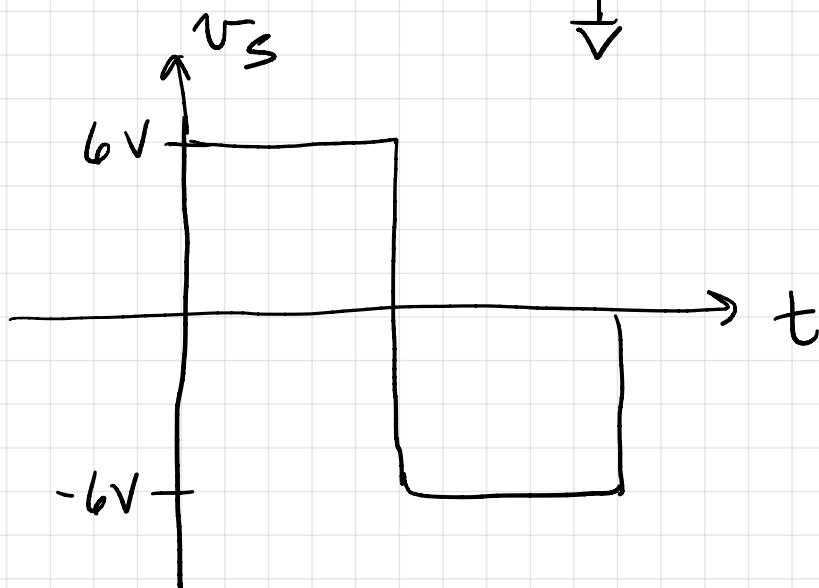
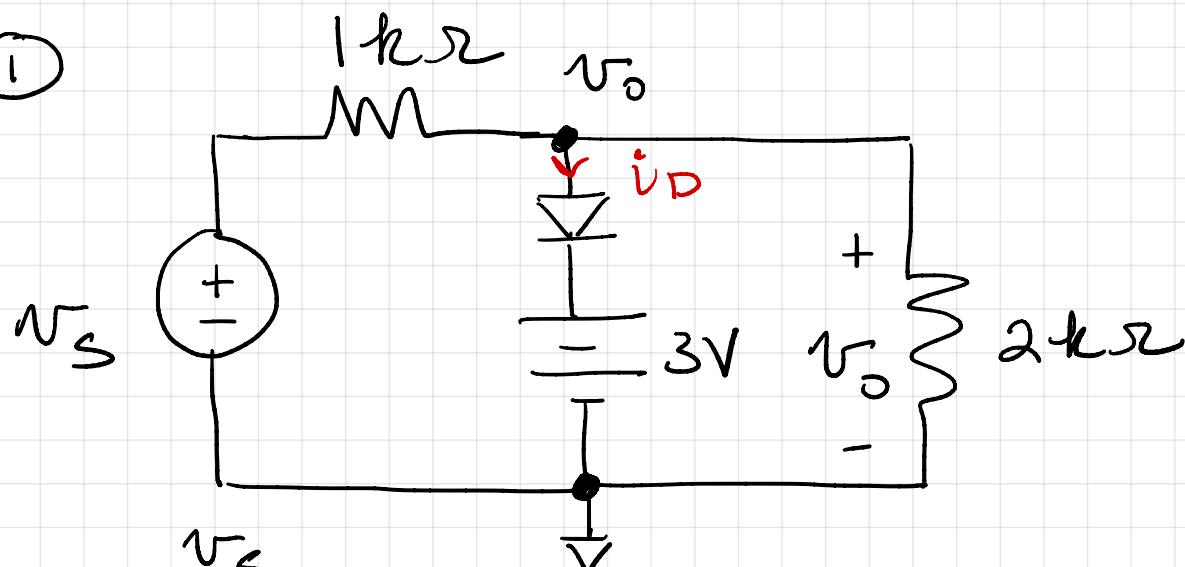


①



by modal analysis :

