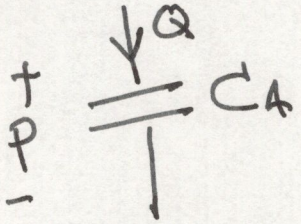
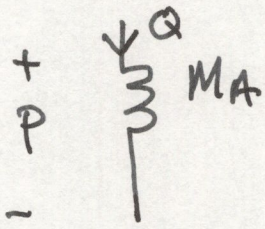
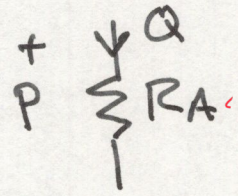
Acoustic Elements

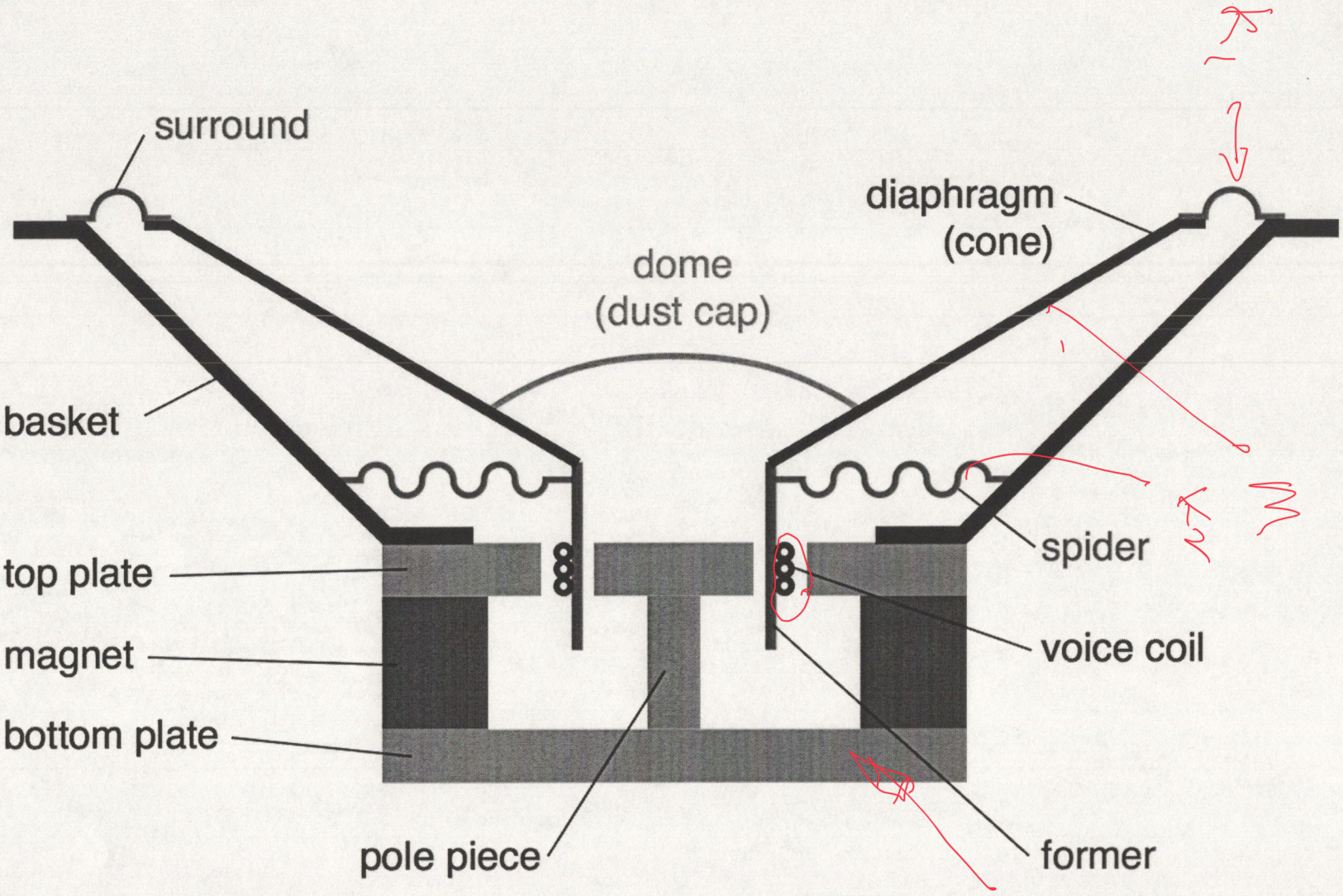


$$C_A = \frac{V}{\rho_0 c^2}$$

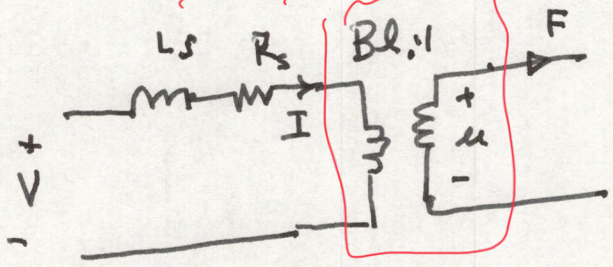


$$M_A = \frac{\rho_0 \ell}{A}$$




surround
diaphragm
(cone)
dome
(dust cap)
basket
spider
top plate
magnet
voice coil
bottom plate
pole piece
former

