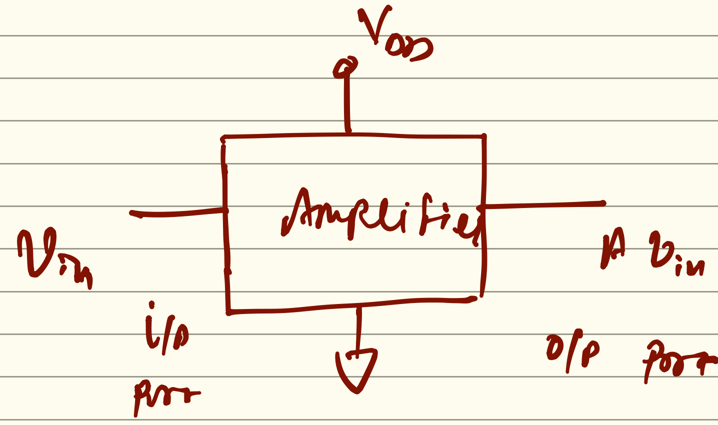
DATE: 19 jan

Analog Elex

⇒

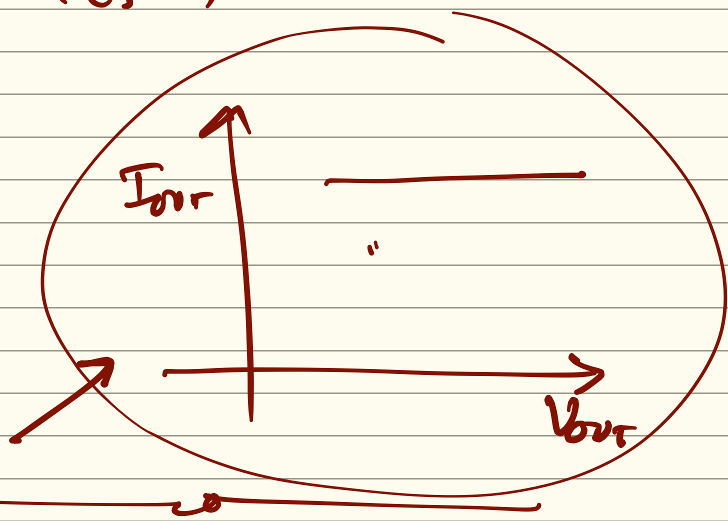


$A\,v_{in} = V_{out}$

⇒ Non linear Active devices → Transistors.

BJT - Active

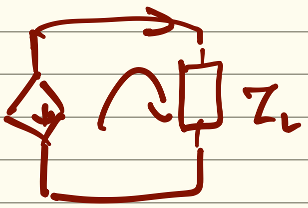
MOS - Sat^n.



⇒ i/p → Amp (i/p)

→ Biasing → operating points.

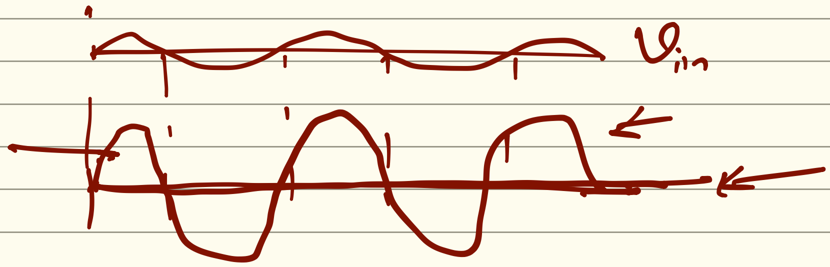
→



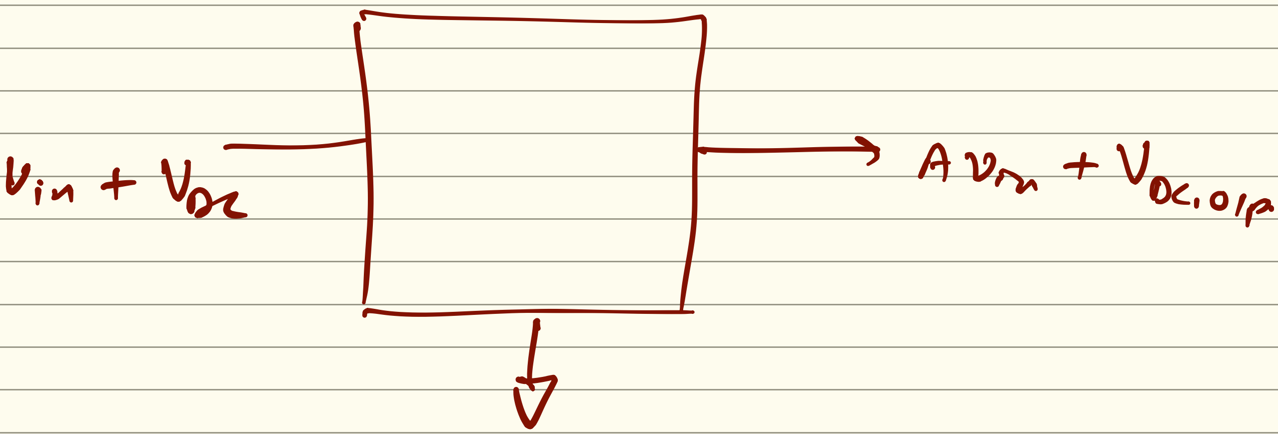
A f(i/p)

Amplification → transistor

⇒

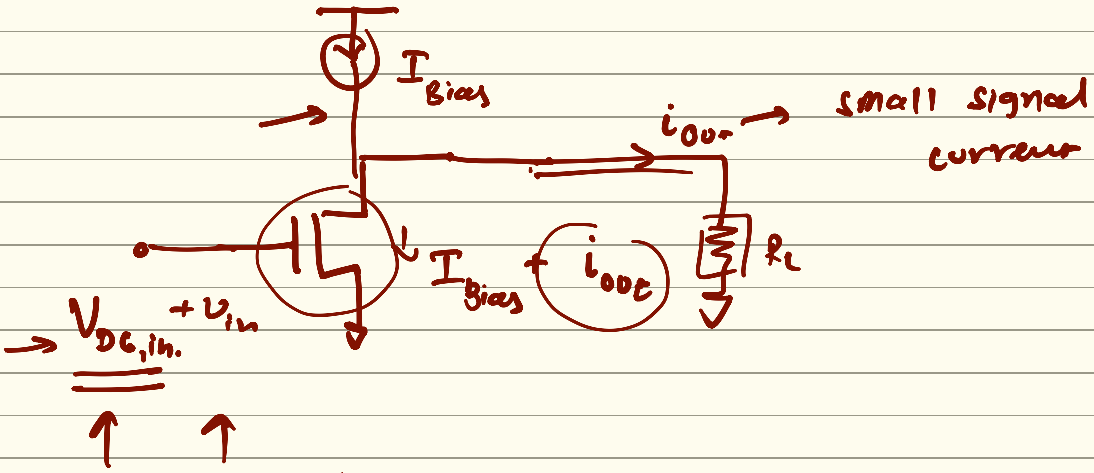


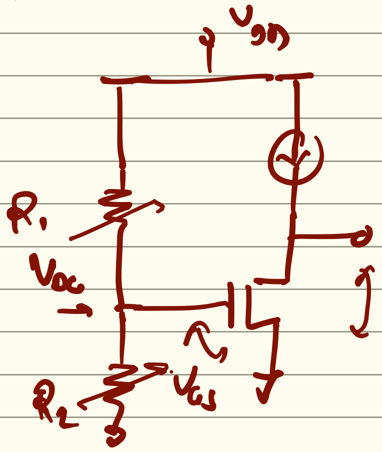
$V_{DC,out}$, X, Y, Z



→ Operating Pt. must be fixed & independent to the i/p (small signal)

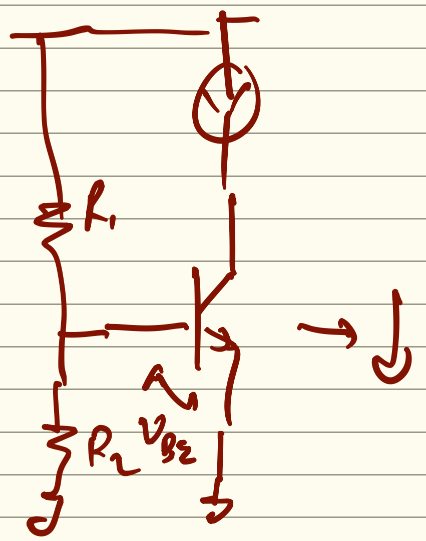
→ Amplification factor must be indep. of D.C. values



