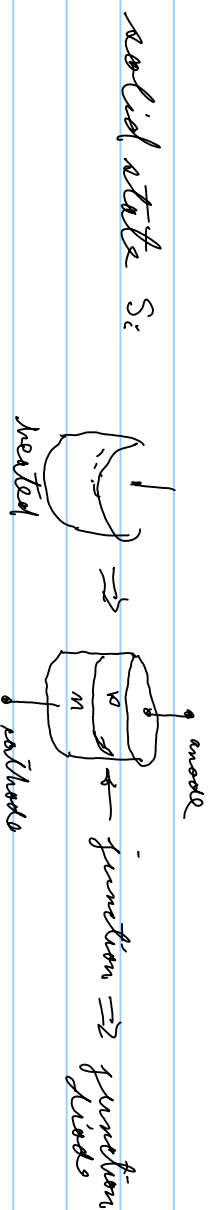
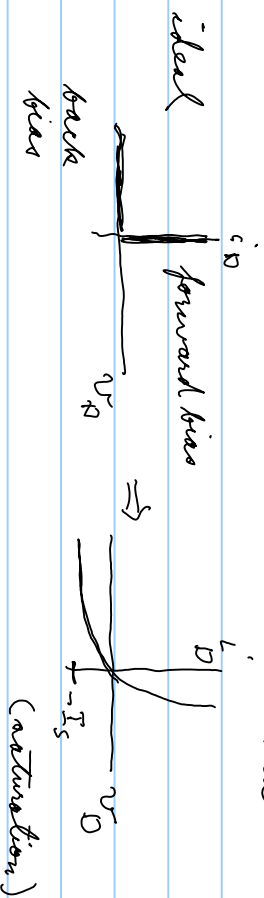
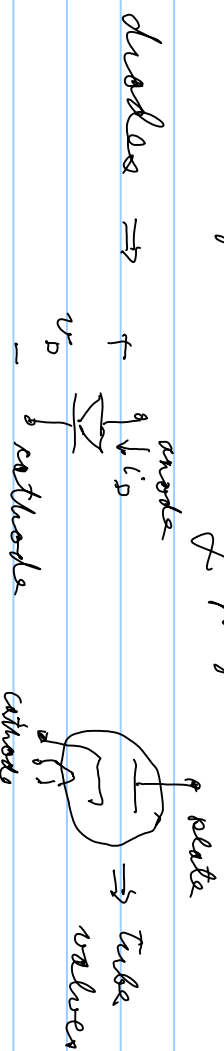


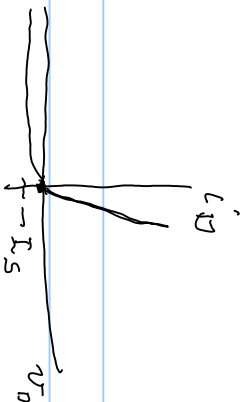
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choose a preliminary paper



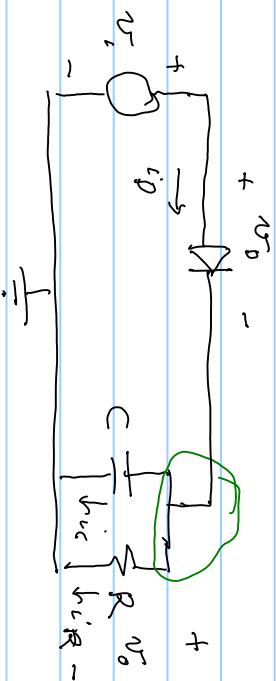
math model



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

$$= kT / q$$

$\approx 26 \text{ mV @ room Temp.}$

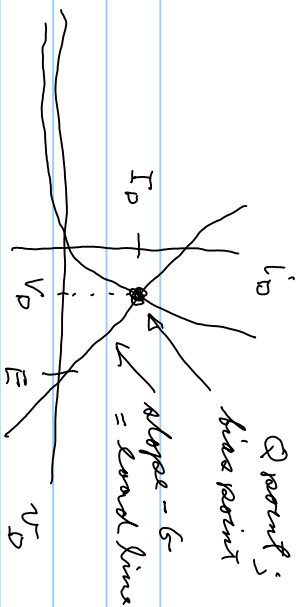


KCL: $0 = i_D + (-i_C) + (-i_R) \Rightarrow i_D = i_C + i_R$

$$i_D = I_S (e^{v_D / V_T} - 1) = C \frac{dv_D}{dt} + G v_D \quad ; \quad G = 1/R$$

KVL: $0 = v_i - v_D - v_D \Rightarrow v_D = v_i - v_D$

$$\Rightarrow I_S (e^{(v_i - v_D) / V_T} - 1) = C \frac{dv_D}{dt} + G v_D \Rightarrow \text{a.c. } v_D + G v_D = (I_S + G) v_D$$



biasing $\Rightarrow$ DC with no input
direct current
 $\frac{dI_D}{dV_D} = 0$, $e^{V_D/V_T} = e^{0/V_T} = 1$