$I \, Bl = F$

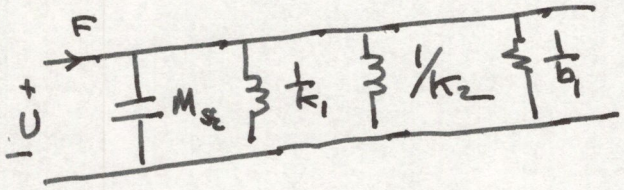


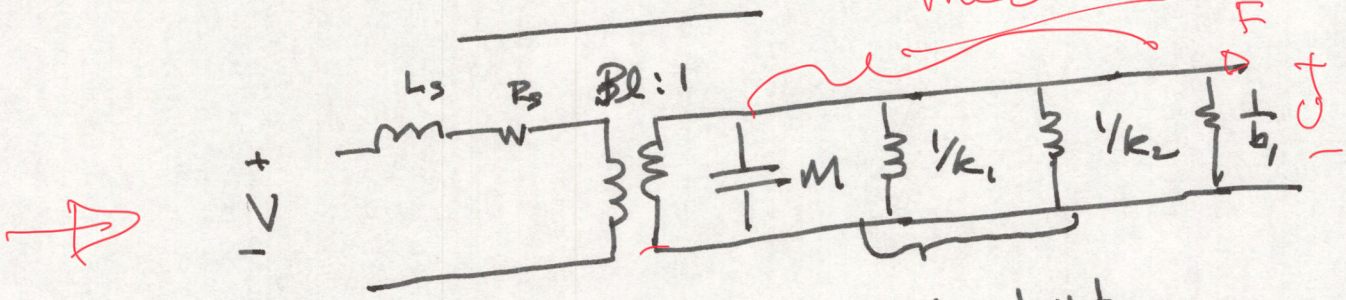
electrical

$$F = Bl \, I$$

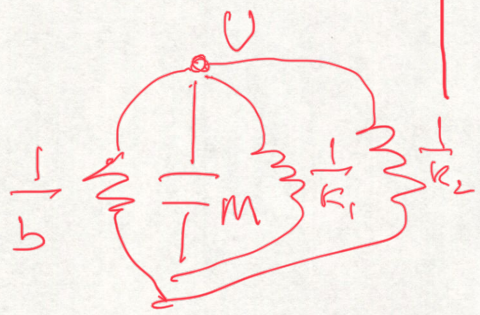
$$U = \frac{1}{Bl} V$$

Consider the mechanic elements



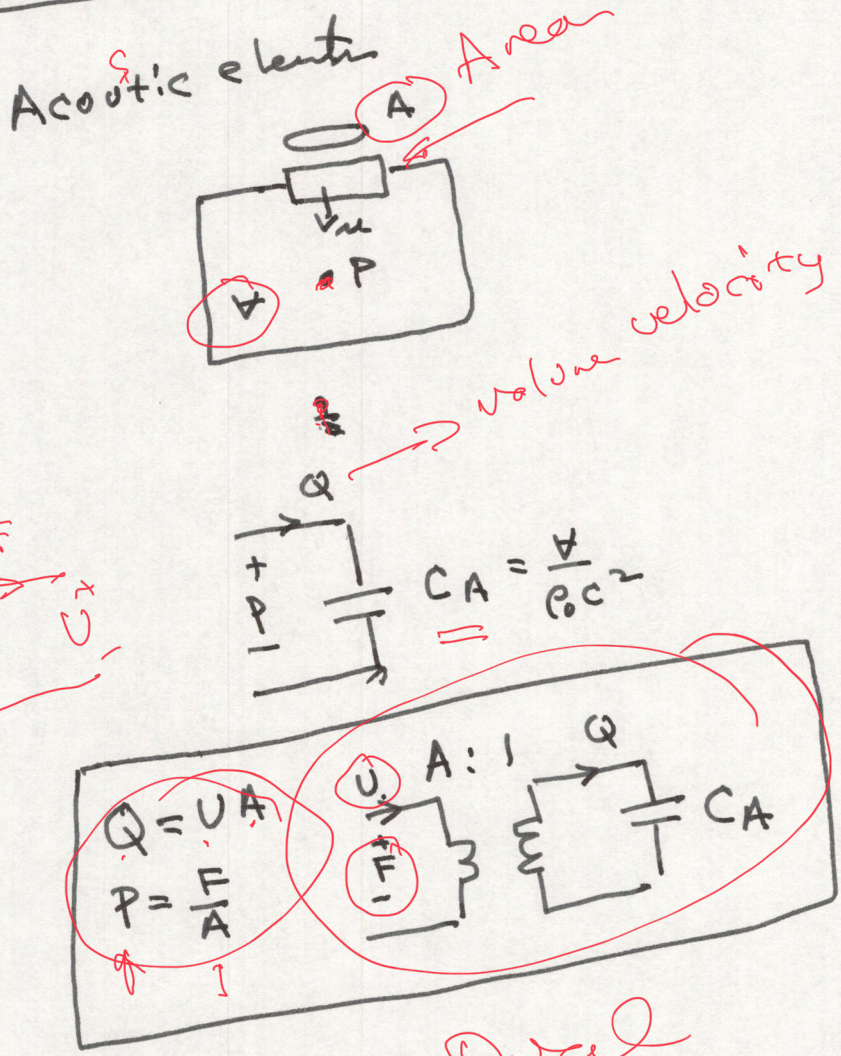


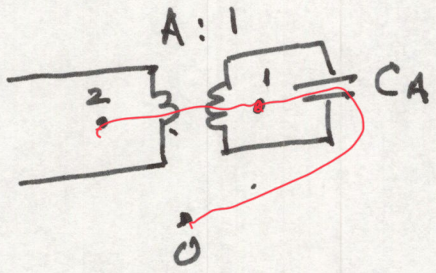
$$\frac{1}{k} = \frac{1}{k_1} \| \frac{1}{k_2}$$