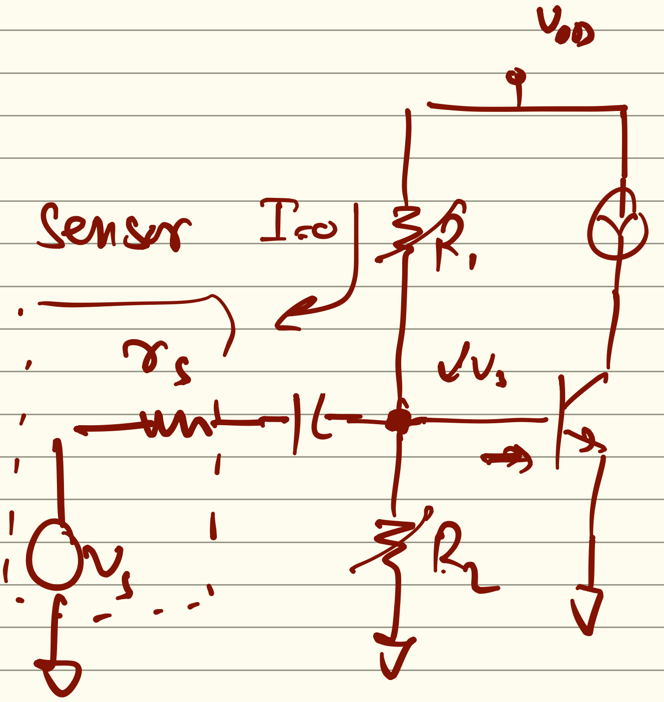


$$\boxed{I_{DC.out} = \mu C_{ox} \frac{W}{L} (V_{GS} - V_{th})^2}$$

$$V_{DC,in} = \frac{V_{DD} \cdot R_2}{R_1 + R_2}$$



$$I_{out_{DC}} = I_0\left(e^{v_{BE}/nv_T} - 1\right)$$

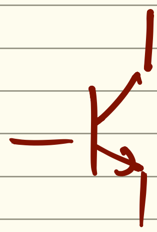


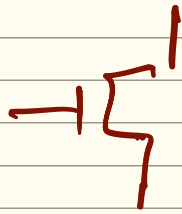
$V_{DD} =$

if you want v_s to appear at i/p

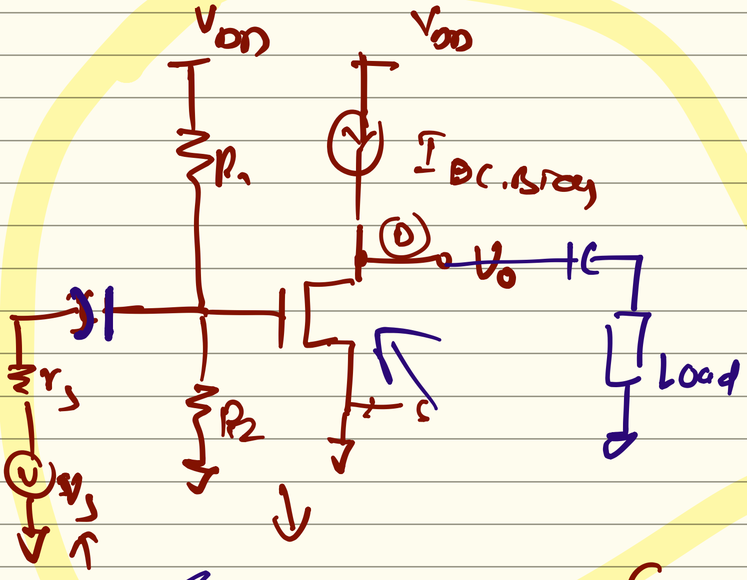
$$\Rightarrow \boxed{v_{i/p} = V_s \cdot \frac{R_2 \| R_1}{R_2 \| R_1 + r_s}}$$

