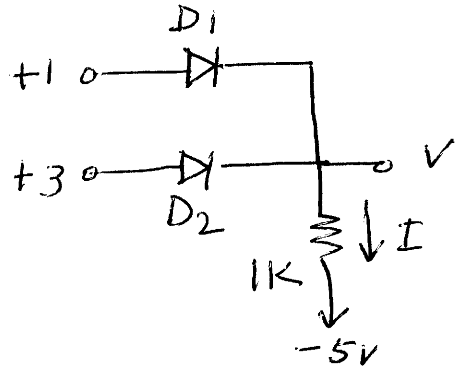
EE341

Assignment #1

3.4 (a)

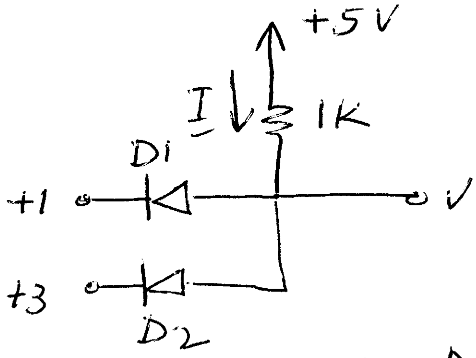


Assume D1 & D2 both ON.
Then $V = 1$ & $V = 3V$
Not possible.
Assume D1 is on & D2 is off
then $V = 1V$ & D2 cannot be off.

Thus D_2 must be ON & D1 must be off
which makes D1 reversed bias
$\therefore V = 3V$

$$\therefore I = \frac{3-(-5)}{1K} = 8mA$$

(b)



D1 & D2 cannot both be ON
Else $V = 1V$ & $V = 3V$ which is impossible

If we assume D2 is ON & D1 is off $\Rightarrow V = 3V$
which means D1 will be forward biased & will have to be ON.
So D2 must be off & D1 is ON

$$\therefore V = 1V \quad \& \quad I = \frac{4V}{1K} = 4mA$$

3.23 If a second diode is added the current per diode will be $I/2$

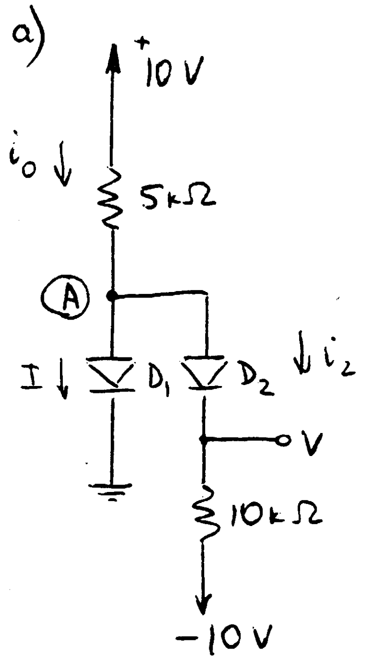
$$\therefore \Delta V = 2.3 n V_T \log \frac{I/2}{I} = -2.3 n V_T \ln 2$$
$$\cong -18 mV$$

EE 341

Assignment # 1

Problem P3.9

a)



The diodes D_1 and D_2 are ideal, but have voltage drop 0.7 V on them.

Suppose, D_1 is not conducting (cut off), and D_2 is conducting.

Then the current through D_2 will be:

$$i_2 = \frac{10\,V - (-10V) - 0.7V}{5k\Omega + 10k\Omega} = 1.28\,mA$$

$V_A = 1.28\,mA \cdot 10k\Omega + 0.7V - 10\,V = 3.56\,V \Rightarrow$ diode D_1 is conducting and our assumption is wrong. By the sam reason we can prove that the case when D_1 is conducting a D_2 is cut off is also wrong. So, both diodes are conduct

Then $V_A = 0.7\,V$. We need to find $I = i_0 - i_2$

$$i_0 = \frac{10\,V - 0.7V}{5k\Omega} = 1.86\,mA$$

$$i_2 = \frac{V_A - 0.7V + 10\,V}{10k\Omega} = \frac{10V}{10k\Omega} = 1\,mA$$

$$V = 0.7V - 0.7V = 0$$

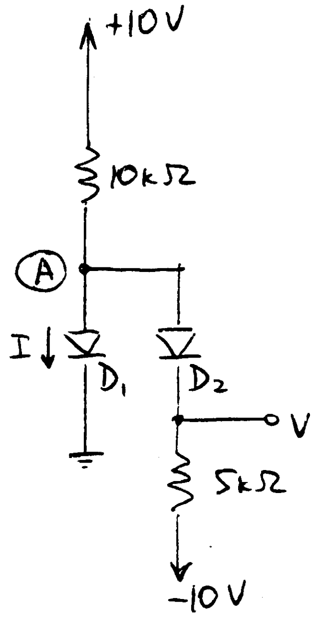
$$I = i_0 - i_2 = 1.86\,mA - 1\,mA = 0.86\,mA$$

$$\boxed{\text{Answer: } I = 0.86\,mA;\ V = 0}$$

C

Problem P3.9

b)



Similar to P3.9(a) we assume that D_1 is not conducting (cut off)

