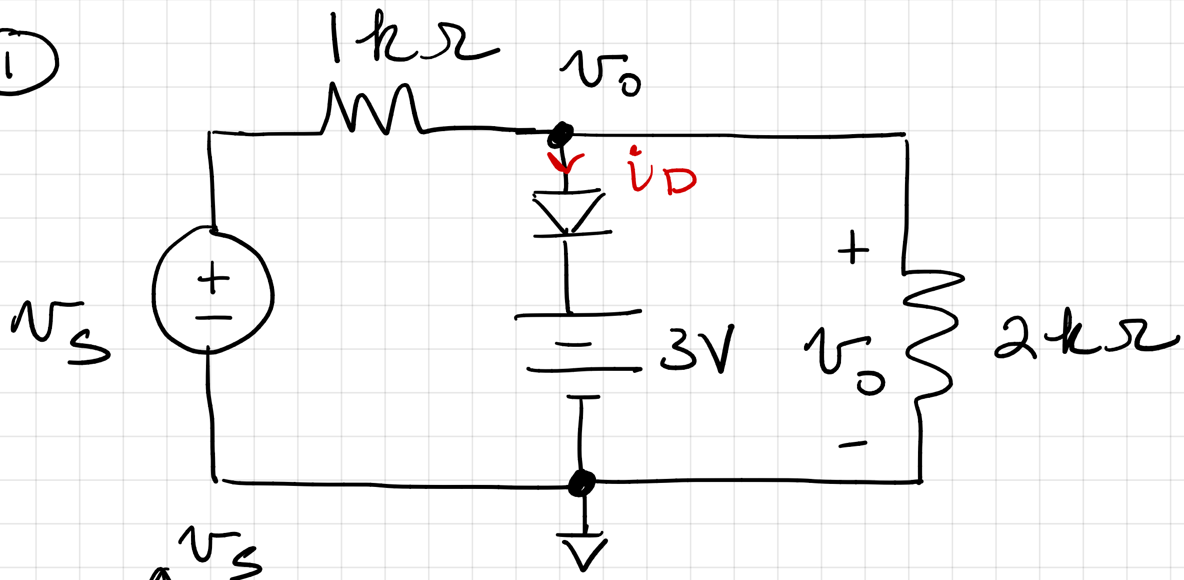
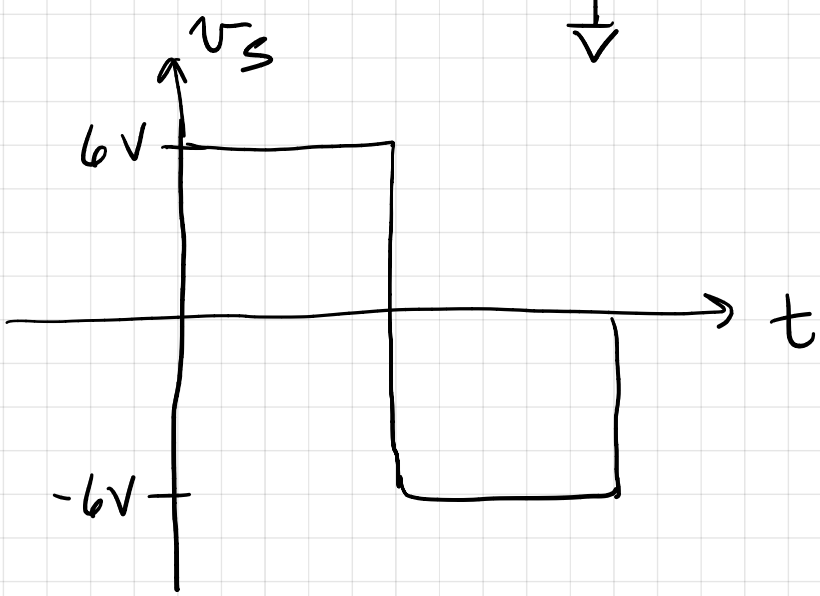
EE 315

Homework #3 – Solutions

(1)





by nodal analysis:

$$\frac{v_o - v_s}{1000} + i_D + \frac{v_o}{2000} = 0$$

$$i_D = \frac{v_s}{1000} - \left(\frac{v_o}{1000} + \frac{v_o}{2000}\right)$$

$$i_D = \frac{v_s}{1000} - \frac{v_o(1.5)}{1000}$$

$$i_D = v_S - 1.5\, v_O \quad (mA)$$

if diode is on : $i_D > 0$

$v_O = 3V$

there are two values of v_S :