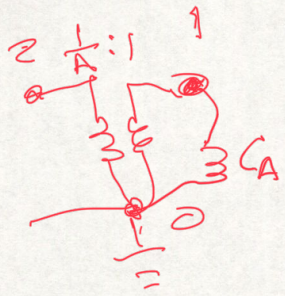


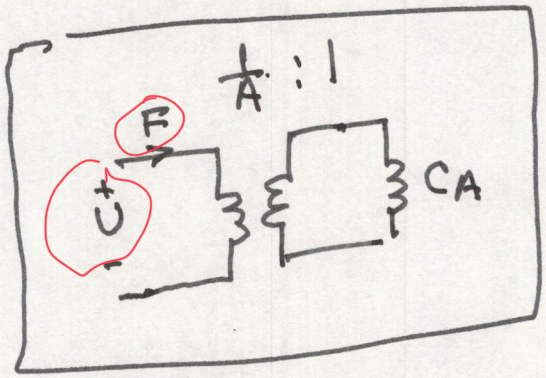
Speaker in a cab

Acoustic elements

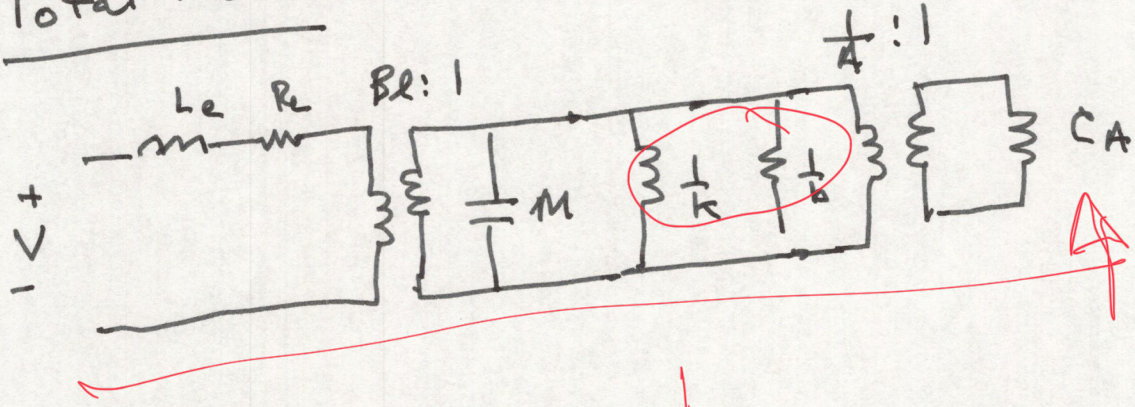


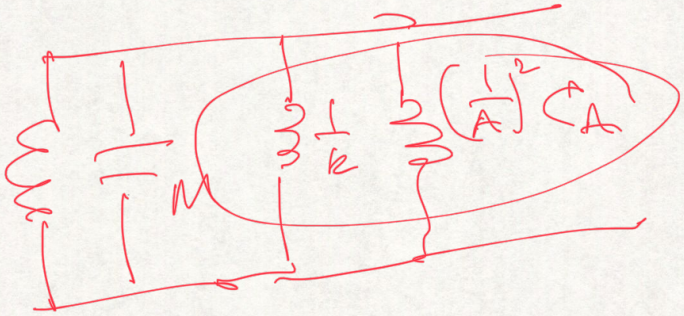

A:1
2
1
C_A
0


2
$\frac{1}{A}$:1
1
C_A
0


$\frac{1}{A}$:1
F
+
U
-
C_A

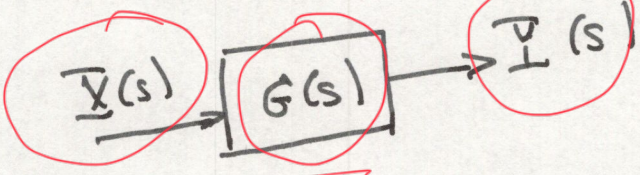
Total model


Le
Re
Bl:1