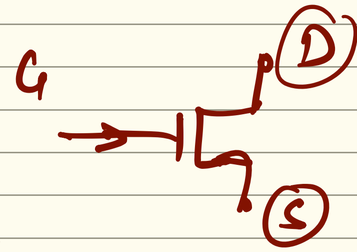
$\Rightarrow$

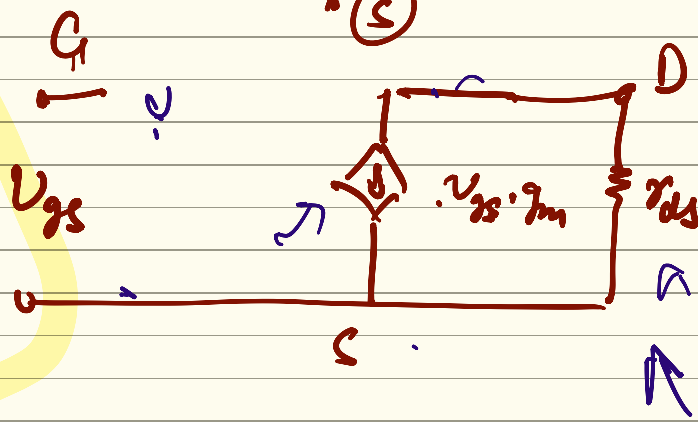


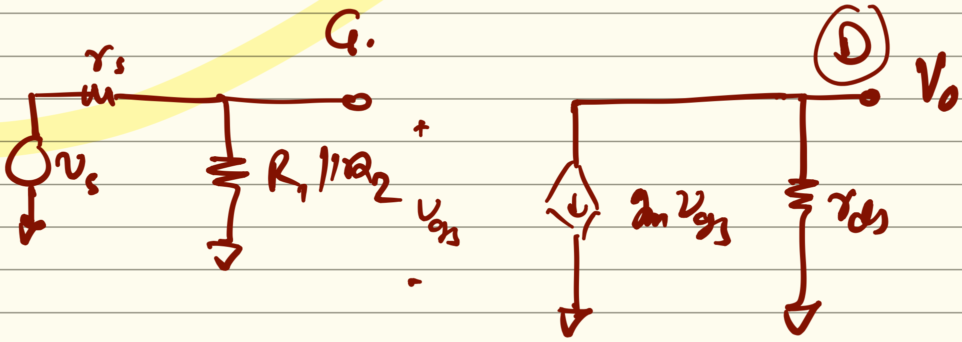


for amplification →

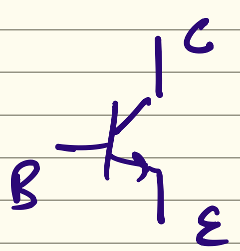


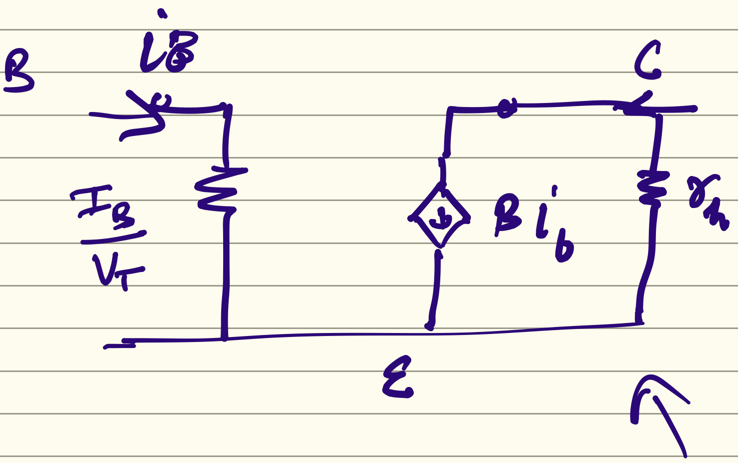






$\frac{V_o}{V_s}$ = small signal vol gain





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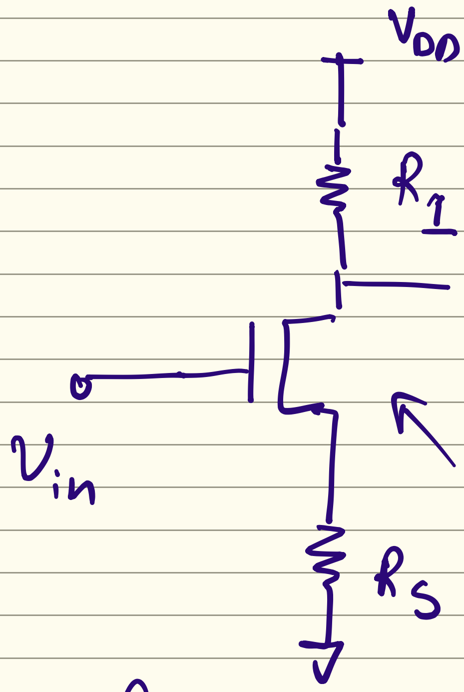
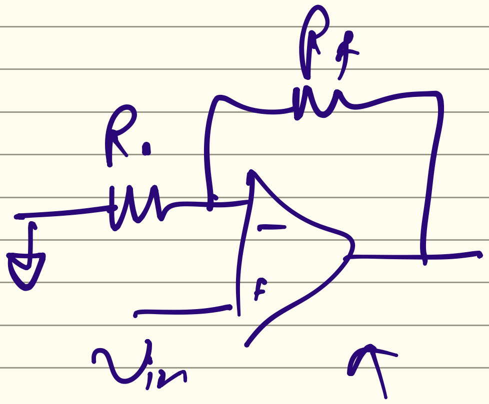
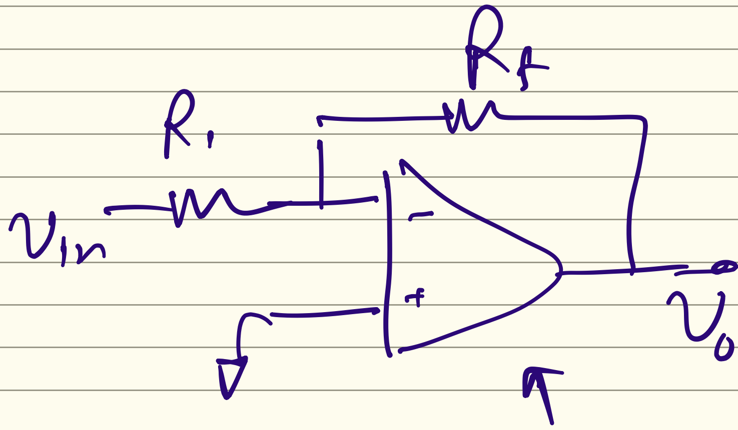


gain ?



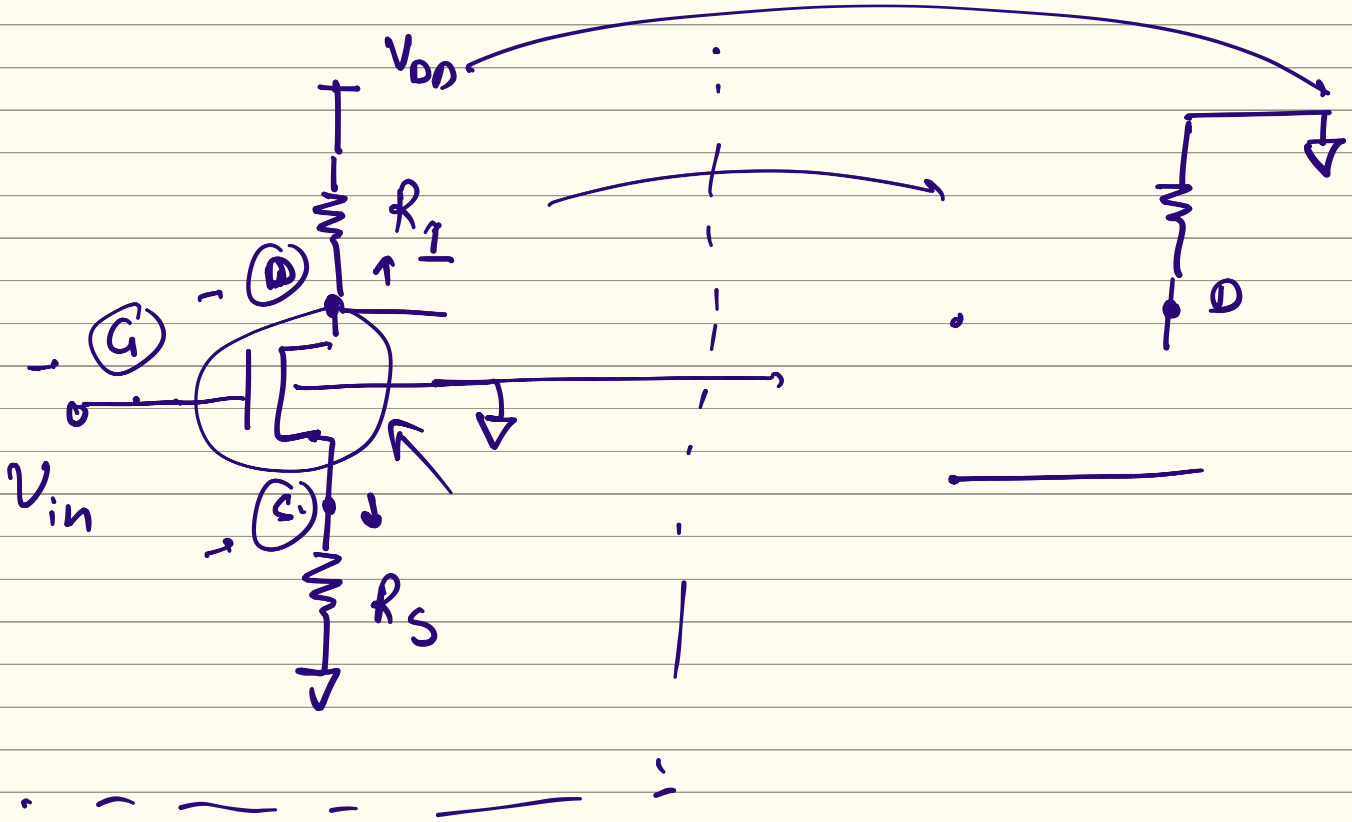


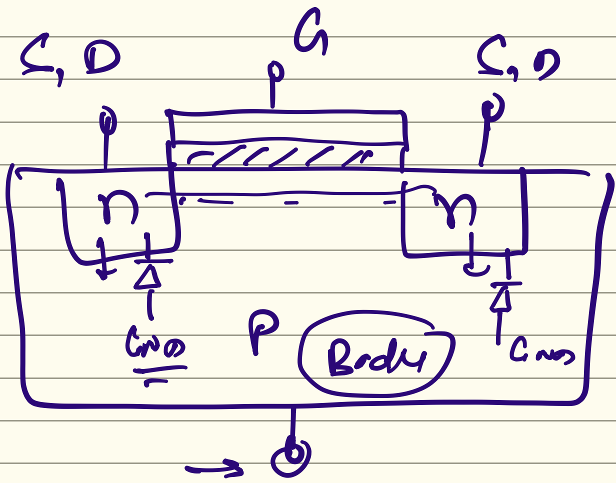
$$\frac{V_o}{V_{in}} = 1 + \frac{R_f}{R_1}$$

non inverting conf.

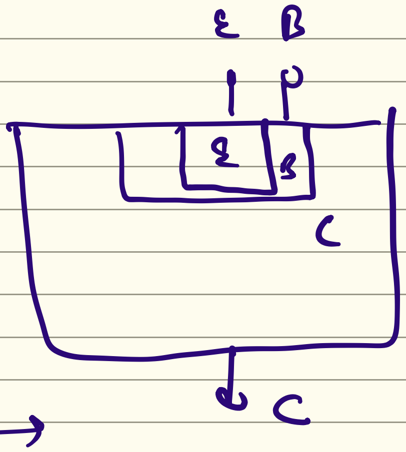
$$\frac{V_o}{V_{in}} = -\frac{R_f}{R_1}$$

