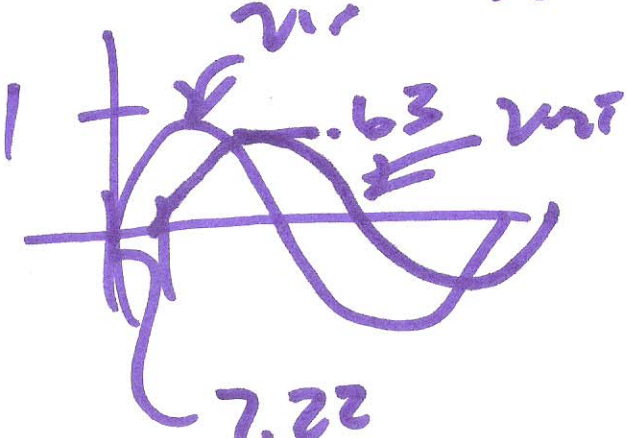
Lecture 21

April 13, 2015

EE 320



$$20 \log \frac{v_{nT}}{v_n} = -4\,dB = .63$$

$$\frac{v_{nT}}{v_n} = 10^{-4/20} = .63$$

$v_n = 1$

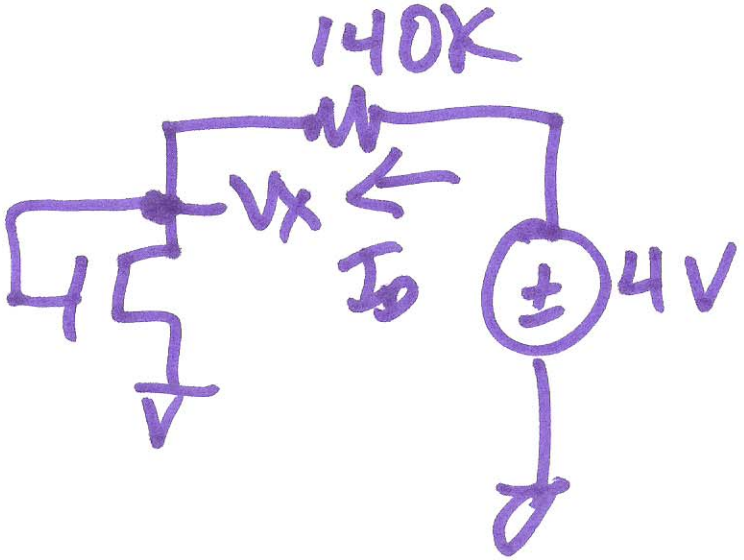
$v_{nT} = .63$

$$\frac{t_d}{T} \cdot 360 = \theta$$

$$t_d = \frac{52}{360} \cdot 50ns$$

$$t_d = \underline{\underline{7.22ns}}$$

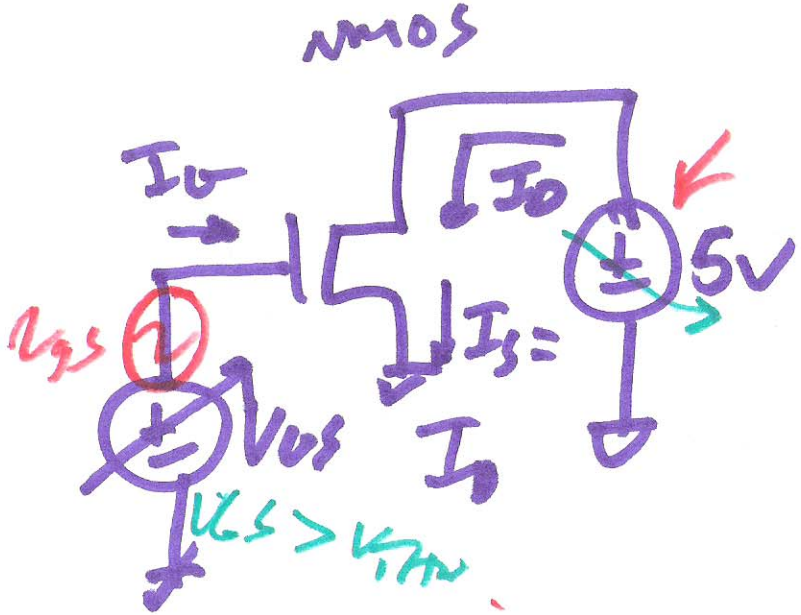
1)

