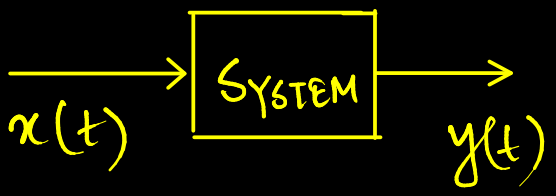
Control Systems Engineering

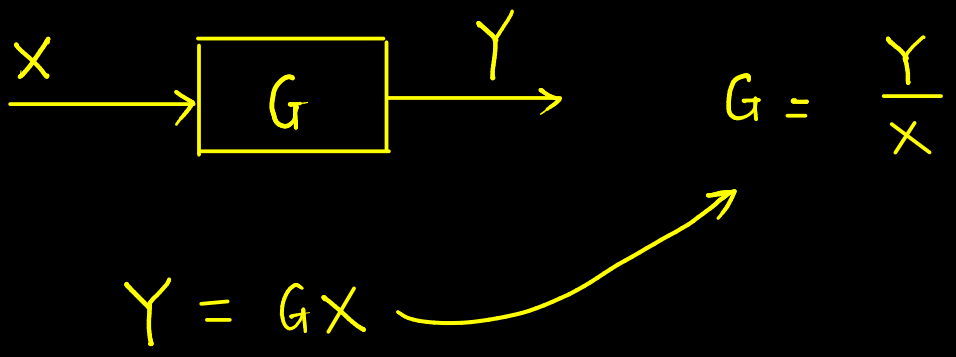
TDG

DAY - 2:

1. Block diagram algebra
2. Signal flow graphs

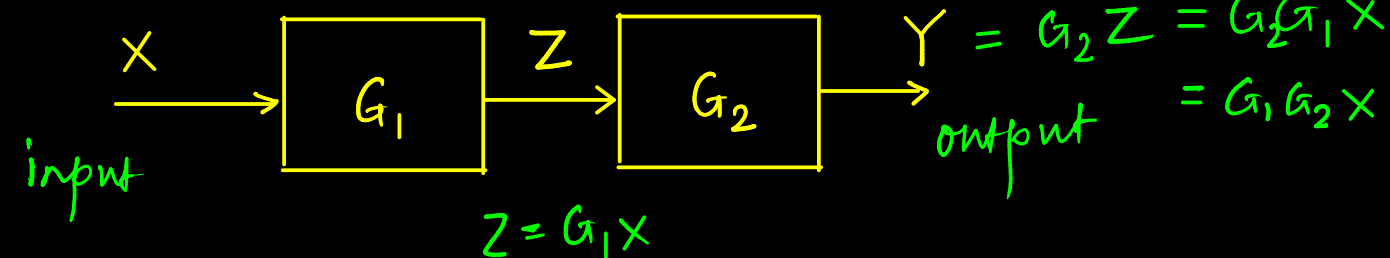
G = transfer function / freq. response function / complex gain