inverting configuration





Small signal modeling



n-Mosfet

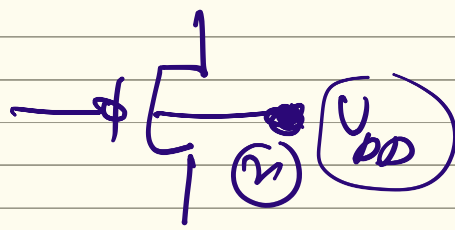
→ V_H = Drain

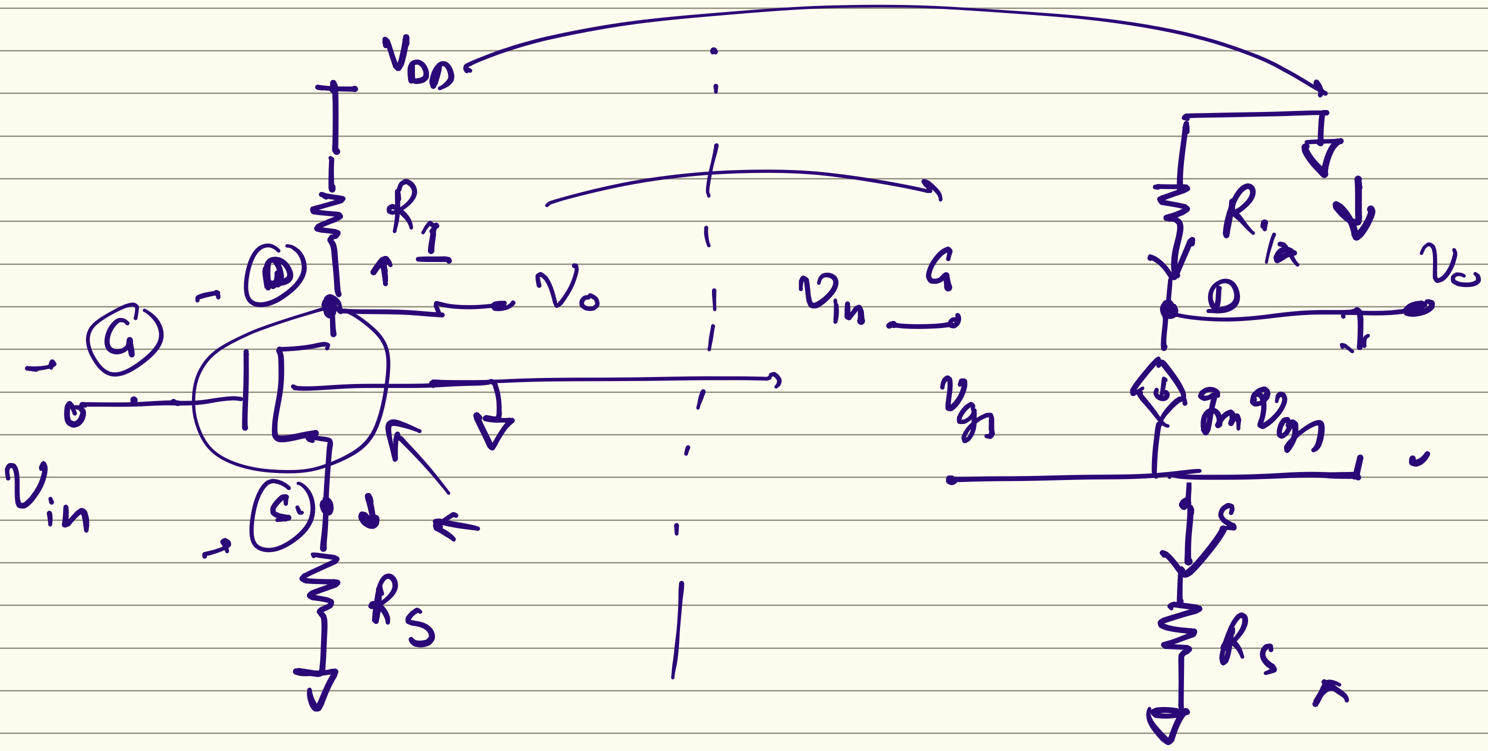
V_L = Source

PMOS

V_H = Source

V_L = Drain





$$v_{gs} = v_{in} - v_s$$

$$-\frac{V_o}{R_1} = g_m\left(V_{in} - V_s\right)$$

$$-\frac{V_o}{R_1} = g_m\left(V_{in} + \frac{V_o R_s}{R_1}\right)$$

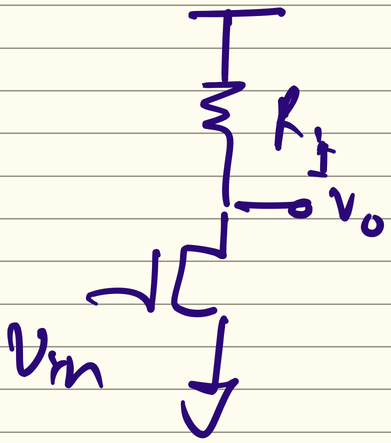
$$-\frac{V_o}{R_1} = \frac{V_s}{R_s}$$

$$-\frac{V_o}{\cancel{R_1}} = g_m\left(\frac{R_1 V_{in} + V_o R_s}{\cancel{R_1}}\right)$$

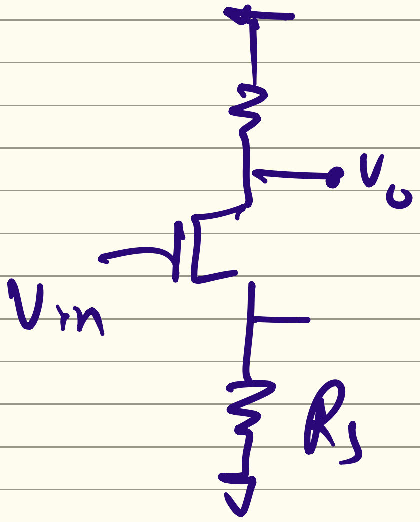
$$\boxed{-\frac{V_o \cdot R_s}{R_1} = V_s}$$

$$-V_o - g_m R_s V_o = g_m R_1 V_{in}$$

$$\boxed{\frac{V_o}{V_{in}} = \frac{-g_m R_1}{1 + g_m R_s}}$$

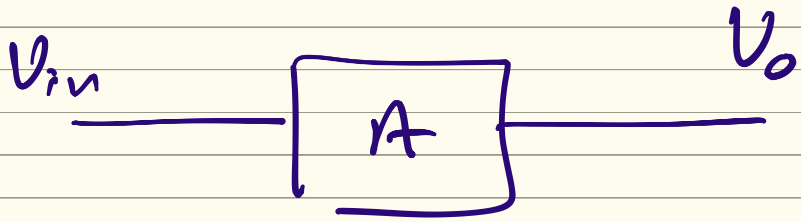


$$= \quad \frac{V_o}{V_{in}} = -g_m R_1$$

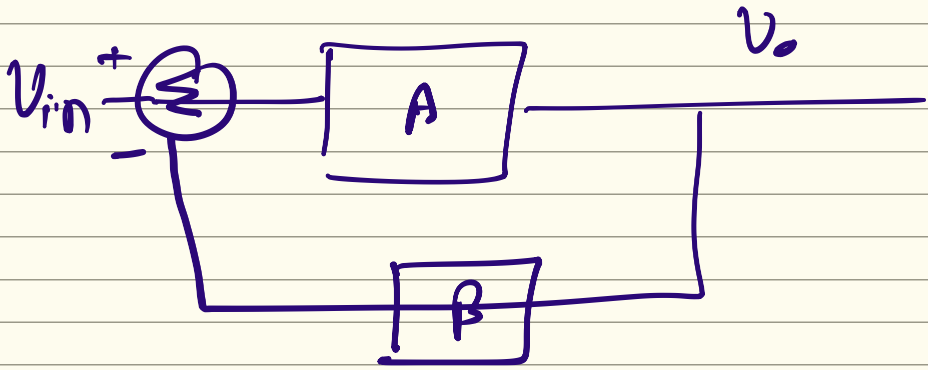


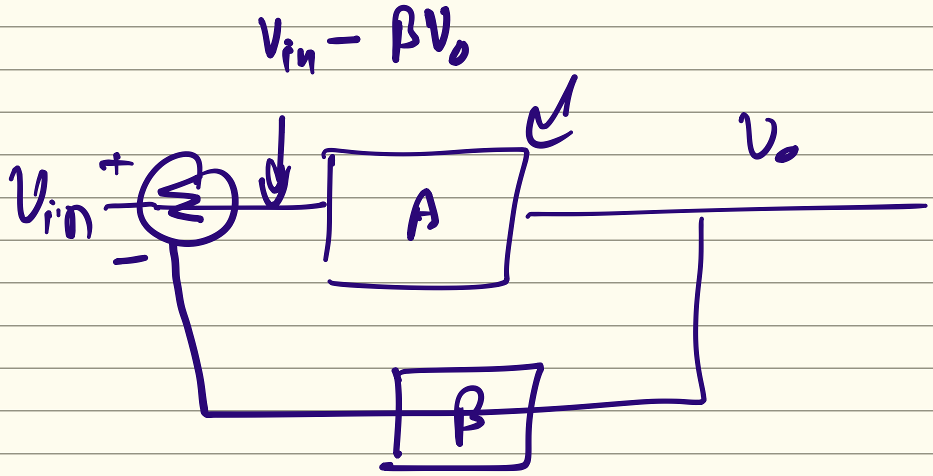
$$= \quad \frac{v_o}{v_{in}} = \frac{-g_m R_1}{1 + g_m R_s}$$

$$\simeq \quad -\frac{R_1}{R_s}$$



open loop condition





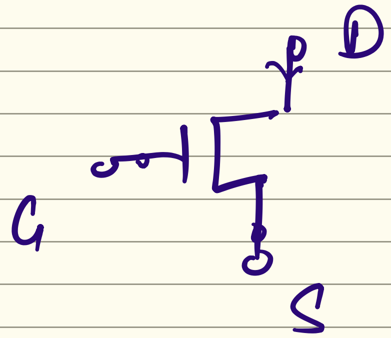
$$V_o = A\left(V_{in} - \beta V_o\right)$$

