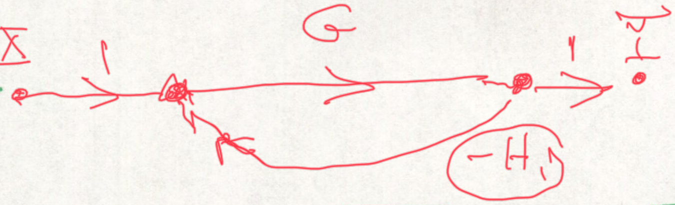
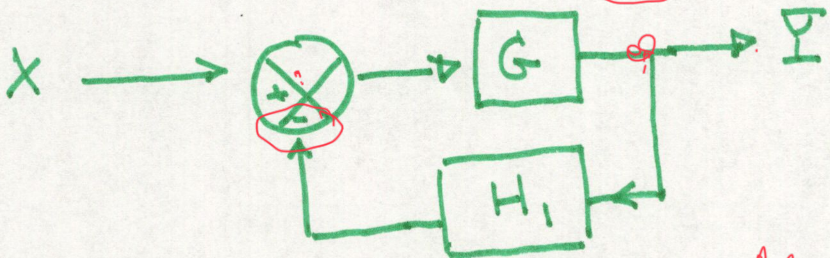
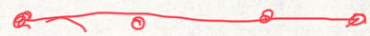
Problem 



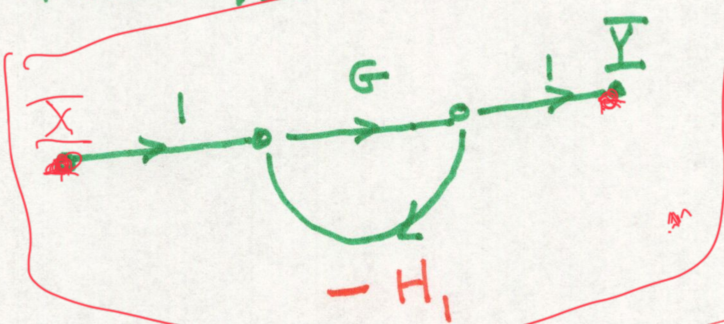
Mason's Gain Form,



$P_1 = G$

A. Build SFG

B. Find Y/X

A. 

B. Forward path gain  $P_1 = 1 \cdot G \cdot 1$

Loops  $L_1 = G(-H) = -GH$

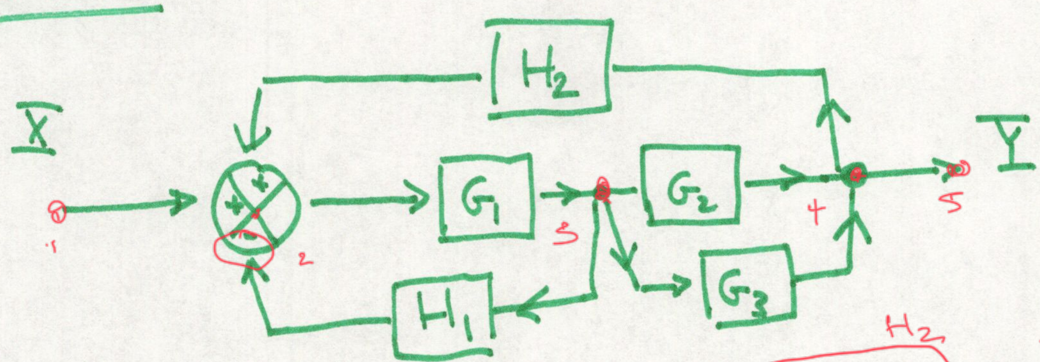
Mason's Gain Formula

$$\Delta = 1 - L_1$$

$$\Delta_1 = 1$$

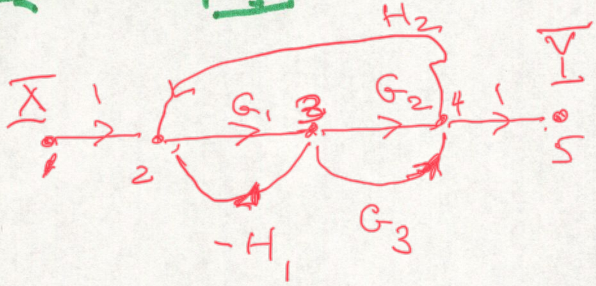
$$\frac{Y}{X} = \frac{P_1 \Delta_1}{\Delta} = \frac{G}{1+GH}$$