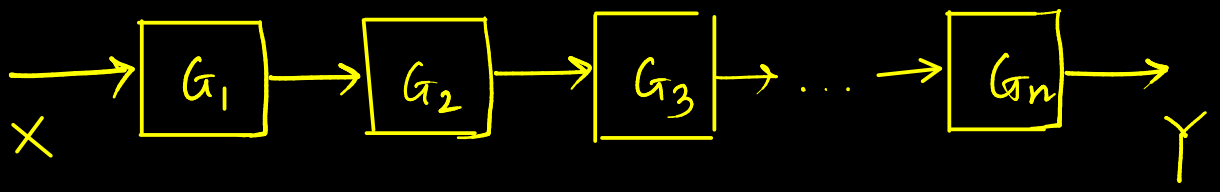


Fundamental structures

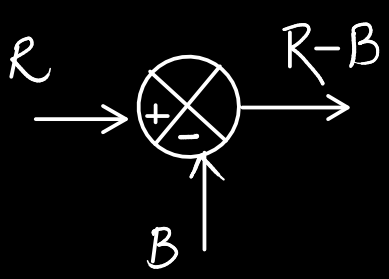
1. Cascade config



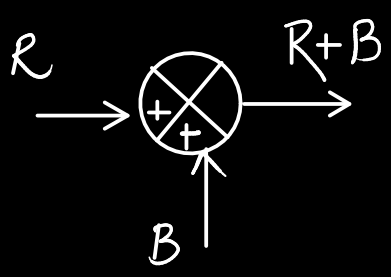
$$Y = G_1 G_2 X$$



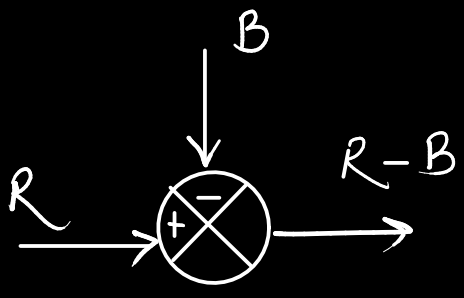
Extra



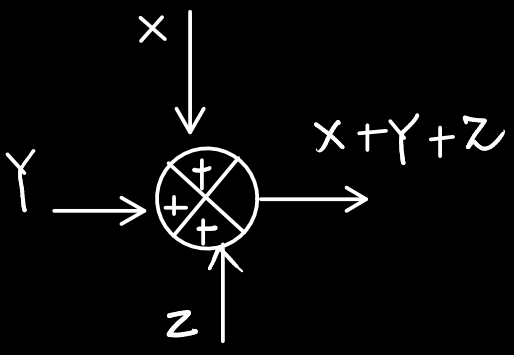
comparator



summing block

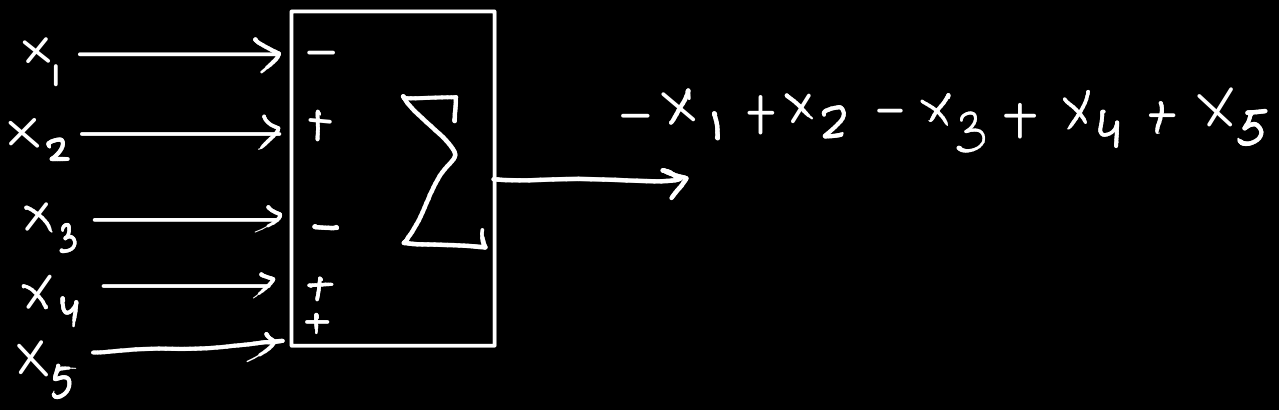


comparator

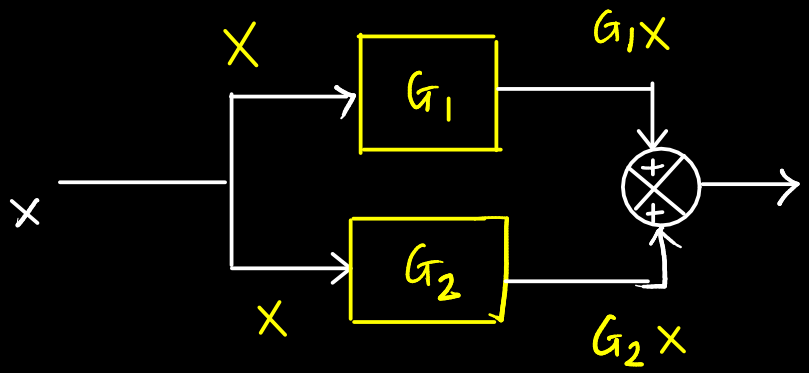


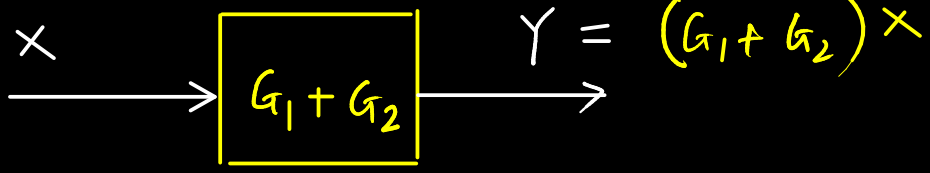
summing block

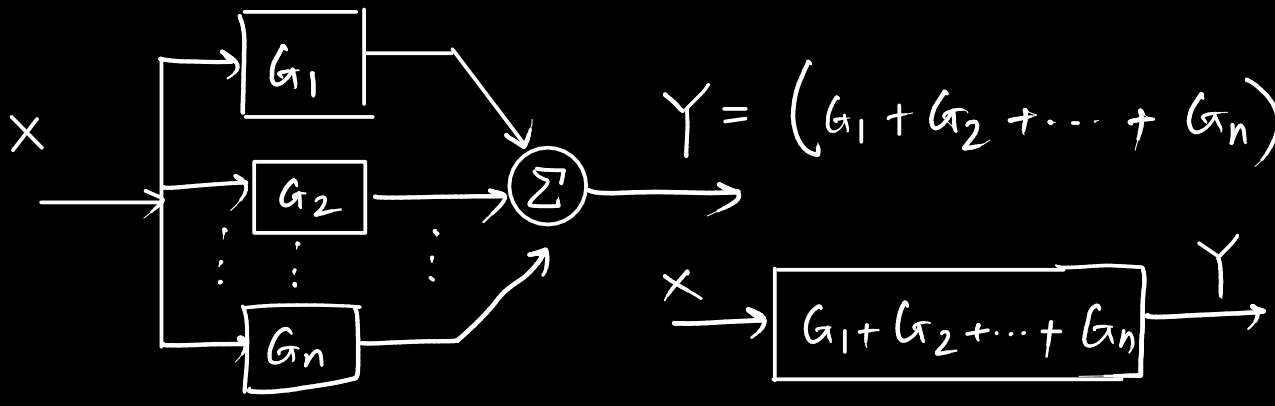
In General



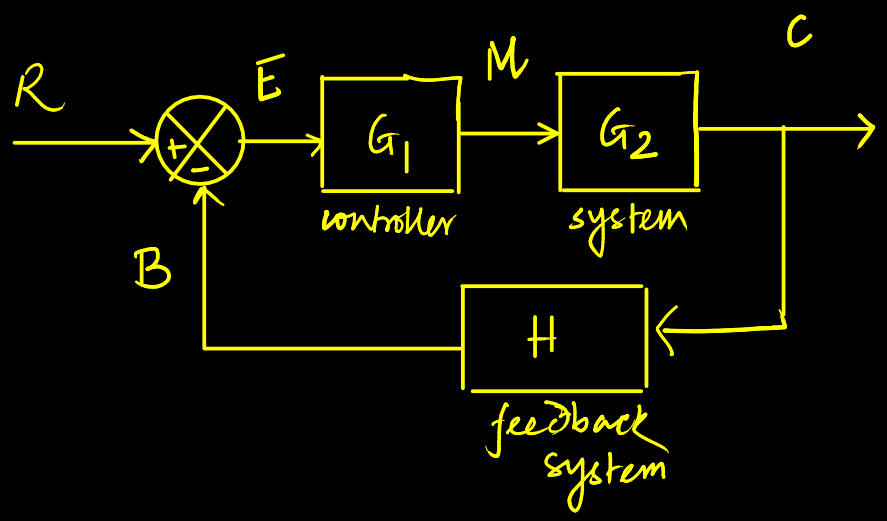
2. Parallel config.