$v_S = +6V$ and $v_S = -6V$

for $v_S = 6V \Rightarrow$ assume diode on

$v_O = 3V$, $i_D = 6 - 1.5(3)$

$i_D = 1.5mA$

yay! diode is on

for $v_S = -6V \Rightarrow$ assume diode on

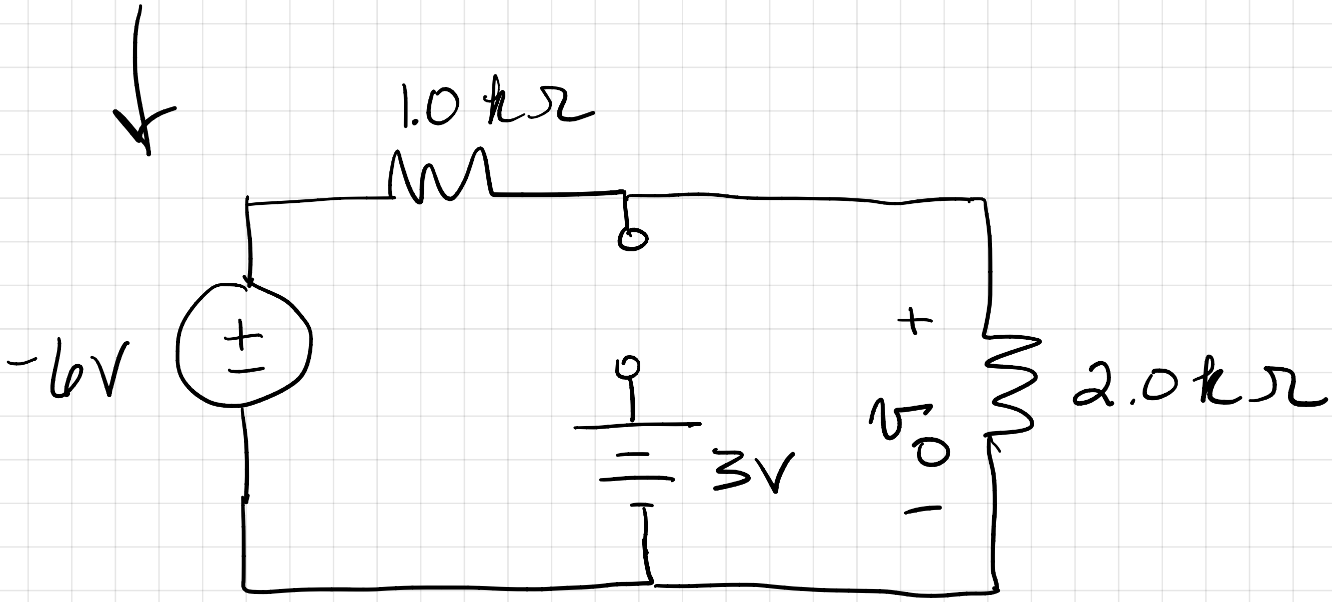
$v_O = 3V$; $i_D = -6 - 1.5(3)$

$= -10.5mA$

$i_D < 0$

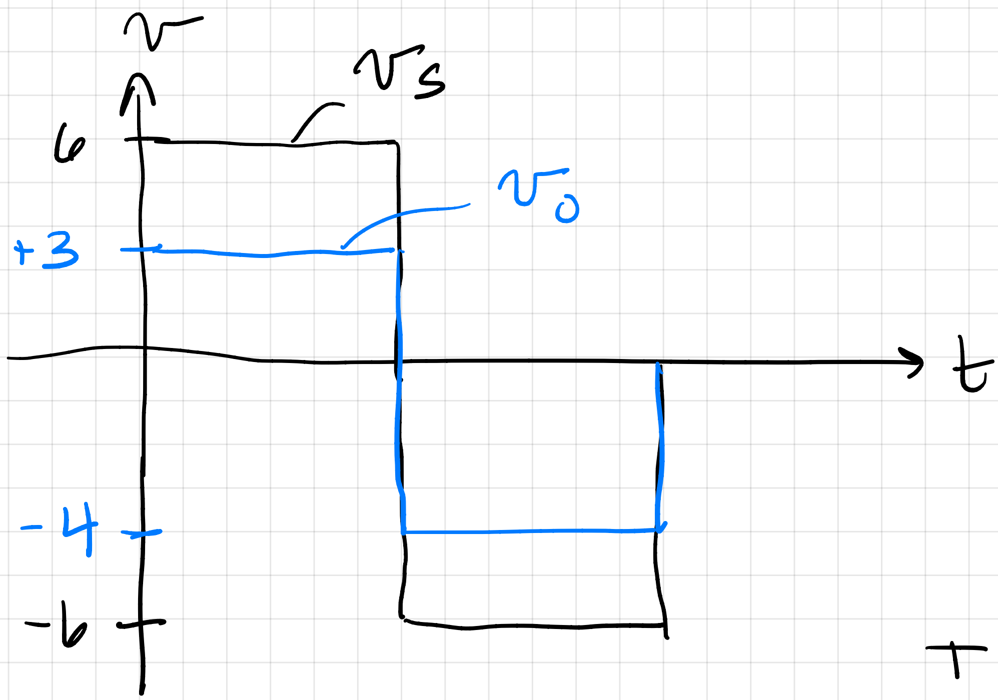
Diode is off!