Problem

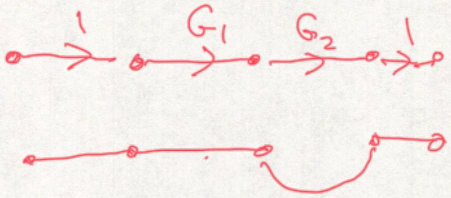


A. SFG

B. Find Y/X



Forward

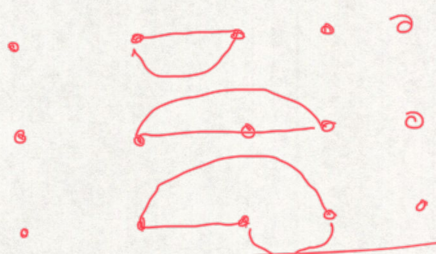


$P_1 = G_1 G_2$

$P_2 = G_1 G_3$ $\cancel{L_1}$ $\cancel{L_2}$ $\cancel{L_3}$

$\boxed{\Delta_2 = 1}$

Loops



$L_1 = G(-H_1)$

$L_2 = G_1 G_2 H_2$

$L_3 = G_1 G_3 H_2$

$$\boxed{\Delta = 1 - (L_1 + L_2 + L_3) + (0)}$$

the

$\boxed{\Delta_1 = 1}$

$L_1 L_2$ X

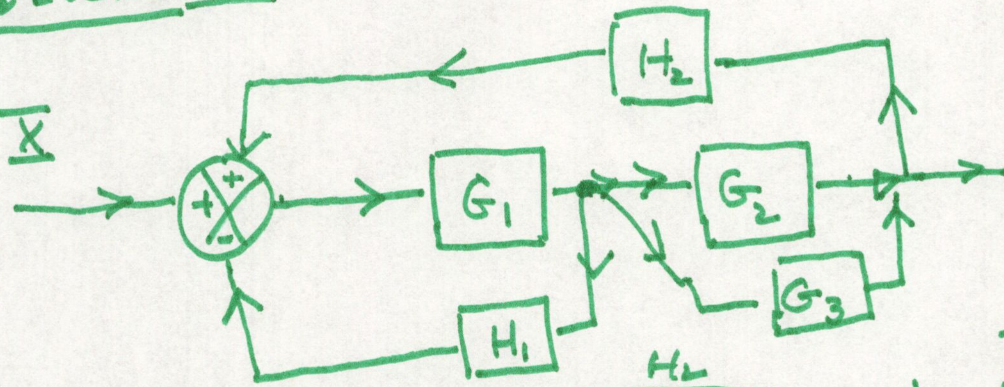
$L_1 L_3$ X

$L_2 L_3$ X

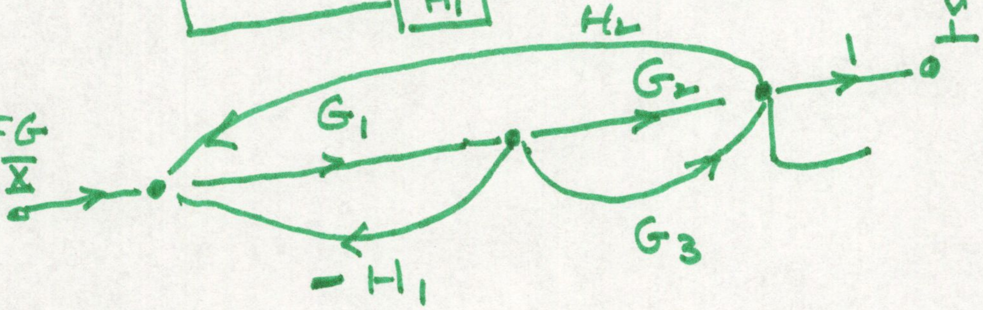
$L_1 L_2 L_3$ X

$$\frac{Y}{X} = \frac{P_1 \Delta_1 + P_2 \Delta_2}{\Delta}$$

Problem soln

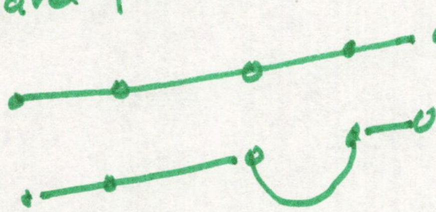


A. SFG



B. Find $\bar{Y}/\bar{X}$

Forward path gain

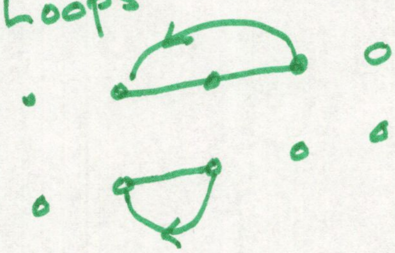


$P_1 = G_1 G_2$

$P_2 = G_1 G_3$

1 Path/Loop missing

Loops



$L_1 = H_2 G_1 G_2$

$L_2 = -H_1 G_1$

0

$L_1 L_2$?

