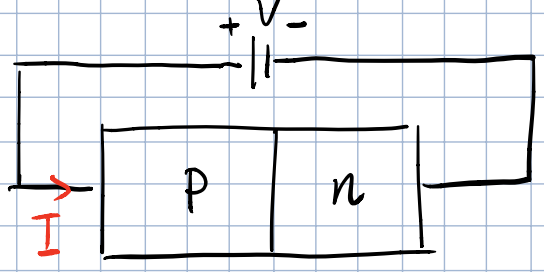
pn junction diodes.



Typical

$$I = I_S\left(e^{V/V_T} - 1\right)$$

thermal voltage. $V_T = \frac{kT}{q}$

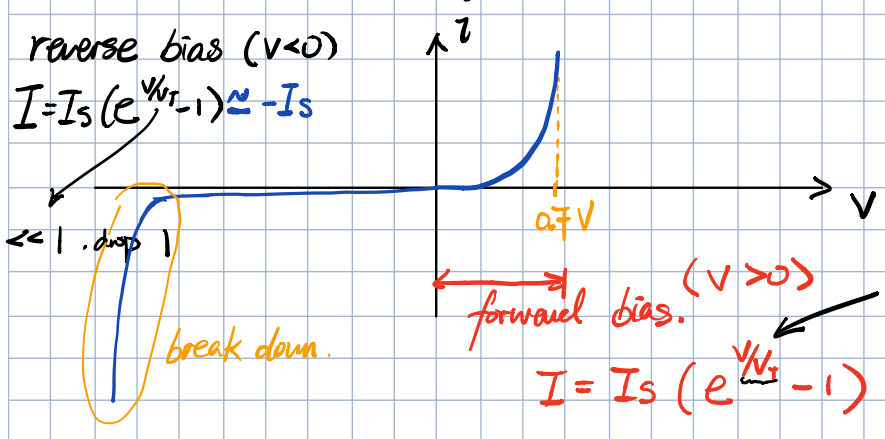
I_S: reverse saturation current (scale current)

$k = 1.38 \times 10^{-23}$ J/k Boltzmann's const.

T = temp. in k.

$q = 1.6 \times 10^{-19}$ C

Typical value for V_T is 25mV (@room temp.)



>> than 1

$$I = I_S\left(e^{V/V_T} - 1\right) \simeq I_S e^{V/V_T}$$

→ Forward bias region $I \simeq I_S e^{V/V_T}$

↑ saturation current proportional to junction area.

Example 1 a silicon diode: 1-mA @ 0.7V forward voltage.

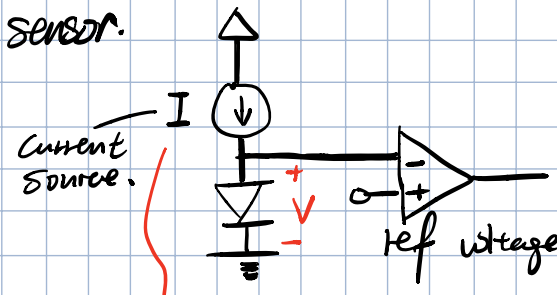
find I_S. What I_S would apply for a 1-A @ 0.7V diode?

$$I = I_S e^{V/V_T} \Rightarrow 1\times10^{-3} = I_S e^{0.7/25},\quad I_S = 6.9\times10^{-16}\,A$$

for 1A diode, $I_S = 6.9\times10^{-13}\,A$ (1-mA to 1-A $\times 1000$)

② I_S is also temp sensitive: double the voltage / 5° rise in temp.

Example 2 temp sensor.

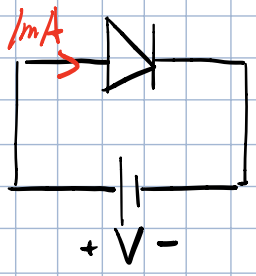


$$I = I_S e^{V/V_T}$$

$$\frac{I}{I_S} = e^{V/V_T} \Rightarrow \ln\frac{I}{I_S} = V/V_T,\quad V = V_T \ln\frac{I}{I_S}$$

detect ↑ ↑ inc. with temp.