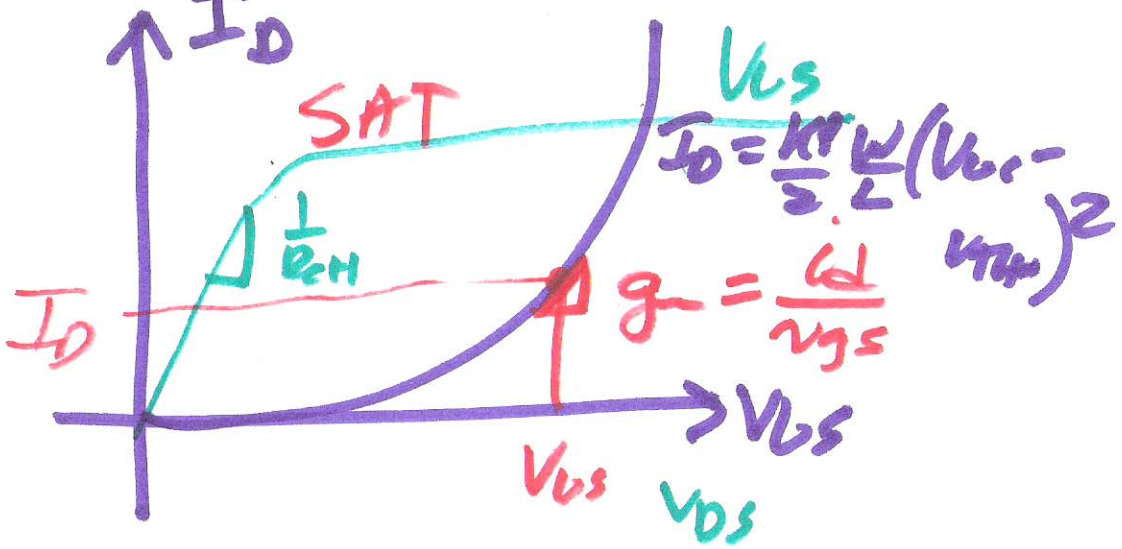


$$\frac{4-V_X}{140K} = \frac{K_P}{2}\frac{W}{L}\left(V_X - V_{THN}\right)^2$$

$$I_D = 20mA$$

$$V_X = 1.2V$$





$$i_d = g_m v_{gs}$$

$$g_m = \left.\frac{\delta i_D}{\delta v_{GS}}\right|_{\substack{I_D = CONST \\ V_{DS} = CONST}} = \frac{\delta}{\delta v_{GS}} \frac{KP}{2}\frac{W}{L}\left(\underbrace{V_{GS} + v_{gs}}_{v_{GS}} - V_{THN}\right)^2$$

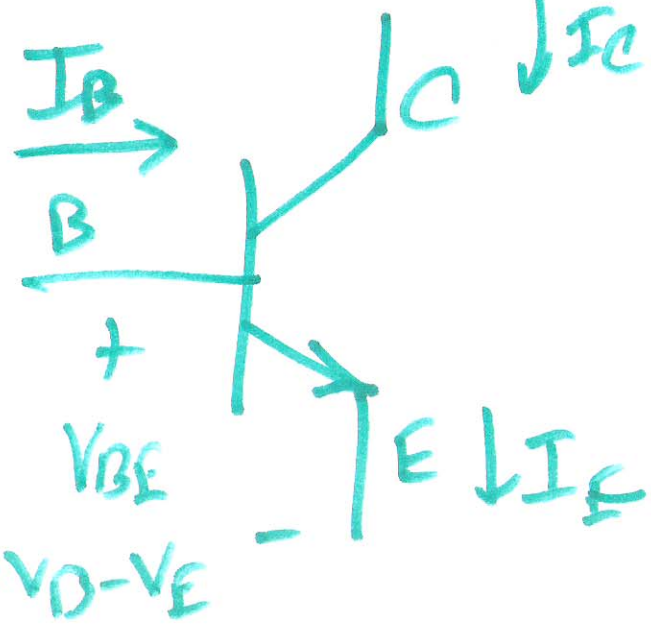
$$\frac{\delta(x-x)}{\delta x} = 1$$

$$= KP\cdot\frac{W}{L}\left(V_{GS} - V_{THN}\right)\cdot\frac{d(\quad)}{d\,v_{GS}}$$

