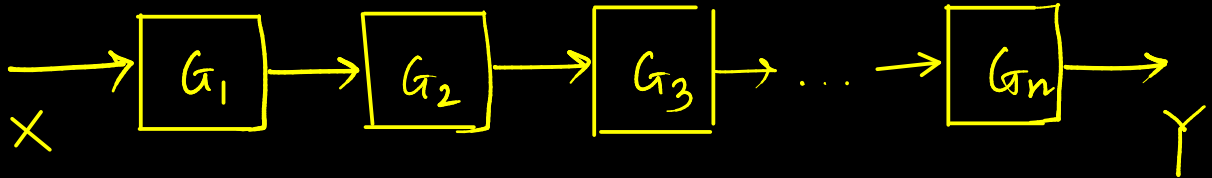
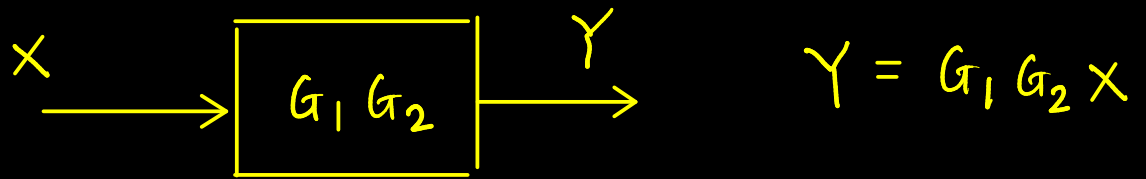
$$G = \frac{Y}{X}$$

