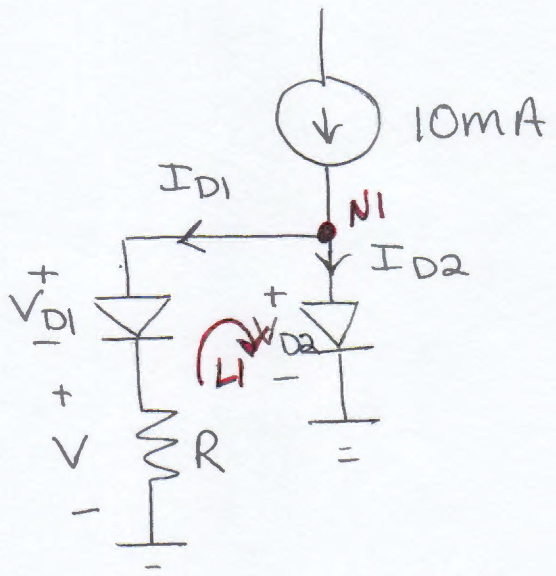
Problem Set #6 - Solutions

(1)



by KVL at loop 1

$$V + V_{D1} - V_{D2} = 0$$

$$V_{D2} - V_{D1} = V$$

$$\boxed{V_{D2} - V_{D1} = 0.08\,V}$$

by KCL at N1

$$\boxed{I_{D1} + I_{D2} = 0.01}$$

$V = 80mV \;/\; R = \dfrac{V}{I_{D1}}$

current ratio $\left\{ \dfrac{I_{D2}}{I_{D1}} = \exp\left(\dfrac{V_{D2}-V_{D1}}{V_T}\right) \right.$

$$\frac{I_{D2}}{I_{D1}} = \exp\left(\frac{0.08}{0.025}\right) = 24.53$$

$$\boxed{I_{D2} = 24.53\, I_{D1}}$$

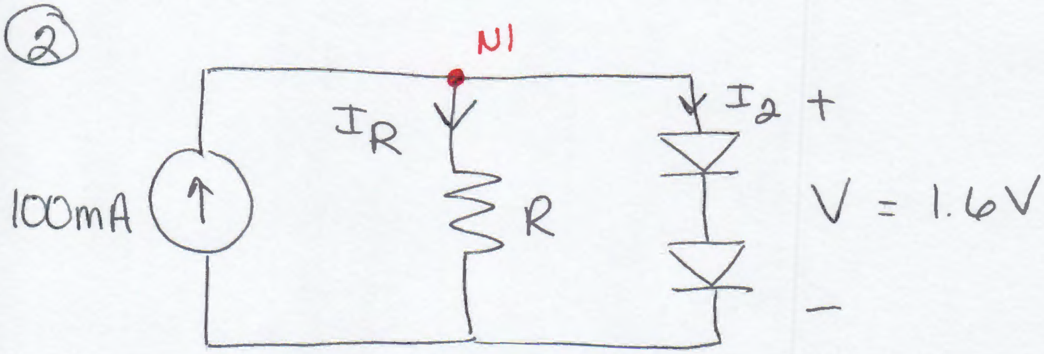
$$I_{D1} + 24.53\, I_{D1} = 0.01$$

$$\boxed{I_{D1} = 0.392\ mA}$$

$$R = \frac{V}{I_{D1}}$$

$$\boxed{R = 204.26\,\Omega}$$

(2)



$I_1 = 1mA$ $\quad$ $I_2 = ?$

$V_1 = 0.7V$ $\quad$ $V_2 = \frac{1.6}{2} = 0.8V$

$$\frac{I_2}{I_1} = \exp\left(\frac{0.8-0.7}{.025}\right) = 54.6$$

$\boxed{I_2 = 54.6\text{ mA}}$ => current through diodes for V=1.6V

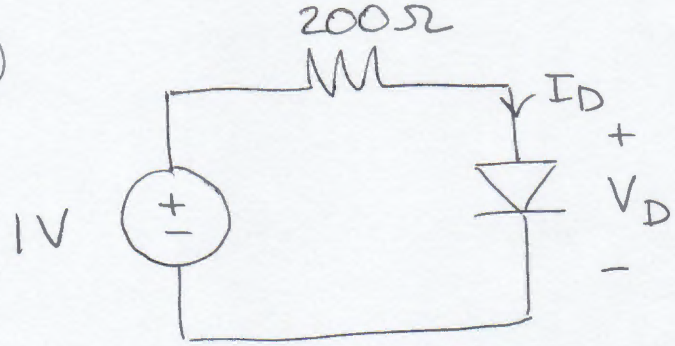
$R = \frac{V}{I_R}$ $\quad$ by KCL @ N1 : $100 = I_R + I_2$