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

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

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

$$i_D = V_S - 1.5 V_0 \text{ (mA)}$$

if diode is on : $i_D > 0$

$$V_0 = 3V$$

there are two values of V_S :

$$V_S = +6V \text{ and } V_S = -6V$$

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

$$V_0 = 3V, i_D = 6 - 1.5(3)$$

you!
diode is on - 

$$i_D = 1.5mA$$

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

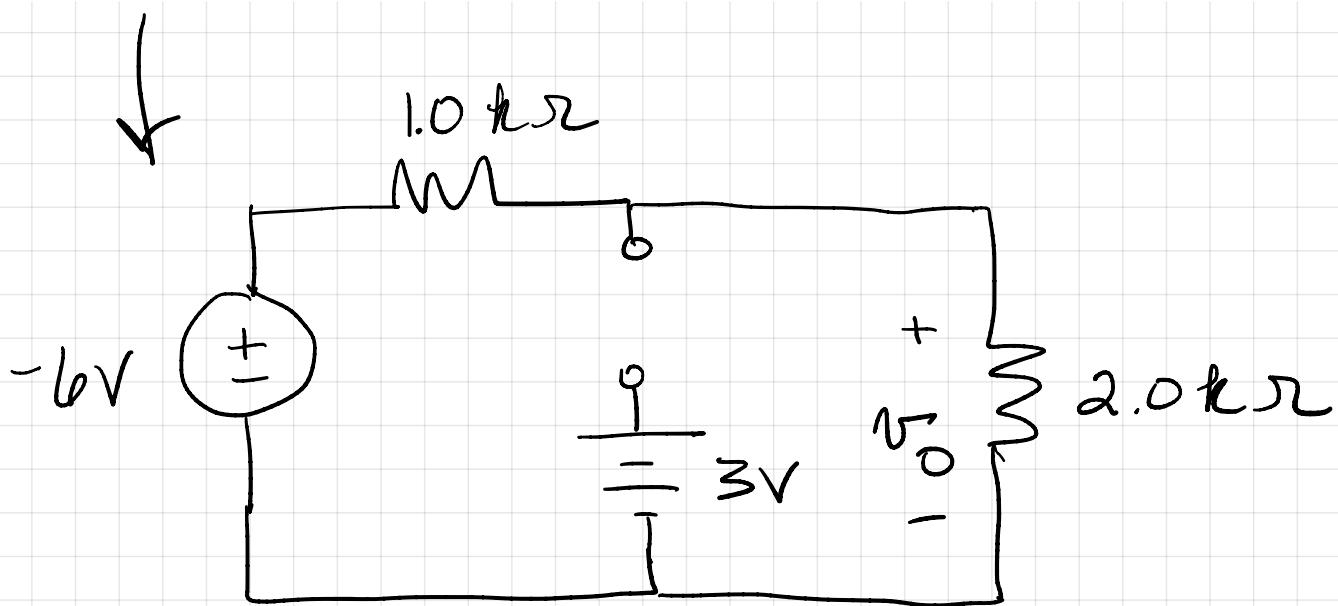
$$V_0 = 3V; i_D = -6 - 1.5(3)$$

Diode is off! - 

$$i_D < 0$$
$$= -10.5mA$$

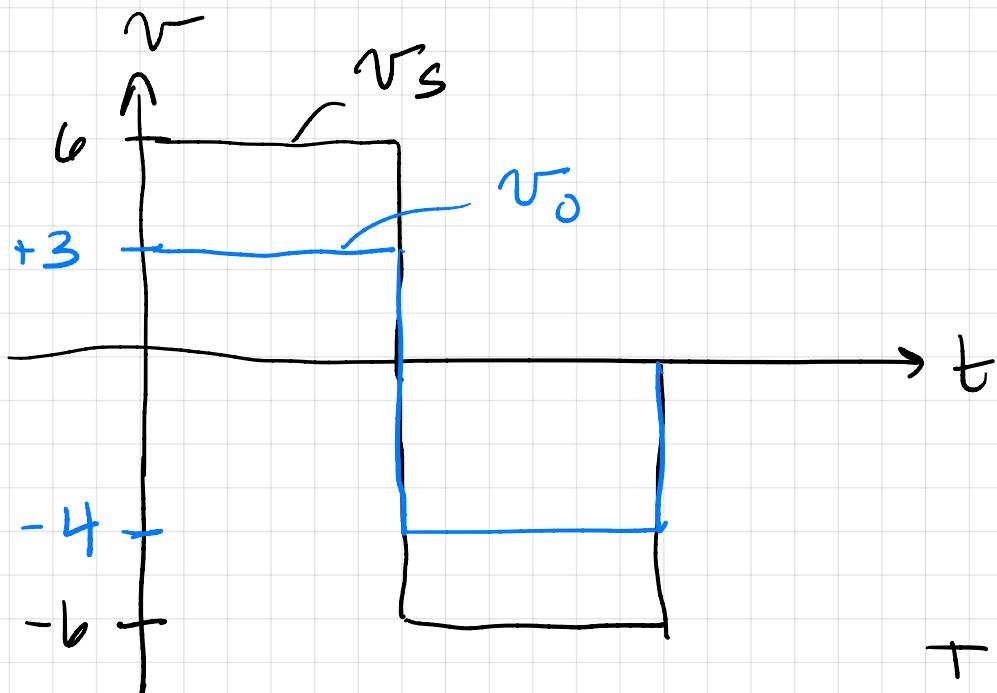
when the diode is off

/



by voltage division

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



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

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

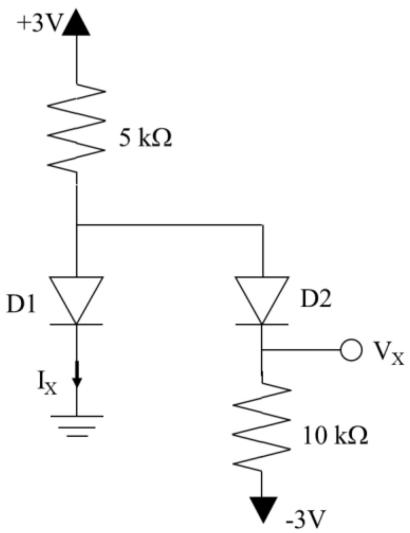