$$Y = GX$$

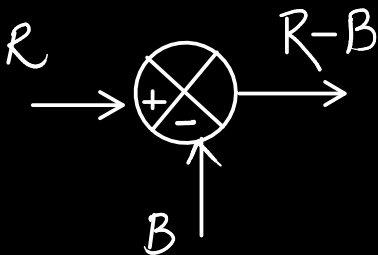
## Fundamental structures

### 1. Cascade config

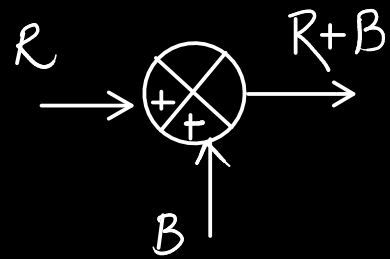




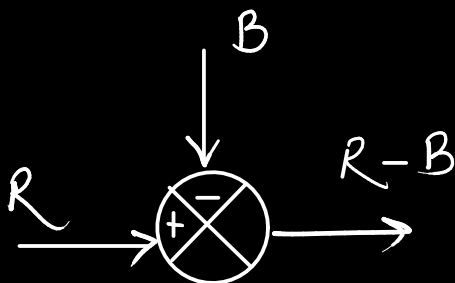
Extra



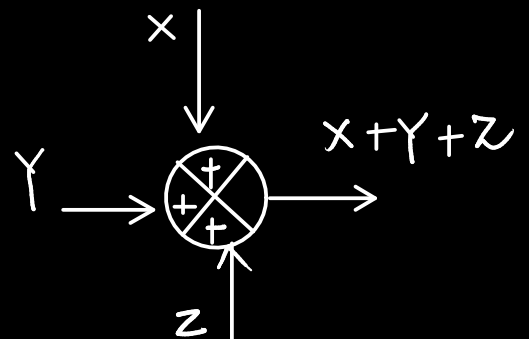
comparator



summing block