$I_R = 45.4\text{mA}$

$$R = \frac{1.6}{45.4\times10^{-3}}$$

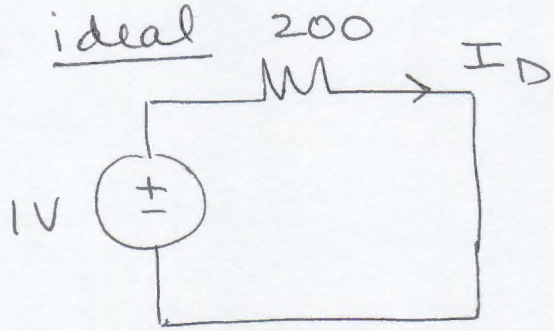
$$\boxed{R = 35.24\,\Omega}$$

3



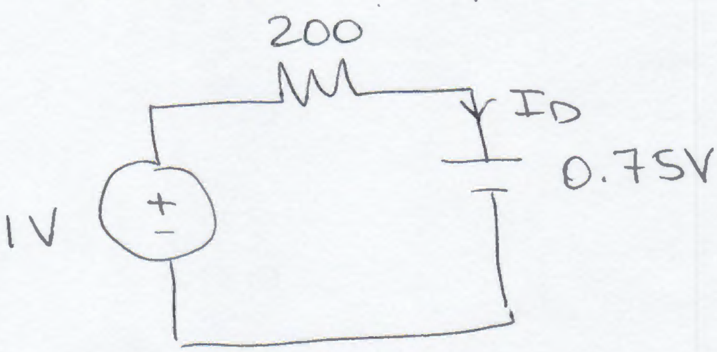
diode: 0.7V for 1mA

a) ideal



$$I_D = \frac{1}{200} = 5\,mA$$

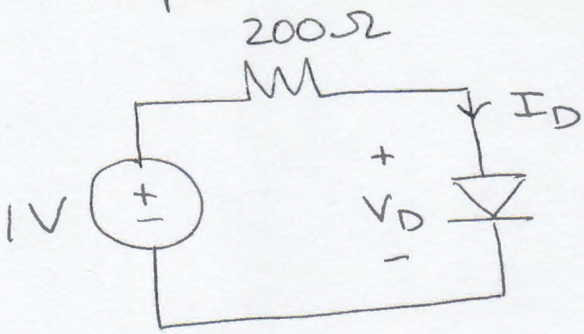
b) constant drop



$$I_D = \frac{1 - 0.75}{200}$$

$$= 1.25\,mA$$

c) exponential model



① use $V_D = 0.7mA$ in Ohm's Law

$$I_D = \frac{1 - 0.7}{200} = 1.5\,mA$$

(not close enough to 1mA)

3c continued

(2) use diode ratio

$I_1 = 1mA$ $I_2 = 1.5mA$

$V_1 = 0.7V$ $V_2 = ?$

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

$$V_2 = 0.7 + 0.025 \ln\left(\frac{1.5}{1}\right)$$

$$V_2 = 0.710\,V$$

(still not close enough)

(3) Back to Ohm's Law

$$I_D = \frac{1 - 0.71}{200} = 1.45mA$$

(4) Back to diode ratio

$$V_3 - V_2 = V_T \ln\left(\frac{I_3}{I_2}\right) = 0.025 \ln\left(\frac{1.45}{1.5}\right)$$

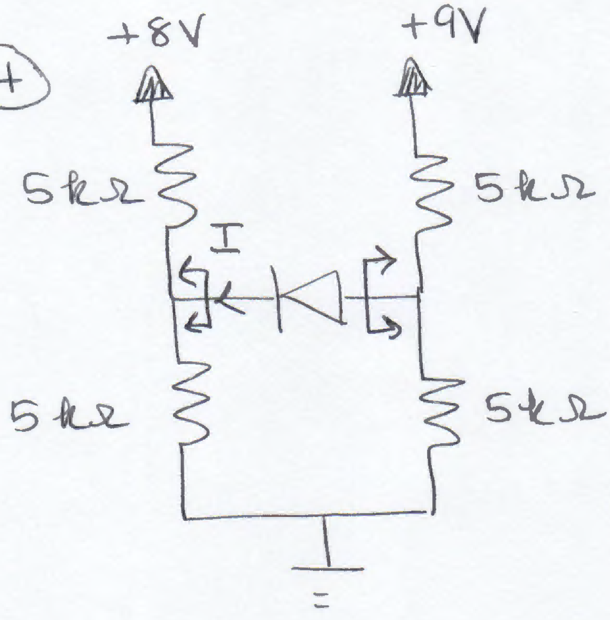
$$V_3 = 0.71 + 0.025\left(\ln\left(\frac{1.45}{1.5}\right)\right) = 0.709\,V$$