when the diode is off



by voltage division

$$v_o = -6\left(\frac{2}{3}\right) = -4V$$



$$\text{Average value} = \frac{1}{T}\int_0^T v_o(t)\,dt$$

$$V_0 = \frac{1}{T}\left[\int_0^{T/2} 3\,dt + \int_{T/2}^{T} -4\,dt\right]$$

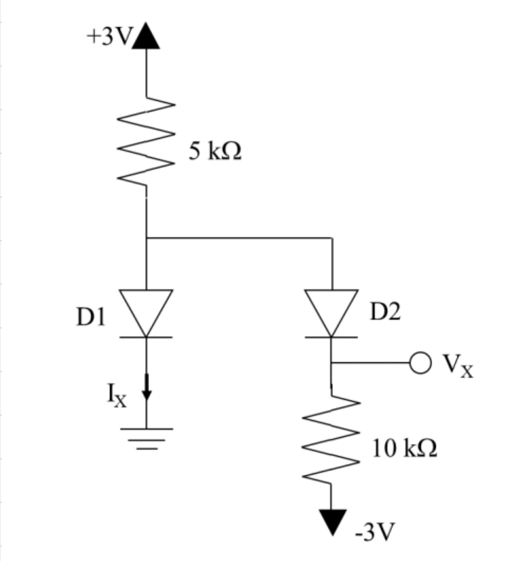
$$= \frac{1}{T}\left[3t \Big|_0^{T/2} + (-4t)\Big|_{T/2}^{T} \right]$$

$$= \frac{1}{T}\left(\frac{3T}{2} + \left(-4T + 2T\right)\right)$$

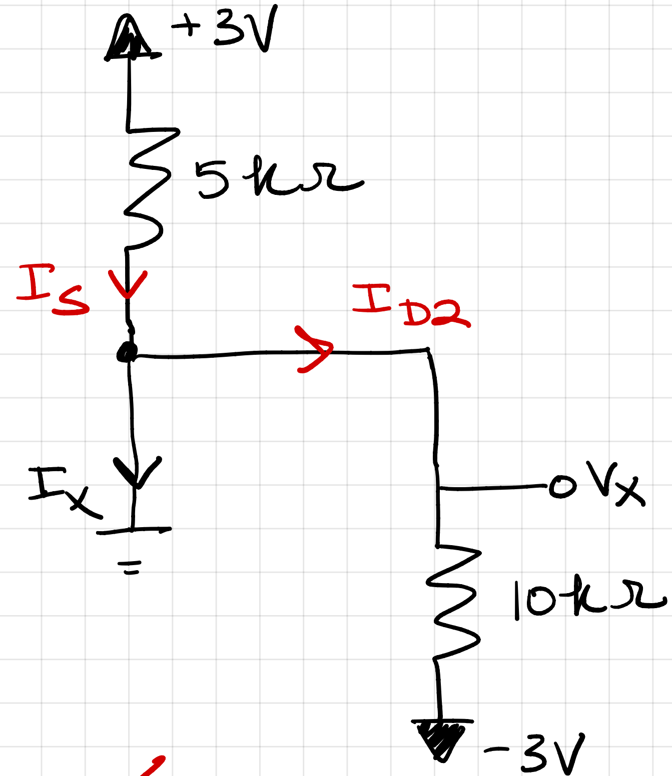
$$= \frac{1}{T}\left(-\frac{T}{2} \right)$$

$$\boxed{V_0 = -0.5\ V}$$

2)



Assume both diodes are on.



