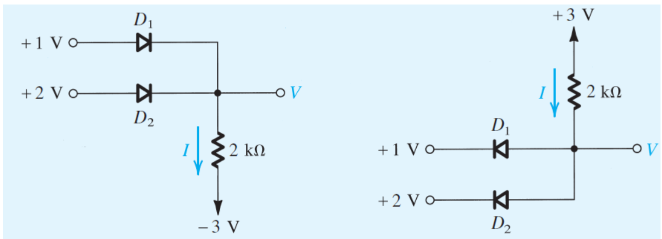
ECE 3355: Electronics

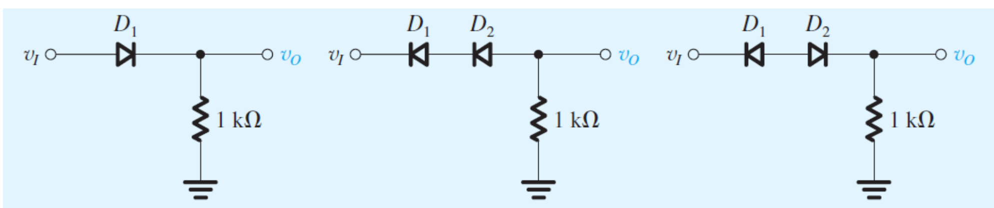
Homework 7

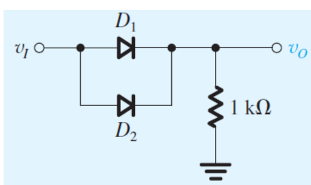
Topic: Diodes I

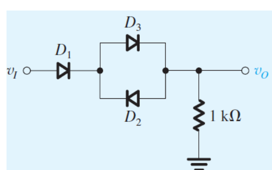
1. For the circuits shown below using ideal diodes, find the values of the labeled voltages and currents.

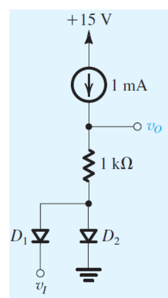


2. In each of the ideal-diode circuits shown below, v_I is a 1-kHz, 5-V peak sine wave. Sketch the waveform resulting at v_O. What are its positive and negative peak values?

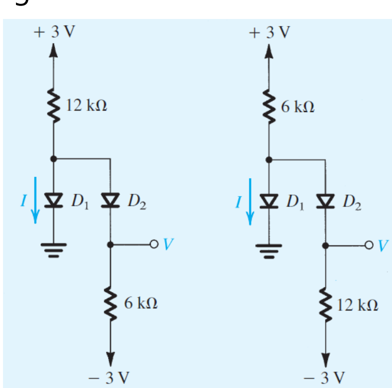




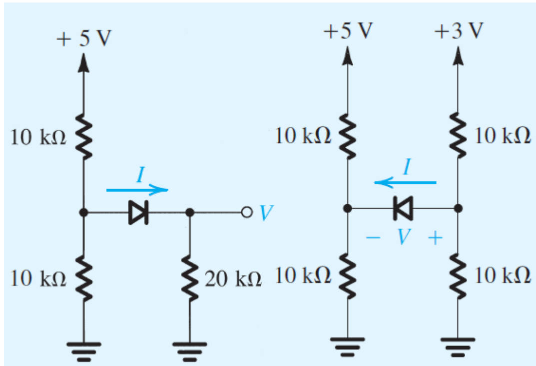




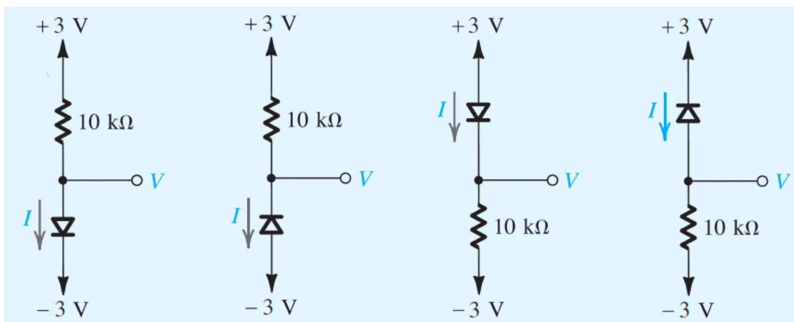
3. Assuming that the diodes in the circuits below are ideal, find the values of the labeled voltages and currents.