(5) Ohm's Law

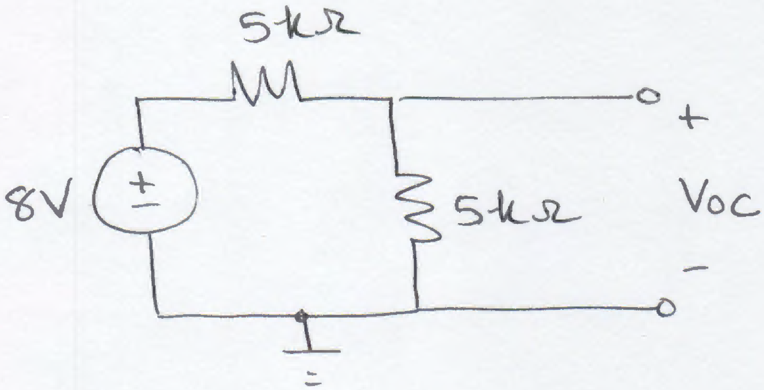
$$I_D = \frac{1 - 0.709}{200} = 1.45mA$$ => matches previous values

$$\boxed{I_D = 1.45\,mA}$$

(4)

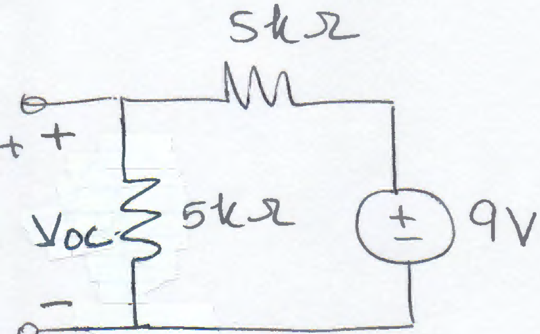


find Thev. Eq ckt on each side.



$$V_{OC} = 8\left(\frac{5}{10}\right) = 4V$$

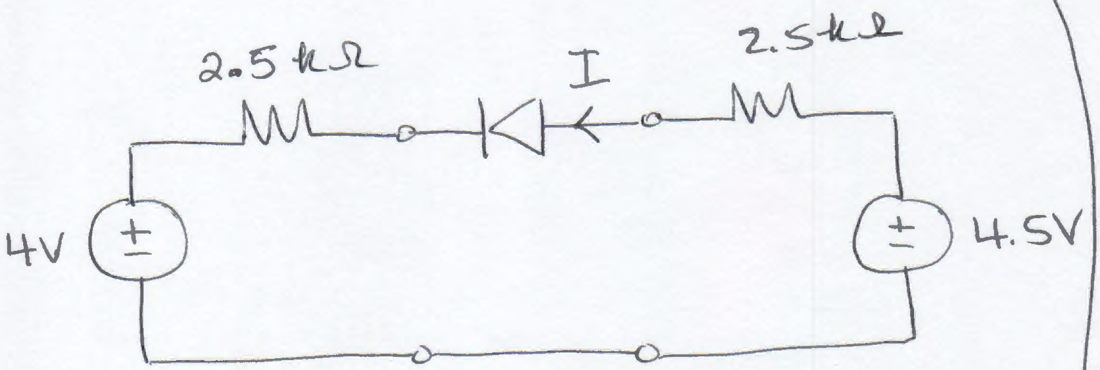
$$R_{TH} = 5 \| 5 = 2.5k\Omega$$



$$V_{OC} = 9\left(\frac{5}{10}\right) = 4.5V$$

$$R_{TH} = 5 \| 5 = 2.5k\Omega$$

redraw



a) Ideal

$$I = \frac{4.5 - 4}{5k} = 0.1mA$$

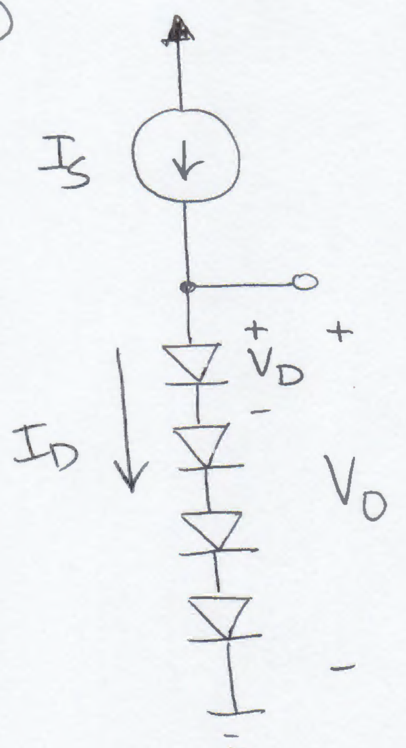
b) constant drop 0.7V

$$I = \frac{4.5 - 0.7 - 4}{5k\Omega}$$

$$= -0.04mA$$

diode is cut off for constant drop

(5)