$$i_D = I_D + i_d$$

$$v_{GS} = V_{GS} + v_{gs} \qquad V_{GS} >> v_{gs}$$

$$\boxed{g_m = KP\cdot\frac{W}{L}\left(V_{GS} - V_{THN}\right)}$$



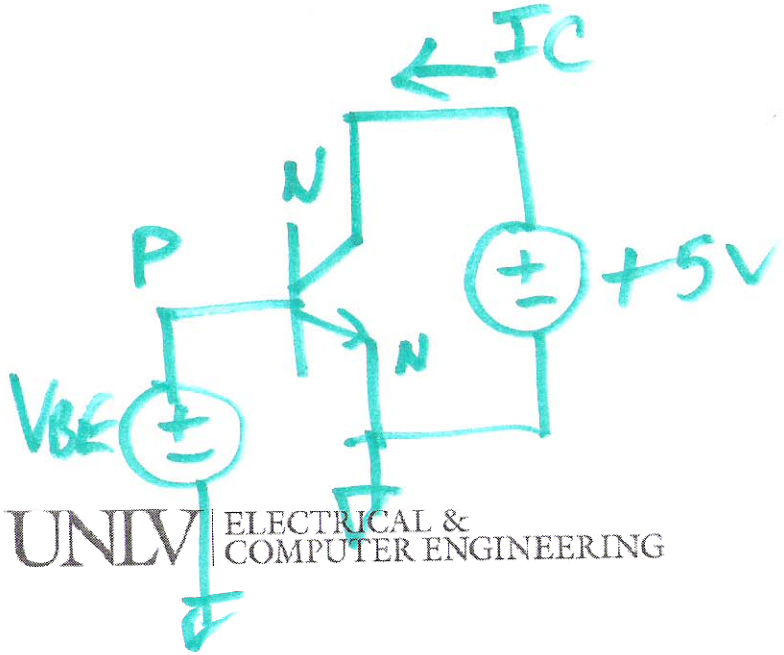
$$\text{Beta} = \beta = \frac{I_C}{I_B}$$