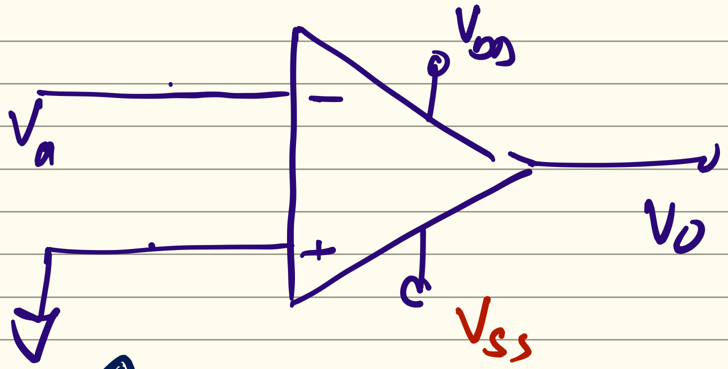
$$V_o\left(1 + A\beta\right) = A V_{in}$$

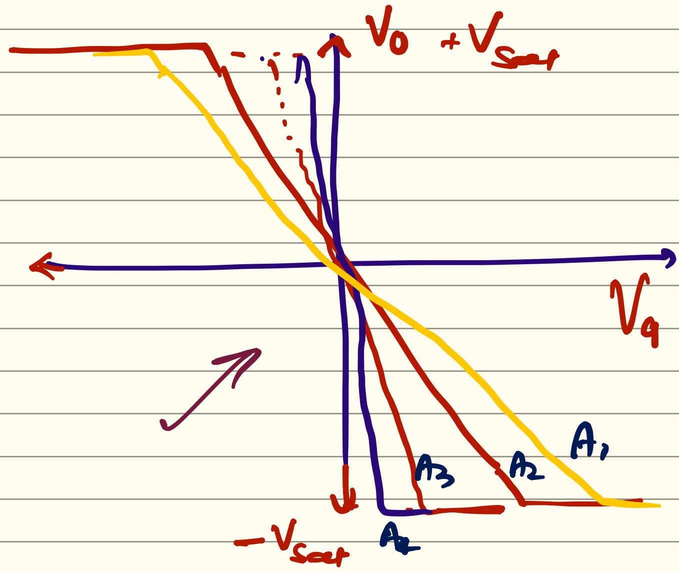
$$\boxed{\frac{V_o}{V_{in}} = \frac{A}{1 + A\beta}}$$