$$= \frac{1}{T} \left[3t \Big|_0^{T/2} + (-4t) \Big|_{T/2}^T \right]$$

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

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

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

(2)



$$I_x \text{ & } I_{D2} > 0$$

$$V_x = 0V$$

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

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

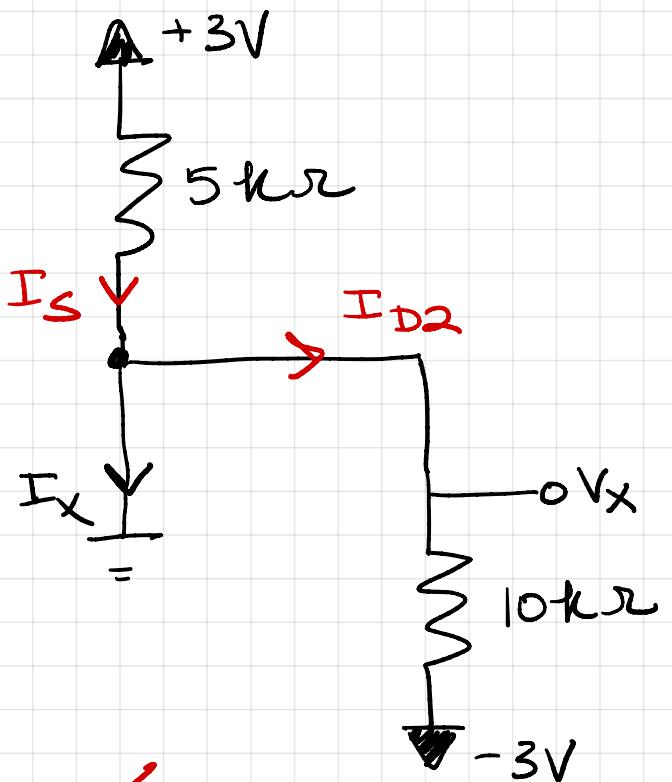
by KCL :

$$I_x = I_S - I_{D2}$$

$$= 0.6 - 0.3$$

$$I_x = 0.3 \text{ mA} \quad \checkmark$$

Assume both diodes are on.

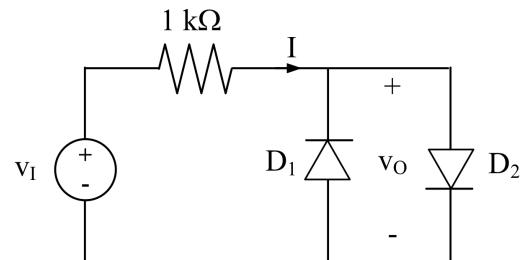


(3)

▼ -3V

3. For the following circuit, $v_I = 10 \cos(t)$ volts.
Assume ideal diodes.

- For what values of v_I is diode 1 on?
- For what values of v_I is diode 2 on?
- What is the peak current value, I (magnitude only required).
- Plot the voltages, v_I and v_O .



