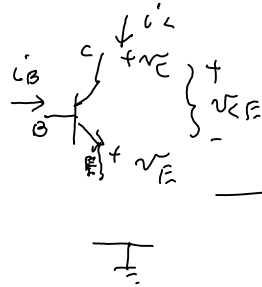
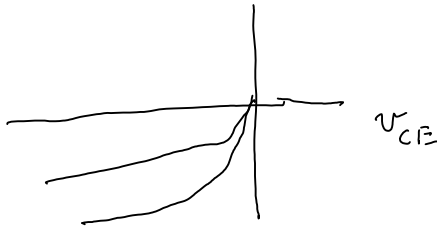
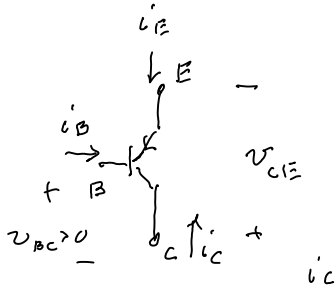
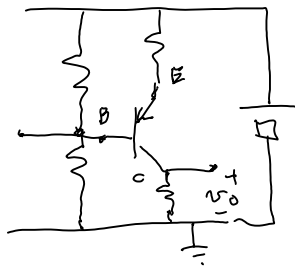
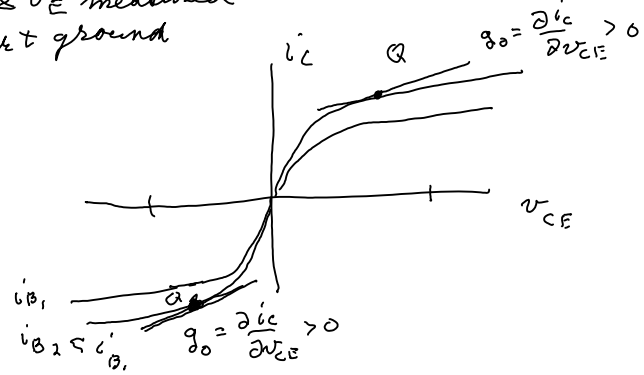


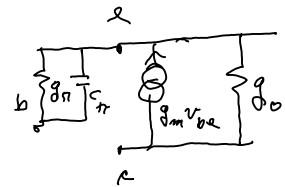
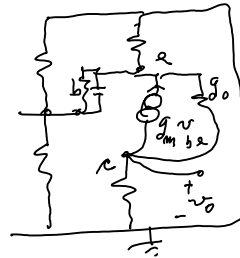
Current mirrors



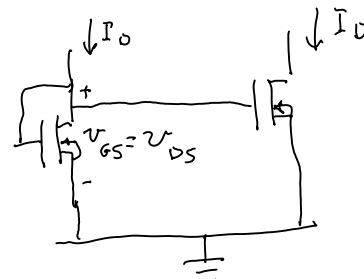
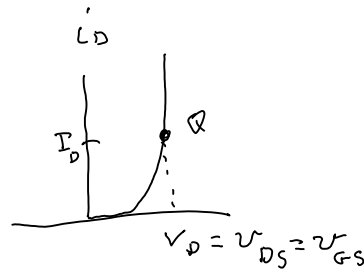
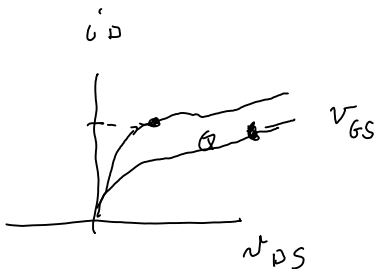
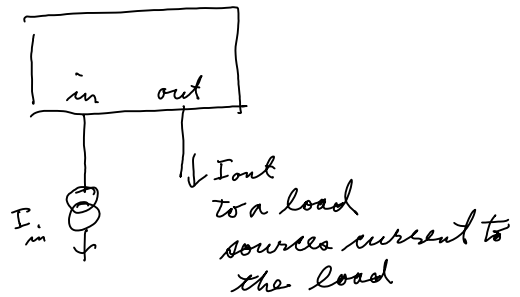
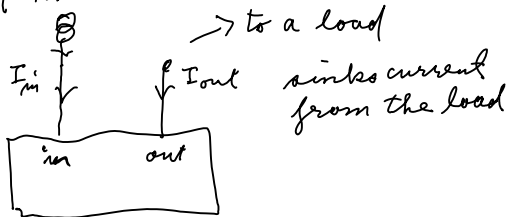
v_C & v_E measured w.r.t ground