A = open loop gain

#

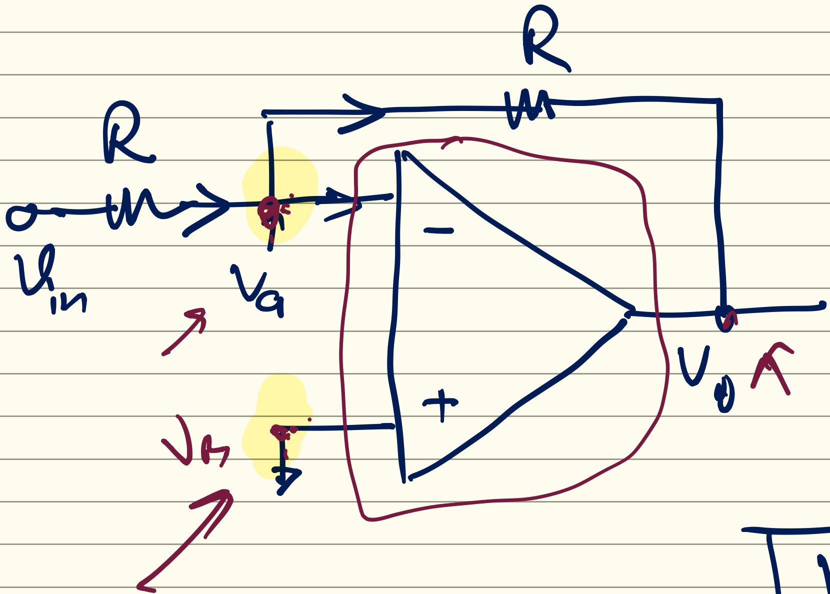






$$V_o = (0 - V_a)A$$

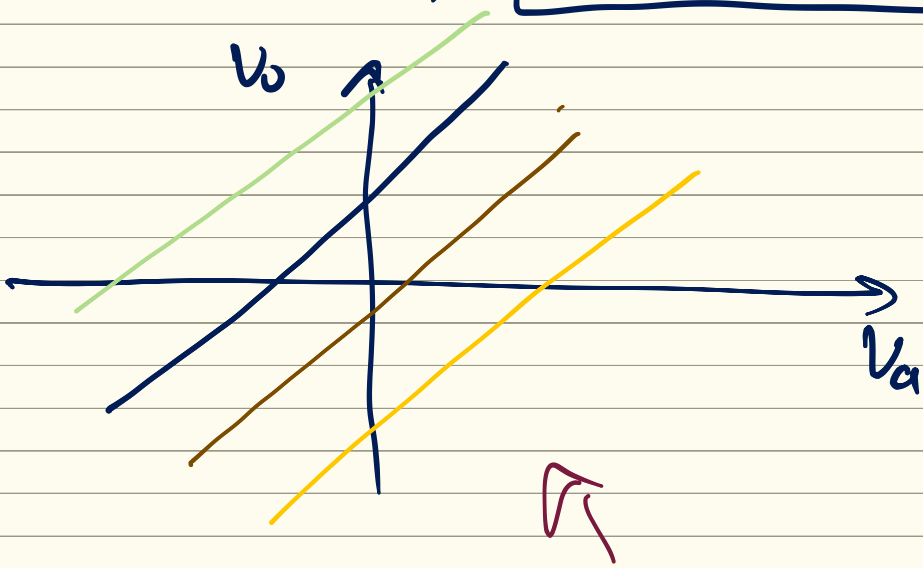
$$A_1 < A_2 < A_3 < A_4$$

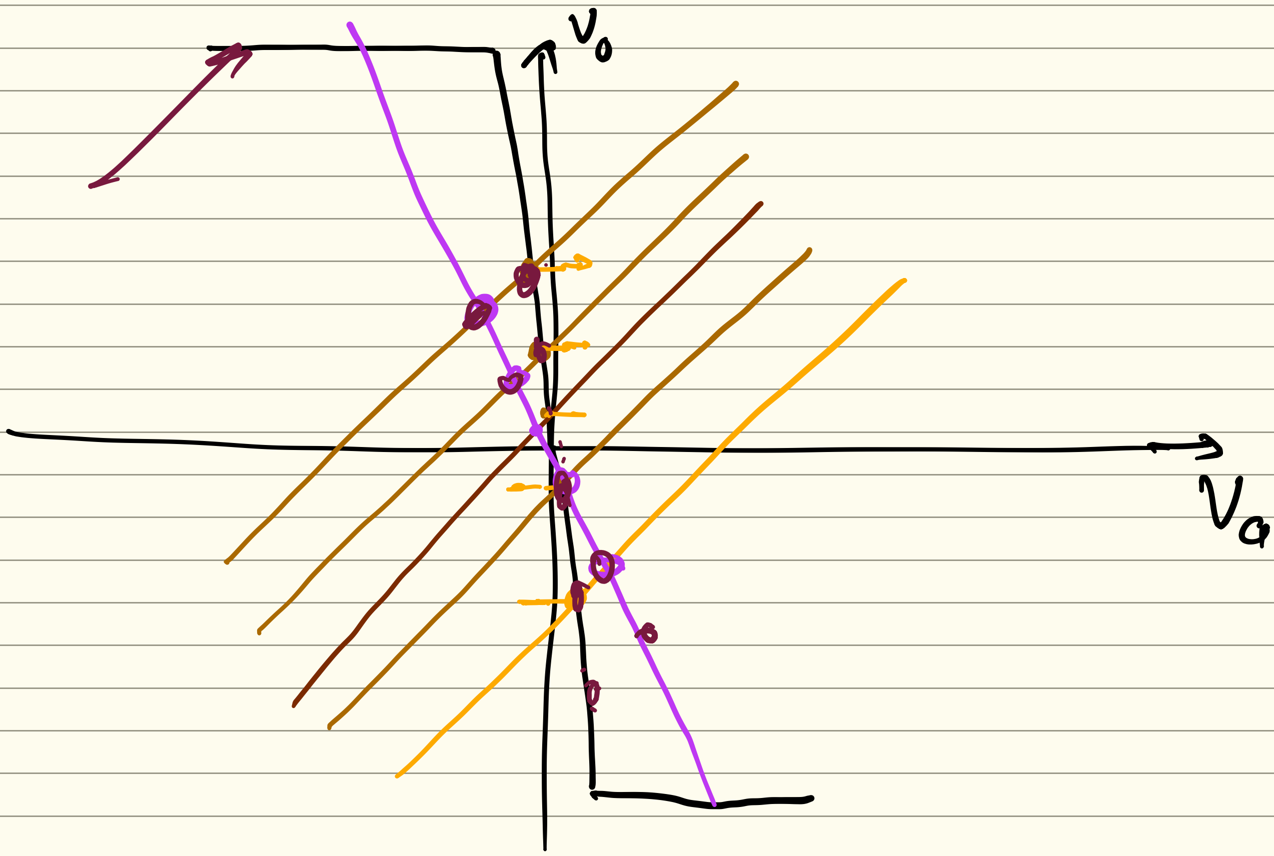


$$\frac{V_{in} - V_a}{\cancel{R}} = \frac{V_a - V_o}{\cancel{R}}$$

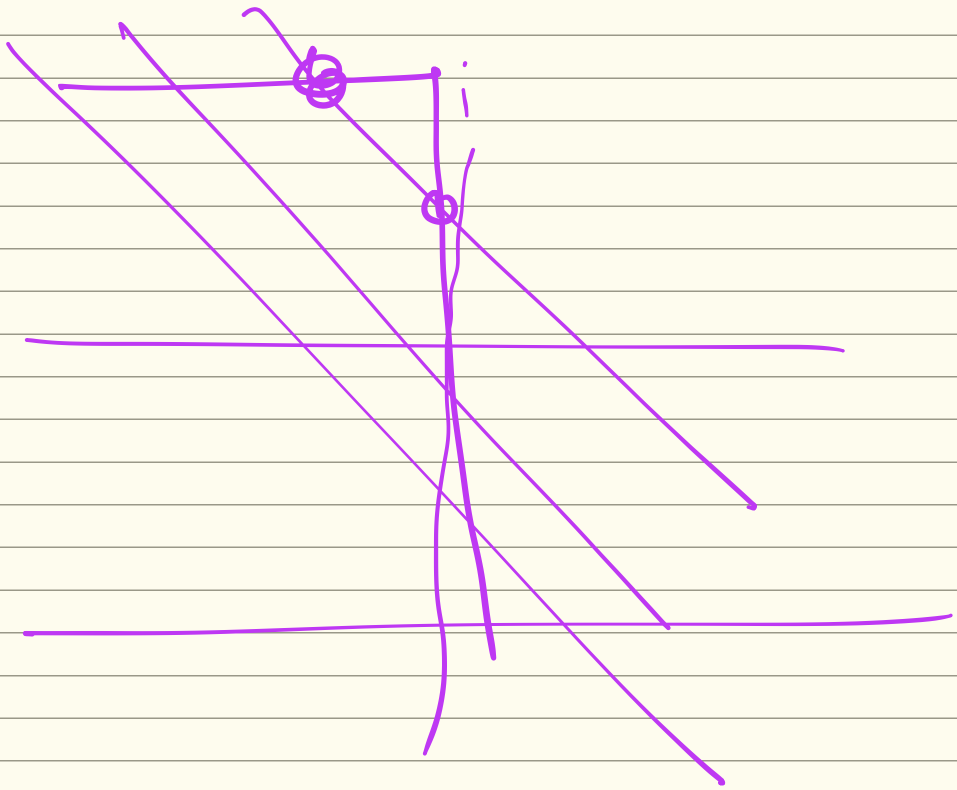
$$2V_a = V_o + V_{in}$$

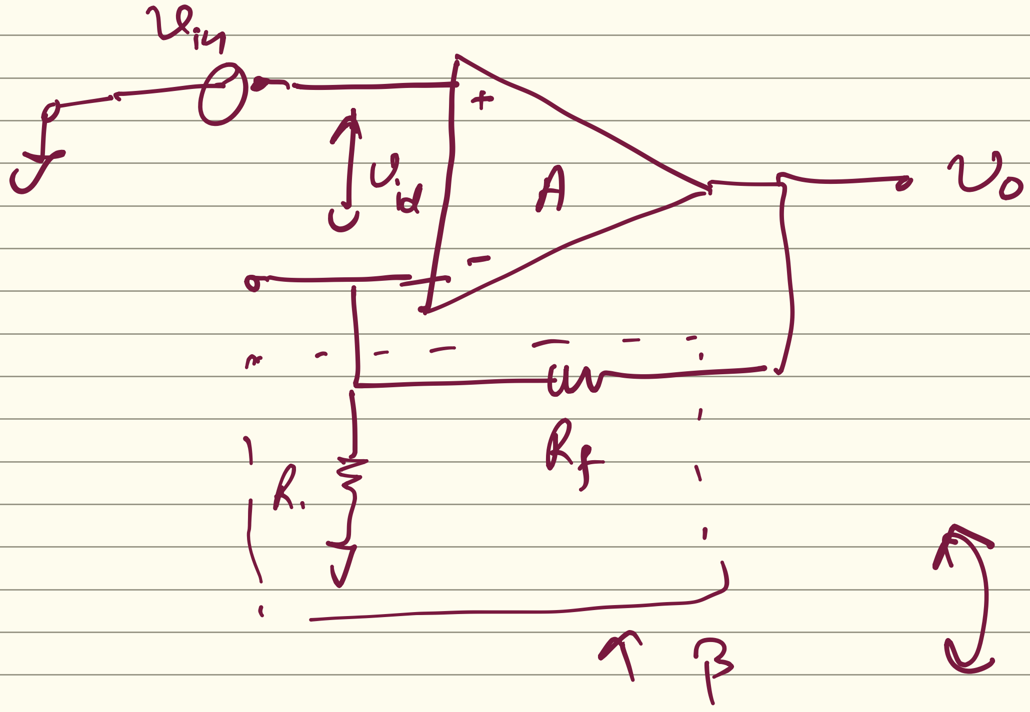
$$\boxed{V_o = 2V_a - V_{in}}$$

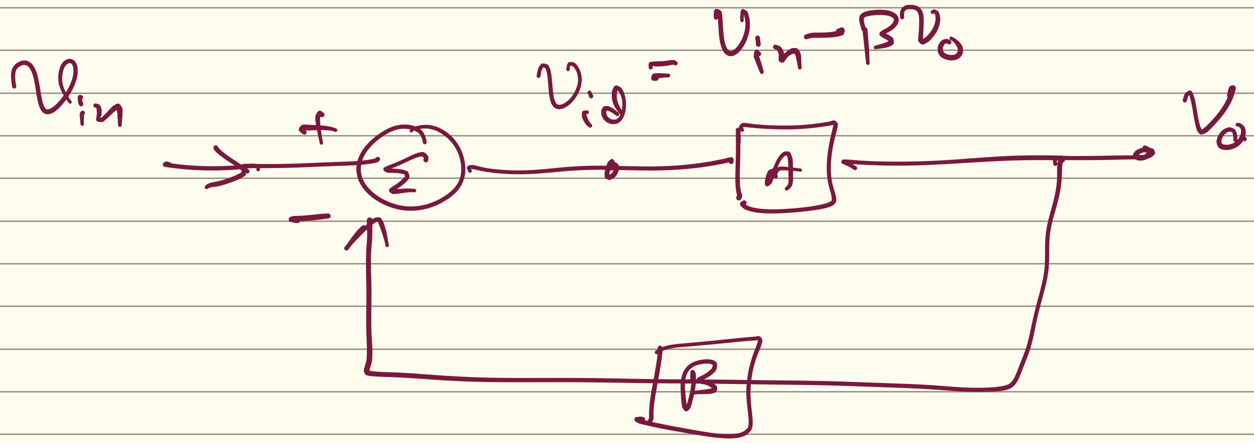




Vo
Va







$$\Rightarrow \quad V_o = \frac{v_{in} \; A}{1 + A\beta}$$

if we are assuming perfect system meaning $A = \infty \Rightarrow$ V. S. $\Rightarrow$