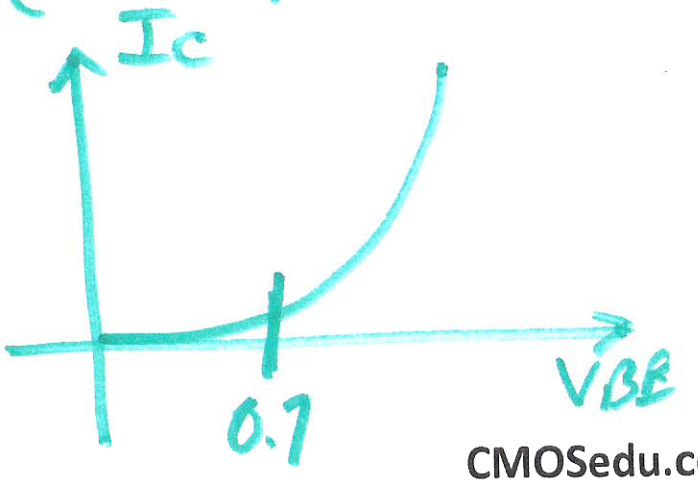
current gain

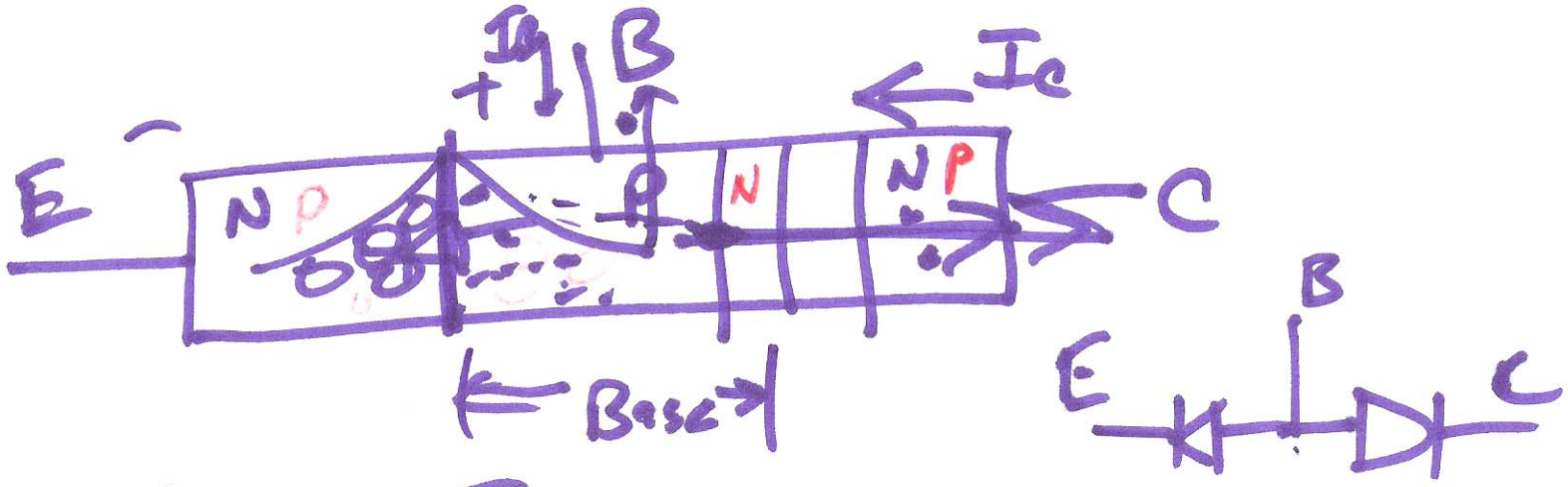
$$V_{CE} = V_C - V_E$$

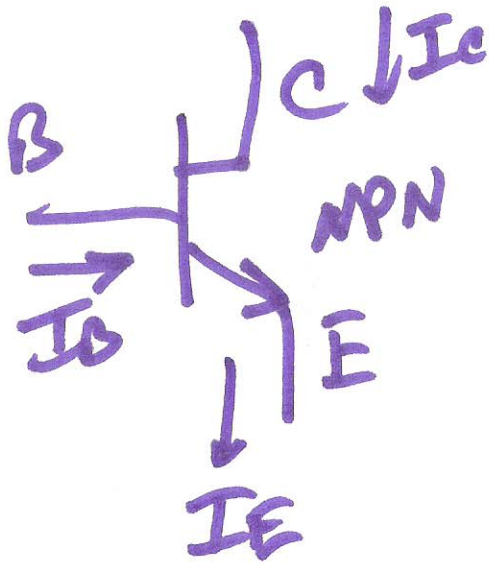
$$I_E = I_C + I_B$$

Bipolar Junction transistors (BJTs)