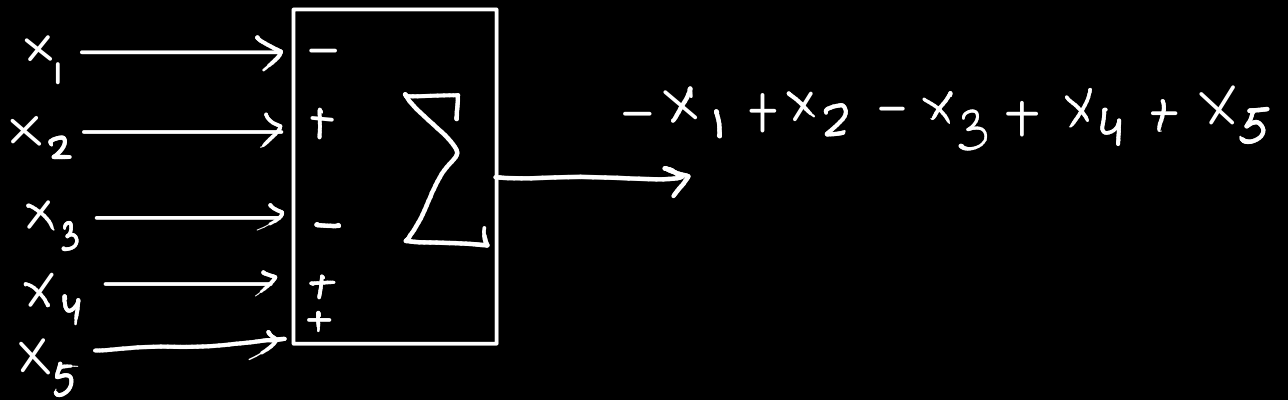


comparator

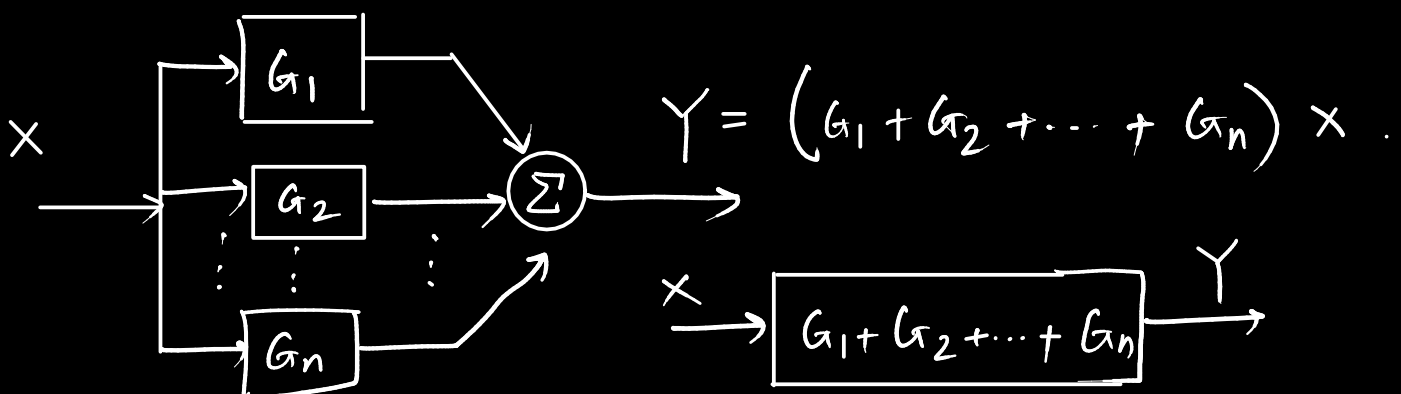
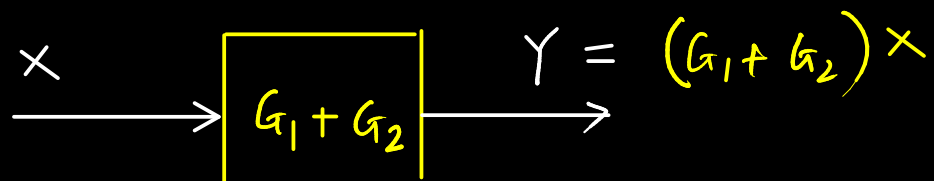
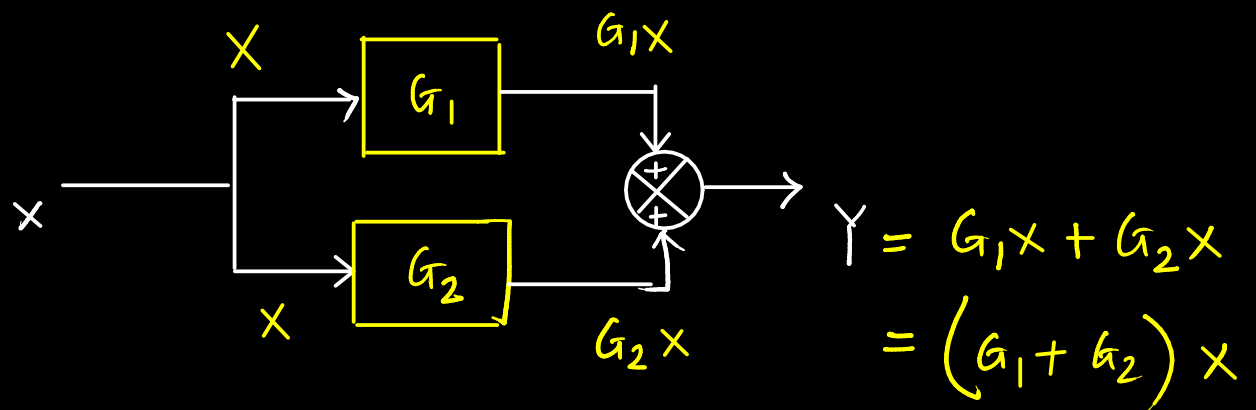


summing block

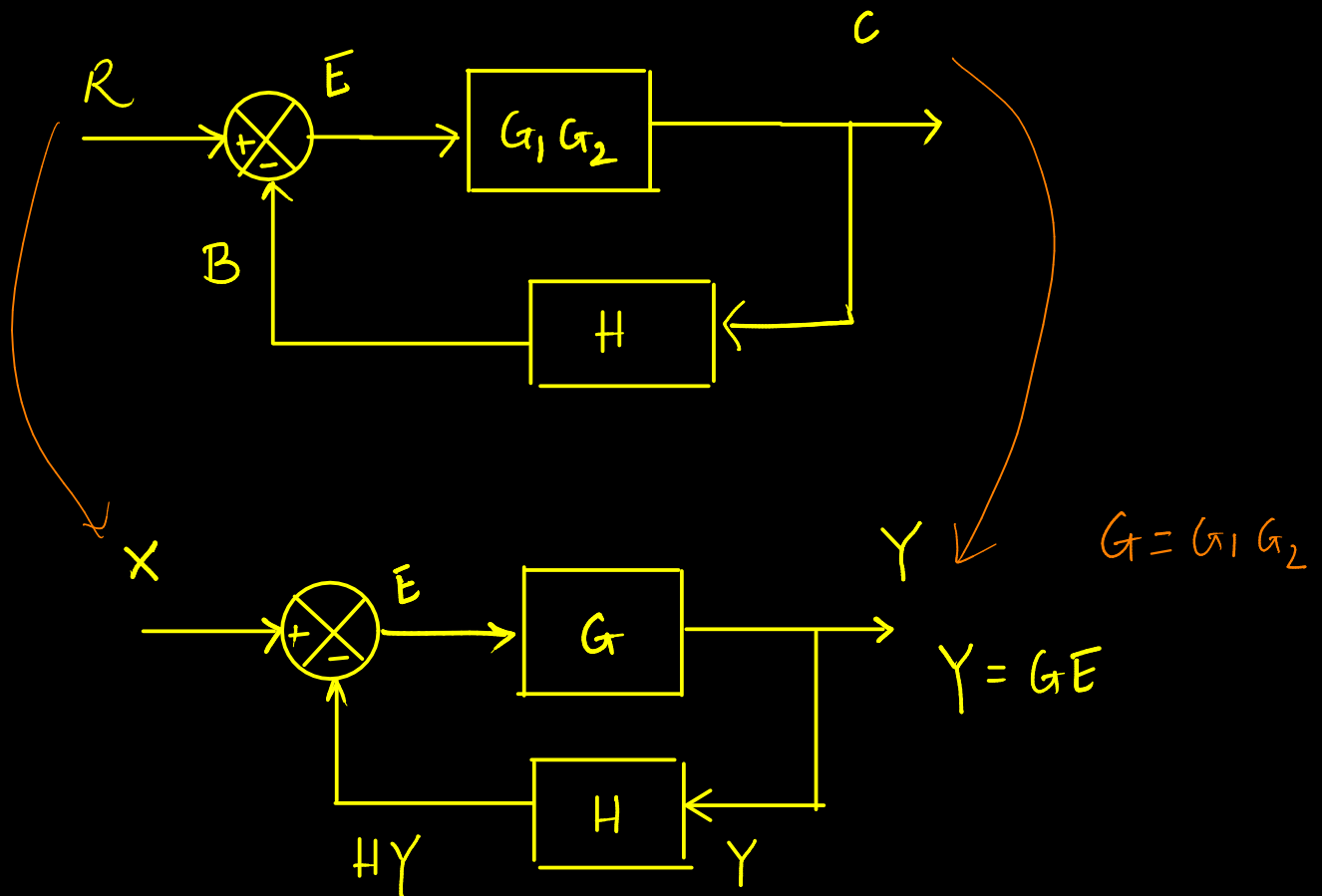
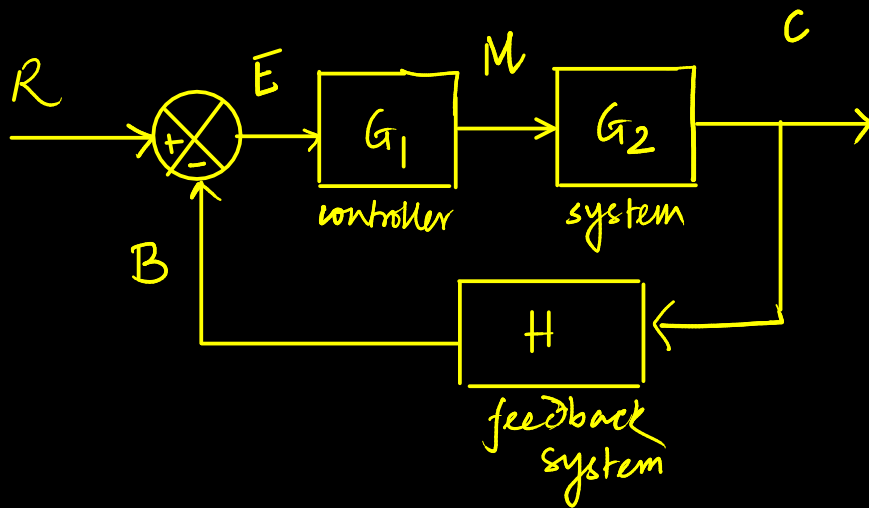
In General