a) D1 is on when $v_I < 0$

$$I = -10 \text{ mA}$$

$$I < 0$$

$$v_O = 0V$$

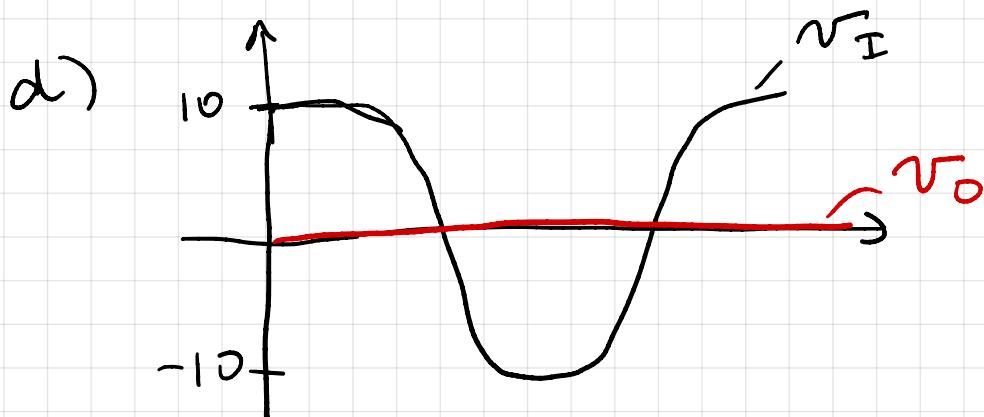
b) D2 is on when $v_I > 0$

$$I = +10 \text{ mA}$$

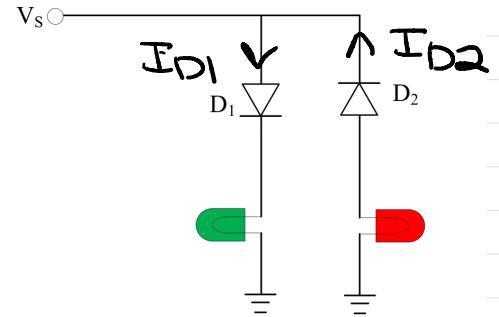
$$I > 0$$

$$v_O = 0V$$

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



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.



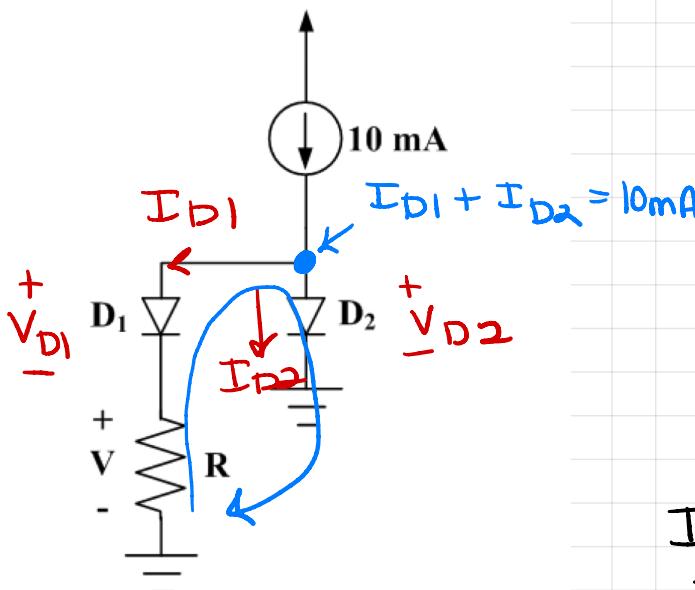
- What does V_s need to be for the green light (only) to be on?
- What does V_s need to be for the red light (only) to be on?
- Can both lights be on simultaneously?