$$\frac{I_C}{I_E} = \alpha$$

↖ fraction of I_C is of I_B

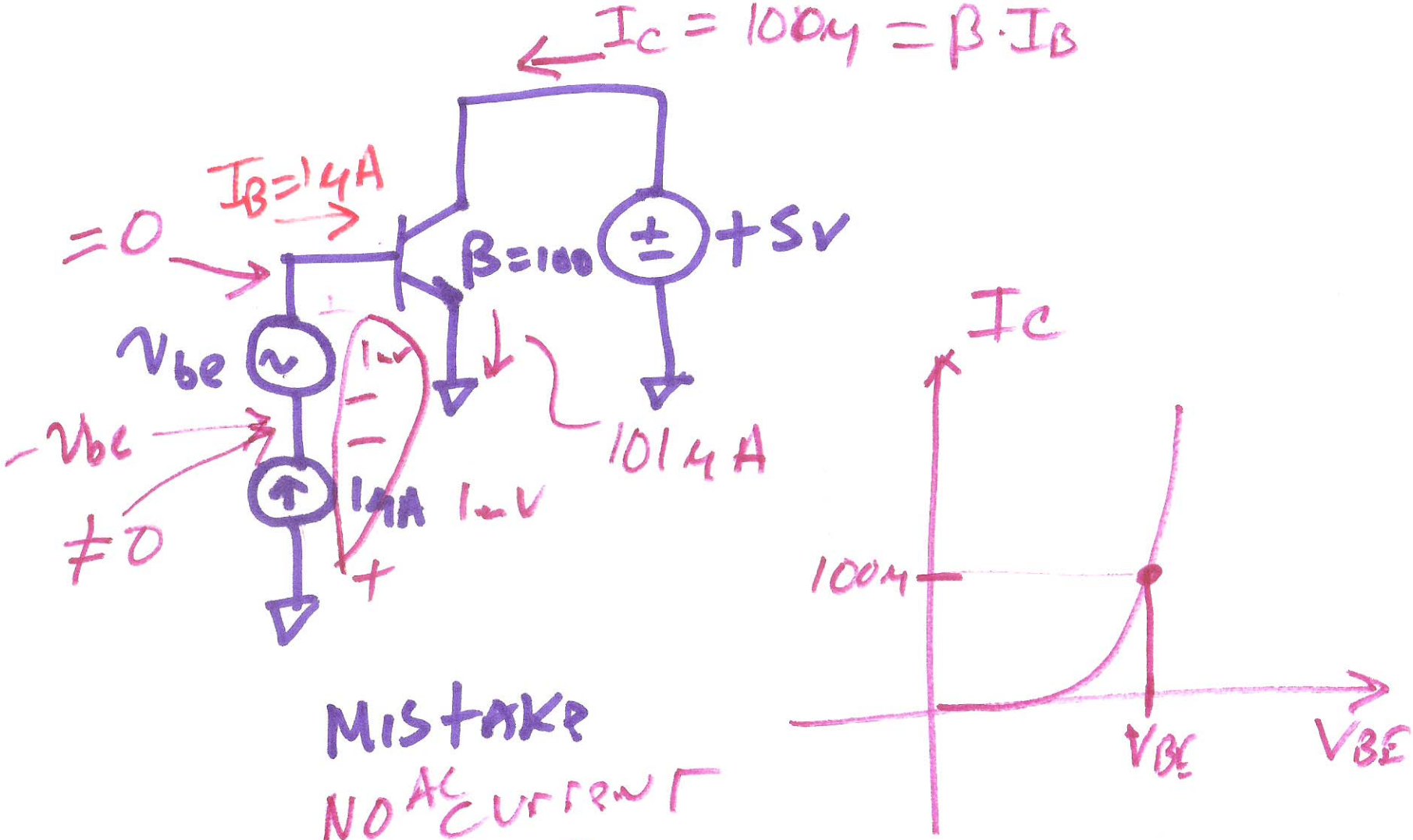
$$\beta = \frac{\alpha}{1-\alpha}$$

$$I_C + I_B = I_E$$

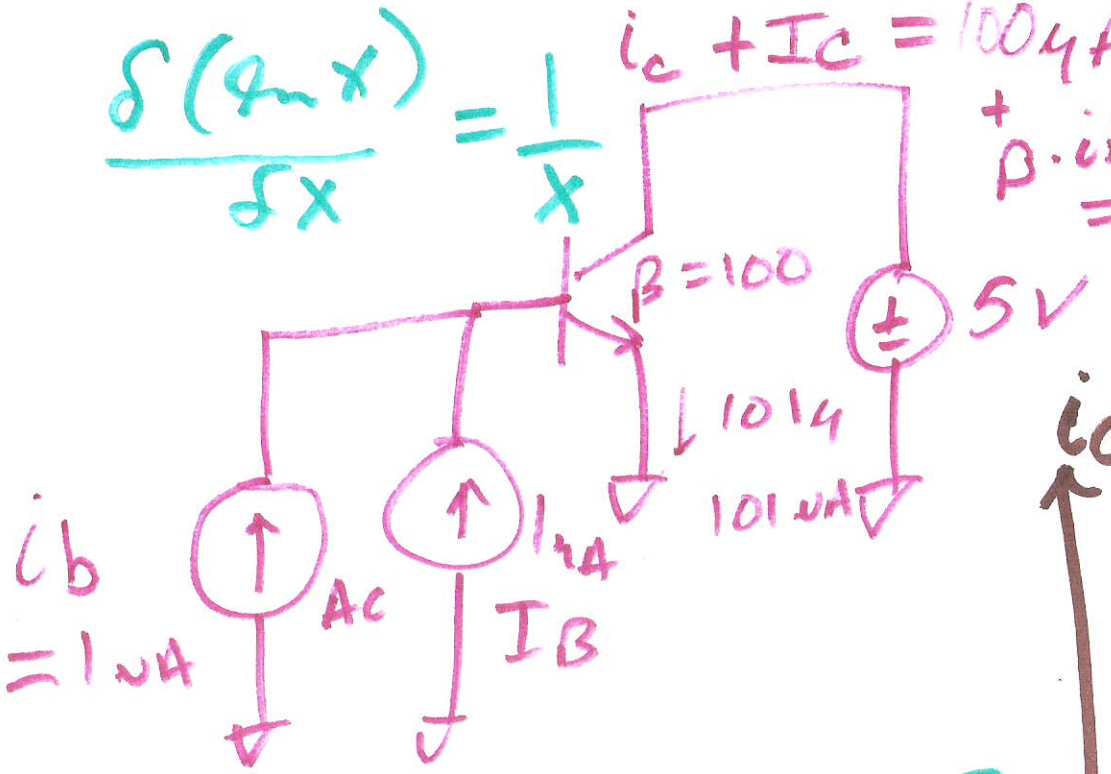
$$I_E = \alpha I_C$$

$$I_B \cdot \beta = I_C$$

$$I_B(\beta+1) = I_E$$


$I_C = 100\mu = \beta \cdot I_B$
$I_B = 1\mu A$
$= 0$
$\beta = 100$
$\pm$
$+5V$
v_{be}
$-v_{be}$
$\neq 0$
1mA
1mV
$101\mu A$
I_C
100μ
V_{BE}
V_{BE}
Mistake
NO AC CURRENT
