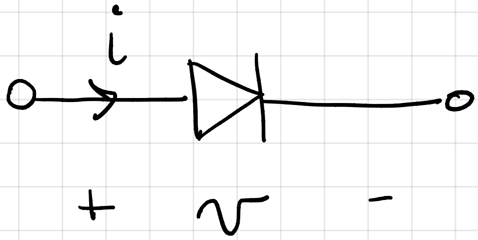
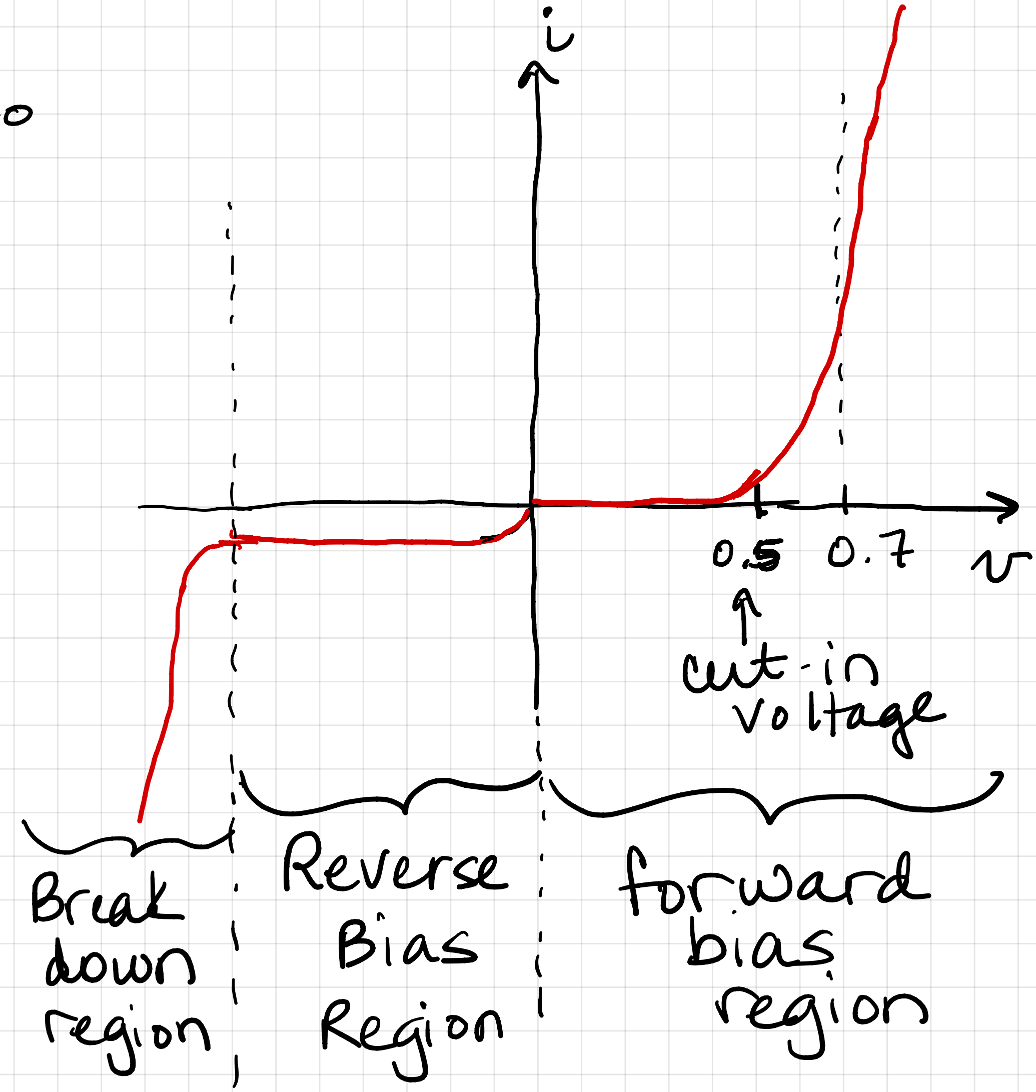




Forward Bias

$$i = I_S \left(\exp\left(\frac{v}{nV_T}\right) - 1 \right)$$

I_S = saturation current

or "scale" current

$\cong 10^{-14} - 10^{-16}$ A

highly dependent on temperature

$n \equiv$ process parameter

$1 \leq n \leq 2$ $\boxed{n = 1}$

$V_T \equiv$ thermal voltage

$$V_T = \frac{kT}{q}$$

$k \equiv$ Boltzman's constant $= 8.62 \times 10^{-5}\ \frac{eV}{K}$

$T =$ operating temp in Kelvin

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

$V_T = 0.025\,V$

$$\boxed{V_T = 25\,mV}$$

↑ at room temp

since $i \gg I_S$

$$\boxed{i \cong I_S \exp\left(\frac{v}{nV_T}\right) \quad n = 1 \quad V_T = 25\,mV}$$