touch yes

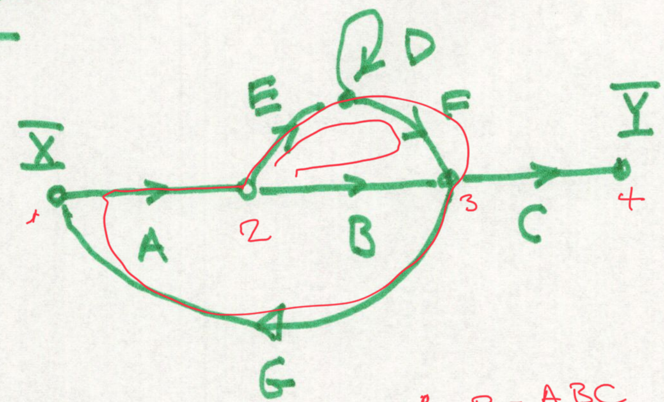
$$\Delta = 1 - (L_1 + L_2) + (\cancel{L_1 L_2})$$

$\Delta_1 = 1$

$\Delta_2 = 1$

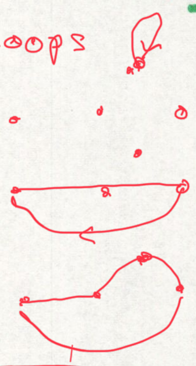
$$\frac{\bar{Y}}{\bar{X}} = \frac{P_1 \Delta_1 + P_2 \Delta_2}{\Delta}$$

Problem



Find Y/X

Loops



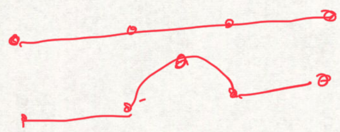
$L_1 = D$

$L_2 = ABG$

$L_3 = AEFG$

$\Delta_2 = 1$

$\cancel{L_1}$ $\cancel{L_2}$ $\cancel{L_3}$



$P_1 = ABC$

$P_2 = AEFC$

$L_1 L_2$ ✓

$L_1 L_3$ X

$L_2 L_3$ X

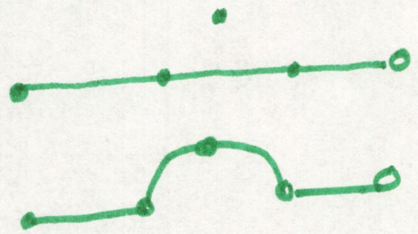
$\Delta = 1 - (L_1 + L_2 + L_3) + L_1 L_2$

