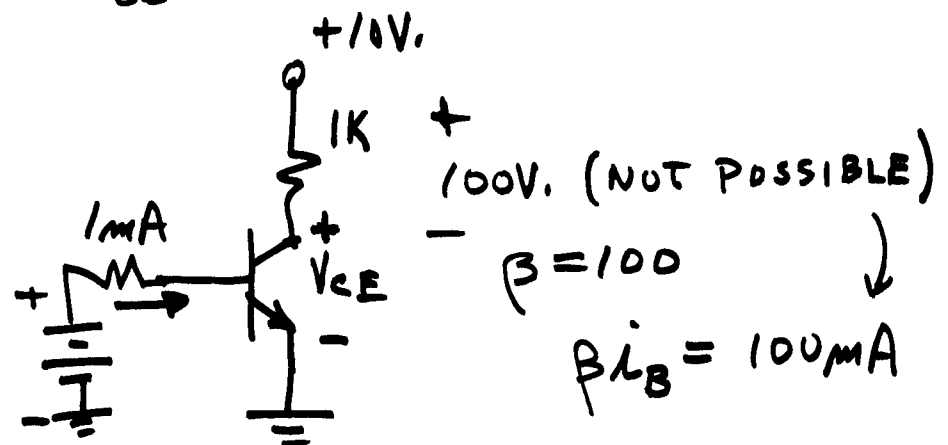
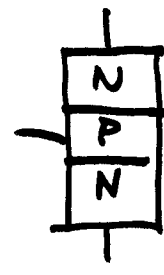
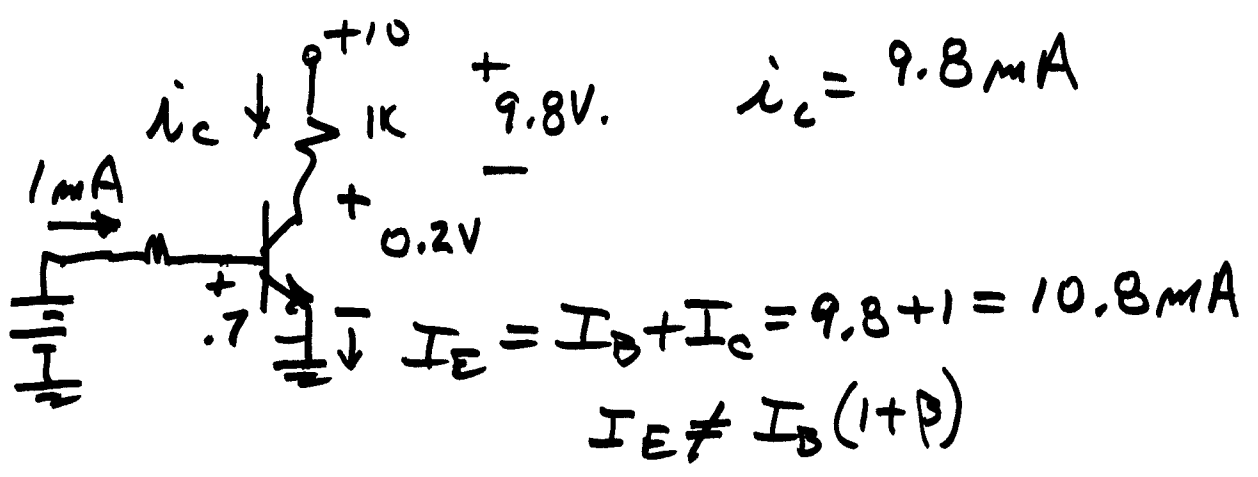
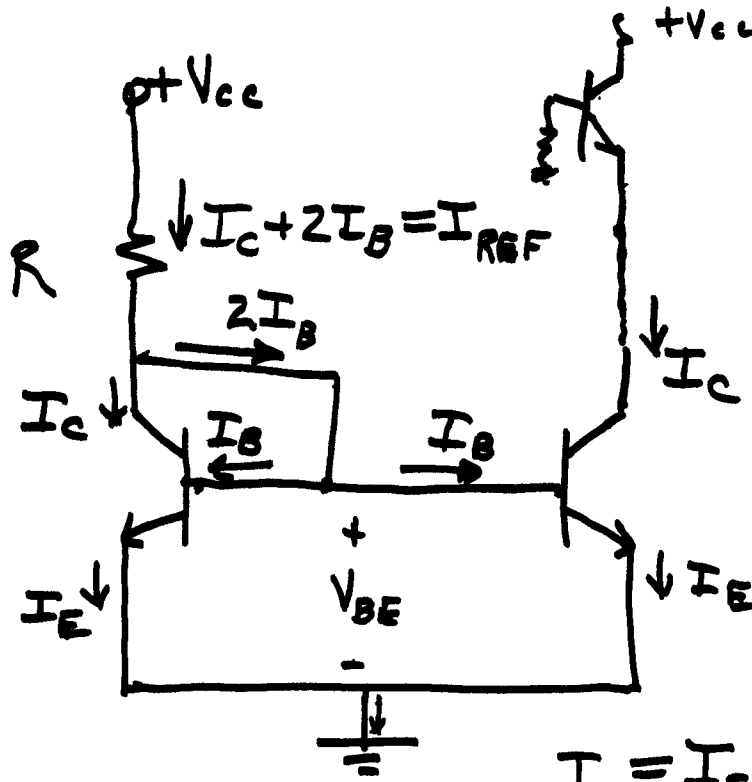