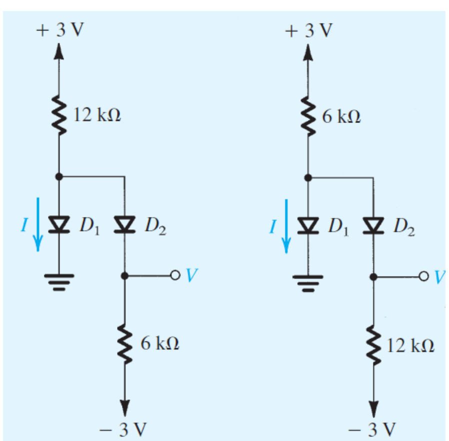
4. Assuming that the diodes in the circuits below are ideal, utilize Thevenin's theorem to simplify the circuits and thus find the values of the labeled currents and voltages.



5. For the circuits shown below, using the constant-voltage-drop (V_D= 0.7 V) diode model, find the voltages and currents indicated.

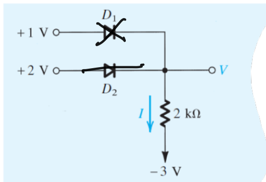


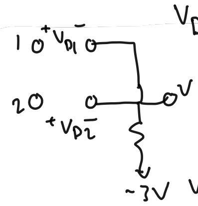
6. For the circuits below, using the constant-voltage-drop (V_D = 0.7 V) diode model, find the values of the labeled currents and voltages.



7. Repeat problems 3 and 4 using a piecewise linear diode model with V_f = 0.6 V, r_d = 1 kΩ, and no reverse bias current.

1. For the circuits shown below using ideal diodes, find the values of the labeled voltages and currents.





$V_{D_1} = V_{D_1}^+ - V_{D_1}^-$
$= 1-(-3)$
$= 4$

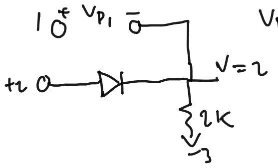
$V_{D_2} = 2-(-3)$
$= 5$
ON

$V = IR$

$I = \frac{V-(-3)}{2K}$

$I = \frac{2+3}{2K}$

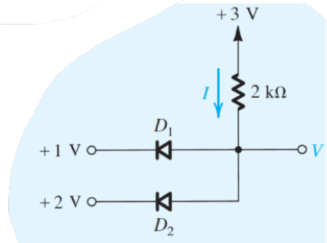
$\boxed{I = 2.5 \, [mA]}$

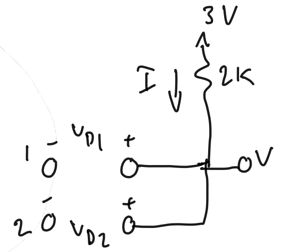


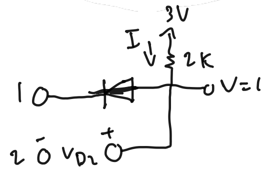
$V_{D1} = 1-2$
$= -1$ off

$D_2 \to FB$
$D_1 \to RB$

$\boxed{V = V_{D2} = 2 \, [V]}$







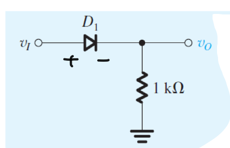
$V_{D2} = 1-2 = -1$
off
$D_2 \to RB$

$V_{D1} = 3-1 = 2$ On
$V_{D2} = 3-2 = 1$
$D_1 \to FB$

$V = V_{D_1} = 1 \, [V]$
$I = \frac{3-V}{2K} = \frac{2}{2K} = 1 \, mA$

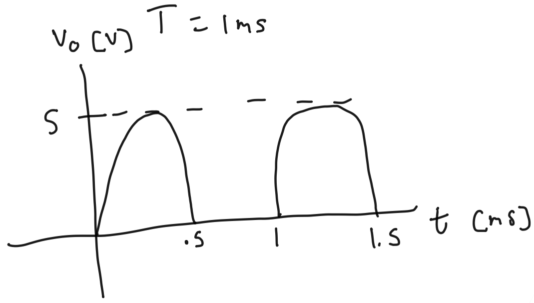
2. In each of the ideal-diode circuits shown below, v_I is a 1-kHz, 5-V peak sine wave. Sketch the waveform resulting at v_O. What are its positive and negative peak values?

