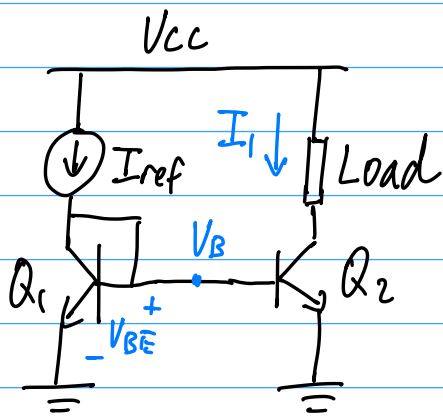


Analysis of BJT current mirror.



$$\text{At } Q_1: I_{\text{ref}} = I_{S1} e^{V_{BE}/V_{T1}}$$
$$V_{BE} = V_{T1} \ln\left(\frac{I_{\text{ref}}}{I_{S1}}\right).$$

The 'magic' of the current source I_{ref} is that it will adjust its voltage to generate the right V_{BE} to make Q_1 carry the desired current. There is a lot of insight to be gained by thinking about how that is possible.

$$\text{At } Q_2: I_1 = I_{S2} e^{V_{BE}/V_{T2}}$$
$$= I_{S2} \exp\left(\frac{V_{T1}}{V_{T2}} \ln\left[\frac{I_{\text{ref}}}{I_{S1}}\right]\right)$$

If $V_{T1} = V_{T2}$ [equal temperatures],

$$I_1 = \frac{I_{S2} I_{\text{ref}}}{I_{S1}}.$$

If $I_{S1} = I_{S2}$ [equal transistor properties]

$$I_1 = I_{\text{ref}}.$$