I_X & $I_{D2} > 0$

$$\boxed{V_X = 0\,V}$$

$$I_{D2} = \frac{0-(-3)}{10} = 0.3\,mA \checkmark$$

$$I_S = \frac{3-0}{5} = 0.6\,mA$$

by KCL: $I_X = I_S - I_{D2}$

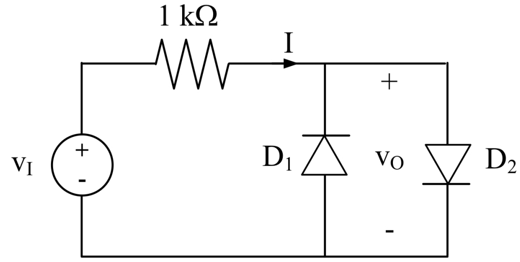
$$= 0.6 - 0.3$$

$$\boxed{I_X = 0.3\,mA} \checkmark$$

3

▼ -3V

3. For the following circuit, $v_I = 10\cos(t)$ volts. Assume ideal diodes.
   a. For what values of v_I is diode 1 on?
   b. For what values of v_I is diode 2 on?
   c. What is the peak current value, I (magnitude only required).
   d. Plot the voltages, v_I and v_O.



a) D1 is on when $v_I < 0$

$I < 0$

$I = -10\text{mA}$

$v_o = 0V$

b) D2 is on when $v_I > 0$

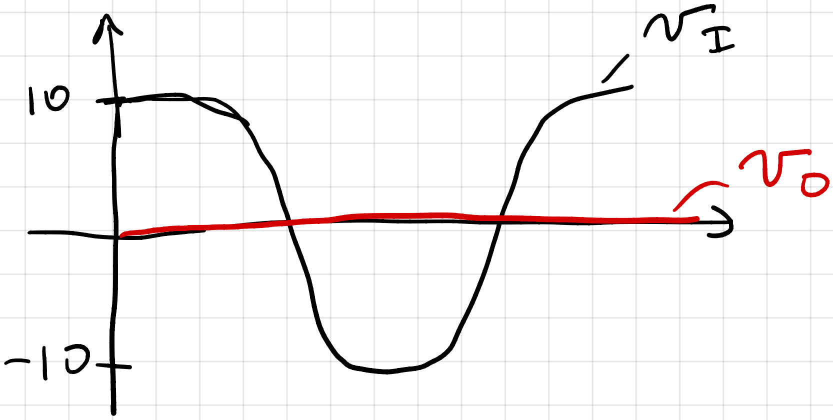
$I > 0$

$I = +10\text{mA}$

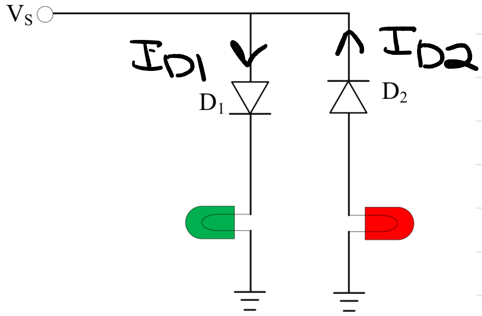
$v_o = 0V$

c) peak current is $\frac{10}{1000} = 10\text{mA}$

d)



4. Consider the following circuit. The voltage, V_S, can be either +3V, 0V, or -3V. The LED lights require +3 volts dropped across them in order to light up. Assume ideal diodes.



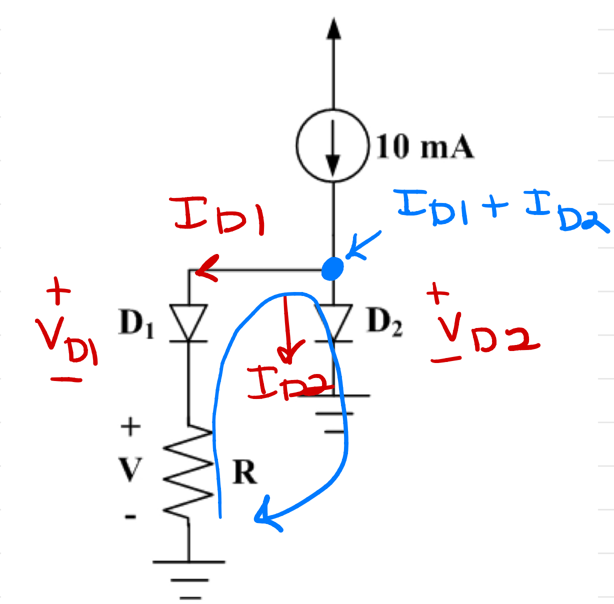
a. What does V_S need to be for the green light (only) to be on?
b. What does V_S need to be for the red light (only) to be on?
c. Can both lights be on simultaneously?

a) $V_S = 3V$

b) $V_S = -3V$

c) no if $V_S = 0$, no current will flow.