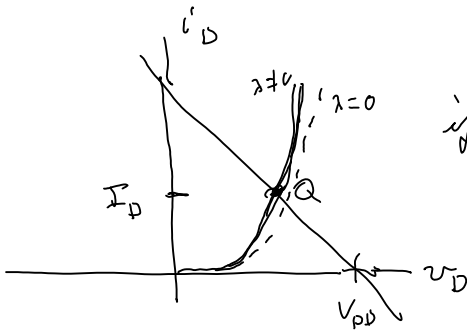


$\Rightarrow$



Current mirrors



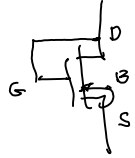


I_D desired

$$v_{GS} - V_{TO} \leq v_{DS} \Rightarrow \text{saturation}$$

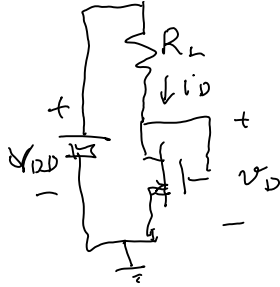
if $v_{GS} = v_{DS} \geq V_{TO} > 0$ NMOS enhancement

$$(v_{DS} = v_{GS}) - V_{TO} \leq v_{DS} \Rightarrow \text{in saturation}$$



$$i_D = \frac{K_P W}{2 L} (v_{GS} - V_{TO})^2 (1 + \lambda v_{GS})$$

$$= k (v_D - V_{TO})^2 (1 + \lambda v_D)$$



$$v_D = V_{DD} - R_L i_D \quad \text{given } I_D$$

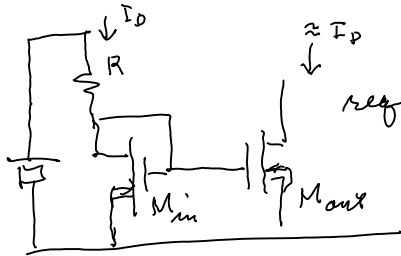
$$V_D = V_{DD} - R_L k (V_D - V_{TO})^2 (1 + \lambda V_D)$$

to solve let $\lambda \approx 0$

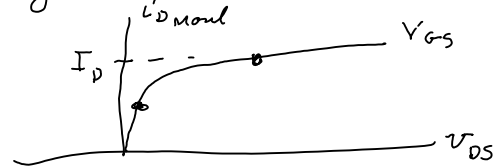
$$\Rightarrow R_L k (V_D^2 - 2V_{TO}V_D + V_{TO}^2) + V_D - V_{DD} = 0$$

can solve for V_D given R_L or for R_L given V_D & I_D

assume find R_L

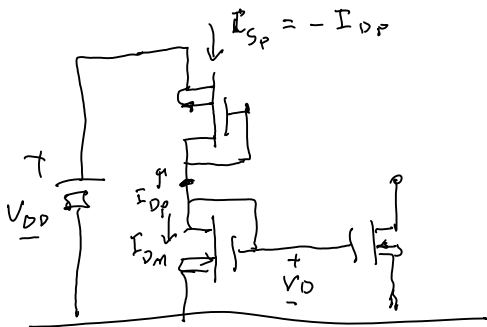
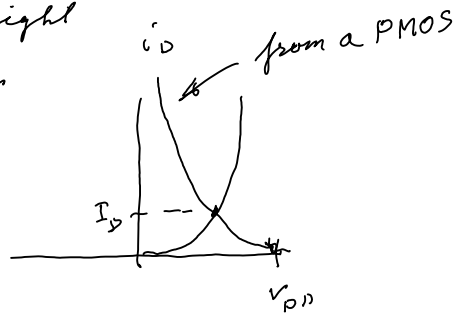
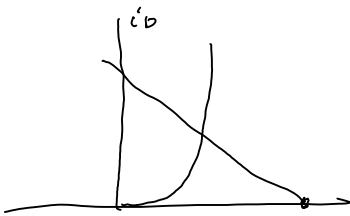


requires that any load keeps M_{out} in saturation



we used a load line which was straight

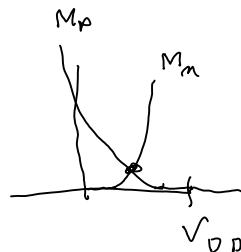
use a CMOS design



$$V_{DD} = V_D - V_{DS_P}$$

$$V_{DS_P} = V_{DD} - V_D$$

$$V_D = V_{DD} + V_{DS_P}$$



$$I_{S_P} = \frac{K_P W}{2 L} (-v_{DS_P} - (-V_{TO_P}))^2$$

↓ Pchannel I_S



$$V_D \Rightarrow V_{DD} + V_{DS_P} = V_{DD} - V_{S_P}$$