2. Parallel config.



### 3. Feedback config (negative feedback config.)



simple negative feedback loop

$$E = X - HY \quad ; \quad Y = GE$$

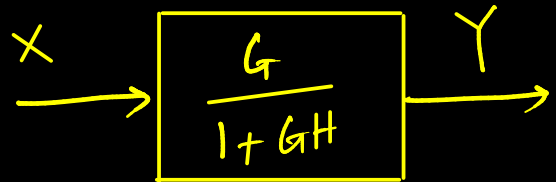
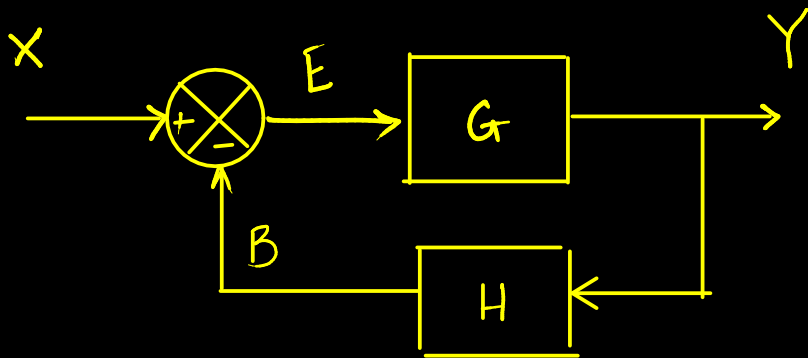
$$\Rightarrow Y = G(X - HY)$$