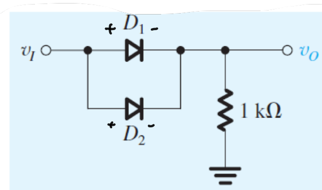
$T = \frac{1}{f} = \frac{1}{1K}$
$T = 1 ms$

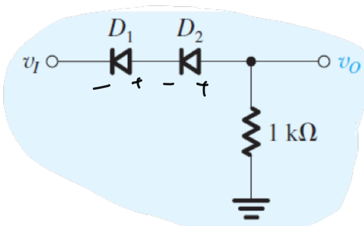


$V_I > 0 \quad D_1 \to FB$
$V_I < 0 \quad D_1 \to RB$

$V_{o\,peak} = 5 \, [V]$
$V_{o\,min} = 0 \, [V]$

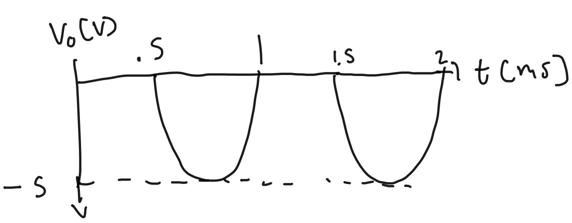


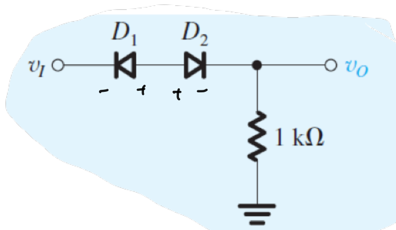




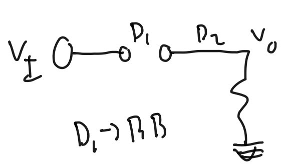
$V_I < 0 \quad D_1, D_2 \to FB$
$V_I > 0 \quad D_1, D_2 \to RB$

$V_{o\,max} = 0 \, [V]$
$V_{o\,min} = -5 \, [V]$



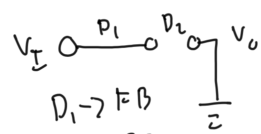


$V_I > 0$



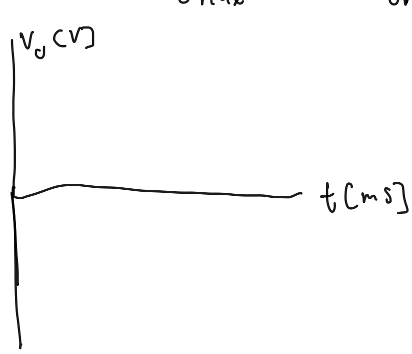
$D_1 \to RB$
$D_2 \to FB$

$V_I < 0$

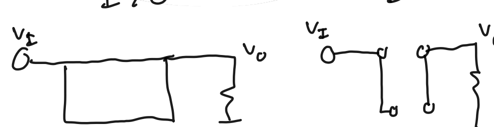


$D_1 \to FB$
$D_2 \to RB$

$\therefore V_{o\,max} = 0 = V_{o\,min}$

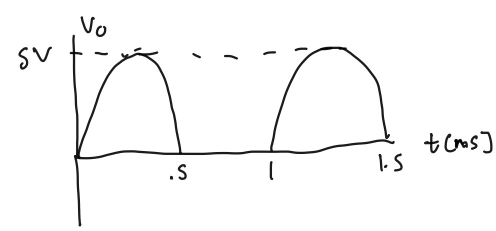


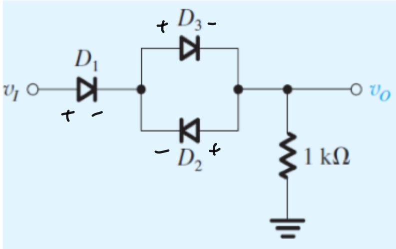
$V_I > 0$ $\quad$ $V_I < 0$



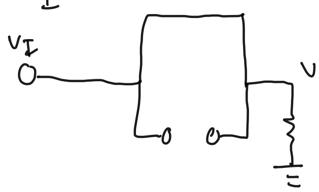
$D_1, D_2 \to FB$ $\quad$ $D_1, D_2 \to RB$

