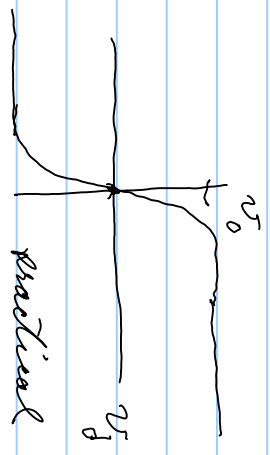
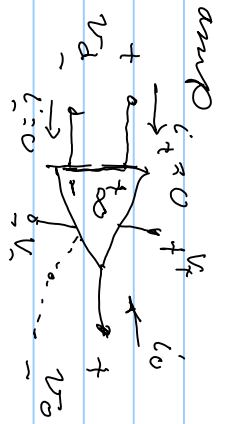


EE301

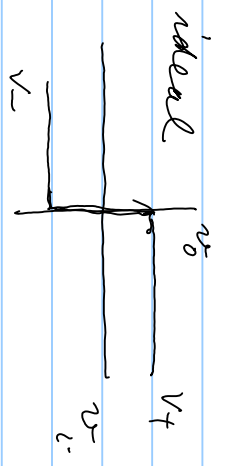
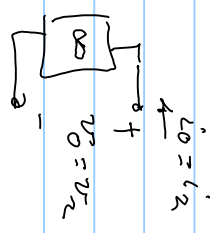
02/06/17

op-amp



$$0 = i_1 = i_2$$

$$0 = v_1 = v_2$$



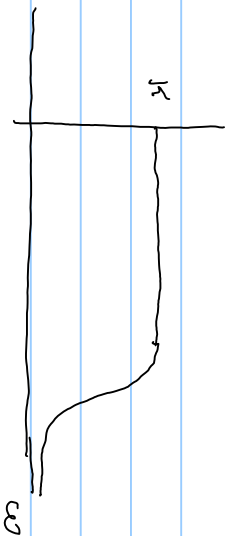
multiten

normal

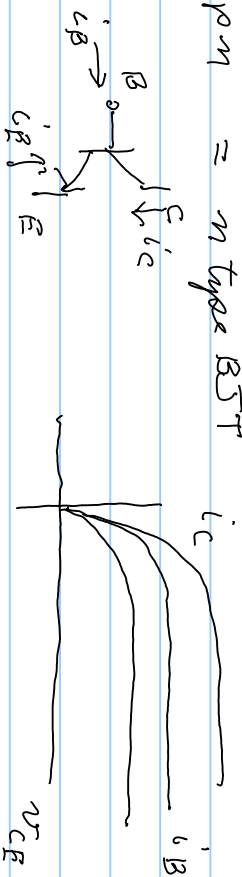
$$\begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix}$$

actually $\frac{v_o}{v_i} \approx 10^6 = K$

$$| \frac{V_O}{V_i}(j\omega) |$$



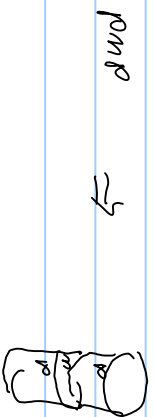
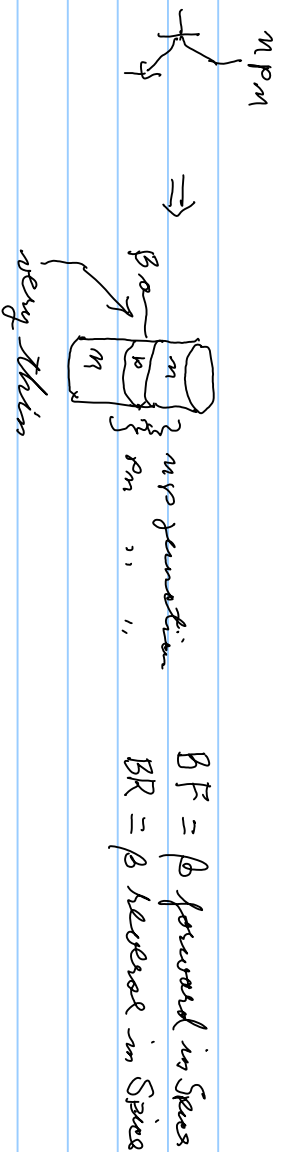
$n_{p,m} \approx n$ type BJT



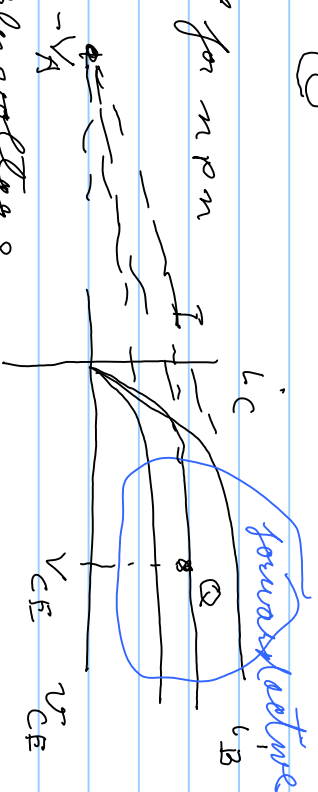
$$i_C = \beta i_B, \quad \beta(\omega) \text{ decreases for } \omega \rightarrow \infty, \quad i = y \quad v$$

$$\begin{bmatrix} i_B \\ i_C \end{bmatrix} = \begin{bmatrix} g_m \\ g_m \end{bmatrix} \begin{bmatrix} v_{BE} \\ v_{CE} \end{bmatrix}$$

$$\begin{bmatrix} i_B \\ i_C \end{bmatrix}$$



Equivalent circuit for $n p n$



$V_A = \text{early voltage}$
 $V_X \Rightarrow V_X \text{ for DC, } V_X = \text{signal behavior, } V_X = \text{total}$

$$i_c = f(v_{ce}, i_b) = f(v_{ce}, I_B) + \frac{\partial f}{\partial v_{ce}} \Big|_Q (v_{ce} - V_{CE}) + \frac{\partial f}{\partial i_b} \Big|_Q (i_b - I_B) + \dots$$

$$= I_C$$

$$\Rightarrow i_c - I_C = i_c = g v_{ce} + \beta i_b, \quad g = \frac{\partial f}{\partial v_{ce}} \Big|_Q \approx \frac{I_C}{V_A}, \quad \frac{\partial f}{\partial i_b} \Big|_Q = \beta$$