CAN flow

$$\frac{\delta(g_m x)}{\delta x} = \frac{1}{x}$$

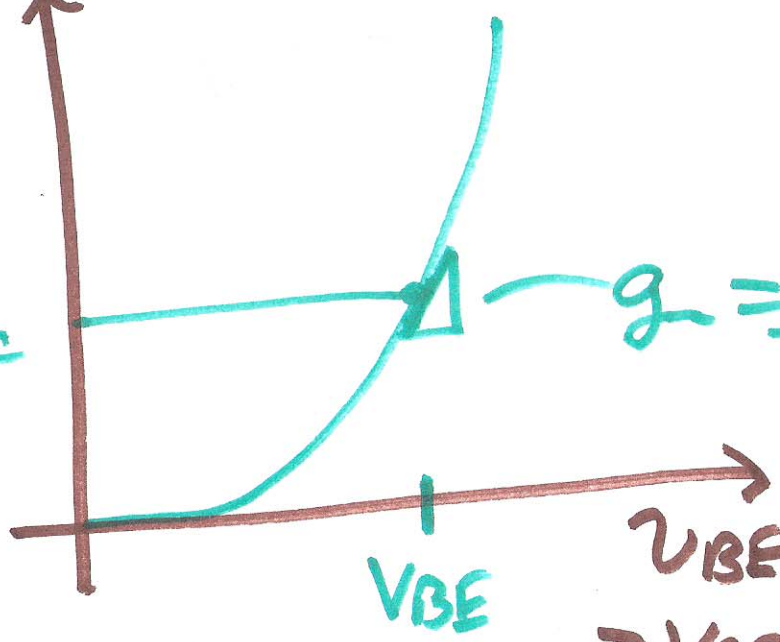


$$I_D = I_S\left(e^{V_D/nV_T} - 1\right)$$

forward

$$I_D = I_S e^{V_D/nV_T}$$

$$i_C = I_C + i_c$$



$$g_m = \frac{\delta i_C}{\delta v_{BE}}$$

$$\beta I_B = I_C$$

$$I_C = I_S e^{V_{BE}/nV_T}$$

$$\frac{1}{g_m} = \frac{\delta v_{be} + V_{BE}}{\delta i_C} = nV_T\left(\ln I_C^{+i_c} - \ln I_S\right) = \ln\frac{I_C}{I_S}$$