⑤



by KVL

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

$$V_{D2} - V_{D1} = V$$
$$= 80mV$$

$V = 80mV$

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

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

$$\frac{I_{D2}}{I_{D1}} = \exp\left(\frac{80}{25}\right)$$

$$R = \frac{80}{0.392}$$

$$\boxed{R = 204.24\ \Omega}$$

$$\frac{I_{D2}}{I_{D1}} = 24.53$$

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

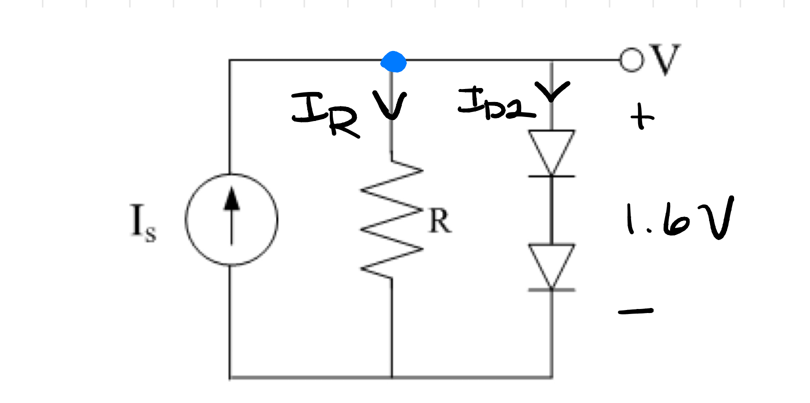
$$I_{D1} + I_{D2} = 10$$

$$25.53\, I_{D1} = 10$$

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

6

$$I_R = I_s - I_{D2}$$



$V = 1.6\text{V}$

$I_s = 100\text{mA}$

for $V_D = 0.7\text{V}$

$I_D = 1\text{mA}$

diodes are identical, so each diode will provide $\frac{1.6}{2} = 0.8\text{V}$

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