$$\Rightarrow Y = GX - GHY$$

$$\Rightarrow Y + GHY = GX$$

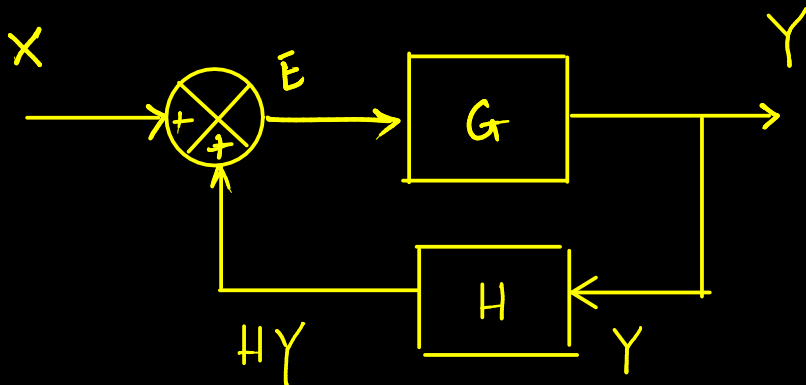
$$\Rightarrow (1 + GH)Y = GX$$

$$\Rightarrow \frac{Y}{X} = \frac{G}{1 + GH}$$



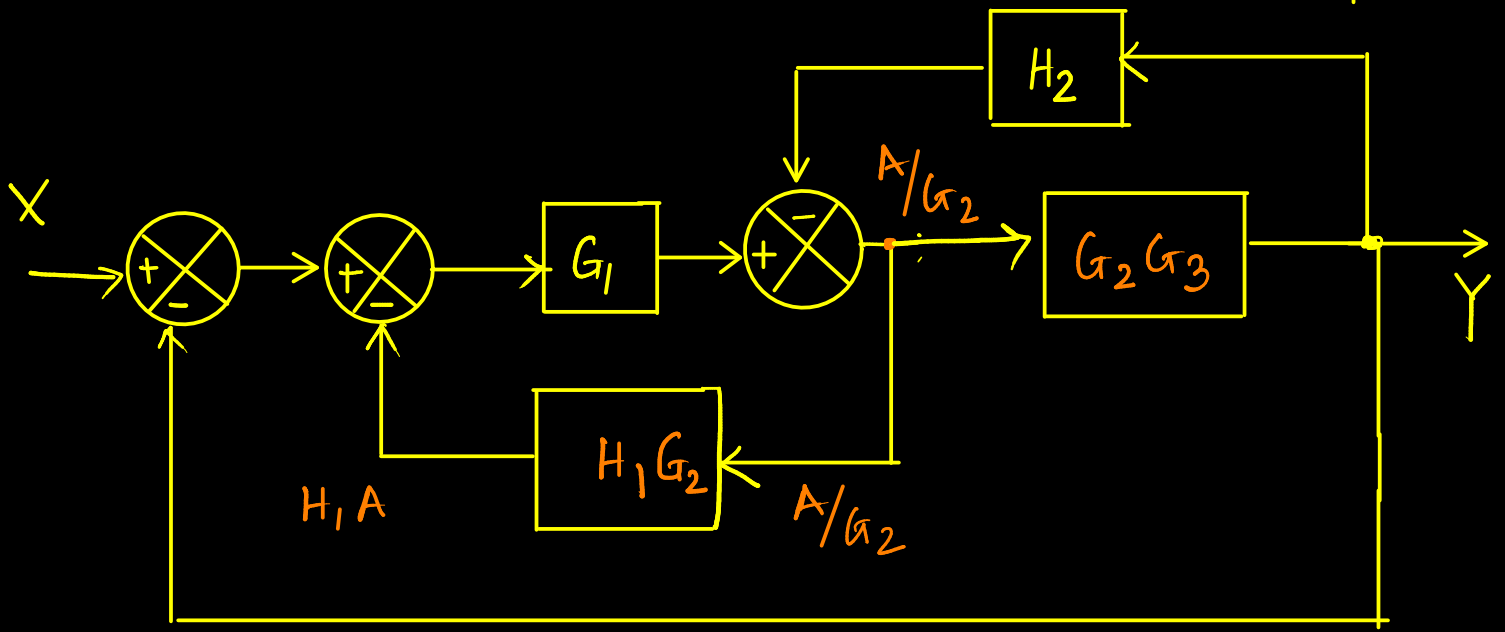
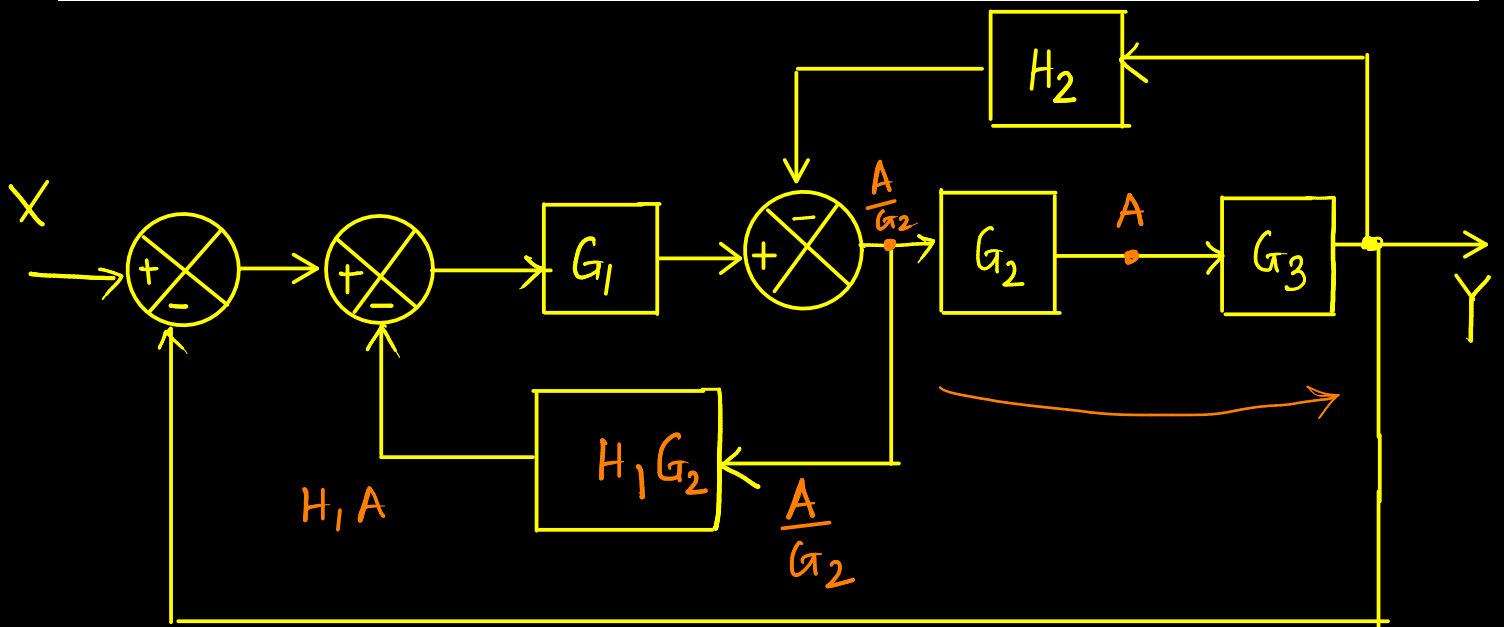
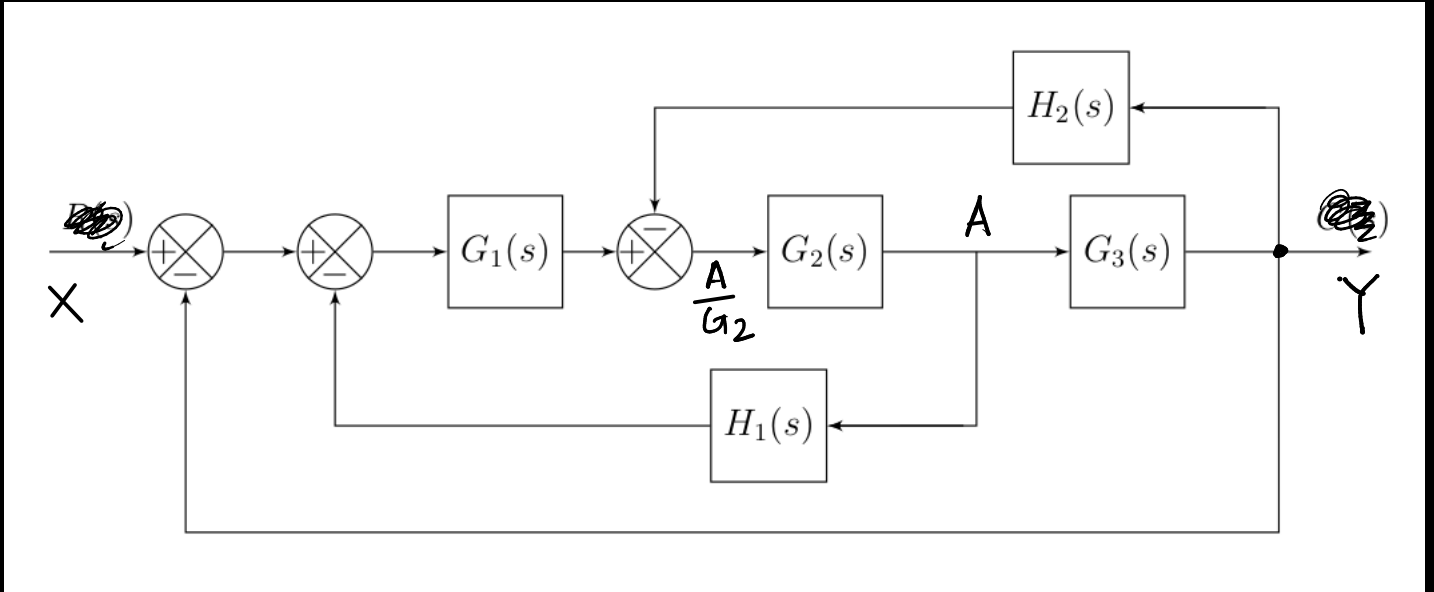
Homework:

