

$$I_{S1} = 6 \times 10^{-17} \text{ A}$$

$$I_C = I_{S1} e^{V_{BE}/V_T}$$

$$I_C = I_L + I_1$$

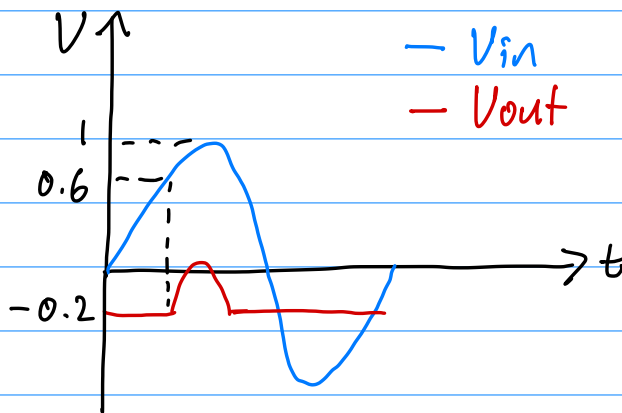
$$I_L = \frac{V_{out}}{R_L}$$

$$\therefore \frac{V_{out}}{R_L} + I_1 = I_{S1} \exp\left(\frac{V_{in} - V_{out}}{V_T}\right)$$

Solve numerically using the symbolic toolbox in Matlab.

When $V_{in} = 1 \text{ V}$, $V_{out} = 0.113 \text{ V}$, $V_{BE} = 0.887 \text{ V}$

When $V_{in} = -1 \text{ V}$, $V_{out} = -0.2 \text{ V}$, $V_{BE} = -0.8 \text{ V}$.



This small integrated transistor has $V_{BE} \approx 0.8 \text{ V}$

\therefore Turn on is when

$$V_{in} \approx -0.2 + 0.8 = 0.6 \text{ V}$$