$$= (1) \exp\left(\frac{0.8 - 0.7}{25 \times 10^{-3}}\right) \text{ (mA)}$$

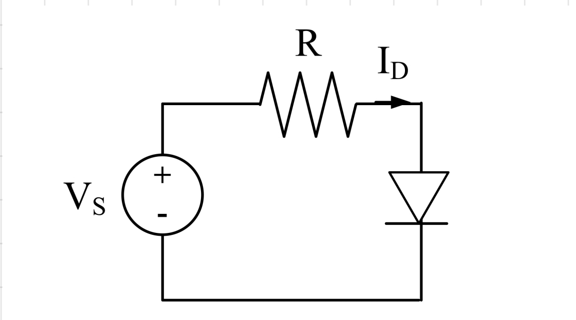
$$I_{D2} = 54.6\text{mA}$$

$$I_R = (100 - 54.6) = 45.4\,mA$$

$$R = \frac{1.6}{45.4 \times 10^{-3}}$$

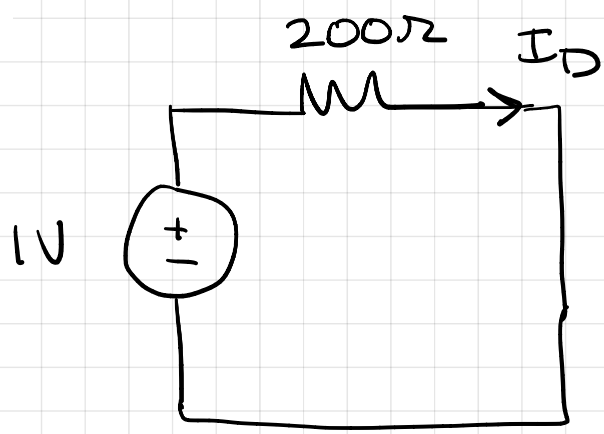
$$\boxed{R = 35.24\,\Omega}$$

7



a) ideal

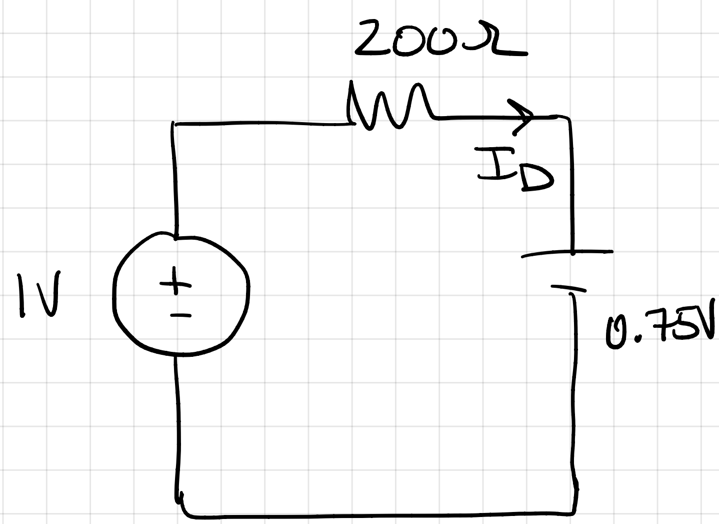
$$I_D = \frac{1}{200} = 5\,mA$$



b) constant drop

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

$$\boxed{I_D = 1.25\,mA}$$



c) let $V_{D_1} = 0.7\,V$

$$I_{D_2} = \frac{1-0.7}{200} = 1.5\,mA$$

$$(I_1, V_1) = (1\,mA, 0.7V)$$

$$(I_2, V_2) = (1.5\,mA, 0.71V) \quad V_2 = V_1 + V_T \ln\left(\frac{I_2}{I_1}\right) = 0.71V$$

$$I_{D3} = \frac{1-0.71}{200} = 1.45\,mA$$

$$V_{D3} = V_{D2} + V_T \ln\left(\frac{I_{D3}}{I_{D2}}\right)$$

$$= 0.709\,V$$

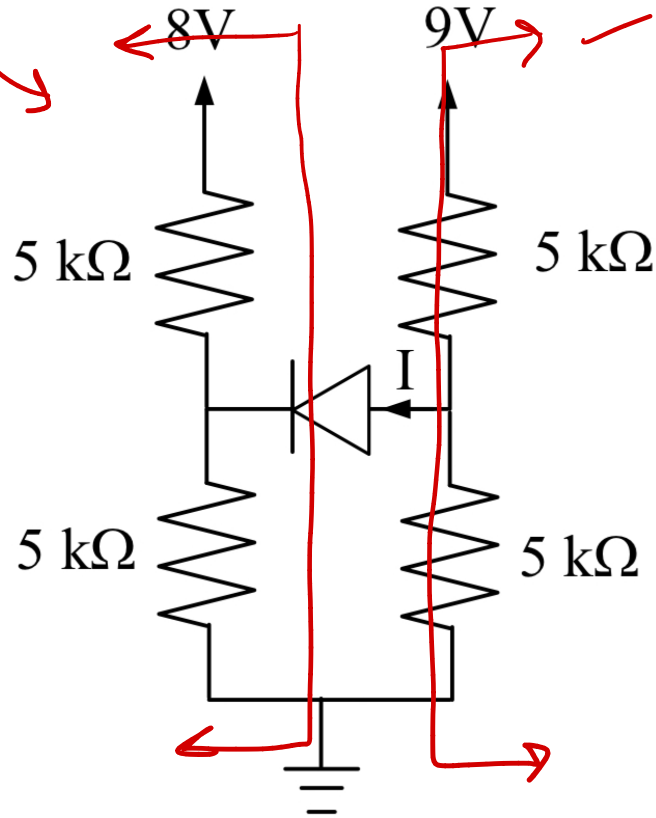
$$I_{D4} = \frac{1-0.709}{200} = 1.45\,mA$$