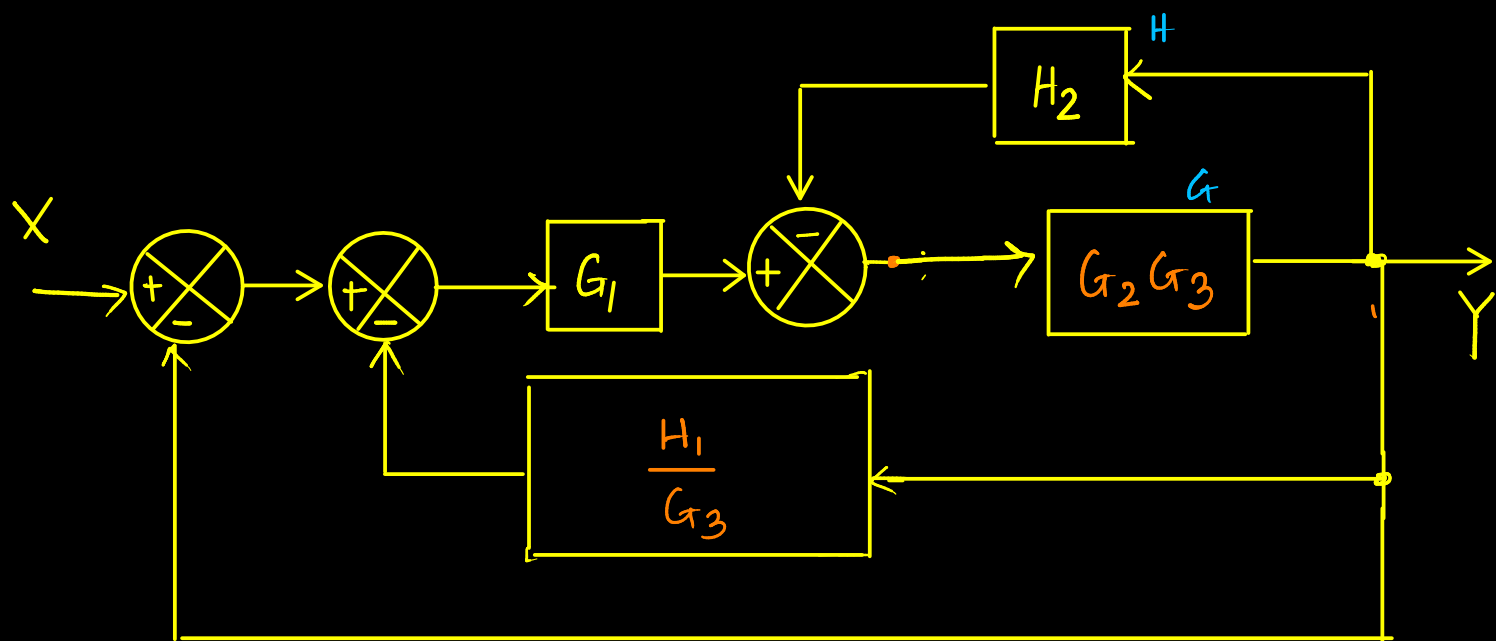
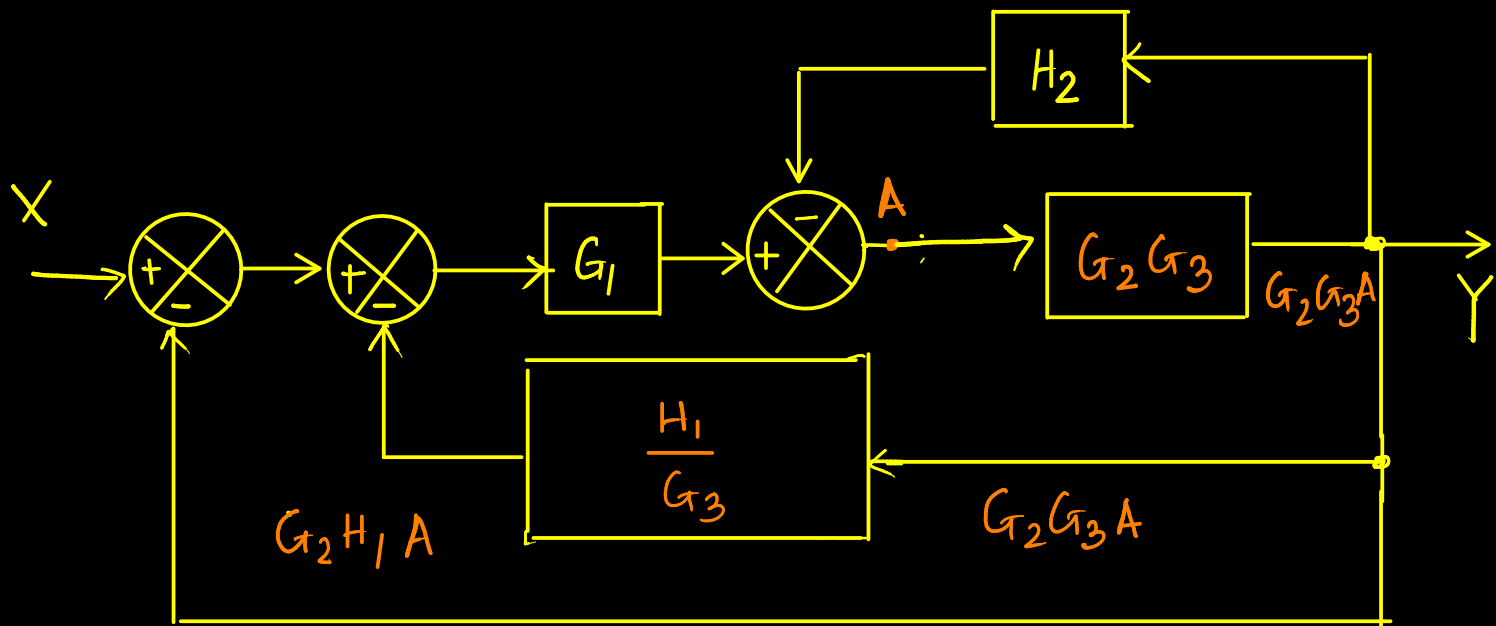
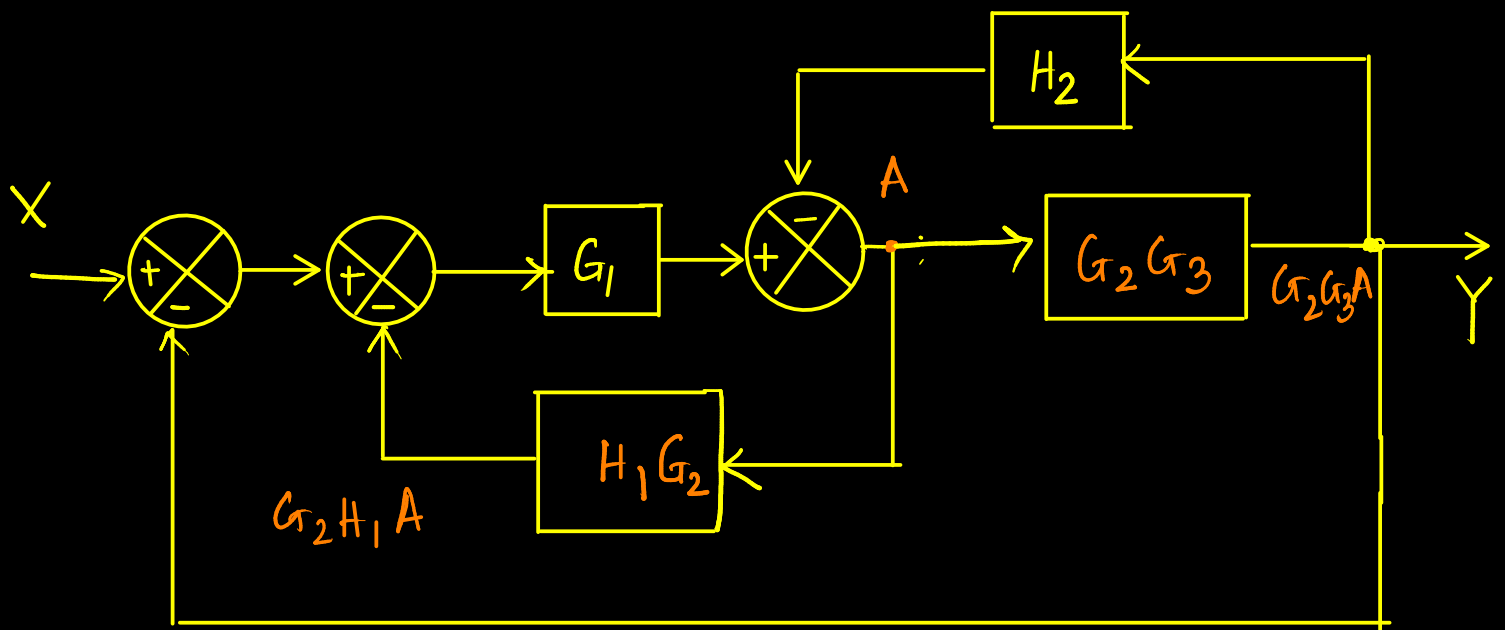
Positive feedback