a) $V_s = 3V$

b) $V_s = -3V$

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

5



$$V = 80mV$$

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

by KVL

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

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

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

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

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

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

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

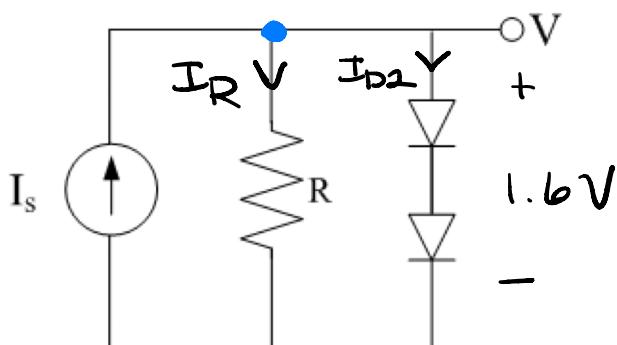
$$R = 204.24 \Omega$$

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

$$25.53 I_{D1} = 10$$

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

⑥ $I_R = I_S - I_{D2}$



$$V = 1.6 \text{ V}$$

$$I_S = 100 \text{ mA}$$

$$\text{for } V_D = 0.7 \text{ V}$$

$$I_D = 1 \text{ mA}$$

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

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

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

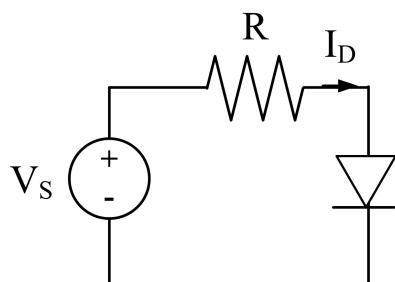
$$I_{D2} = 54.6 \text{ mA}$$

$$I_R = (100 - 54.6) = 45.4 \text{ mA}$$

$$R = \frac{1.4}{45.4 \times 10^{-3}}$$

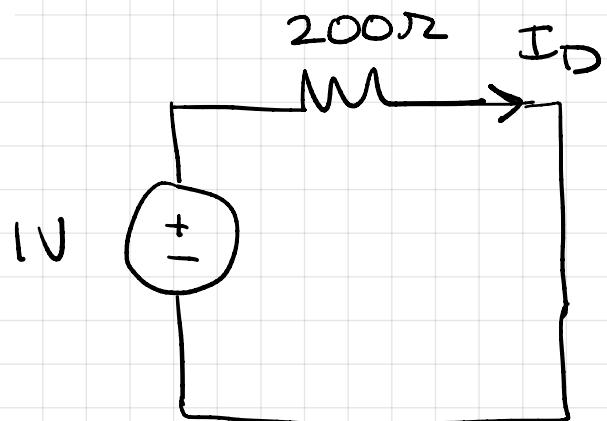
$R = 35.24 \Omega$

7



a) ideal

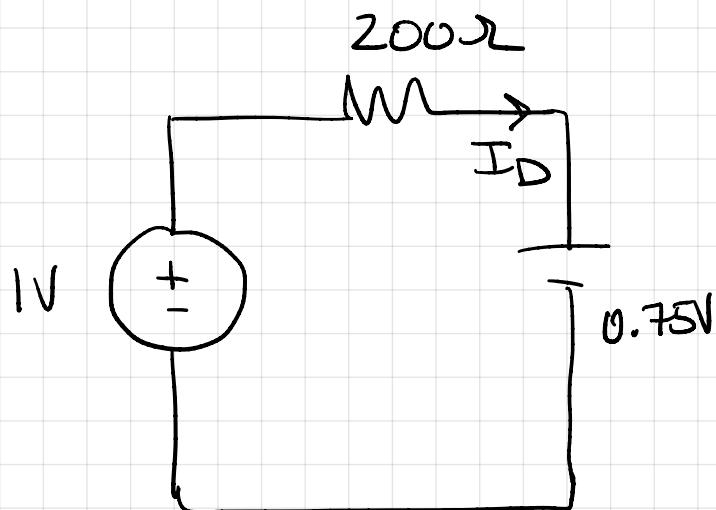
$$I_D = \frac{1}{200} = 5 \text{ mA}$$



b) constant drop

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

$I_D = 1.25 \text{ mA}$



c) let $V_{D1} = 0.7V$

$$I_{D2} = \frac{1 - 0.7}{200} = 1.5 \text{ mA}$$

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

$$(I_2, V_2) = (1.5 \text{ mA}, 0.71V)$$

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

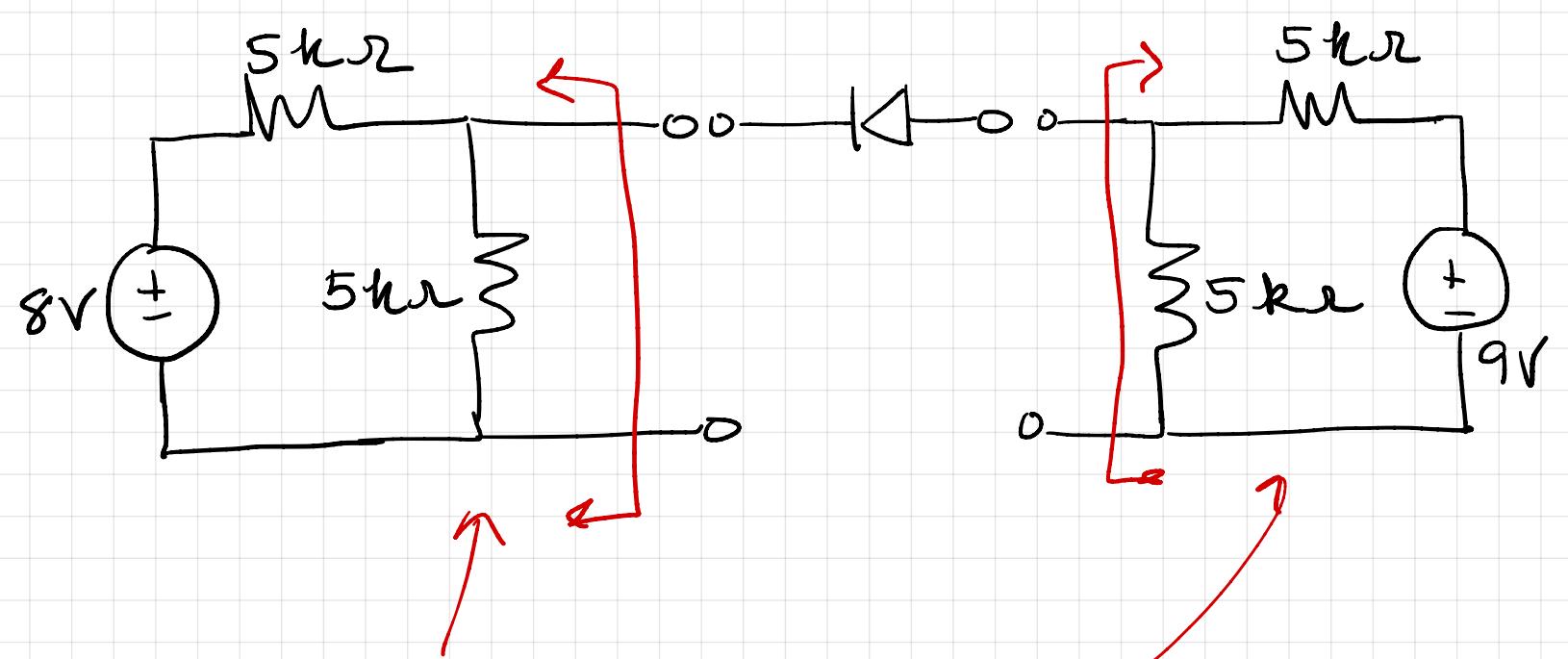
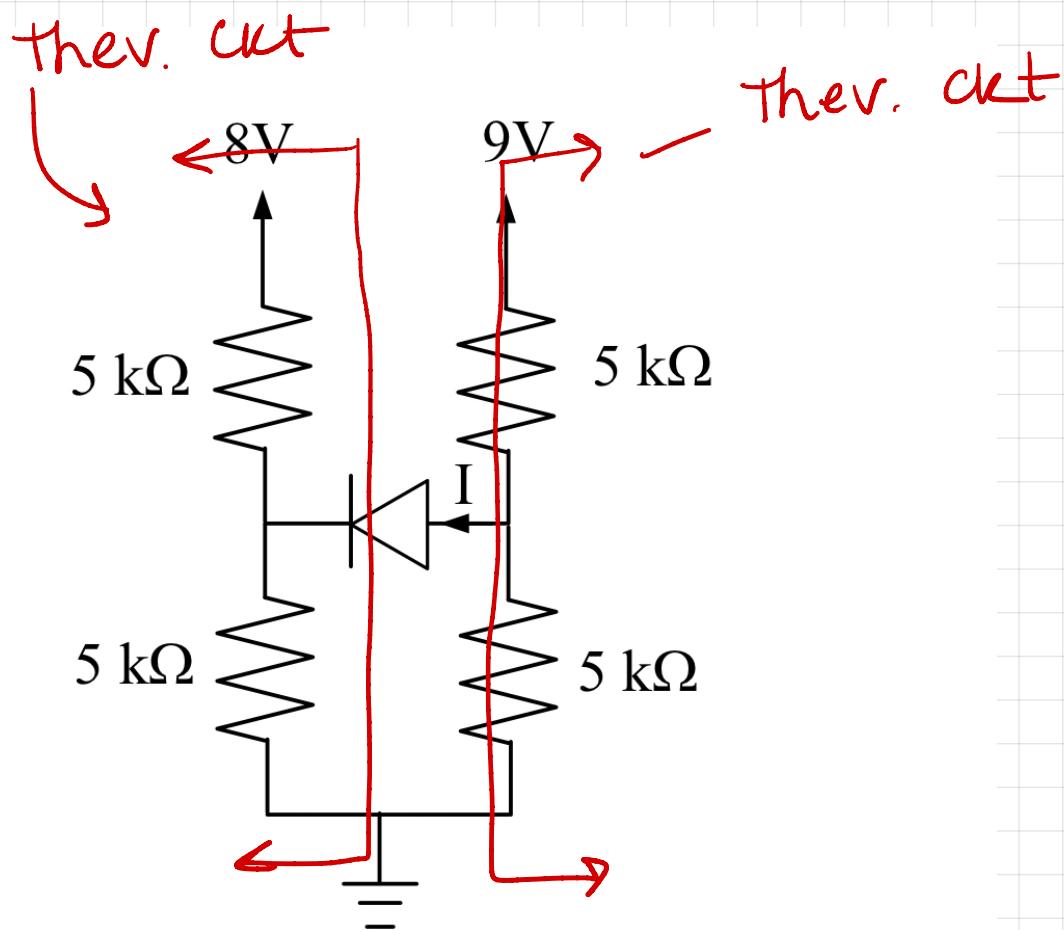
$$I_{D3} = \frac{1 - 0.71}{200} = 1.45 \text{ mA}$$