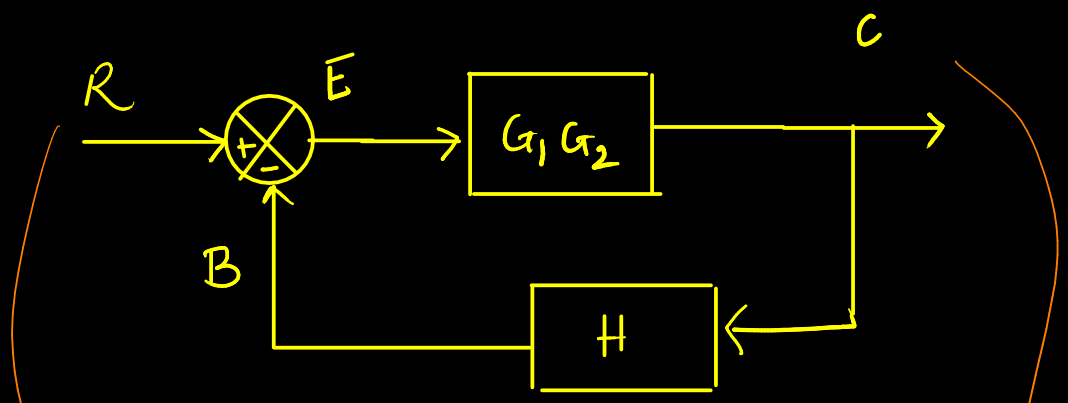






3. Feedback config (negative feedback config.)





simple negative feedback loop

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

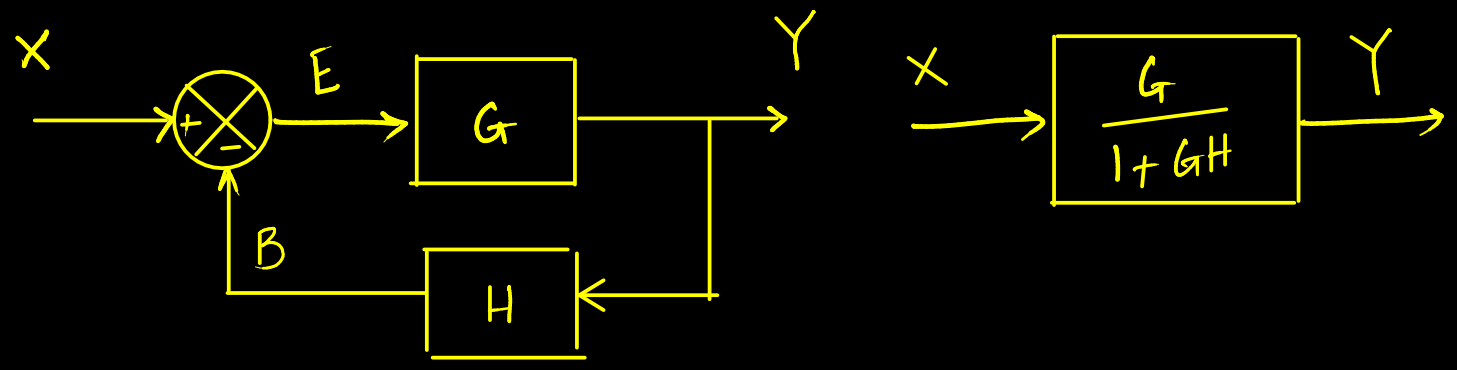
$$\Rightarrow \quad Y = G(X - HY)$$

$$\Rightarrow \quad Y = GX - GHY$$

$$\Rightarrow \quad Y + GHY = GX$$

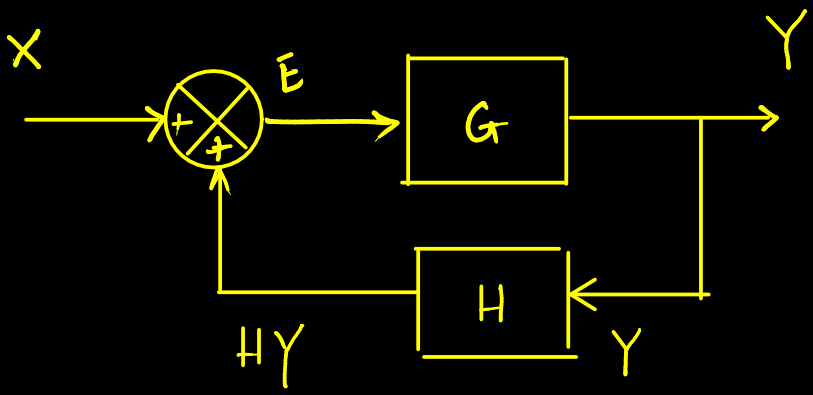
$$\Rightarrow \quad (1 + GH)\,Y = GX$$

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



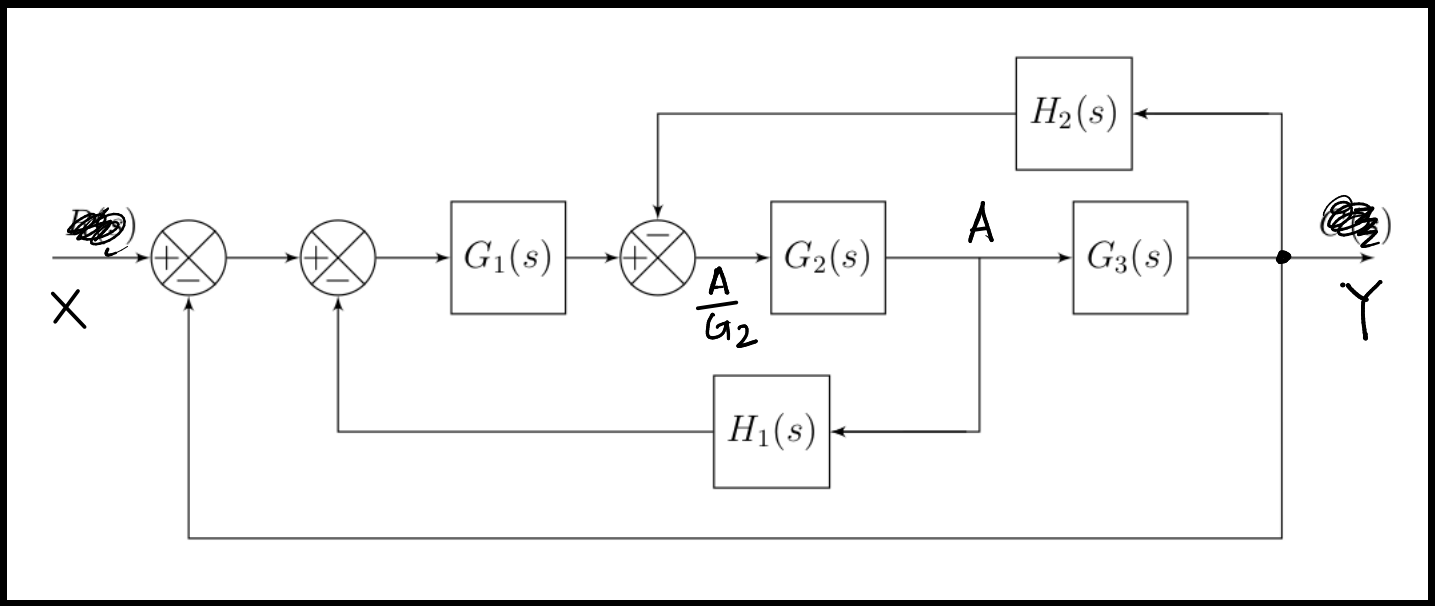
Homework:

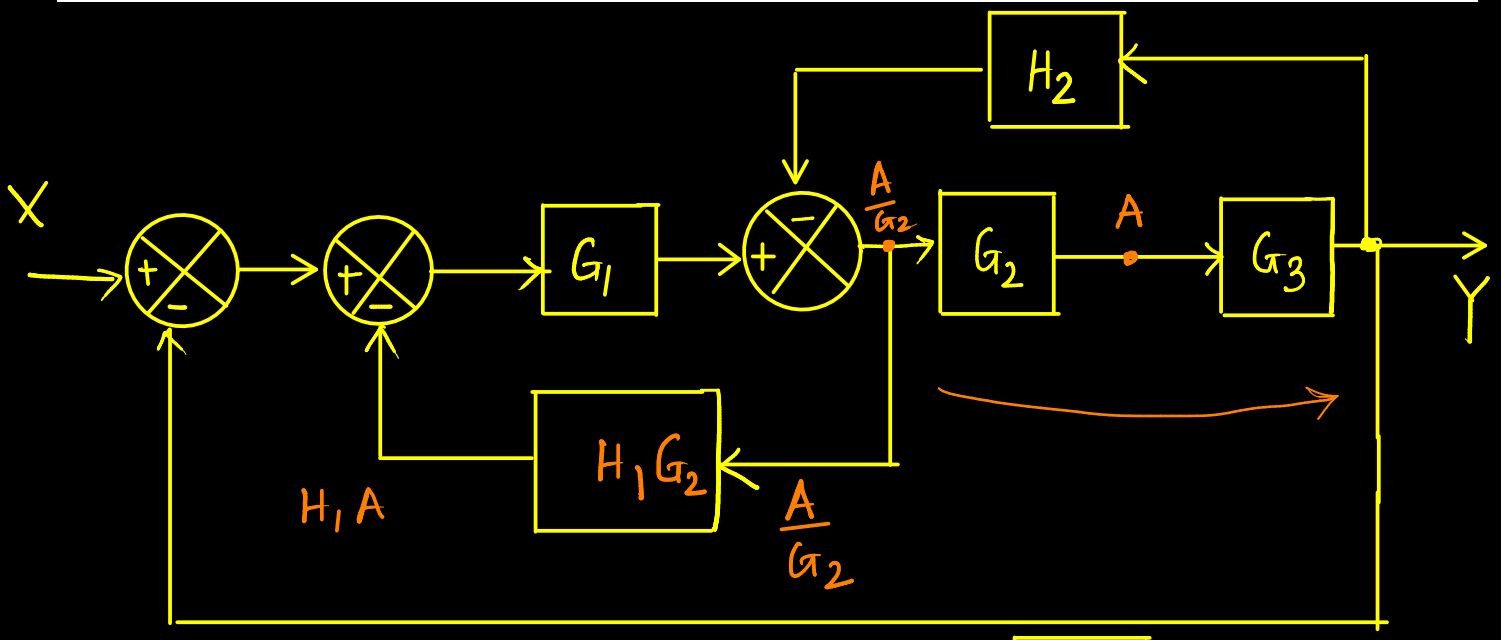
Positive feedback

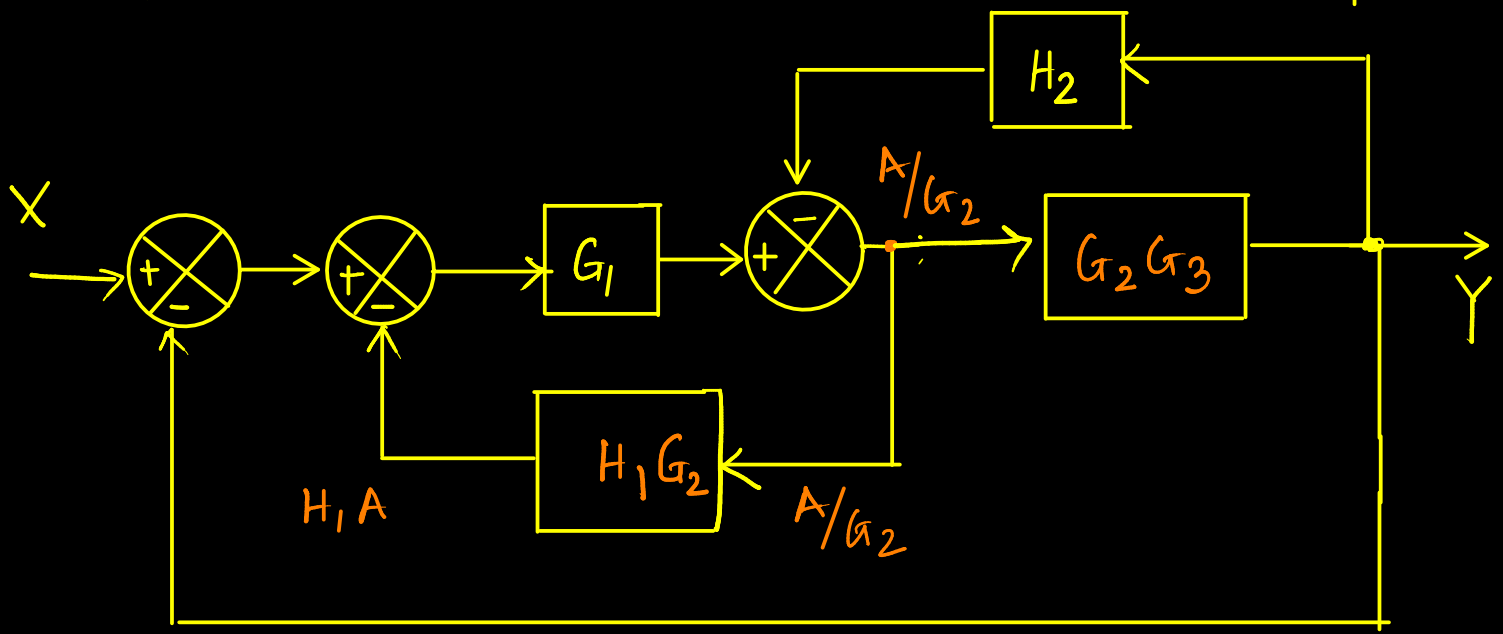


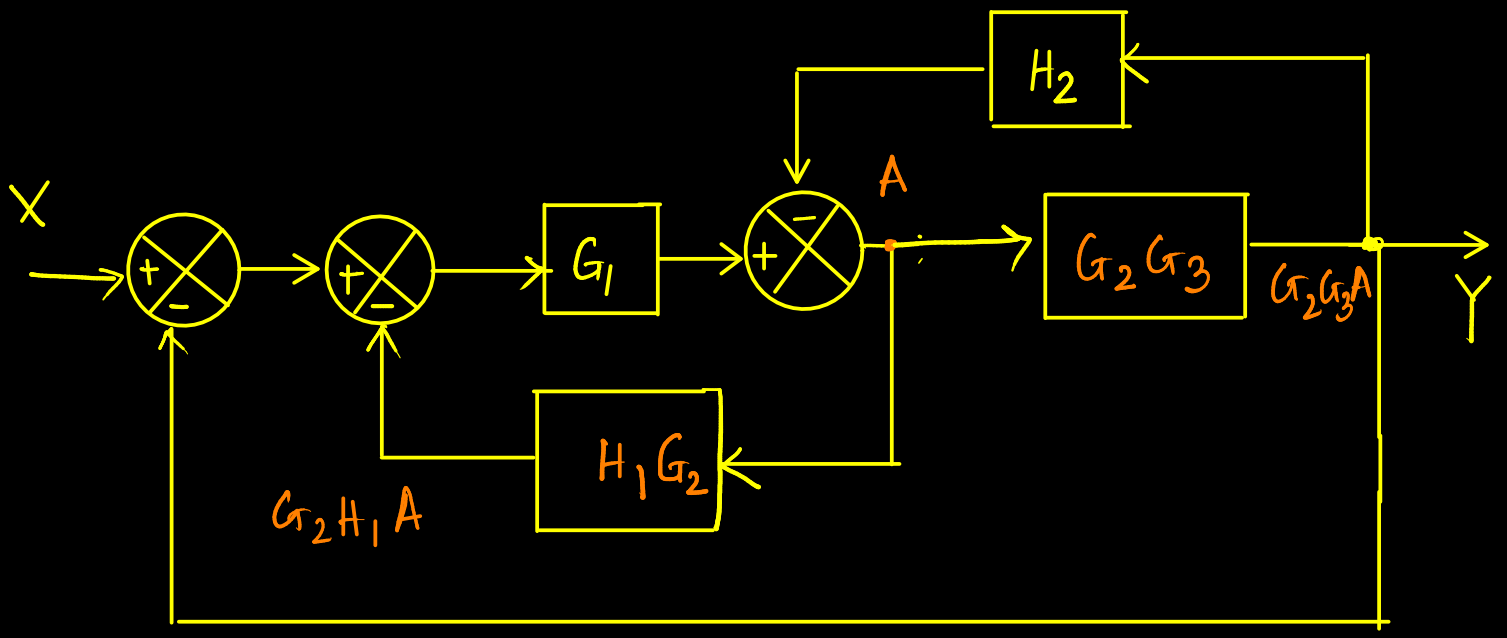
$$\frac{Y}{X} = \frac{G}{1 - GH}$$

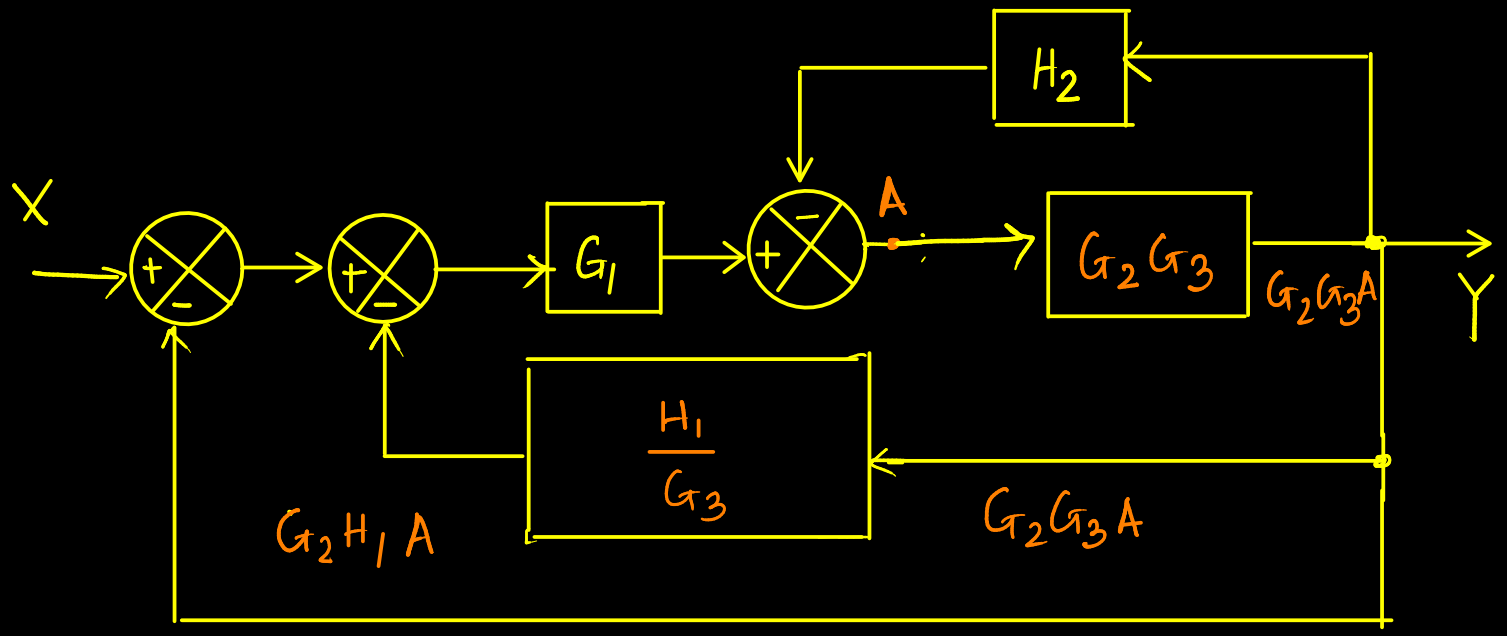
Big examples

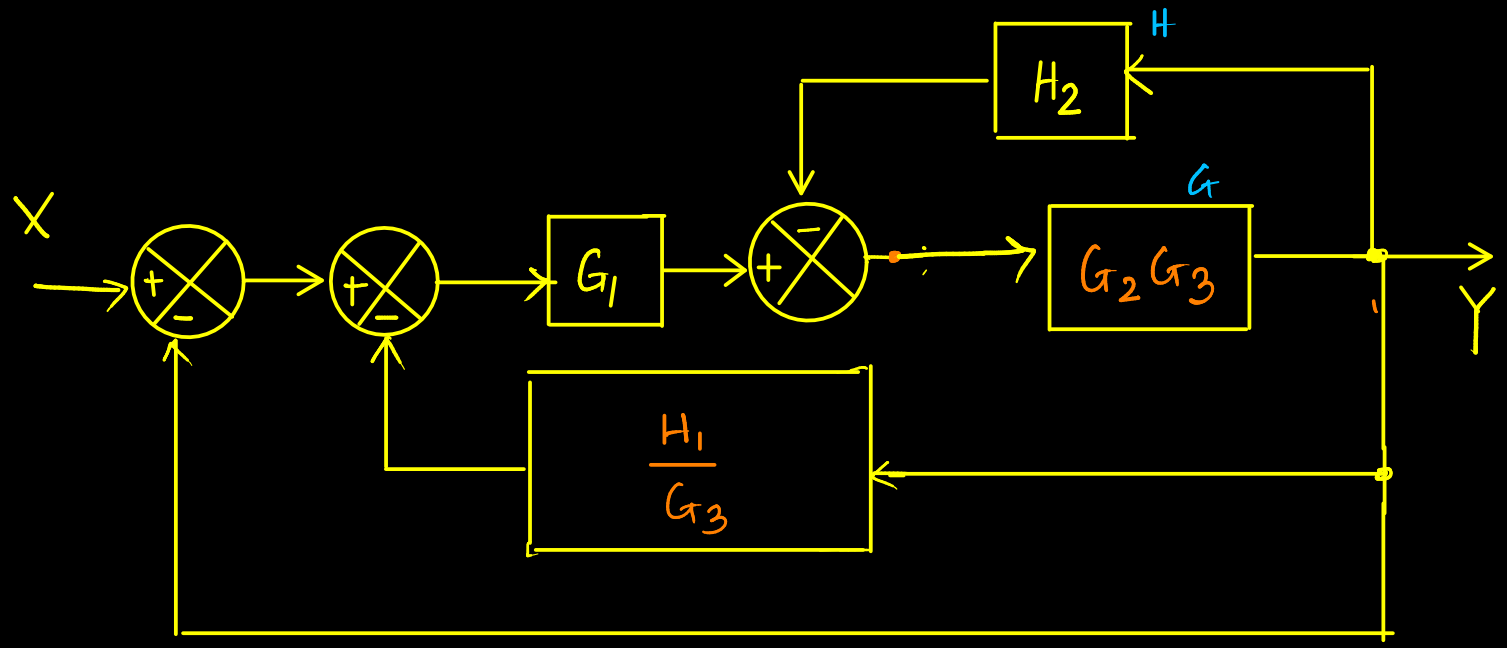