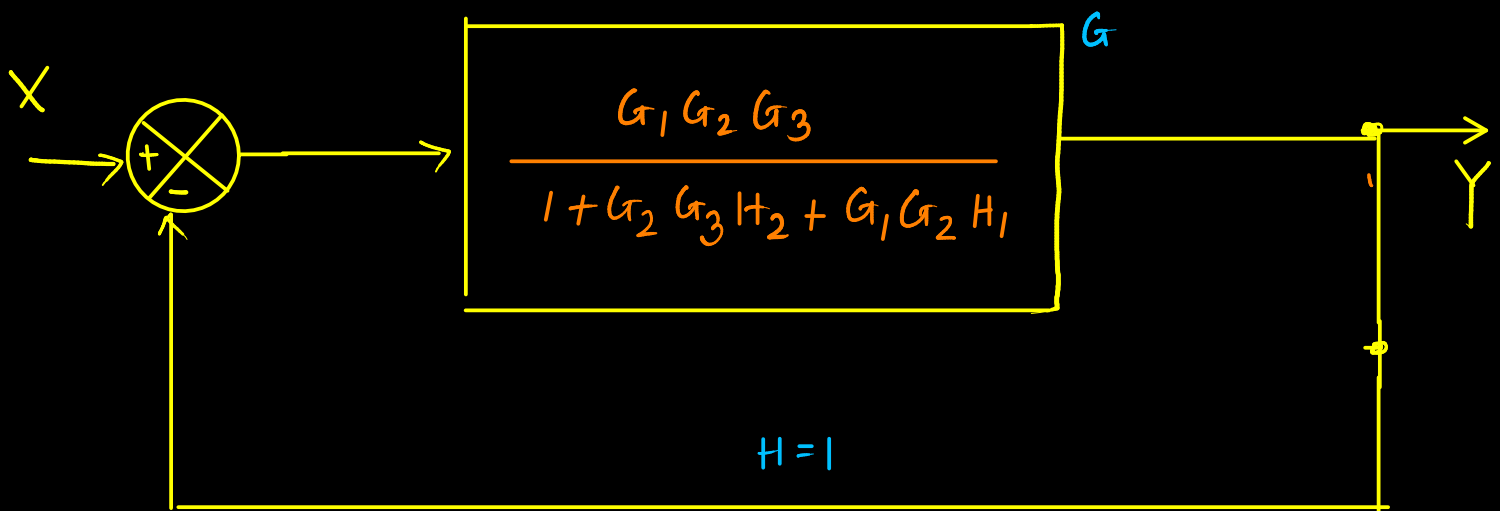
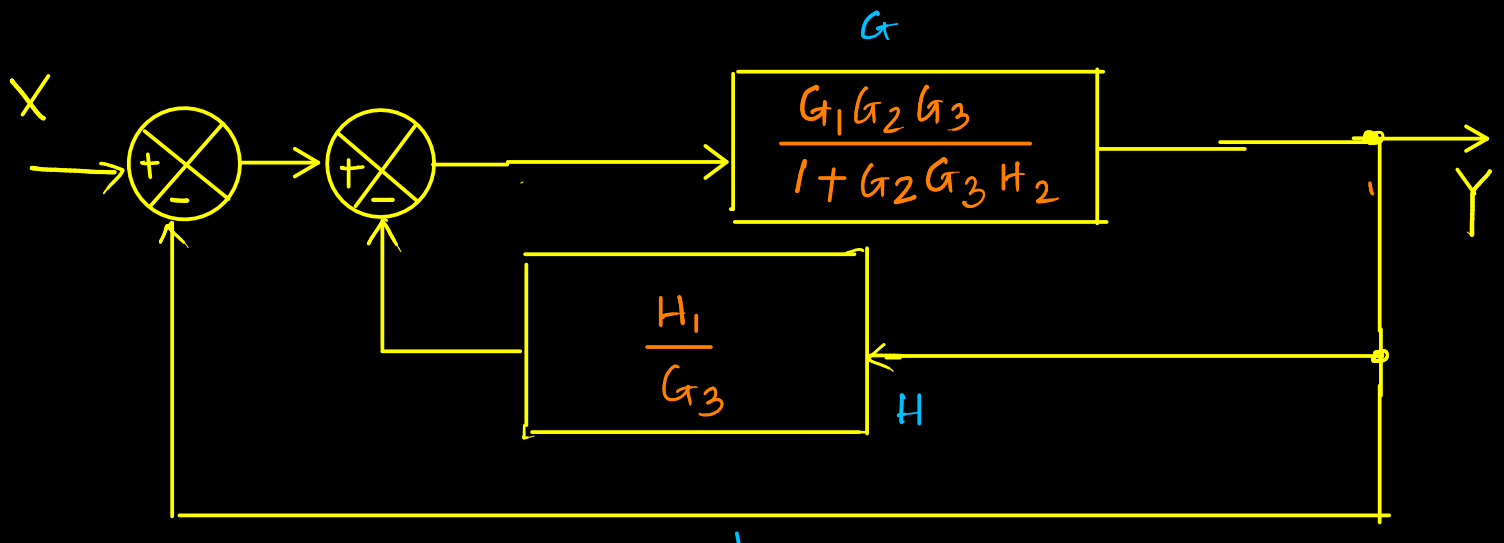
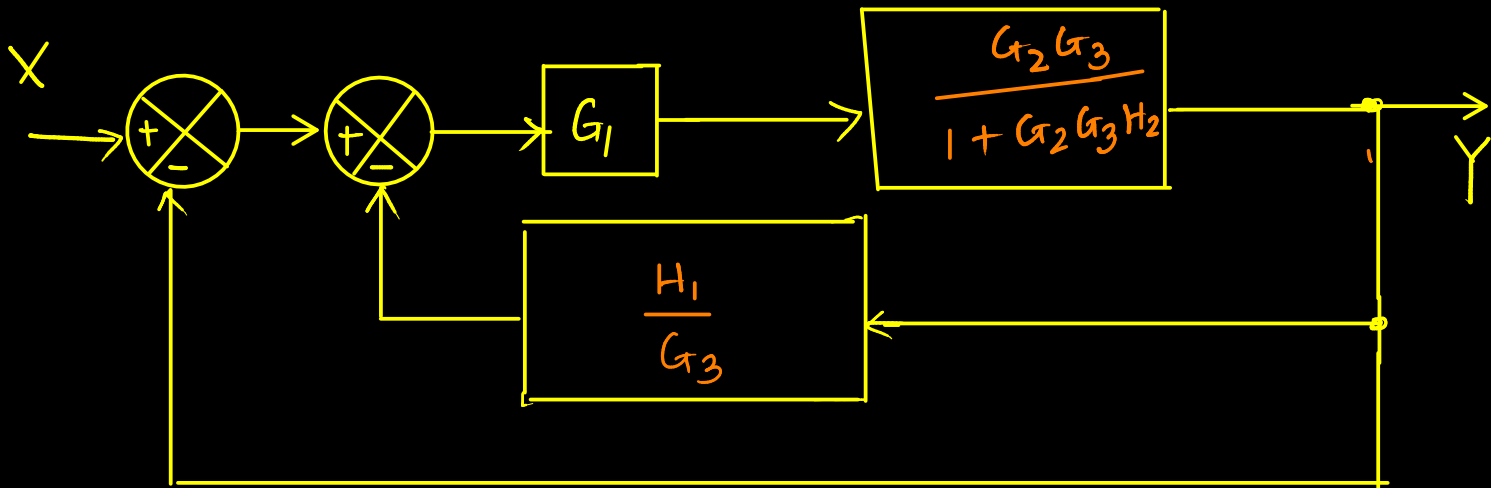