$$V_{D3} = V_{D2} + V_T \ln\left(\frac{I_{D3}}{I_{D2}}\right)$$
$$= 0.709V$$

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

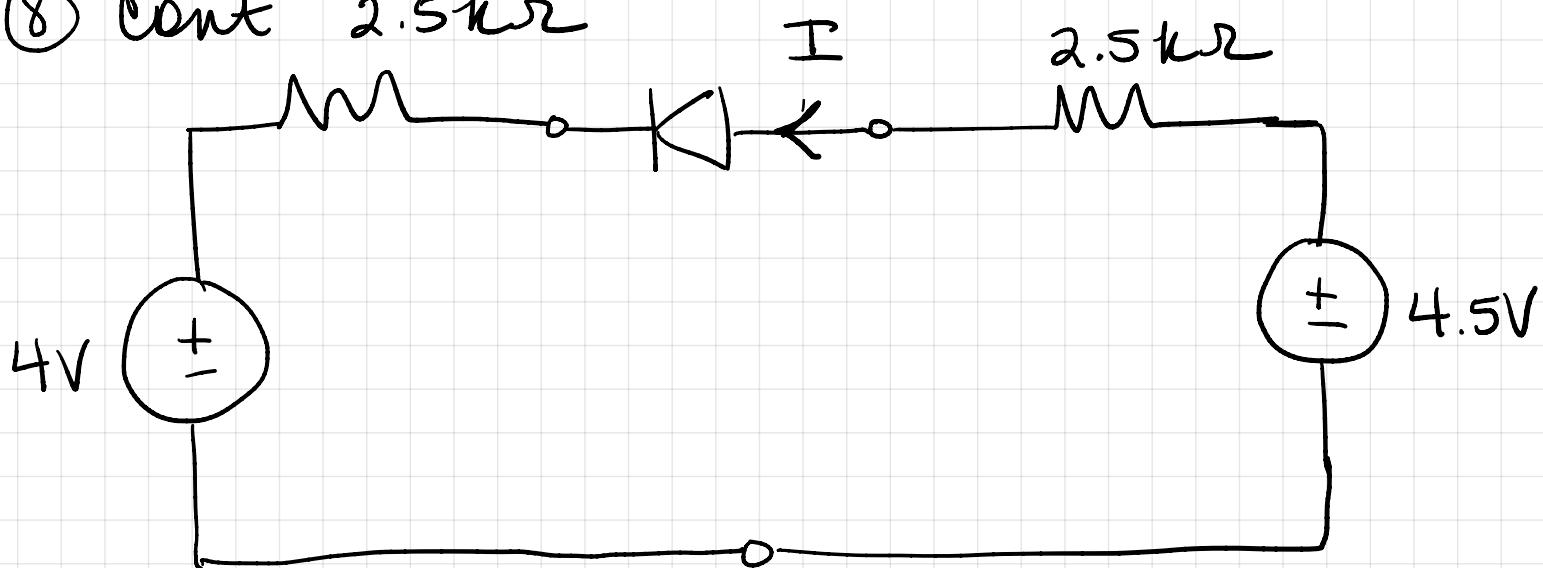
$$I_D = 1.45 \text{ mA}$$

8



find
Thevenin equivalent
circuit

⑧ cont $2.5\text{ k}\Omega$



a) ideal

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

b) constant drop

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

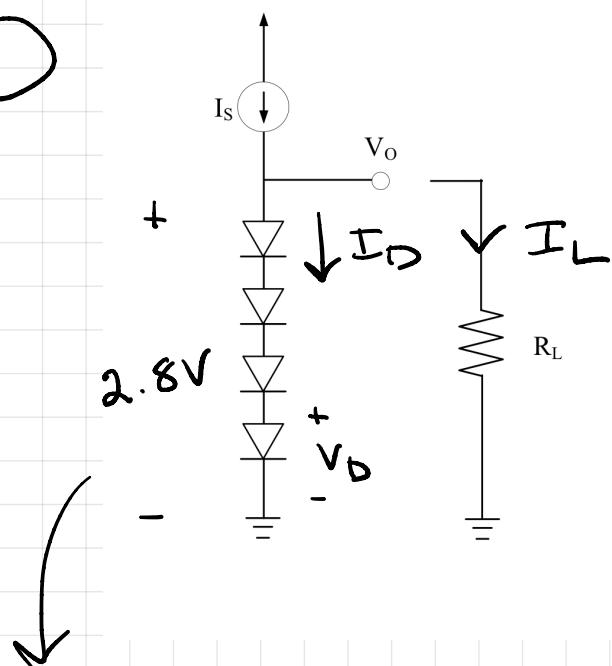
$$I = -0.04\text{ mA}$$

current is negative

diode is off

$I = 0$!

(9)

sat current 10^{-16} A $I_s = ?$ for $V_o = 2.8 \text{ V}$

diodes identical.

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

$$I_D = (10^{-16})(\exp(0.7/0.025))$$

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

$$\text{If } I_L = 0.1 \text{ mA}$$