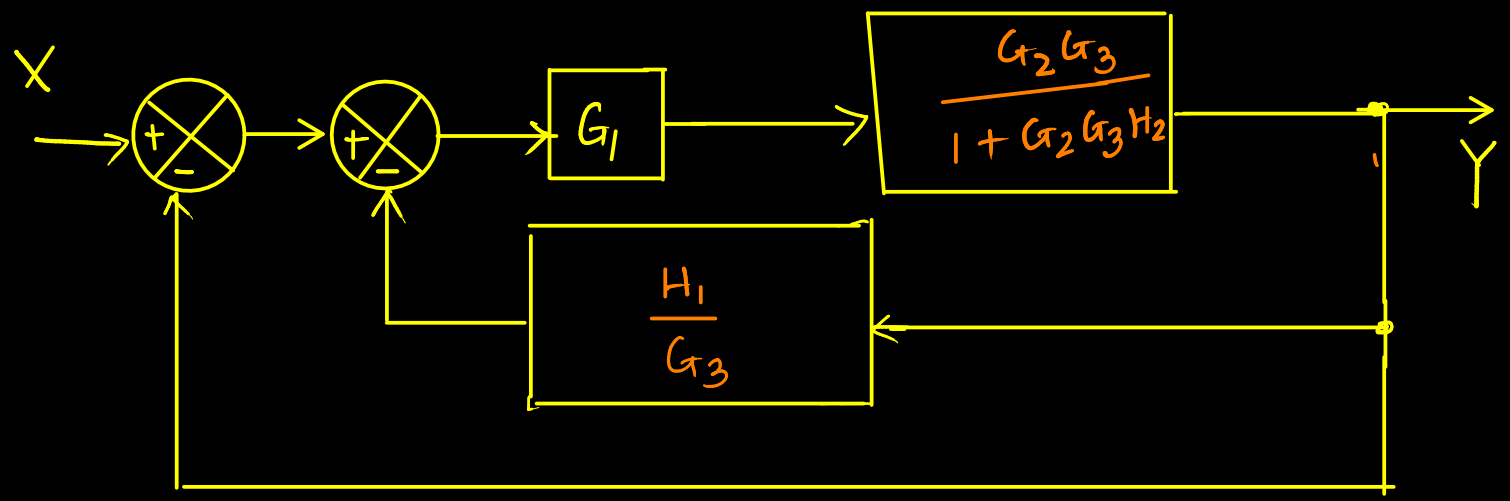


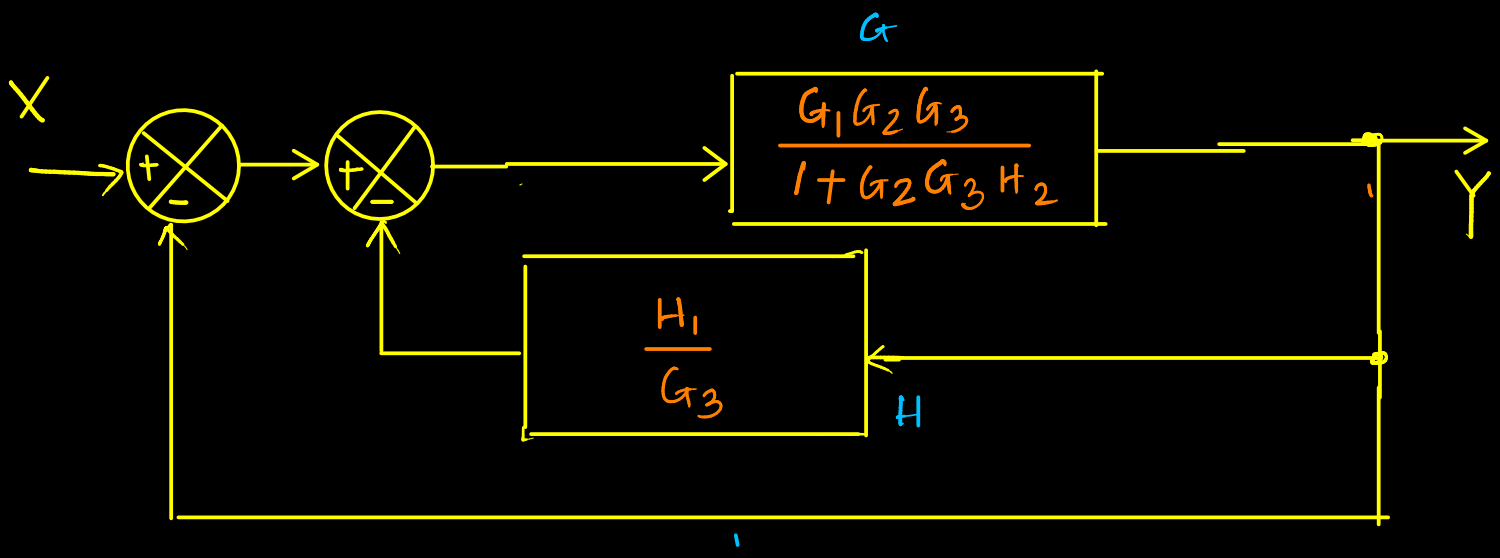


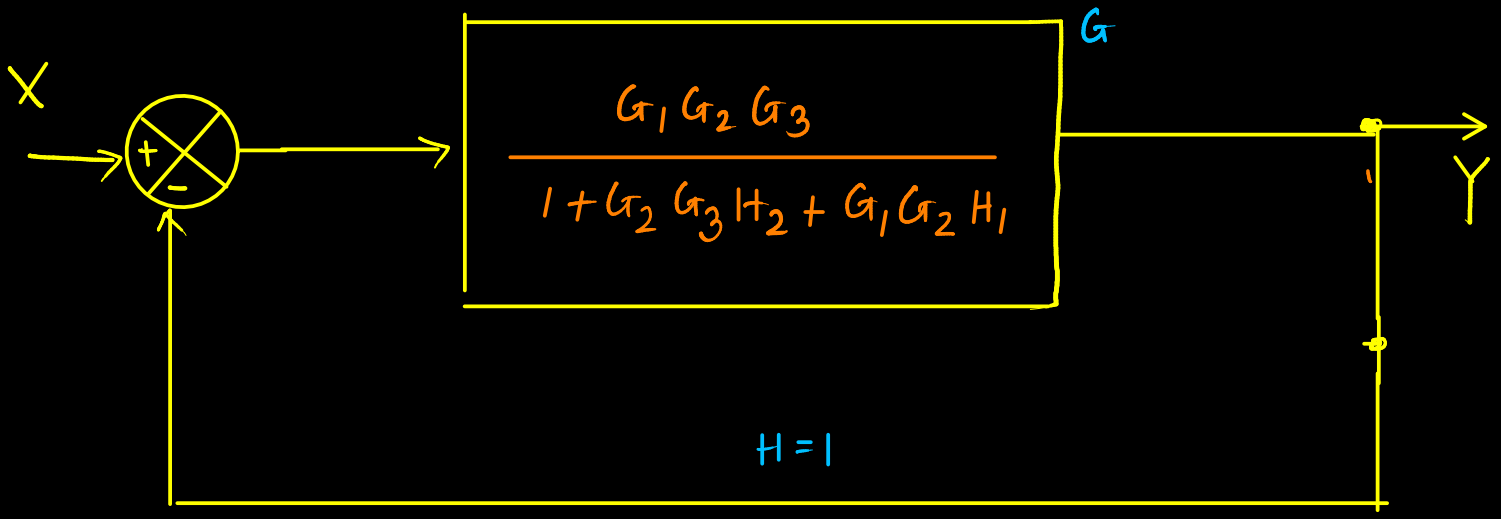

X
+
−
+
−
G1
A
H2
G2G3
G2G3A
Y
H1G2
G2H1A

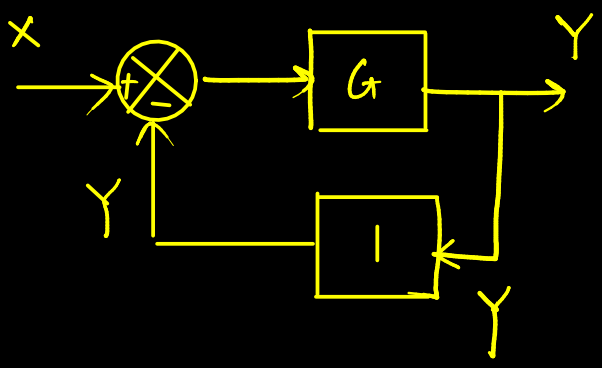

X
+
−
+
−
G1
A
H2
G2G3
G2G3A
Y
H1/G3
G2H1A
G2G3A


H
H2
G
X
+
−
+
−
G1
G2G3
Y
H1/G3