SATURATION
 $i_c \neq \beta i_B$
 $V_{CE} \approx 0.2V.$



$\therefore i_c \neq \beta i_B \Rightarrow$ SATURATION
 ASSUME $V_{CE} = 0.2V.$





BJT
CURRENT
MIRROR

$$I_C = I_S \left(e^{V_{BE}/V_T} - 1 \right)$$

SAME $V_{BE} \Rightarrow$ SAME CURRENTS
SAME β

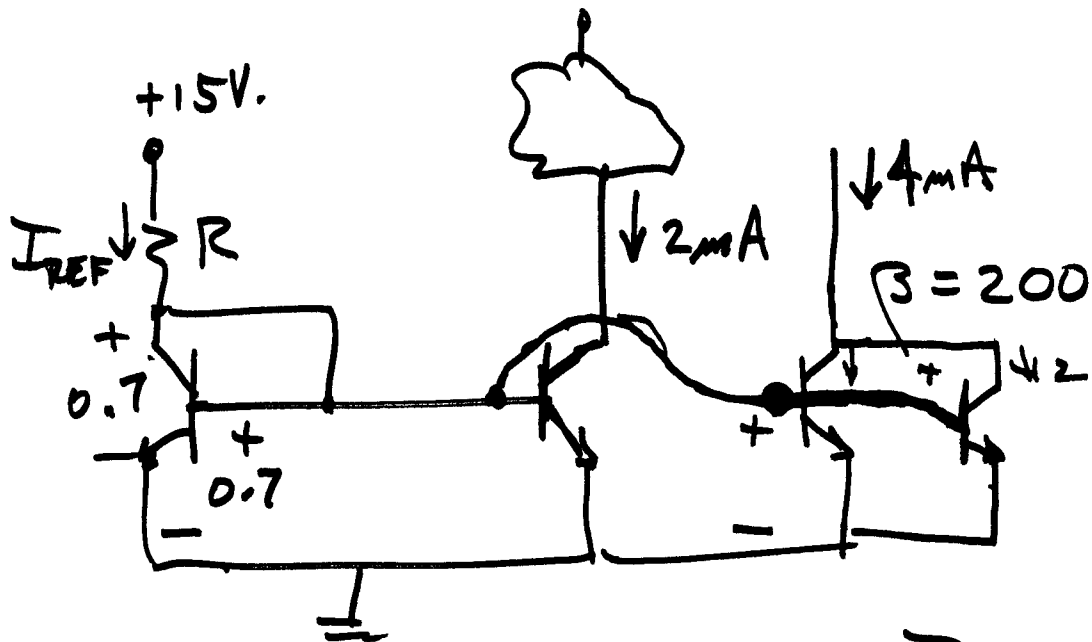
$$I_{REF} = I_C + 2I_B$$

$$I_B = \frac{I_C}{\beta}$$

$$I_{REF} = I_C + 2 \frac{I_C}{\beta} = I_C \left(1 + \frac{2}{\beta} \right)$$

$$I_C = \frac{I_{REF}}{1 + \frac{2}{\beta}}$$

$$I_{REF} = \frac{V_{CC} - V_{BE}}{R} = \frac{V_{CC} - 0.7}{R}$$



$$I_c = \frac{I_{REF}}{1 + \frac{2}{\beta}} = 2\text{mA} \Rightarrow I_{REF} = 2.02\text{mA}$$

$$R = \frac{15 - 0.7}{2.02\text{mA}} = 7.08\text{K}\Omega$$