$$I_D = I_s - I_L = 0.145 - 0.1$$

$$I_D = 0.045 \text{ mA}$$

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

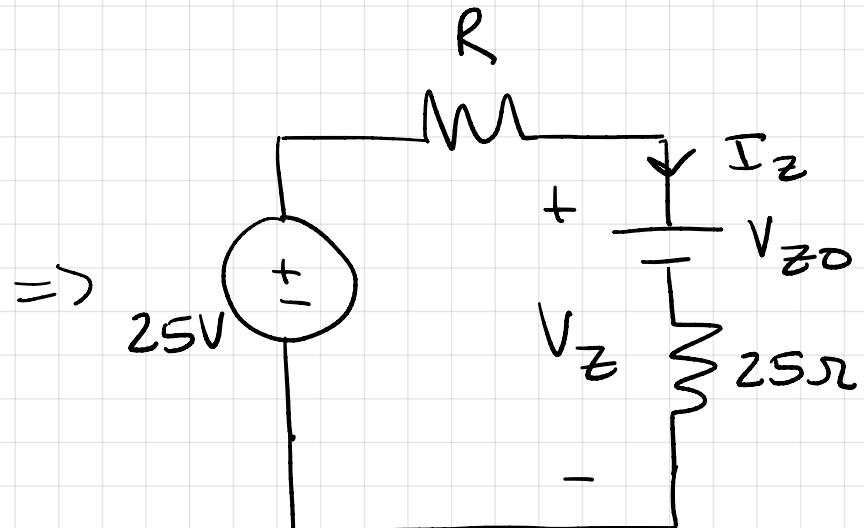
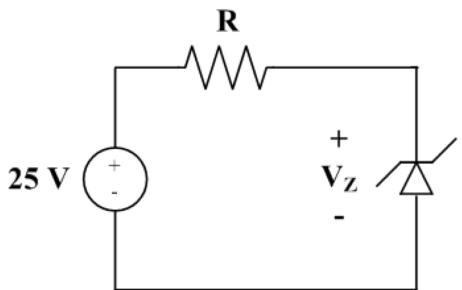
$$= 0.025 \ln \left(\frac{0.045 \times 10^{-3}}{10^{-16}} \right)$$

$$V_D = 0.671 \text{ V}$$

$$V_o = 4V_D = 2.68 \text{ V}$$

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

10



$$V_Z = 9.1V$$

$$I_Z = 3mA$$

$$V_{Z0} = V_Z - I_Z r_Z$$

$$= 9.1 - (0.003)(25)$$

$$V_{Z0} = 9.025V$$

$$\text{for } I_Z = 5mA$$

$$V_Z = V_{Z0} + I_Z r_Z$$

$$V_Z = 9.025 + (0.005)(25)$$

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

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

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

$$\boxed{R = 3.17 \times 10^3 \Omega}$$