$\frac{1}{A}$:1
+
V
-
M
$\frac{1}{k}$
b
C_A


M
$\frac{1}{k}$
$\left(\frac{1}{A}\right)^2 C_A$

Representation of System

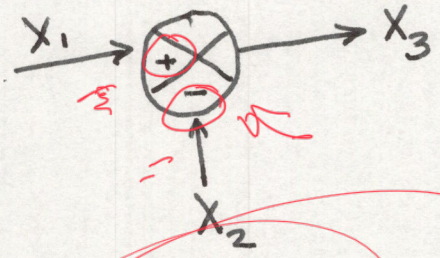
Block Diagram

1. 

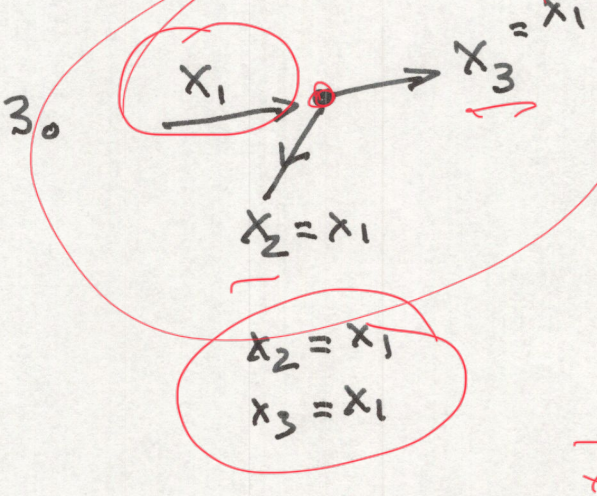
Basic system unit

$$Y = GX$$

summing junction

2. 

$$X_3 = X_1 - X_2$$

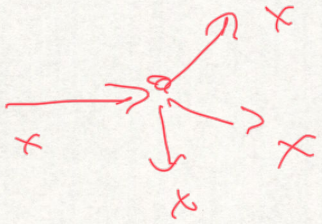
3. 