$V_{o\,max} = V_I = 5$ $\quad$ $V_{o\,min} = 0$



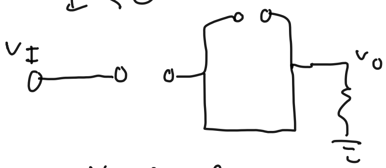


$V_I > 0$

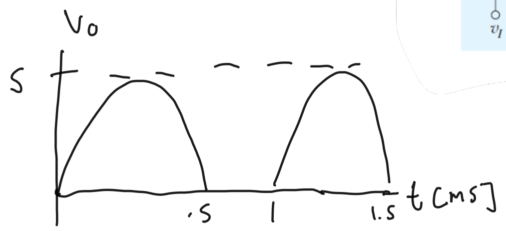


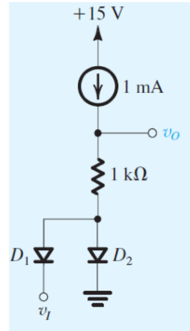
$V_{omax} = V_O = 5$

$V_I < 0$

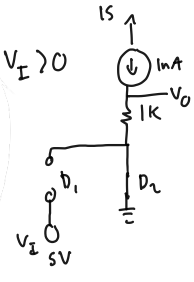


$V_{Imin} = 0$

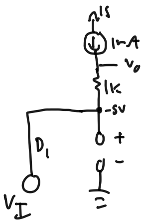




$V_I > 0$



$V_I < 0$



$V_I > 0$

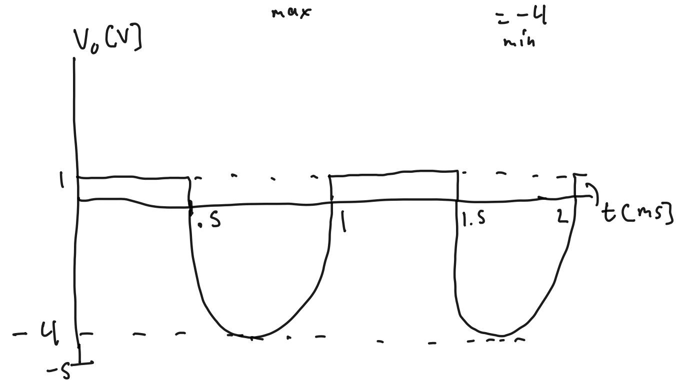
$V_o = 1K(1mA)$

$V_o = 1[V]$
max

$V_I < 0$

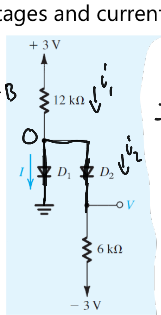
$V_o = -5 + 1$

$= -4$
min



3. Assuming that the diodes in the circuits below are ideal, find the values of the labeled voltages and currents.

assume $D_1, D_2 \rightarrow FB$



$i_1 = \frac{3-0}{12K} = 0.25\ [mA]$

$I_{D_2} = \frac{0-(-3)}{6K} = 0.5\ [mA]$

@ O node KCL:

$i_1 = I_{D2} + I$

$I = i_1 - I_{D2} = .25 - .5$

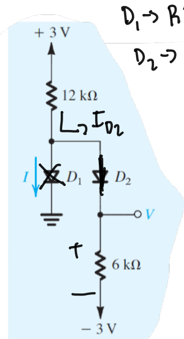
$I = -0.25\ [mA]$

$\Downarrow$

$D_1 \rightarrow RB$

$D_1 \rightarrow RB$

$D_2 \rightarrow FB$



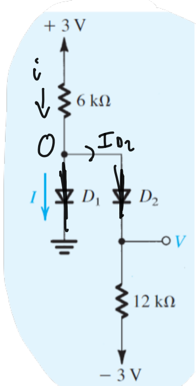
$I_{D2} = \frac{3-(-3)}{12K + 6K} = \frac{1}{3} mA$