$$= \frac{1}{g_m} = \frac{nV_T}{I_C + i_c}$$

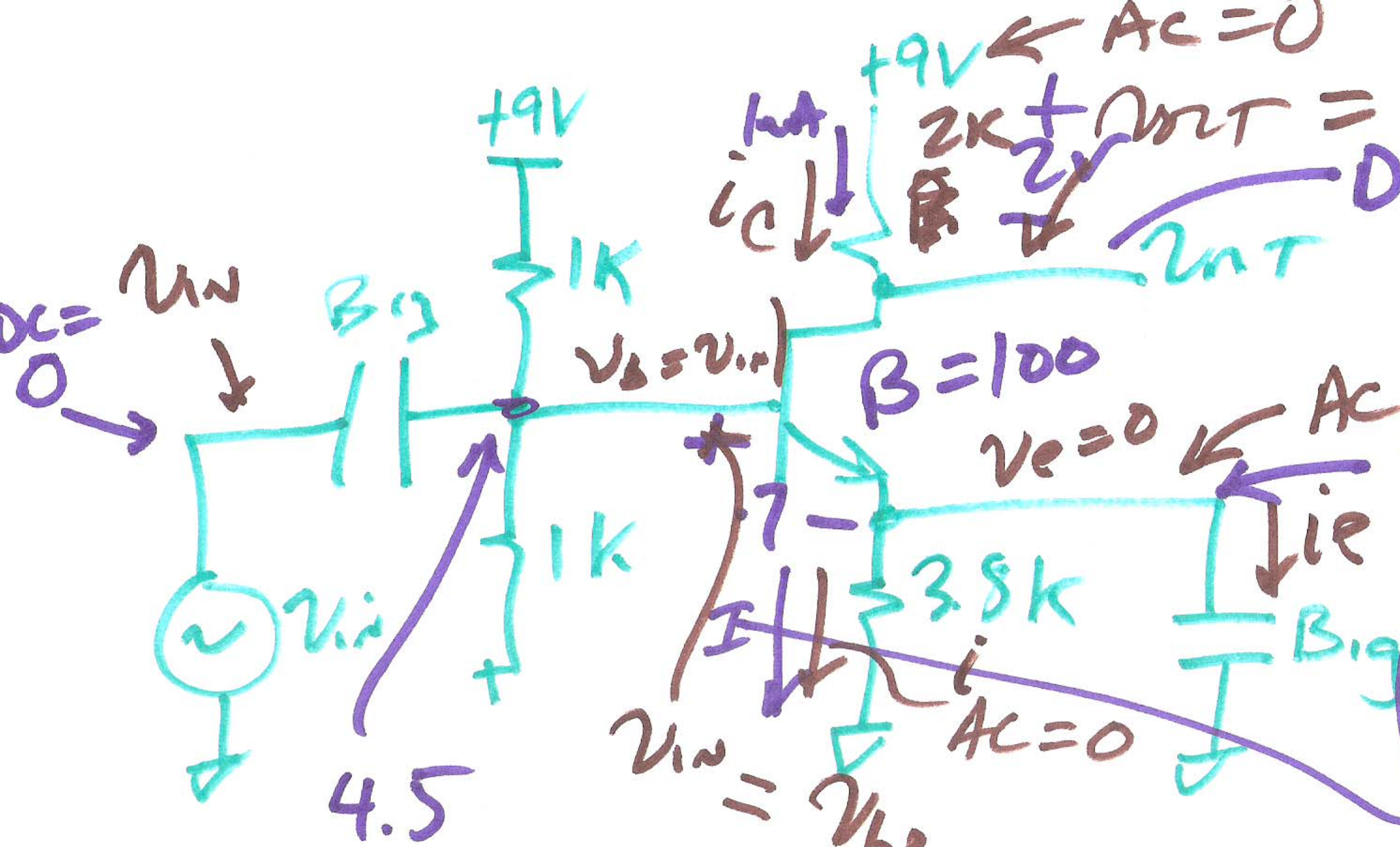
$$g_m \approx \frac{I_C}{N V_T}$$

$$I_C = 100\mu A$$

$$g_m = \frac{100\mu}{1.25mV} = 4\frac{mA}{V}$$

$$\boxed{i_c = v_{be} \cdot g_m}$$

$$i_c = 25mV \cdot 4\frac{mA}{V} = 100nA$$



DC = 9 − 2 = 7V

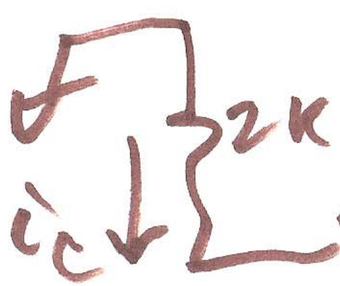
$g_m = 40\,mA/V$

$g_m = \frac{I_c}{nV_T} = \frac{1mA}{1.25m}$

$I_E = \frac{3.8}{3.8k} = 1mA$

$v_{in} = v_{be}$

$i_c = g_m v_{in} = g_m v_{be}$



$v_{out} = -i_c \cdot 2K$

$= -g_m v_{in} \cdot 2K$

$$\frac{v_{out}}{v_{in}} = -g_m 2K$$