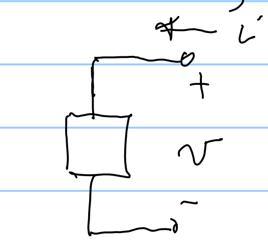
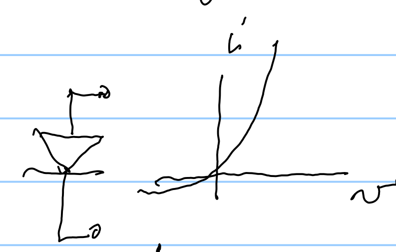
EE303H
09/08/15

Note Title 9/8/2015

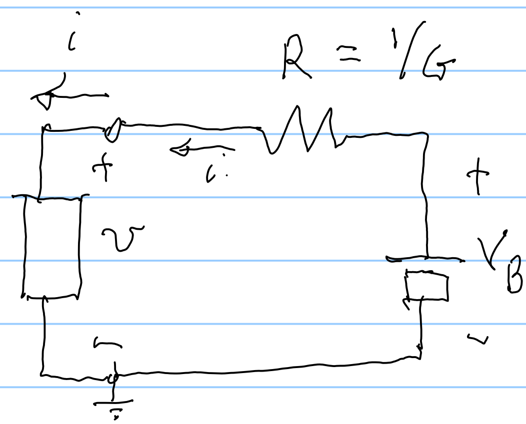
Load lines, bias = Q points, small signal notation

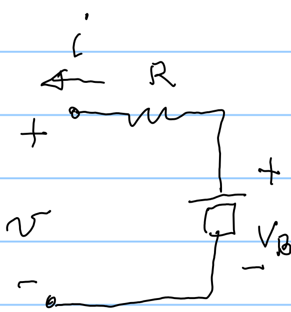


$i = f(v)$



$i_D = f(v_D)$



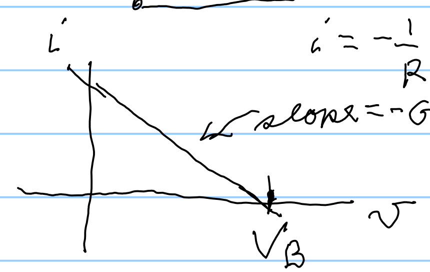


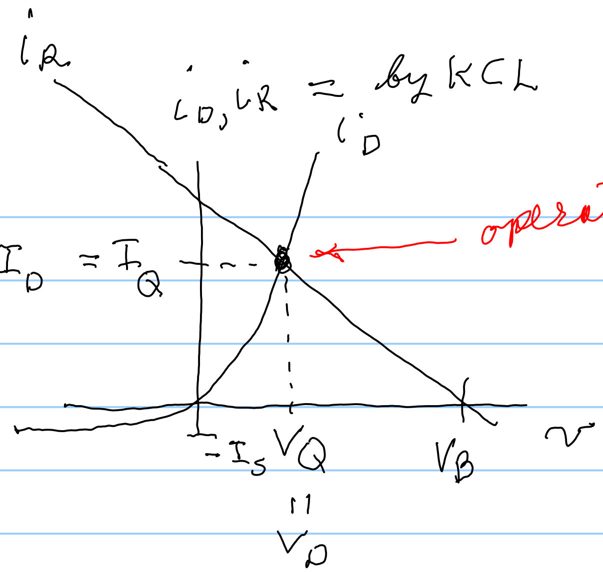
KVL:

$v = -Ri + V_B$

$\Rightarrow Ri = V_B - v$

$i = -\frac{1}{R}(v - V_B) = -G(v - V_B)$





notation

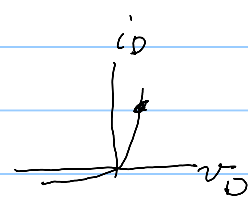
x_Y = total

x_y = signal

X_Y = bias

$$x_Y = X_Y + x_y$$

$$i_D = f(v_D)$$



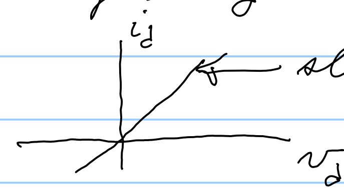
by Taylor series:

$$i_D = i_D\Big|_Q + \frac{1}{\cancel{2!}\ 1!}\frac{df}{dv_D}\Big|_Q (v_D - V_D) + \frac{1}{\cancel{3!}\ 2!}\frac{d^2 f}{dv_D^2}(v_D - V_D)^2 + \dots$$

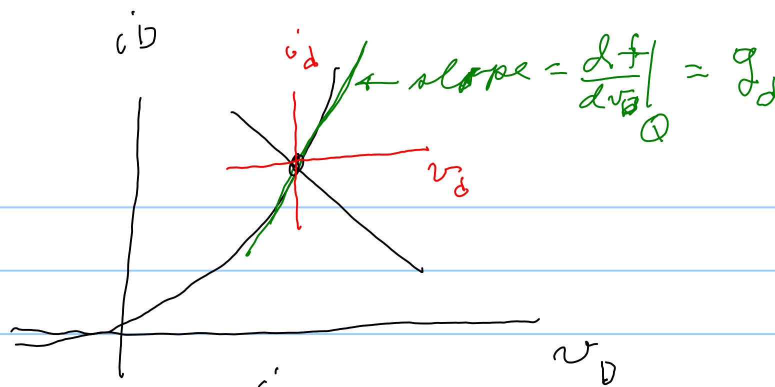
$$i_D = I_D + \frac{1}{2!}\frac{df}{dv_D}\Big|_Q v_d + \dots$$