$I = 0$ ✓

$V - (-3) = 6K I_{D2}$

$V = 6K I_{D2} - 3$

$V = 6K(\frac{1}{3}mA) - 3 = -1\ [V]$ ✓



Assume $D_1, D_2 \rightarrow FB$

$i = \frac{3-0}{6K} = 0.5mA$

$I_{D2} = \frac{0-(-3)}{12K} = 0.25mA$

KCL @ 0V: $i = I_{D2} + I$

$I = i - I_{D2}$

$= .5 - .25$

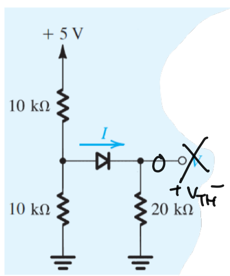
$I = 0.25mA$ ✓

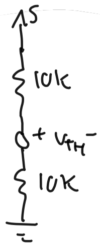
$V - (-3) = I_{D2} 12K$

$V = 12K(.25m) - 3$

$V = 0$ ✓

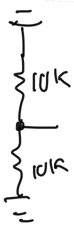
4. Assuming that the diodes in the circuits below are ideal, utilize Thevenin's theorem to simplify the circuits and thus find the values of the labeled currents and voltages.





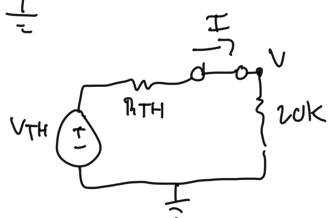
$$V_{TH} = 5\left(\frac{10k}{10k+10k}\right)$$
$$= 5\left(\frac{1}{2}\right)$$
$$V_{TH} = 2.5\ [V]$$

Req:



$10k \parallel 10k$

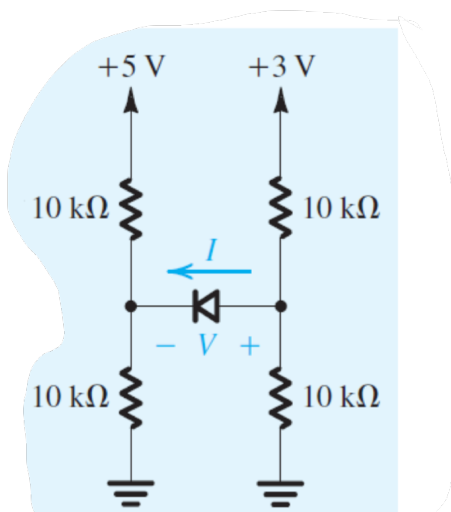
$R_{TH} = 5k$



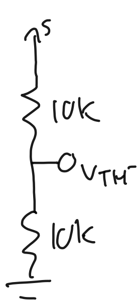
$$I = \frac{V_{TH}}{R_{TH}+20k} = \frac{2.5}{25k}$$

$$I = 0.1\ mA$$

$$V = V_{TH}\left(\frac{20k}{20k+R_{TH}}\right)$$
$$= 2.5\left(\frac{20k}{25k}\right)$$
$$V = 2\ [V]$$

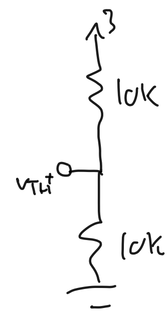


V_{TH}^- $\qquad$ V_{TH}^+



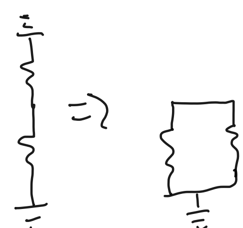
$$V_{TH}^- = 5\left(\frac{10k}{20k}\right)$$
$$= 2.5\ V$$