$\Delta_1 = 1 - (L_1)$

$$\frac{Y}{X} = \frac{P_1\Delta_1 + P\Delta_2}{\Delta}$$

Problem soln

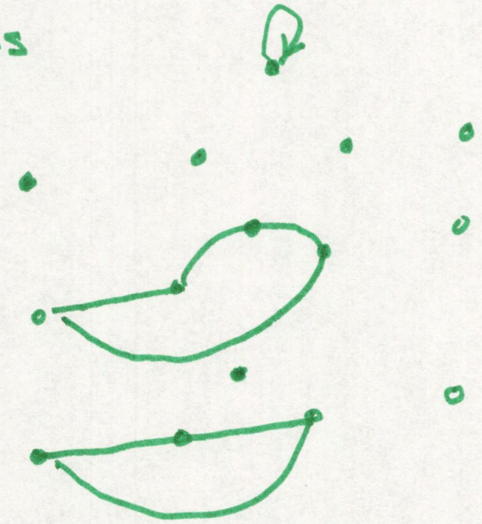
Forward Path



$P_1 = ABC$

$P_2 = AEFC$

Loops



$L_1 = D$

$L_2 = AEFG$

$L_3 = ABG$

$$\Delta = 1 - (L_1 + L_2 + L_3) + [L_1L_3] - [0]$$

$L_1 L_2$ ×
$L_1 L_3$ ✓ } two @ a time
$L_2 L_3$ ×

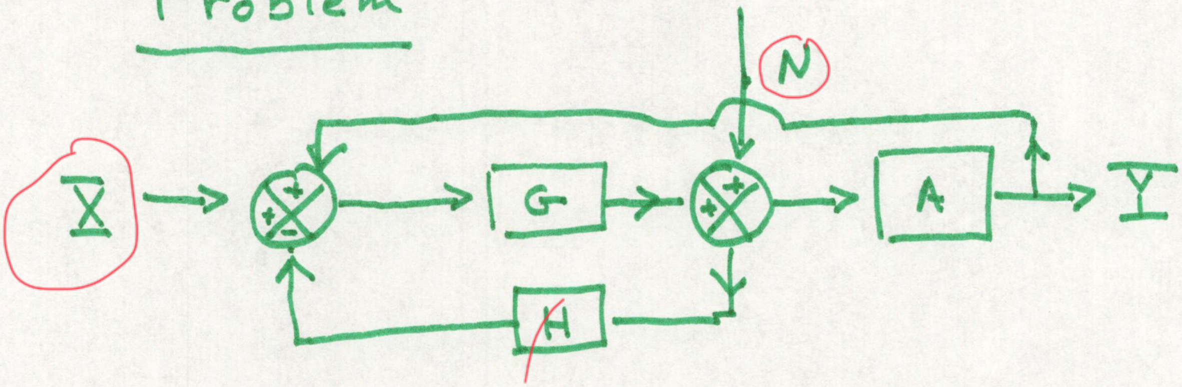
$L_1 L_2 L_3$ × } three @ a time

$\Delta_1 = 1 - L_1$

$\Delta_2 = 1$

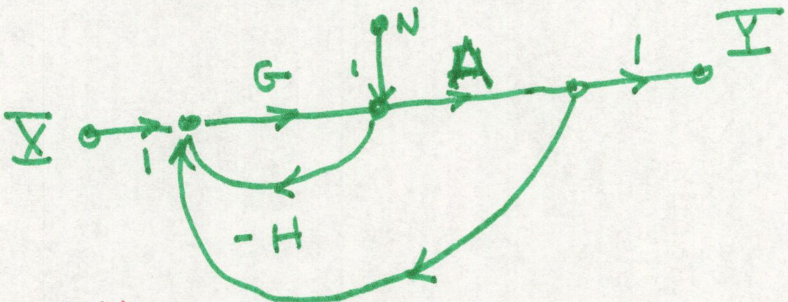
$$Y = \frac{P_1 \Delta_1 + P_2 \Delta_2}{\Delta}$$

Problem

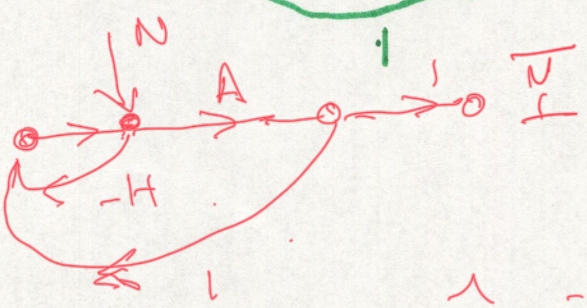


Find Y

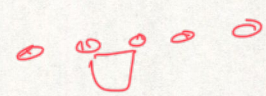
$$Y = \left(\frac{Y}{X}\right)\Bigg|_{N=0} X + \left[\frac{Y}{N}\right]\Bigg|_{X=0} N$$



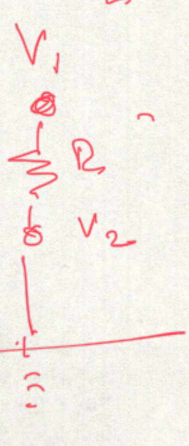
$$\frac{Y}{X}\Bigg|_{N=0} = \frac{P_1}{1-(L_1+L_2)}$$