$$\frac{Y}{X} = \frac{G}{1 - GH}$$

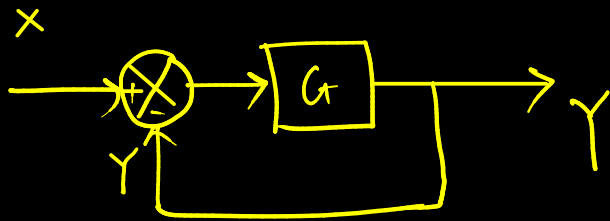
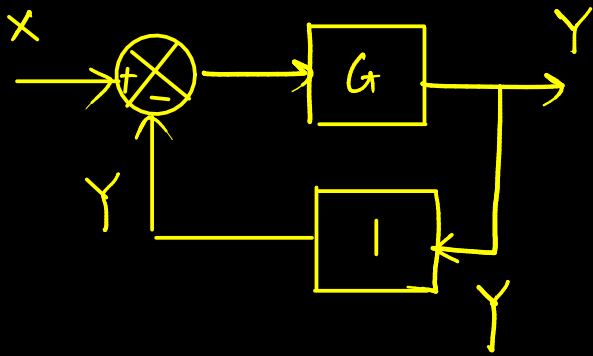
# Big examples











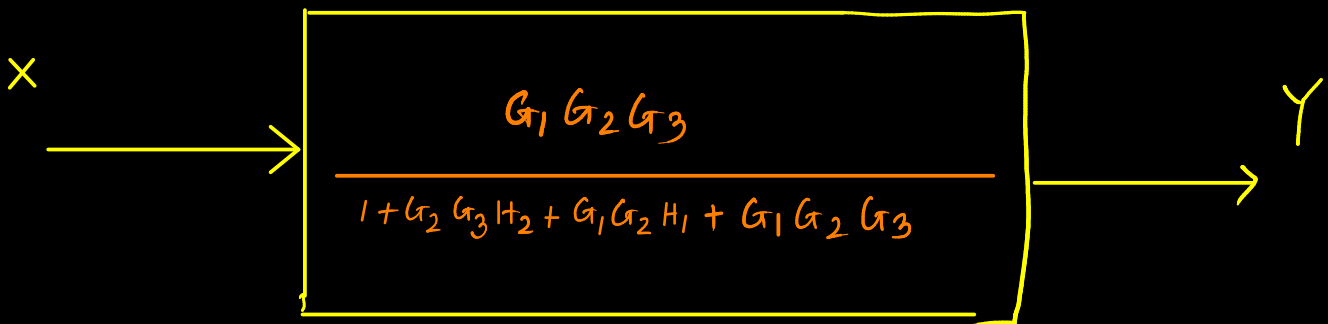
$$G = \frac{G_1 G_2 G_3}{1 + G_2 G_3 H_2}$$

$$H = \frac{H_1}{G_3}$$

$$\frac{G}{1 + GH} = \frac{\frac{G_1 G_2 G_3}{1 + G_2 G_3 H_2}}{1 + \frac{G_1 G_2 \cancel{G_3}}{1 + G_2 G_3 H_2} \cdot \frac{H_1}{\cancel{G_3}}}$$

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

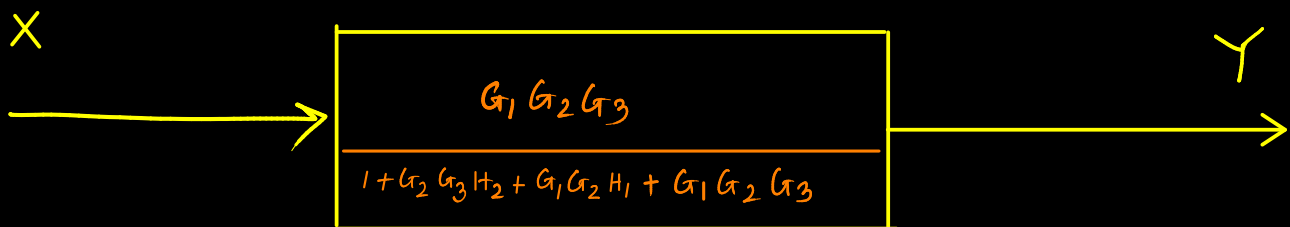
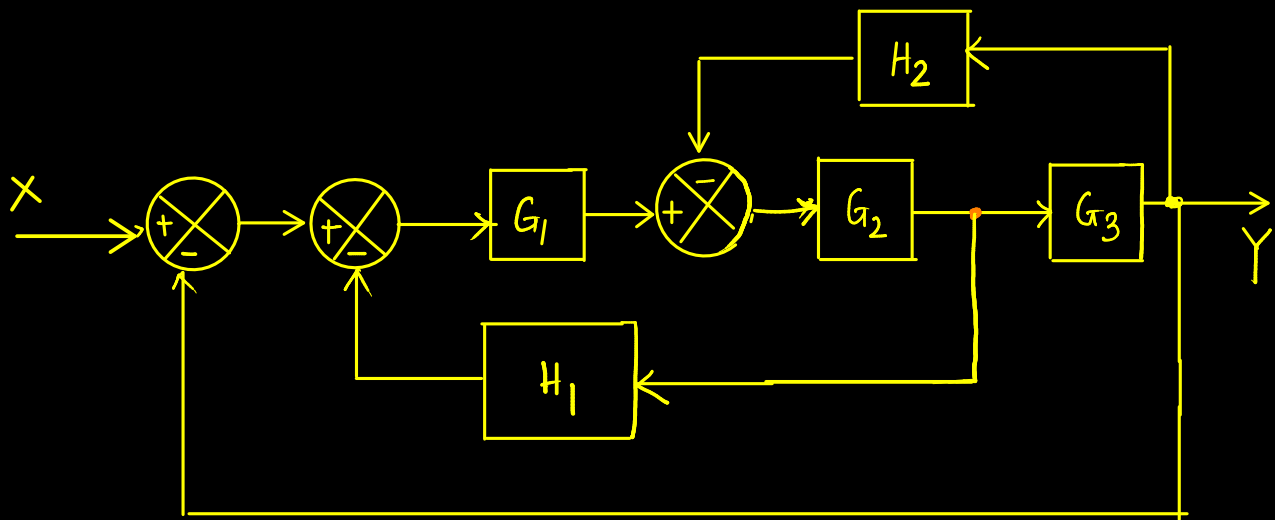
$$= \frac{G_1 G_2 G_3}{1 + G_2 G_3 H_2 + G_1 G_2 H_1}$$



$$G = \frac{G_1 G_2 G_3}{1 + G_2 G_3 H_2 + G_1 G_2 H_1}$$

$$H = 1$$

$$\begin{aligned} \frac{G}{1 + GH} &= \frac{G}{1 + G} = \frac{\frac{G_1 G_2 G_3}{1 + G_2 G_3 H_2 + G_1 G_2 H_1}}{1 + \frac{G_1 G_2 G_3}{1 + G_2 G_3 H_2 + G_1 G_2 H_1}} \\ &= \frac{G_1 G_2 G_3}{1 + G_2 G_3 H_2 + G_1 G_2 H_1 + G_1 G_2 G_3} \end{aligned}$$



Homework (aka. assignment!)  
Find the overall TF  $\frac{Y}{X}$