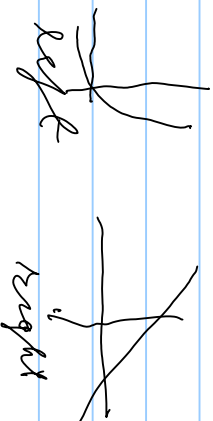
$$I_S(e^{-V_D/V_T} - 1) = G V_D = G(-V_D) = I_S(e^{V_D/V_T} - 1) \Rightarrow V_D \approx 0 \text{ when } V_T \approx 0$$

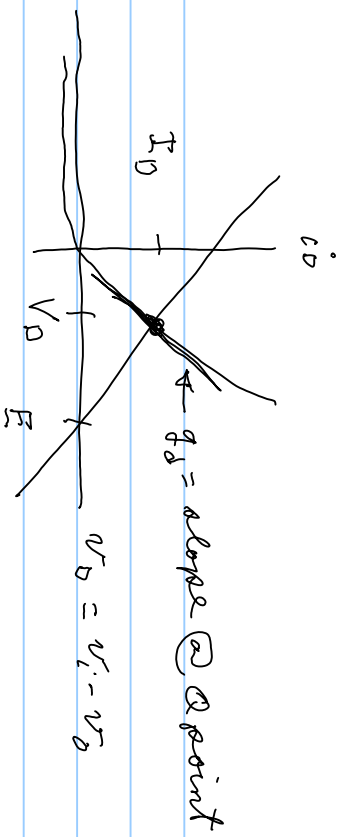
mutual solution

let $V_T = E$ a battery voltage $\Rightarrow V_D = E - V_D \Rightarrow V_D = E - V_D$

$$I_S(e^{-V_D/V_T} - 1) = G(E - V_D)$$

holds for bias, any real E



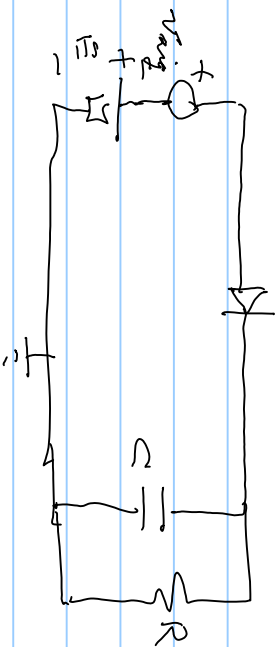


if $v_i = E$, $v_D = V_D = Q \text{ pt value}$

$v_D = E - V_D = \text{constant}$

if $v_i = E + v_i'$, $|v_i'| \ll E \Rightarrow \text{small signal}$

if $|v_i'| \ll E$ $\Rightarrow |v_o| \neq 0$
call small signal.

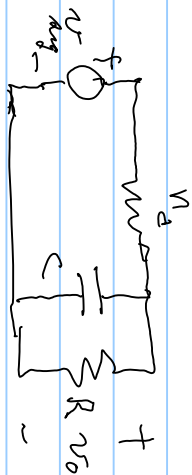


$$\dot{v}_D = I_S (e^{v_D/V_T} - 1) = I_S (e^{v_D/V_T} + 1 \cdot \frac{\partial v_D}{\partial v_D}) + \frac{1}{2!} \frac{\partial^2 v_D}{\partial v_D^2} (v_D - v_D)^2 + \dots$$

$$\begin{aligned} x_g &= \text{signal} &= I_D + \frac{\partial i_D}{\partial v_D} \bigg|_{v_D} & \downarrow & \frac{\partial^2 i_D}{\partial v_D^2} \bigg|_{v_D} \\ x_y &= \text{total} & \dot{v}_D - I_D = \dot{i}_D = \frac{\partial i_D}{\partial v_D} \bigg|_{v_D} & \cdot v_D = g_D \cdot v_D & \\ x_y &= \text{bias} & \end{aligned}$$

ignores for small signal

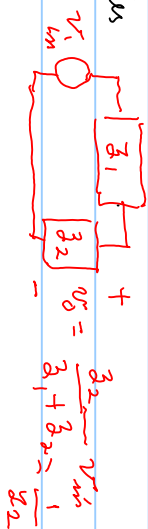
$$v_D = 1/g_D$$



$$\frac{v_D}{v_{sig}} = \frac{1}{R C + G} = \frac{1}{1/g_D C + G} = \frac{1/g_D C}{1 + G/g_D}$$

$\Rightarrow (A + \frac{G}{C}) v_D = \frac{g_D}{C} v_{sig}$, $A = d/dt$ need voltage divider

$\Rightarrow$ differential equation $\frac{d v_D}{dt} + G v_D = \frac{g_D}{C} v_{sig}$



$$v_D = \frac{z_2}{z_1 + z_2} v_{in}$$
