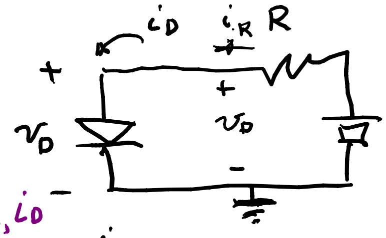
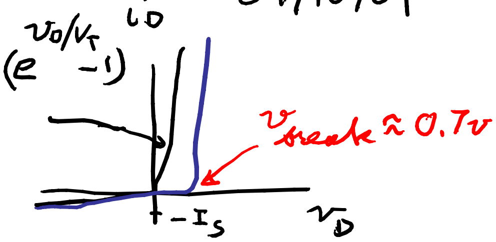
Load lines

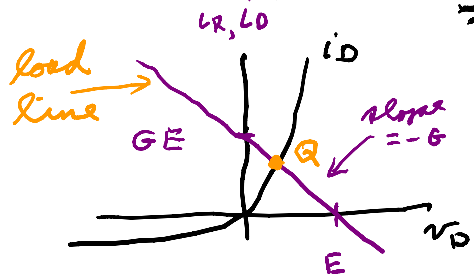
EE303H
09/10/09



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



↙ law of components



KVL $v_D = E - R i_R$

but $i_R = i_D$ by KCL

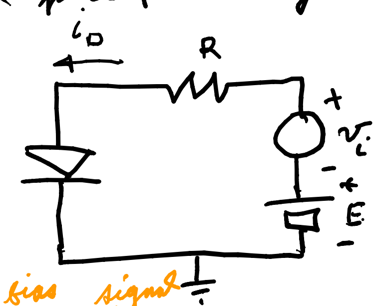
$$i_R = -\frac{(v_D - E)}{R} = -\frac{v_D}{R} + \frac{E}{R}$$

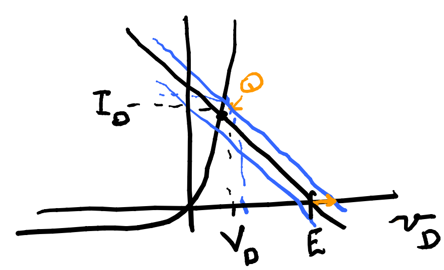
$$= -G v_D + GE$$

Q = operating point of this circuit
= quiescent point
= bias point

R = load resistor on the diode

To use put a signal on top of E, v_i



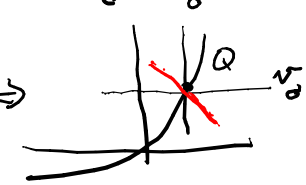


$i_D = I_D + i_d$ (total = bias + signal)

$v_D = V_D + v_d$

if v_i is small i_d is small
" " " v_d " "
" " " i_d " "

$i_D - I_D = i_d$, $v_D - V_D = v_d$ ⇒



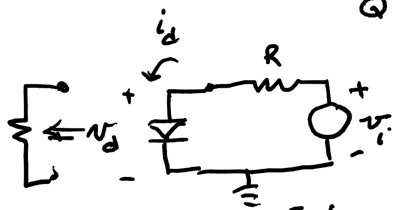
To evaluate i_d vs. v_d use Taylor series expansion

$$i_D = i_D\Big|_Q + \frac{\partial i_D}{\partial v_D}\Big|_Q (v_D - V_D) + \frac{1}{2!}\frac{\partial^2 i_D}{\partial v_D^2}(v_D - V_D)^2 + \cdots$$

if v_d is small, i.e. $|v_D - V_D|$ is small

$$\approx \quad i_D = I_D + \left.\frac{\partial i_D}{\partial v_D}\right|_Q v_d \Rightarrow i_D - I_D = i_d = \left.\frac{\partial i_D}{\partial v_D}\right|_Q \cdot v_d$$

$$g_d = \left.\frac{\partial i_D}{\partial v_D}\right|_Q$$

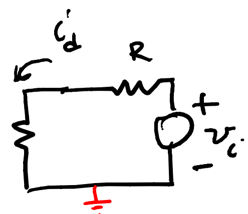


$\Leftarrow$ small signal equivalent

$$i_D = I_S\left(e^{v_D/V_T} - 1\right); \quad \left.\frac{\partial i_D}{\partial v_D}\right|_Q = \left.\frac{I_S}{V_T} \cdot e^{v_D/V_T}\right|_{v_D = V_D}$$

$$g_d = \frac{I_S}{V_T} e^{V_D/V_T}$$

$$\frac{1}{g_d} = r_d$$



$$i_d = \frac{v_i}{R + r_d}$$