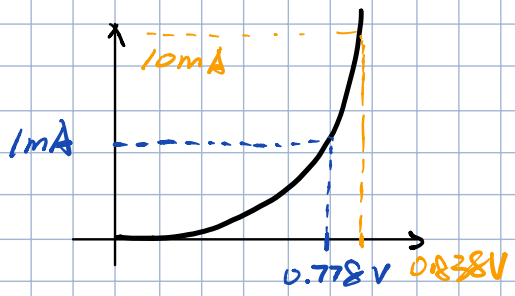
Example 3



Given $I_S = 10^{-16}A$, the forward bias is 1mA

a) What voltage is applied to the diode?

$$V = V_T \ln\frac{I}{I_S} = (25\,mV)\ln\frac{1mA}{10^{-16}A} = 0.778\,V$$



b) How much should the voltage increase to raise the current by a factor of 10?

$$V_1 = V_T \ln\frac{I_1}{I_S} \qquad V_2 = V_T \ln\frac{I_2}{I_S}$$

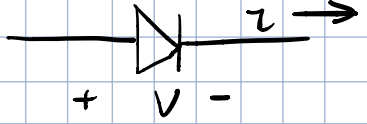
$$V_2 - V_1 = V_T \ln\frac{I_2}{I_1}$$

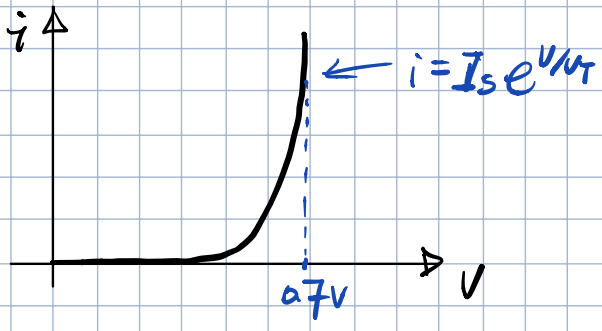
$$V_2 - V_1 = V_T \ln\frac{10I_1}{I_1} = 60mV$$

$$V_2 = 60mV + 0.778V$$

$$V_2 = 0.838V$$

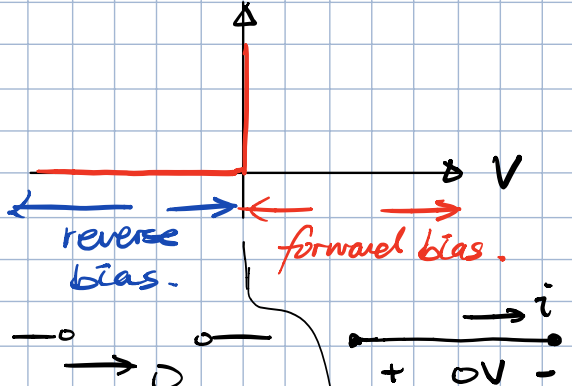
→ pn junction diode model (forward bias region)





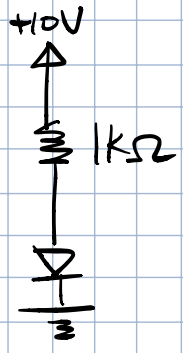
Ideal diode, Simple diode circuits.

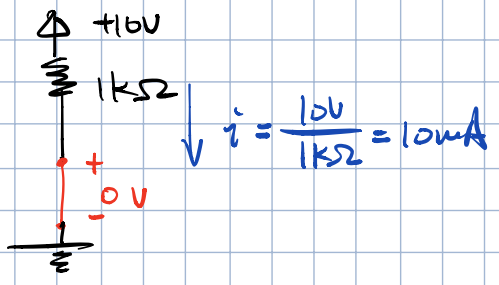
ideal diode model.

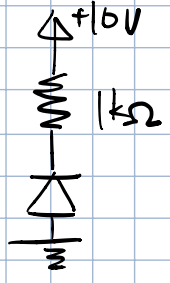


diode is OFF | diode is ON

take a guess. diode is ON







Guess diode is OFF