$$I_1 = I_S \exp\left(\frac{V_1}{V_T}\right)$$

$$I_2 = I_S \exp\left(V_2/V_T\right)$$

$$\frac{I_2}{I_1} = \frac{\cancel{I_S} \exp\left(V_2/V_T\right)}{\cancel{I_S} \exp\left(V_1/V_T\right)}$$

$$\frac{I_2}{I_1} = \exp\left(\frac{V_2}{V_T} - \frac{V_1}{V_T}\right)$$

$$\frac{I_2}{I_1} = \exp\left(\frac{V_2 - V_1}{T}\right)$$

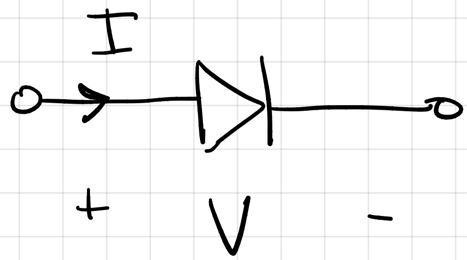
(I_1, V_1) what I_2 is for V_2?
use ratio relationship
to determine I_2

$$V_2 - V_1 = V_T \ln\left(\frac{I_2}{I_1}\right)$$

Given a diode operating
in forward bias region
$V_T = 25mV$

at 0.7V, the current is 1mA

at 0.75V, what is the new
current?



$V_1 = 0.7V \quad I_1 = 1mA$

$V_2 = 0.75V \quad I_2 = ?$

$$\frac{I_2}{I_1} = \exp\left(\frac{V_2 - V_1}{V_T}\right)$$

$$I_2 = I_1 \cdot \exp\left(\frac{V_2 - V_1}{V_T}\right)$$

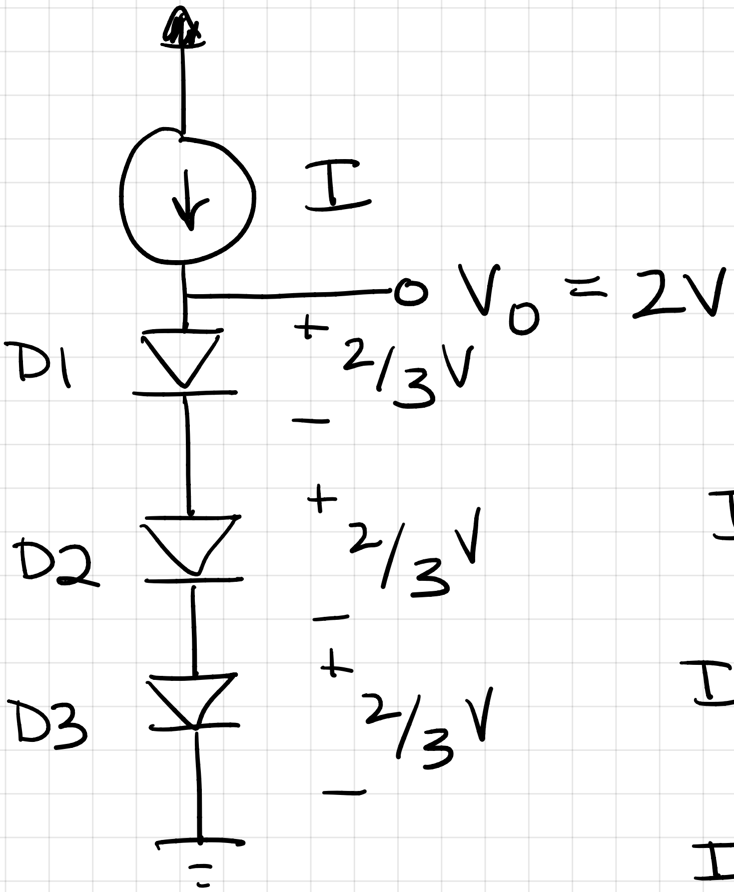
$$I_2 = 1\times10^{-3} \cdot \exp\left(\frac{.75 - .7}{.025}\right)$$

$$= 7.39mA$$

(I, V)