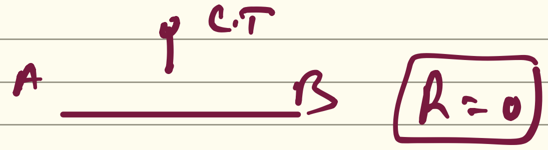
$$\Rightarrow \boxed{V_o = \left(1 + \frac{R_f}{R_1}\right) V_{in}}$$

OPAMP

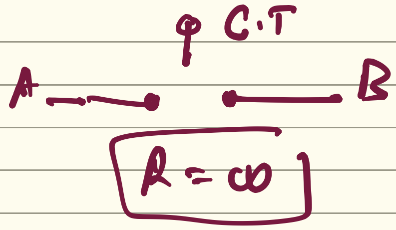
IDEAL		Practical
⇒ B.W =	∞	kHz , MHz , GHz ,

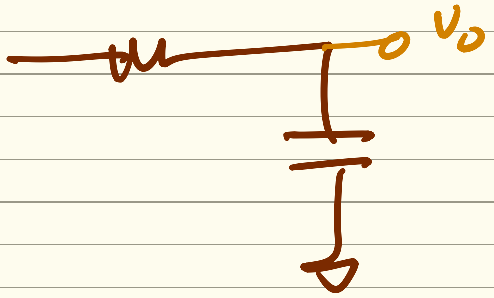
⇒

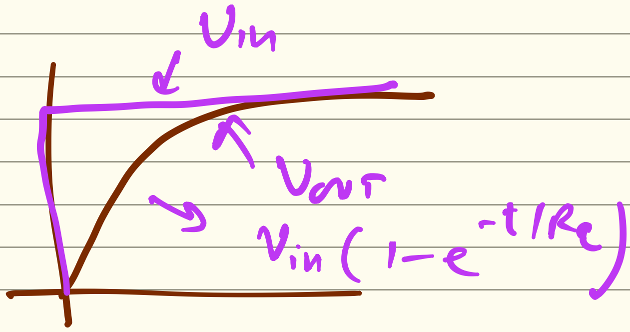
ON



off







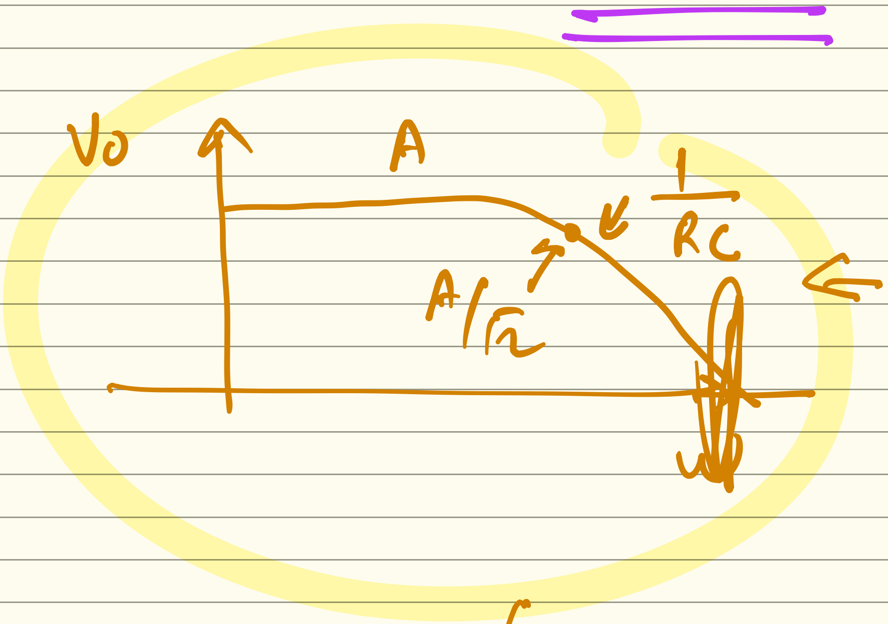
$RC = ?$

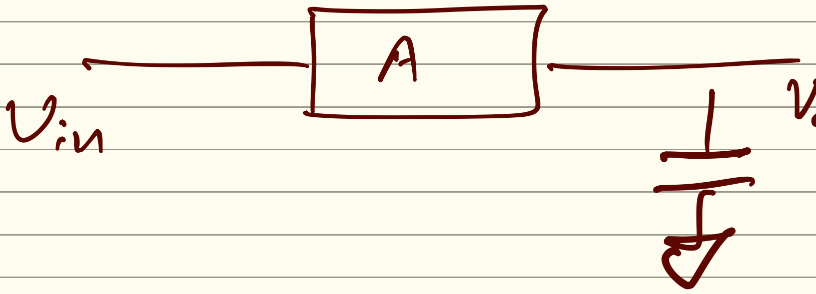
$t = RC$

$V_o(t = RC)$

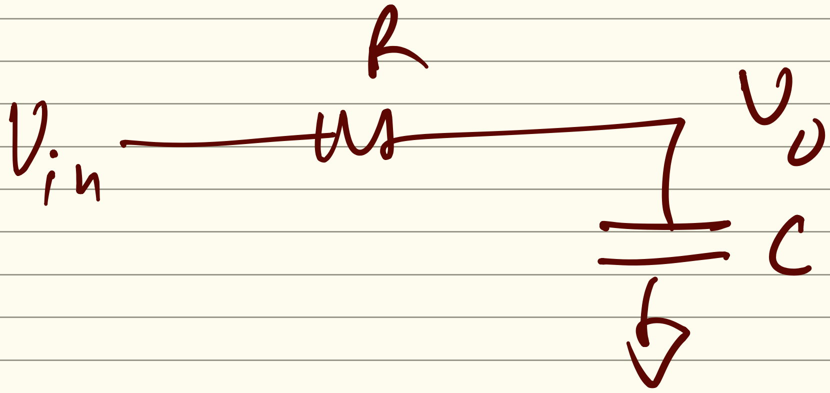
$= \frac{V_{in}}{e}$

$= .63 \cdot V_{in}$



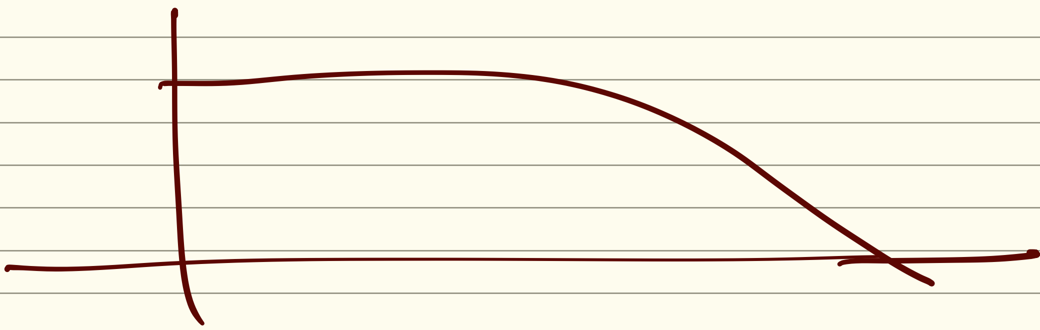


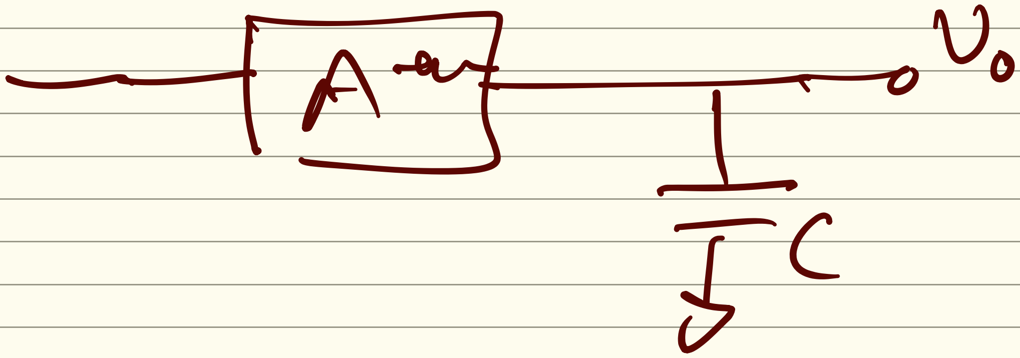
$V_o = A V_{in}$



$$V_o = \frac{V_{in} \cdot 1/sC}{R + \frac{1}{sC}} = \frac{V_{in}}{RsC + 1}$$

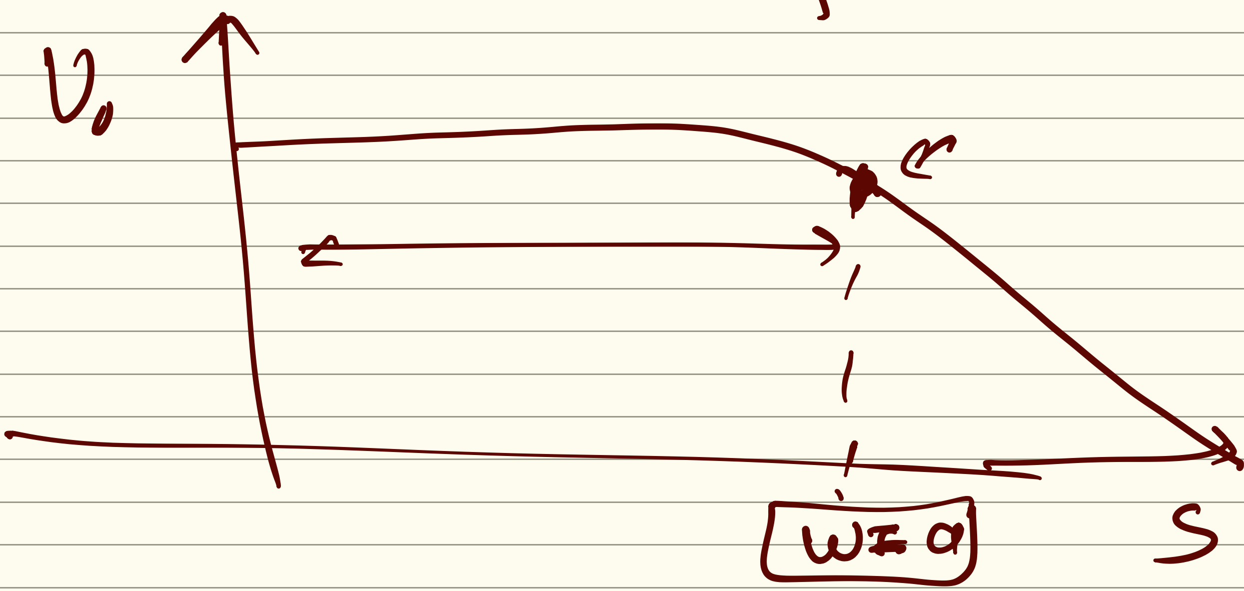
$$\Rightarrow \frac{V_{in}}{\frac{s}{a} + 1} \qquad \boxed{a = \frac{1}{RC}}$$