$$R_{TH}^- = 10k \parallel 10k$$
$$= 5k\Omega$$

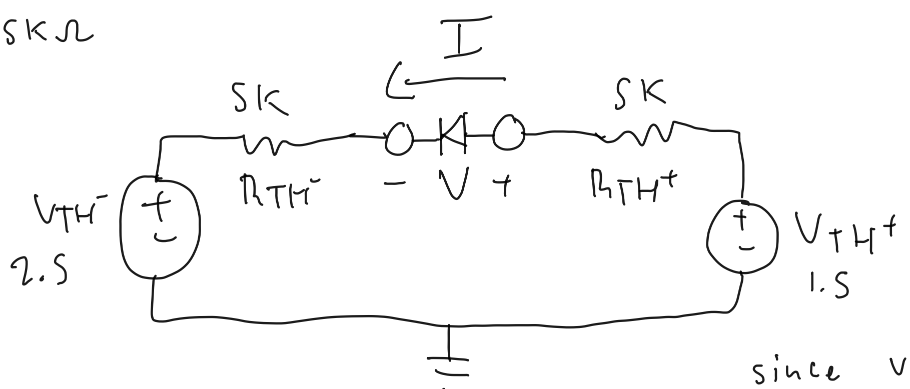


$$V_{TH}^+ = 3\left(\frac{10k}{20k}\right)$$
$$= 1.5\ [V]$$

R_{TH}^+



$R_{TH}^+ = 10k \parallel 10k = 5k\Omega$



since voltage lower on anode side

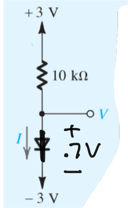
$D \rightarrow RB$

$\therefore\ I = 0$

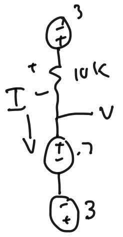
$$V = 1.5 - (2.5)$$

$$V = -1\ [V]$$

5. For the circuits shown below, using the constant-voltage-drop (V_D= 0.7 V) diode model, find the voltages and currents indicated.



D → FB higher V on anode
lower on cathode



KVL: $-3 + 10K I + 0.7 - 3 = 0$

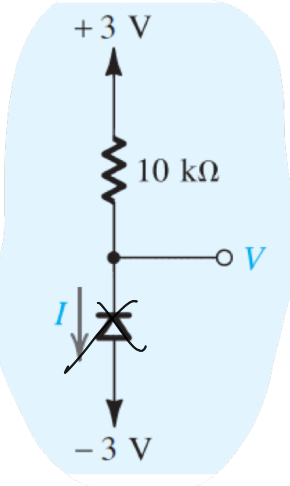
$10K I = 5.3$

$\boxed{I = 0.53\ mA}$

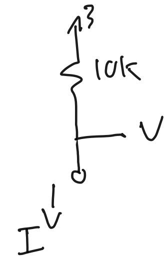
$V - (-3) = 0.7$

$V = 0.7 - 3$

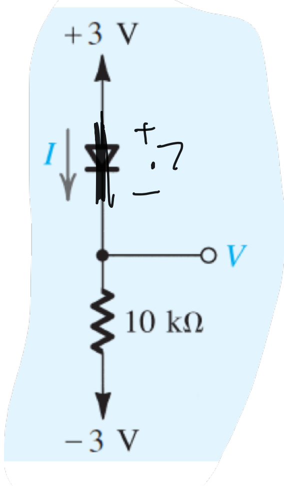
$\boxed{V = -2.3\ [V]}$



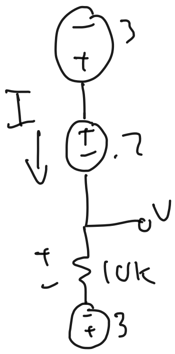
anode at low V
cathode at higher V
∴ D → RB



$\boxed{I = 0\ (A)}$
$\boxed{V = 3\ [V]}$



D → FB



KVL: $-3 + .7 + I\,10K - 3 = 0$

$I\,10K = 5.3$

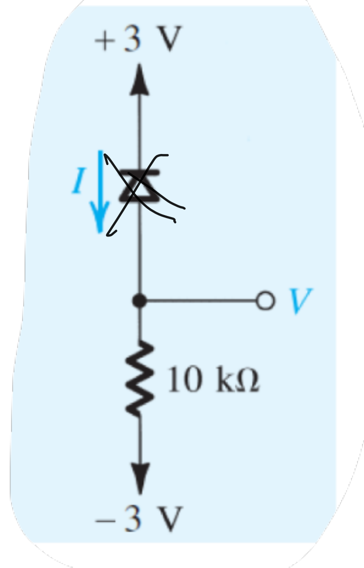
$\boxed{I = 0.53\ mA}$

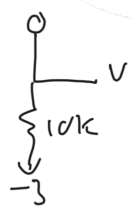
$V - (-3) = I\,10K$

$V = 10K(.53m) - 3$

$\boxed{V = 2.3\ [V]}$

D → RB

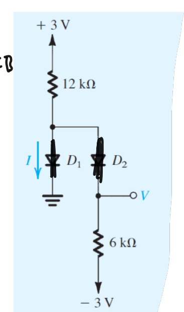


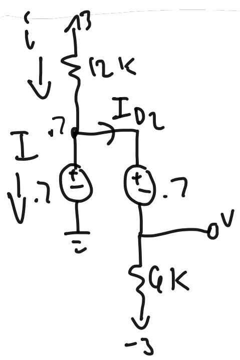


$\boxed{I = 0\ A}$
$\boxed{V = -3\ [V]}$

6. For the circuits below, using the constant-voltage-drop (V_D = 0.7 V) diode model, find the values of the labeled currents and voltages.