$(1mA, 0.7V)$

$(7.39mA, 0.75)$



Diodes are identical

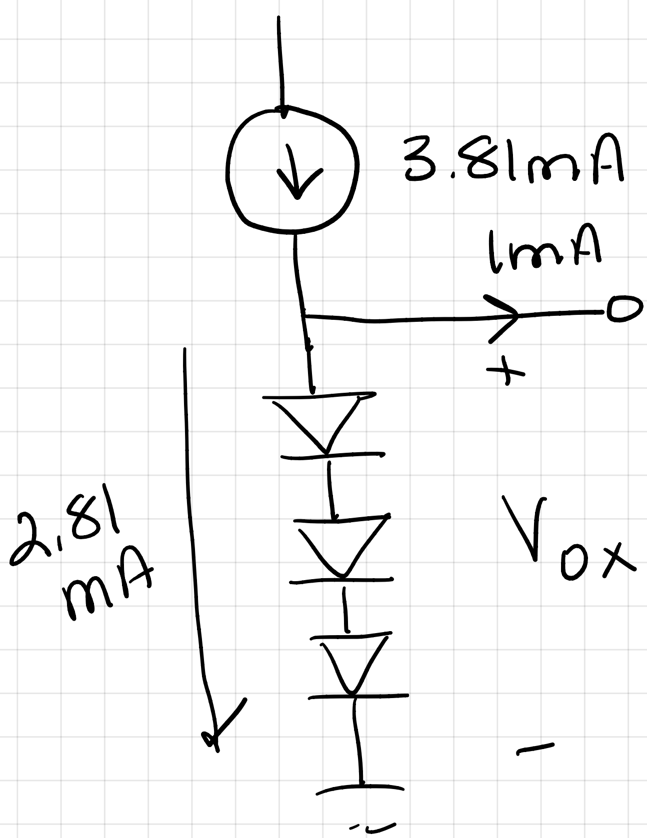
$I_S = 10^{-14}A$

What is I ?

$$I = I_S \exp\left(\frac{V}{V_T}\right)$$

$$I = 10^{-14} \exp\left(\frac{2/3}{.025}\right)$$

$$I = 3.81 \text{ mA}$$



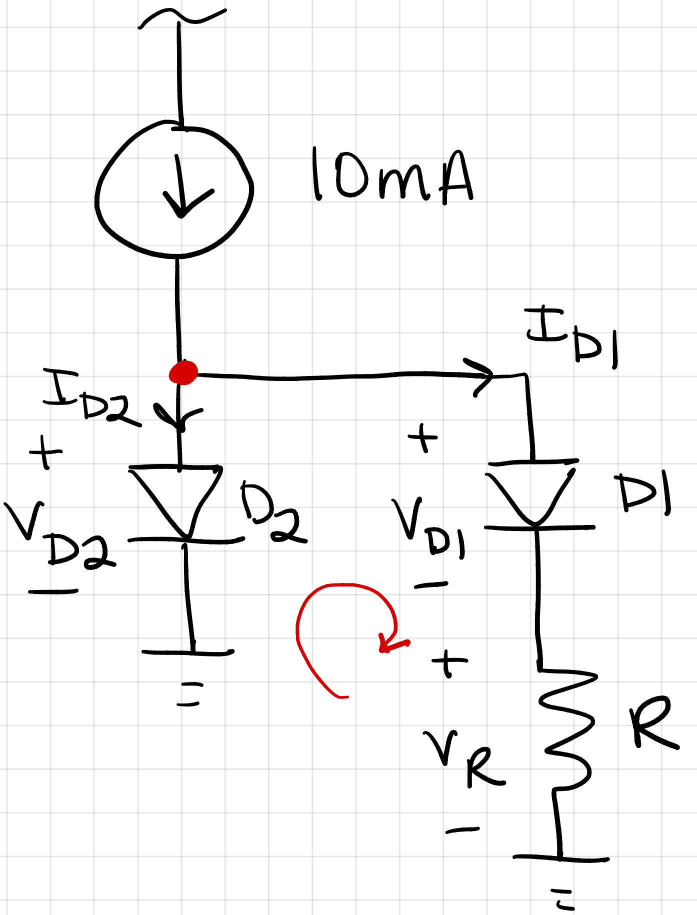
what is the change in the output voltage

$$V_2 - V_1 = V_T \ln\left(\frac{I_2}{I_1}\right)$$

$$\Delta V_o = V_2 - V_1$$

$$\Delta V_o = 0.025 \ln\left(\frac{2.81}{3.81}\right)$$

$$\Delta V_o = -22.58 \text{mV}$$



Diodes are matched|identical and operating in forward bias region.

Design R such that

$V_R = 50mV$

$V_T = 25mV$

$n = 1$

by KVL:

$$V_{D2} - V_{D1} - V_R = 0$$

$$V_R = V_{D2} - V_{D1} = 50mV$$

by KCL $\quad I_{D1} + I_{D2} = 10mA$

$$V_R = I_{D1}(R)$$

$$\frac{I_{D2}}{I_{D1}} = \exp\left(\frac{V_{D2} - V_{D1}}{V_T}\right)$$

$$\frac{I_{D2}}{I_{D1}} = \exp\left(\frac{.05}{.025}\right)$$

$$\boxed{\frac{I_{D2}}{I_{D1}} = 7.39}$$

$$I_{D2} = 7.39 I_{D1}$$

$$I_{D1} + 7.39 I_{D1} = 10mA$$

$$8.39 I_{D1} = 10mA$$

$$I_{D1} = 1.19mA$$

$$R = \frac{V_R}{I_{D1}} = \frac{0.05}{1.19 \times 10^{-3}}$$

$$\boxed{R = 42.02\,\Omega}$$