one input multiple equal outputs

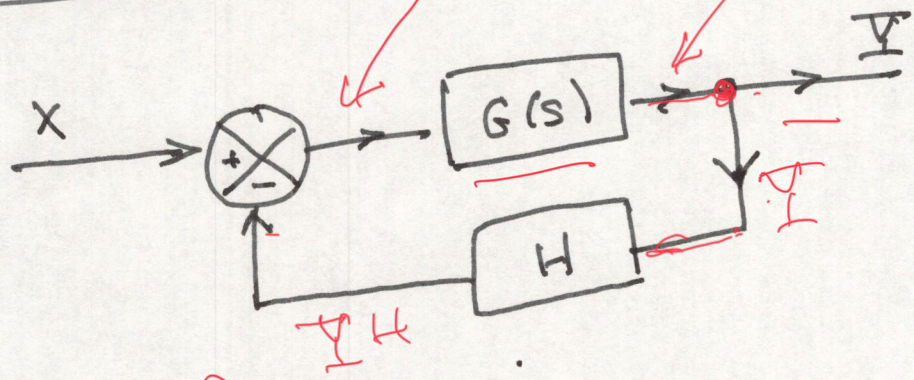
$X_2 = X_1$

$X_3 = X_1$

Fan out

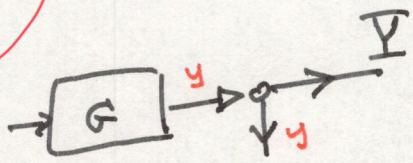


Consider

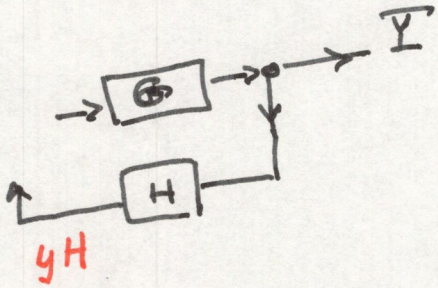


Find $\frac{Y}{X}$

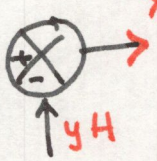
1°



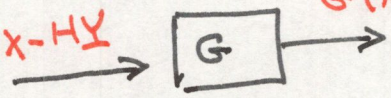
2°



3° X



4°



5° $G[X-HY] = Y \Rightarrow GX = Y[1+GH]$

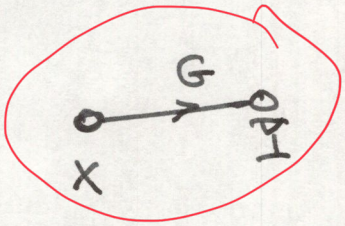
$$\frac{Y}{X} = \frac{G}{1+GH}$$

Signal Flow Graph

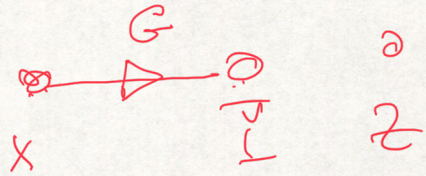
nodes

edge

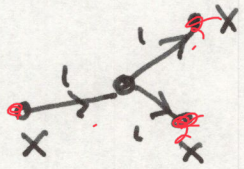
1°



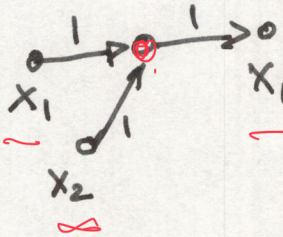
$XG = Y$



2°



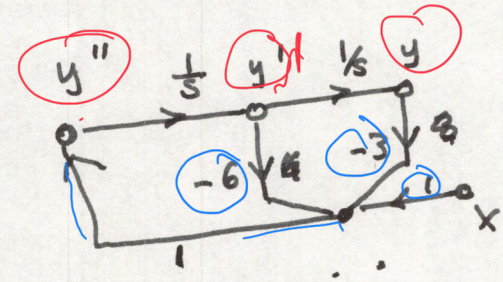
3°



$X_1 + X_2$

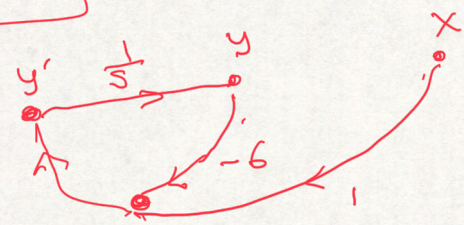
Consider

$$y'' + 6y' + 3y = x \quad \Rightarrow \quad y'' = -6y' - 3y + x(1)$$



$$y' + 6y = x$$

$$y' = x - 6y$$

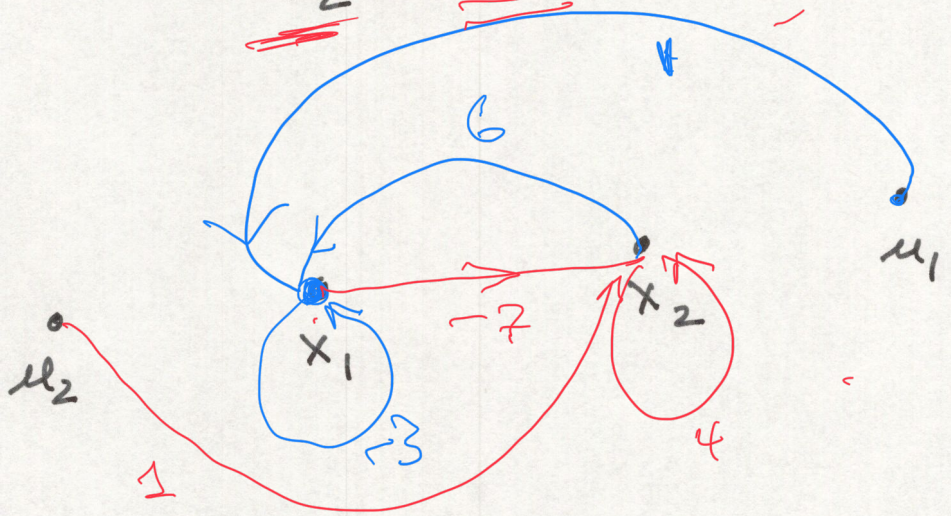


$\frac{1}{s}$ ⇒ integrate