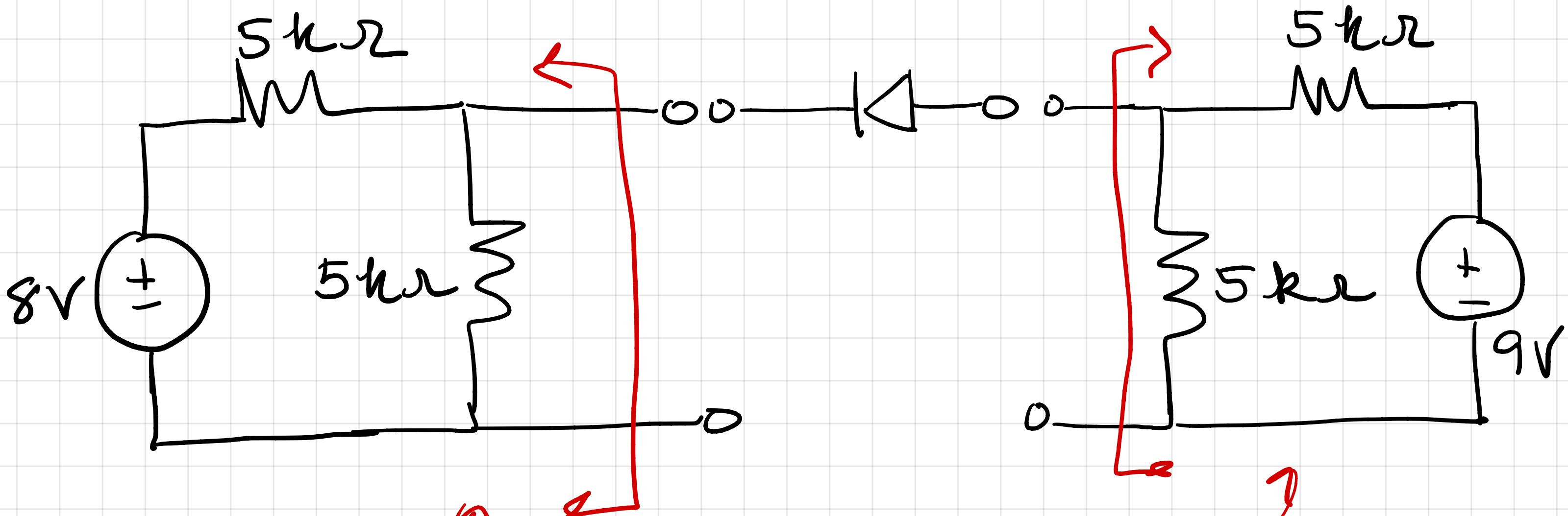
$$\boxed{I_D = 1.45\,mA}$$

8

thev. ckt

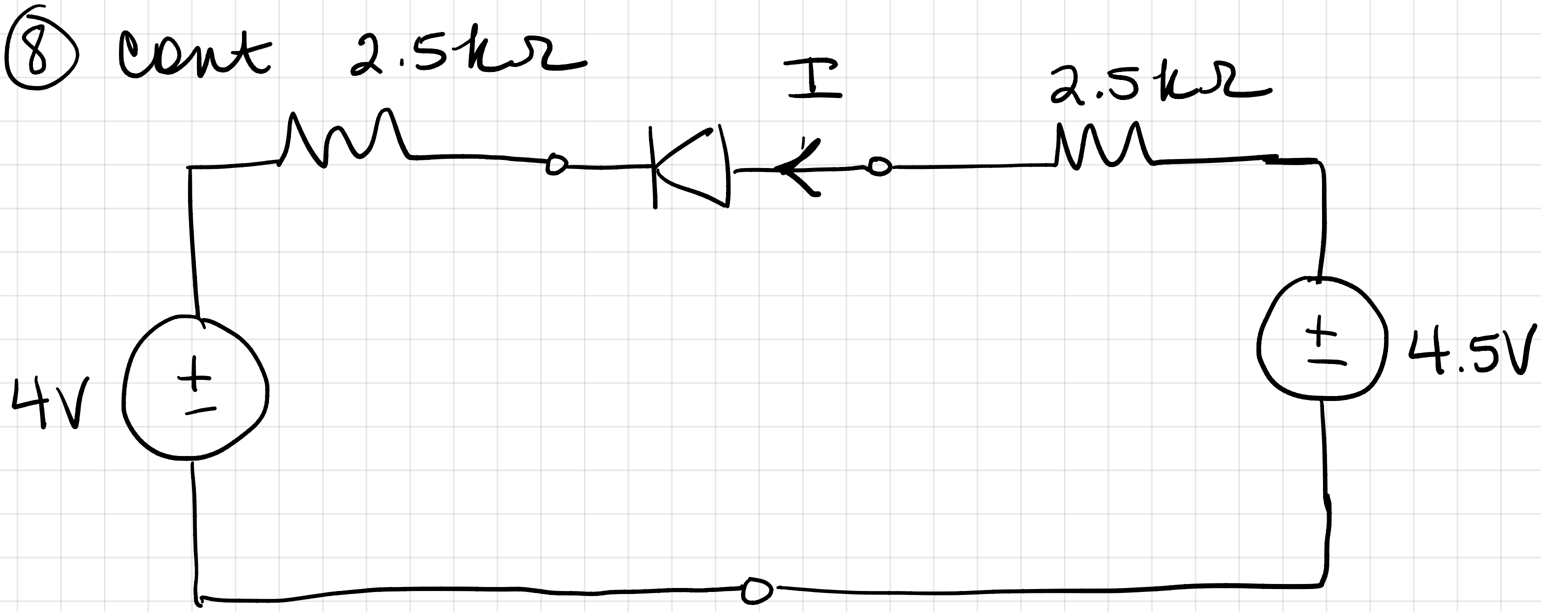
thev. ckt





find
Thev equivalent
ckts

⑧ cont



a) ideal

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

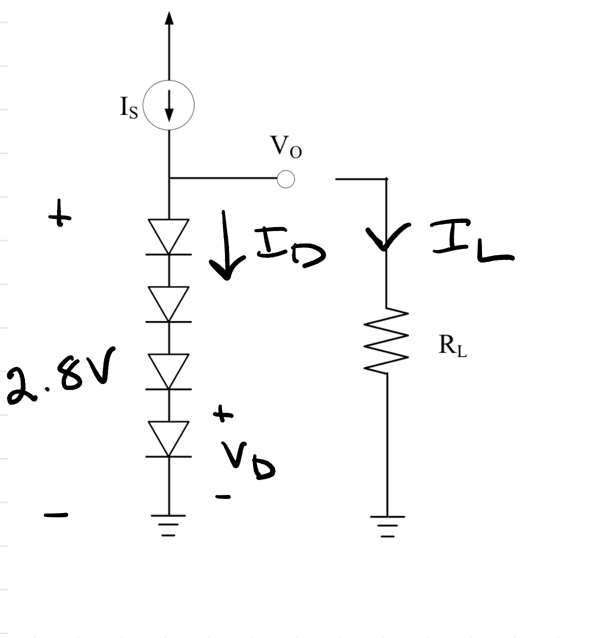
b) constant drop

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

$$I = -0.04\,mA$$

current is negative
diode is off
I = 0 !

(9)



sat current 10^{-16} A

$I_S = ?$ for $V_o = 2.8V$

diodes identical.

each diode has $\frac{2.8}{4}$ V or 0.7 V

$$I_D = (10^{-16})(\exp(.7/.025))$$

$$I_D = 0.145\,mA \quad \text{(no load)}$$

If $\quad I_L = .1mA$