X
+
−
+
−
G_1
$\frac{G_2 G_3}{1 + G_2 G_3 H_2}$
Y
$\frac{H_1}{G_3}$


G
X
+
−
+
−
$\frac{G_1 G_2 G_3}{1 + G_2 G_3 H_2}$
Y
$\frac{H_1}{G_3}$
H


G
X
+
−
$\frac{G_1 G_2 G_3}{1 + G_2 G_3 H_2 + G_1 G_2 H_1}$
Y
H = 1



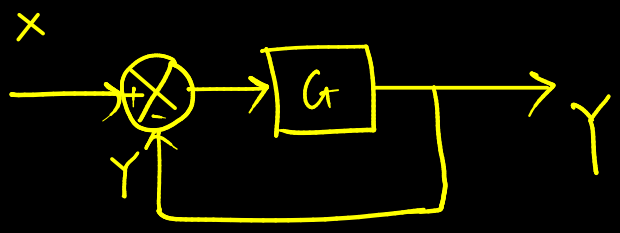
$$G = \frac{G_1 G_2 G_3}{1 + G_2 G_3 H_2}$$

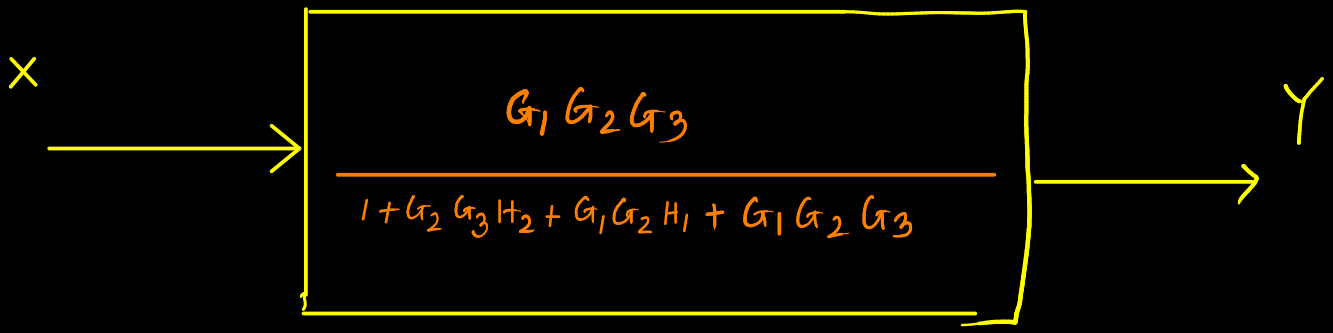
$$H = \frac{H_1}{G_3}$$

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

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

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



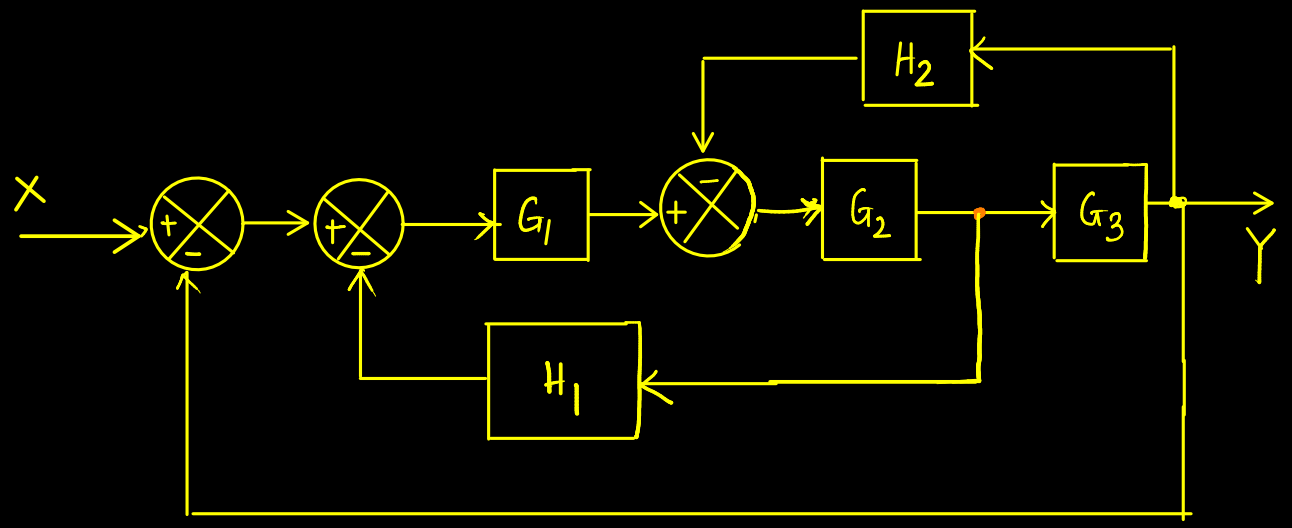