Assume $D_1, D_2 \to FB$





$i = \frac{3 - .7}{12K} = 0.19\ mA$

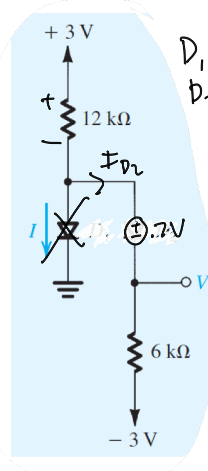
$I_{D2} = \frac{0.7 - 0.7 - (-3)}{6K}$

$I_{D2} = 0.5\ mA$

$I = i - I_{D2}$

$= .19 - 0.5$

$I = -.31$ ✗



$D_1 \to RB$
$D_2 \to FB$

$\boxed{I = 0}$

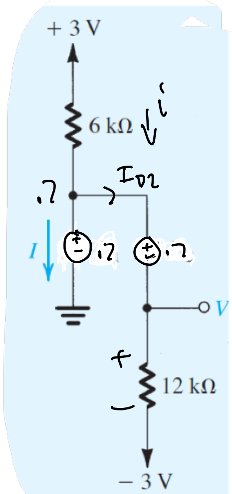
$I_{D2} = \frac{3 - 0.7 - (-3)}{12K + 6K}$

$I_{D2} = 0.29\ mA$

$V = 3 - 12K I_{D2} - 0.7$

$V = 2.3 - 12K(.29m)$

$\boxed{V = -1.23\ [V]}$



$D_1, D_2 \to FB$

$I_{D2} = \frac{0.7 - 0.7 - (-3)}{12K}$

$I_{D2} = 0.25\ mA$

$i = \frac{3 - 0.7}{6K} = 0.38\overline{33}\ mA$

$I = i - I_{D2} = 0.38\overline{33} - 0.25$

$\boxed{I = 0.1\overline{33}\ mA}$

$V - (-3) = I_{D2}\,12K$

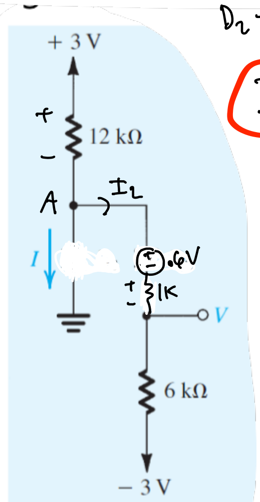
$V = 12K\,I_{D2} - 3$

$\boxed{V = 0\ [V]}$

7. Repeat problems 3 and 4 using a piecewise linear diode model with $V_f = 0.6$ V, $r_d = 1$ kΩ, and no reverse bias current.

$D_1 \rightarrow RB$

$D_2 \rightarrow FB$



$\boxed{I = 0}$

$$I_2 = \frac{3 - 0.6 - (-3)}{12K + 1K + 6K} = 0.28\,mA$$

$$\frac{3 - V_A}{12K} = I_2$$

$$3 - V_A = 12K\,I_2$$

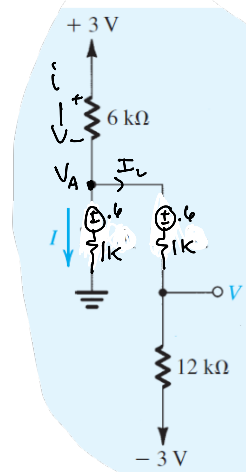
$$V_A = -0.41$$

$$V_A - V = 0.6 + I_2\,1K$$

$$V = V_A - .6 - 1K\,I_2$$

$$\boxed{V = -1.295\,(V)}$$

$D_1, D_2 \rightarrow FB$



$$i = I_2 + I$$

$$\left(\frac{3 - V_A}{6K} = \frac{V_A - .6}{1K} + \frac{V_A - .6 - (-3)}{13K}\right) 78K$$