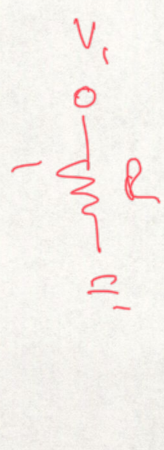
$L_1 = -HG$

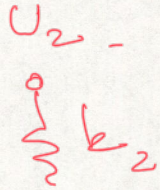


$\hat{P}_1 = A$

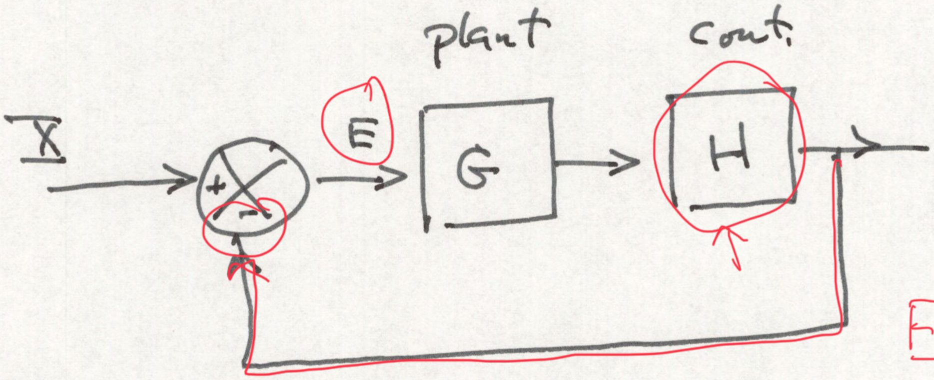


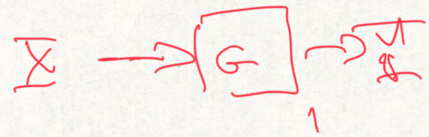
$=$





Steady state error





obj

$X - Y = 0$

$E = X - Y$

$$\boxed{\frac{Y}{X} = \frac{GH}{1+GH}}$$

$$\boxed{E = X - Y}$$

$$\frac{E}{X} = 1 - \frac{Y}{X} = \frac{1}{1+G}$$

$E = X - Y$

$$\frac{E}{X} = 1 - \frac{Y}{X}$$

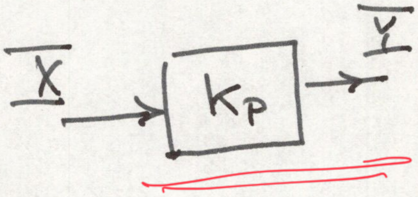
$$\frac{E}{X} = 1 - \frac{GH}{1+GH}$$

$$\frac{E}{X} = \frac{1+GH-GH}{1+GH}$$

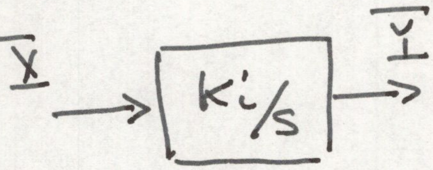
$$\boxed{\frac{E}{X} = \frac{1}{1+GH}}$$

$$\Rightarrow \boxed{E(s) = \frac{1}{1+GH} X}$$

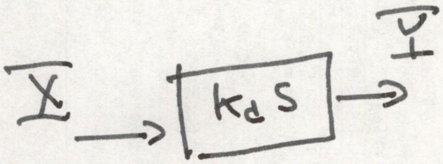
Control Action



$$\boxed{\bar{Y} = k_p \bar{X}}$$ prop-cont



$$\boxed{\bar{Y} = \frac{k_i}{s} \bar{X}}$$ integral cont



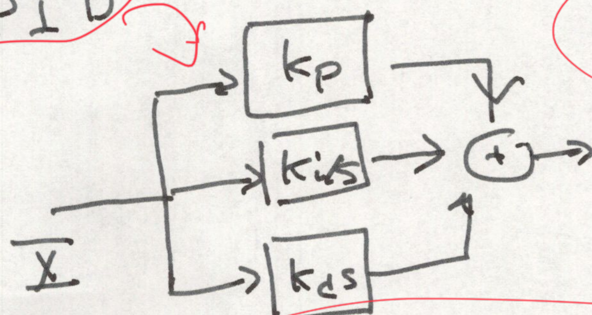
$$\boxed{\bar{Y} = k_d s \bar{X}}$$ deriv-cont

$$y = k_i \int x\,dt$$

$$y = k_d \frac{dx}{dt}$$

PID

PI



$$\bar{Y} = \left[k_p + \frac{k_i}{s} + k_d s\right] \bar{X}$$

adjust k_p, k_i, k_d

Final value thm

$$\lim_{s \to 0} sE(s) = \lim_{t \to \infty} e(t)$$

where $E(s) \xleftrightarrow{\mathcal{L}} e(t)$