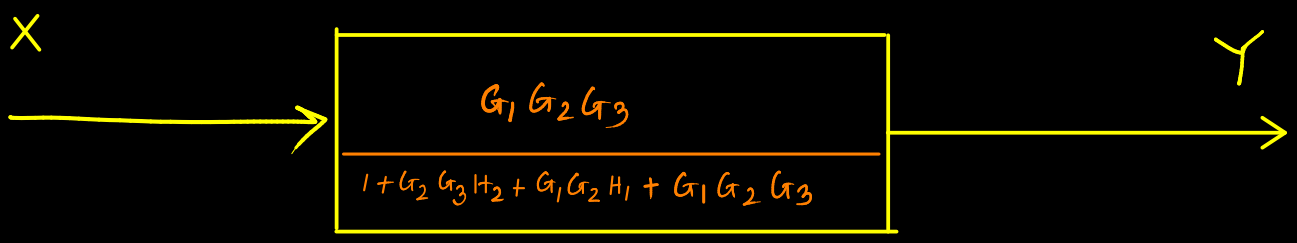
$$G = \frac{G_1 G_2 G_3}{1 + G_2 G_3 H_2 + G_1 G_2 H_1}$$

$$H = 1$$

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

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





Homework (aka. assignment!)

Find the overall TF $\frac{Y}{X}$