$$39 - 13V_A = 78V_A - 46.8 + 6V_A + 14.4$$

$$97V_A = 71.4$$

$$V_A = 0.736 > V_{f1}, V_{f2}$$ ✓

$$I = \frac{V_A - .6}{1K}$$

$$\boxed{I = 0.136\,mA}$$

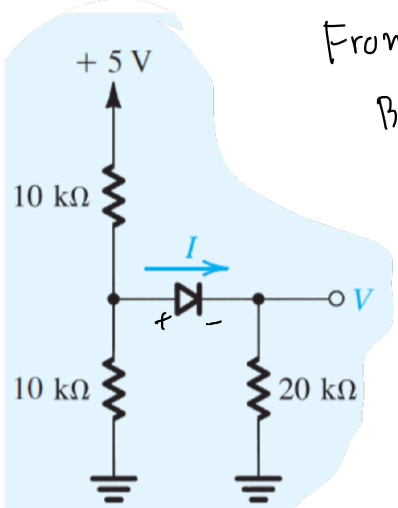
$$I_2 = \frac{V_A - .6 + 3}{13K}$$

$$V_A - V = .6 + I_2\,1K$$

$$V = V_A - .6 - 1K\left(\frac{V_A + 2.4}{13K}\right)$$

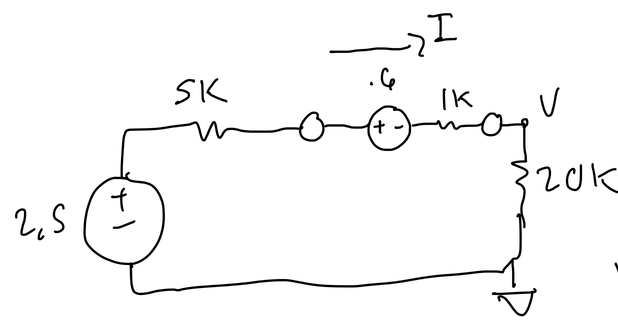
$$\boxed{V = -0.105\,(V)}$$

4.



From 4: $V_{TH} = 2.5\,(V)$

$R_{TH} = 5K$ $D \rightarrow FB$



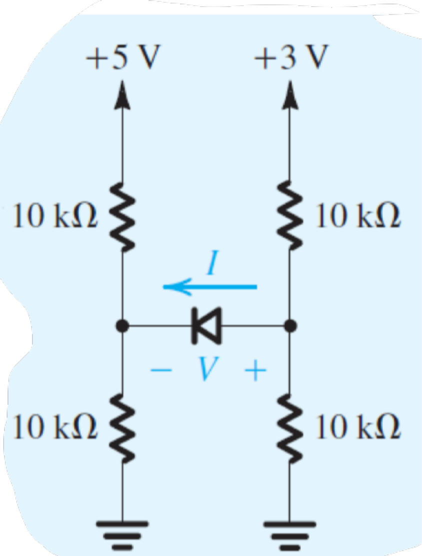
$$I = \frac{2.5 - .6}{5K + 1K + 20K}$$

$$\boxed{I = 0.0731\,mA}$$

$$V - 0 = 20K\,I$$

$$V = 20K(.0731m)$$

$$\boxed{V = 1.462\,(V)}$$

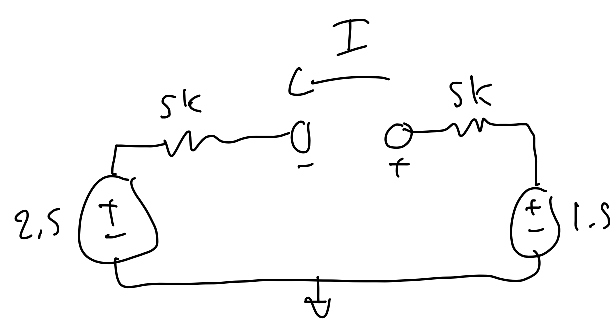


$V_{TH}^- = 2.5$

$R_{TH} = 5K$

$V_{TH}^+ = 1.5$

$R_{TH} = 5K$



since voltage lower on anode side $D \rightarrow RB$ and "open"

$\boxed{I = 0A \quad V = -1\,(V)}$