$$I_D = I_S - I_L = .145 - 0.1$$

$$I_D = 0.045\,mA$$

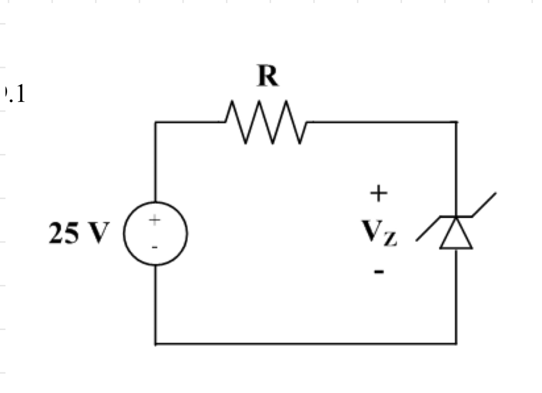
$$V_D = V_T \ln\left(\frac{I_D}{10^{-16}}\right)$$

$$= 0.025 \ln\left(\frac{.045 \times 10^{-3}}{10^{-16}}\right)$$

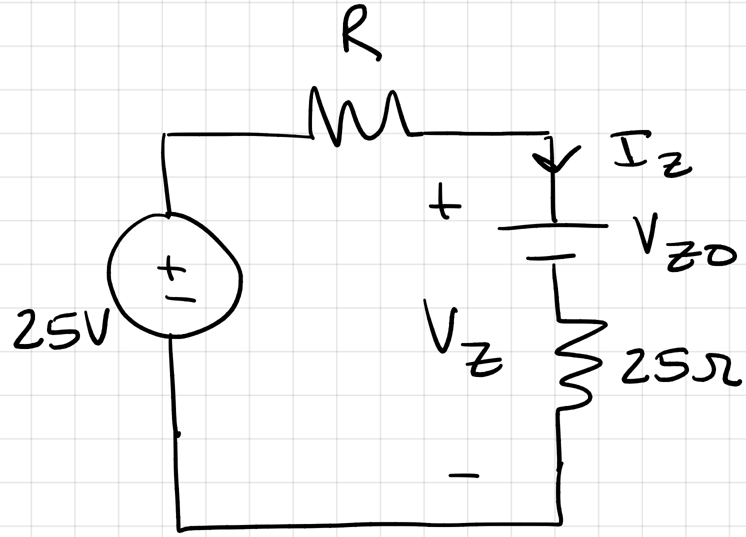
$V_D = 0.671\,V \qquad V_o = 4V_D = 2.68V$

$$\boxed{\Delta V_o = 2.68 - 2.8 = -0.12V}$$

10



$\Rightarrow$



$V_Z = 9.1V$

$I_Z = 3mA$

$V_{Z0} = V_Z - I_Z r_Z$

$= 9.1 - (.003)(25)$

$V_{Z0} = 9.025V$

for $I_Z = 5mA$

$V_Z = V_{Z0} + I_Z r_Z$

$V_Z = 9.025 + (.005)(25)$

$\boxed{V_Z = 9.15\,V}$

$$R = \frac{25 - V_Z}{I_Z}$$

$$R = \frac{25 - 9.15}{5 \times 10^{-3}}$$

$$\boxed{R = 3.17\,k\Omega}$$