$$\frac{1}{s} \quad \frac{1}{s+a} \quad \frac{1}{s^2}$$

$$\dot{x}_1 = 6x_2 - 3x_1 + u_1$$

$$\dot{x}_2 = -7x_1 + 4x_2 + u_2$$



Mason's Gain Formula

$$\frac{Y}{X} = \frac{\sum_i \Delta_i P_i}{\Delta}$$

1° P_i forward path gains from X to Y

2° Δ graph determinant

$$\Delta = 1 - \sum_i L_i + \sum_i L_i L_j - \sum_i L_i L_j L_k + \cdots$$

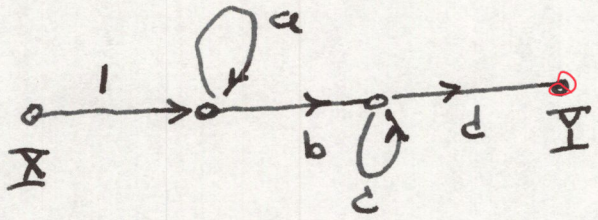
non touching loop

3° Δ_i cofactor after removal of P_i touching loop

$$\Delta_i = 1 - \sum_j L_j + \sum_k L_j L_k - \sum_l L_j L_k L_m$$

Loop

example

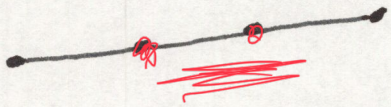


$\Delta = 1 - [L_1 + L_2]$

$+ [L_1 L_2]$

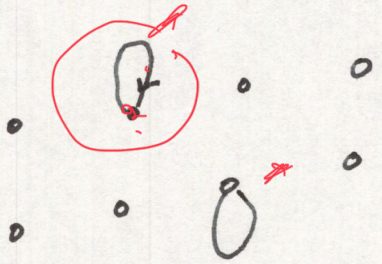
Find $\frac{Y}{X}$

FP



$P_1 = 1 \cdot b \cdot d$

Loops:



$L_1 = a$

$L_2 = c$

touch RT

" "

$\Delta_1 =$

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

$\Delta_1 = 1$ ✓

$$\frac{Y}{X} = \frac{P_k \Delta_k}{\Delta}$$