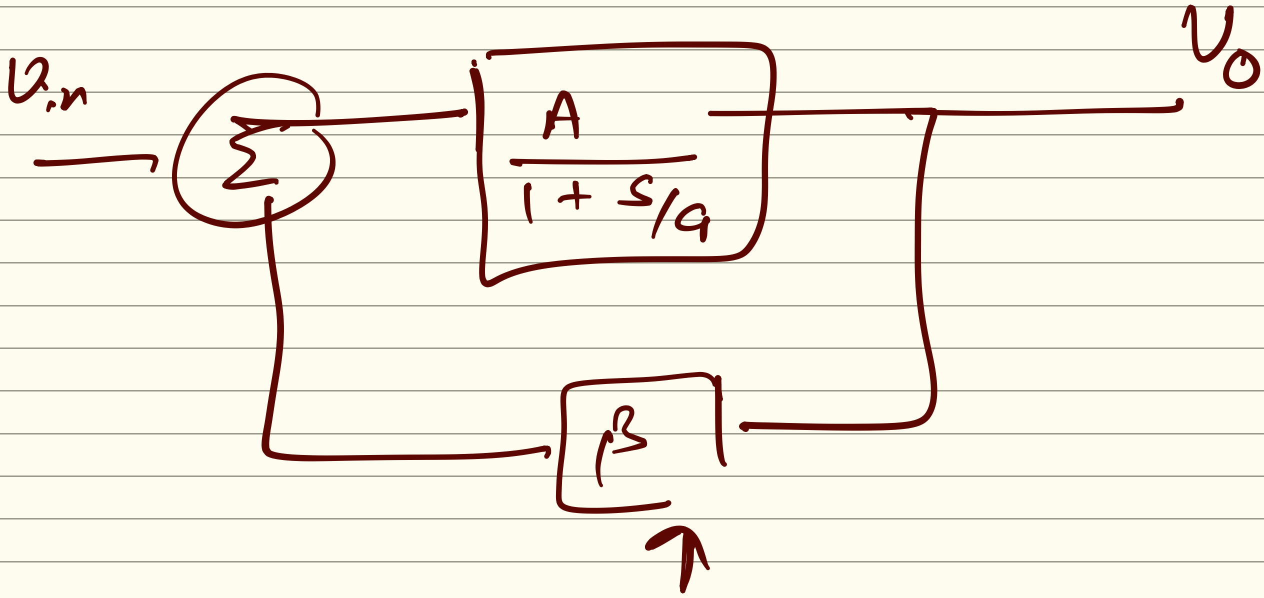


$$V_o = A \cdot V_{in}$$

$$V_o = \frac{A}{1 + \frac{s}{a}} \cdot V_{in}$$



3dB B.W



$$V_o = \frac{A}{1+A\beta}$$

$$A \Rightarrow \frac{A}{1+\frac{s}{a}}$$

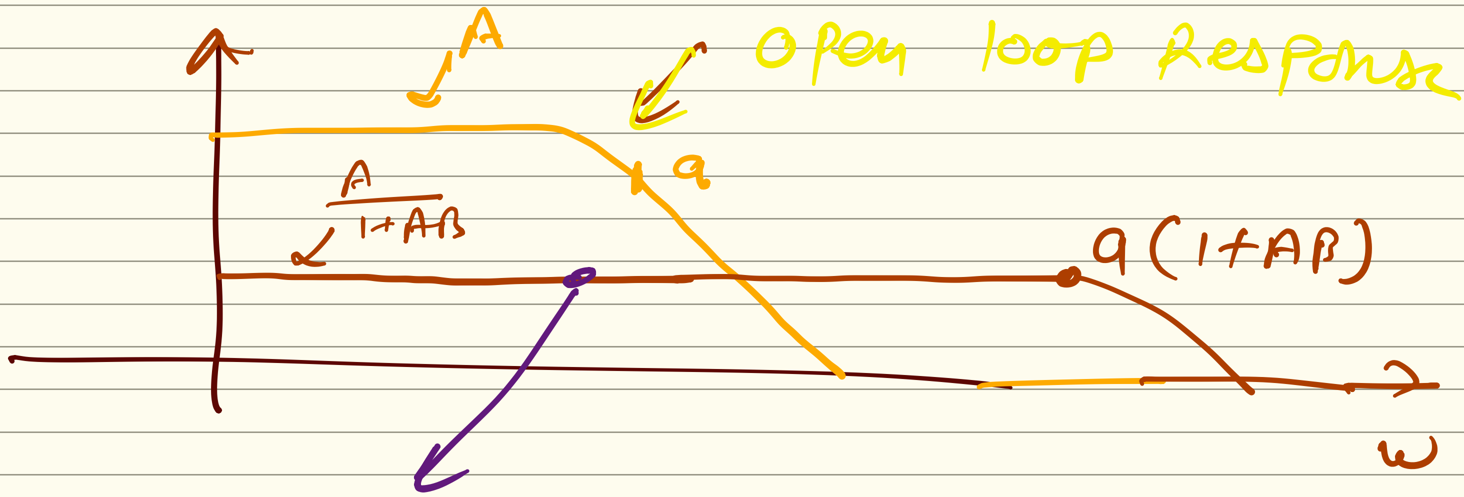
$$\boxed{B.W = a}$$

?

$$= \frac{\frac{A}{1+\frac{s}{a}}}{1+\frac{A}{1+\frac{s}{a}}\cdot\beta}$$

$$\frac{\frac{A}{\cancel{\left(1+\frac{s}{a}\right)}}}{\frac{1+\frac{s}{a}+A\cdot\beta}{\cancel{\left(1+\frac{s}{a}\right)}}}$$

$$\Rightarrow \frac{A}{1+A\beta\left\{1+\frac{s}{a(1+A\beta)}\right\}} = \frac{v_o}{v_{in}}$$



Closed loop Response

When single pole system is to be considered →

$$B.W \times GAIN = \text{const.}$$

$$A \cdot a = \frac{A}{1+\cancel{AB}} \cdot a(1\cancel{+AB})$$

$$= A \cdot a$$

Open loop ; Closed loop