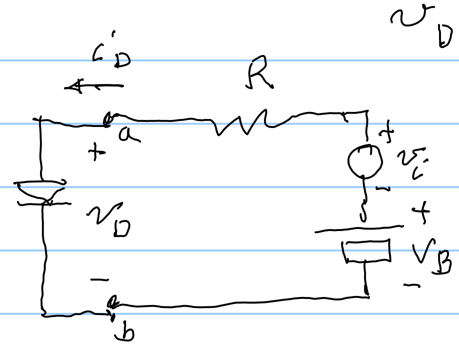
ignore if small signal

$$i_d = i_D - I_D = \frac{df}{dv_d}\Big|_Q \cdot v_d \Rightarrow$$

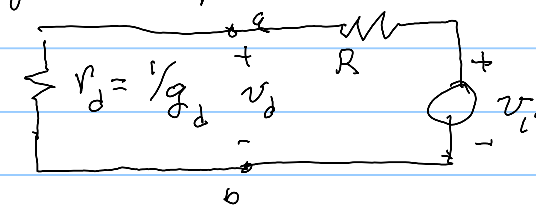


slope = $\frac{df}{dv_d}\Big|_Q$

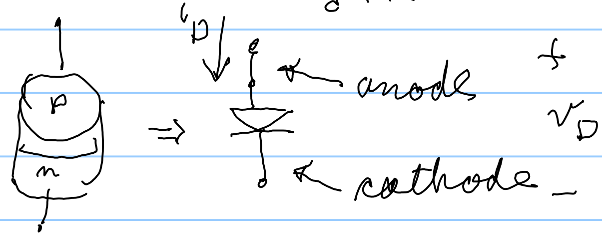




⇒ small signal equivalent



$$v_d = \frac{r_d}{r_d + R} \cdot v_i \Rightarrow \text{voltage gain} = \frac{v_d}{v_i} = \frac{1}{1 + R/r_d} < 1$$

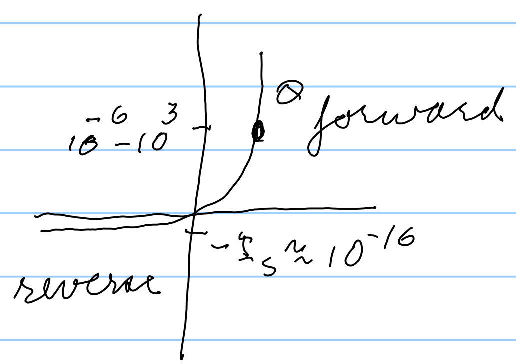


$$i_D = I_S\left(e^{v_D/V_T} - 1\right)$$

V_T = thermal voltage

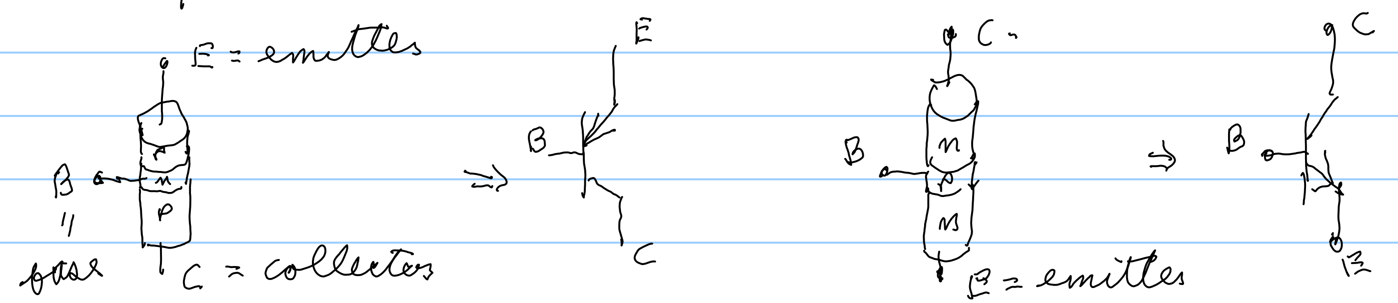
$= kT/|q| \approx 26$ milliVolt @ room T

$$g_d = \left.\frac{d f(v_D)}{d v_D}\right|_{v_D = V_D} = \left.\frac{d}{d v_D}\left(I_S\left(e^{v_D/V_T} - 1\right)\right)\right|_Q = \left.\frac{I_S}{V_T} e^{v_D/V_T}\right|_Q = \frac{I_S}{V_T} e^{V_D/V_T}$$

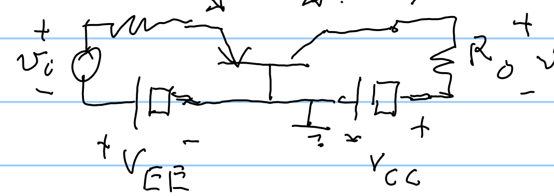


if Q is in forward region $i_D \approx I_S e^{v_D/V_T}$

$$g_d \approx \frac{I_D}{V_T}$$



$i_C \approx \alpha i_E$ if properly bias $\quad \alpha \approx 1$; $\alpha = 0.999$



$v_o = R_o i_E \approx R_o \cdot \frac{r_d}{r_d + R_i} \cdot v_i \Rightarrow gain = \frac{r_d}{r_d + R_i} \cdot R_o > 1$ possible