$I_S = 1\times10^{-16}$ A

$V_O = 2.8$ V

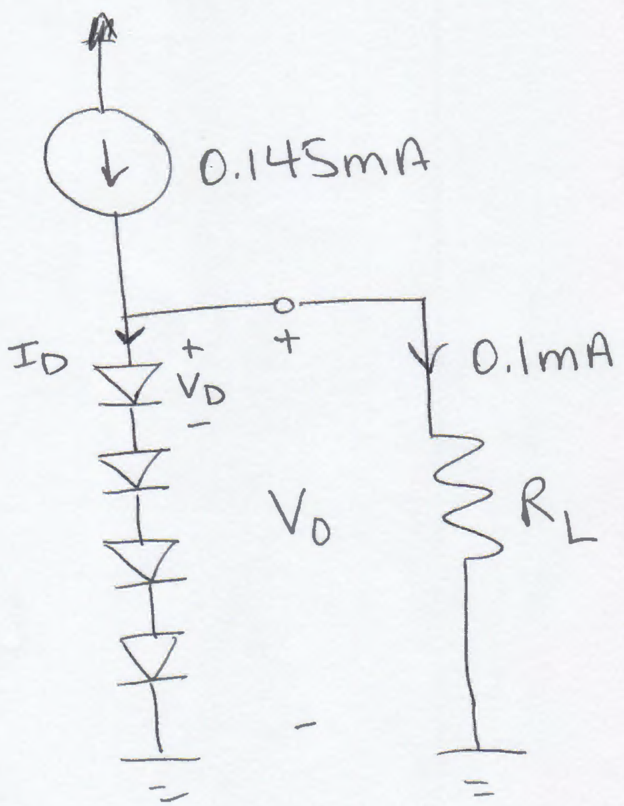
$\frac{V_O}{4} = 0.7$ V $\quad \boxed{V_D = 0.7V}$

$I_D = I_S \exp\left(\frac{V_D}{V_T}\right)$

$\boxed{I_D = 0.145 \text{ mA}}$

$I_S = I_D = 0.145$ mA

By KCL



by KCL

$0.145 = I_D + 0.1$

$I_D = 0.045$ mA

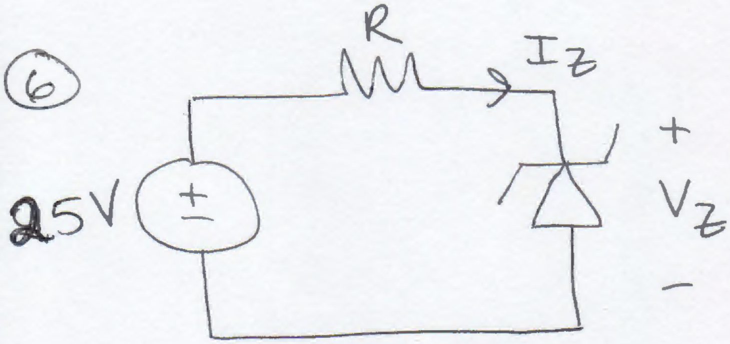
$V_D = V_T \ln\left(\frac{I_D}{I_S}\right)$

$\boxed{V_D = 0.671V}$

$V_O = 4V_D = 2.68$ V

$\Delta V_O = 2.68 - 2.8 = -0.12$ V

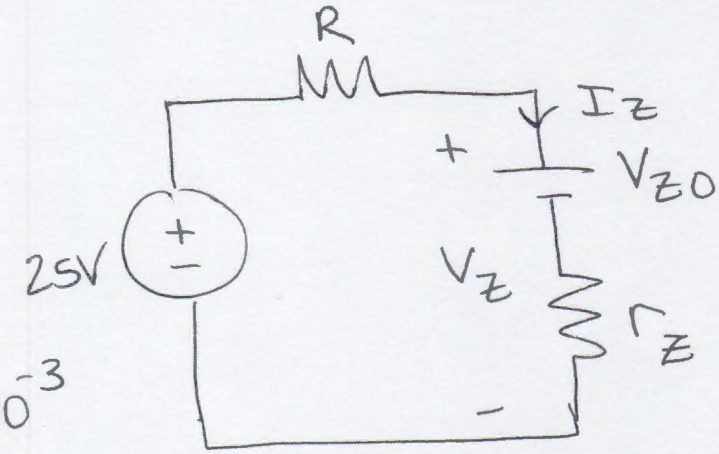
6



$$V_Z = I_Z r_Z + V_{ZO}$$

$$9.1 = (0.003)(25) + V_{ZO}$$

$$\boxed{V_{ZO} = 9.025V}$$



$$I_Z = \frac{25 - V_{ZO}}{R + r_Z}$$

$$I_Z = \frac{25 - 9.025}{R + 25} = 5 \times 10^{-3}$$

$$R = 3.17\,k\Omega$$