The current through D_2 will be:

$$i_2 = \frac{10V-(-10V)-0.7V}{10k\Omega + 5k\Omega} \approx 1.28\,mA$$

$$V_A = 1.28mA \cdot 5k\Omega + 0.7V - 10V \approx -2.9V < 0.7V$$

So, the assumption was correct and D_1 is cut off and $I = 0$

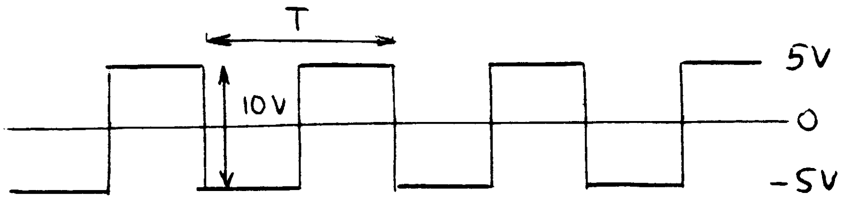
$$V = V_A - 0.7V = -2.9V - 0.7V = -3.6\,V$$

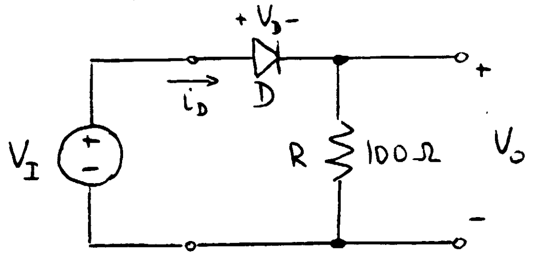
$$\boxed{\text{Answers: } I = 0 \;;\; V \approx -3.6\,V}$$

P.S. Actually, one should check the case when both diodes are conducting and prove that it's wrong. If both diodes are conducting, then the resulting current through D_1 will be in opposite direction than it's shown in the Figure. This means that D_1 is cut-off, and the assumption that both D_1 and D_2 are conducting is wrong.

Problem 3.13

Applied voltage :





Diode conducting for half the cycle (T/2)

$V_D = 0$, $V_o = V_{I\,max} = 5V$

$i_D = \frac{5V}{100\Omega} = 50\ mA$

$V_{o\,average} = \frac{V_o}{2} = 2.5V$ $\quad i_{D\,average} = 25\ mA$

$V_{max\ reverse} = -5V$

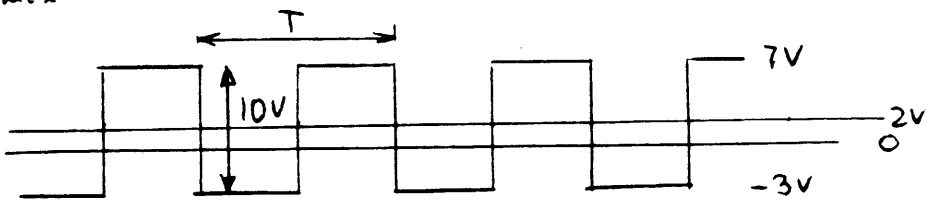
Problem 3.14

The average voltage $V_{I\,average}$ should be 2V

Then $2V = \frac{1}{T}\left(\frac{V_{I\,max} \cdot T}{2} + \frac{(V_{I\,max} - 10V) \cdot T}{2} \right)$

It follows $V_{I\,max} = 7V$

Applied voltage :



Diode still conducting for half the cycle (T/2)

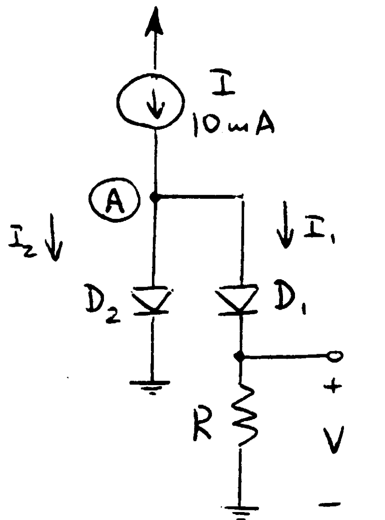
$V_D = 0$, $V_o = V_{I\,max} = 7V$

$i_D = \frac{7V}{100\Omega} = 70\ mA$

$V_{o\,average} = \frac{V_o}{2} = 3.5V$ $\quad i_{D\,average} = 35\ mA$

$V_{max\ reverse} = -3V$

Problem P3.26



D_1 and D_2 are identical.

From their i-V characteristics: 10 mA @ 0.7 V
100 mA @ 0.8 V

First, let's find n and I_S of the diodes
For any two operating points of a diode:

$$n = \frac{V_2 - V_1}{2.3\, V_T \log_{10} \frac{i_2}{i_1}}$$

Let $V_1 = 0.7V$ $i_1 = 10\,mA$
$V_2 = 0.8V$ $i_2 = 100\,mA$

Then $$n = \frac{0.8V - 0.7V}{2.3\ 0.025V \log_{10}\left(\frac{100\,mA}{10\,mA}\right)} = \frac{0.1V}{2.3 \cdot 0.025V \cdot 1} \approx \underline{\underline{1.739}}$$

$$I_S = i_1 \exp\left(-\frac{V_1}{nV_T}\right) = 10\,mA \cdot \exp\left(-\frac{0.7V}{1.739 \cdot 0.025V}\right) \approx$$

$$\approx 10^{-2} A \cdot 10^{-\frac{0.7V}{2.3 \cdot 1.739 \cdot 0.025}} = 10^{-2} A \cdot 10^{-7} = \underline{\underline{10^{-9} A}}$$

$$\boxed{n = 1.739\ ;\ I_S = 10^{-9} A}$$

Now, most of the students approximated $n = 1.739$ by $n = 2$.
You can not do this since it changes the characteristics drastically.
If $n = 1.739$, then for $V = 0.7V$ $I = 10\,mA$ (as given).
If $n = 2$, then for $V = 0.7V$ $I = 10^{-9}A \cdot \exp\left(\frac{0.7V}{2 \cdot 0.025V}\right) = 1.22\,mA$, more than 8 times smaller. Most of the students ~~who~~ could not find the solution just because of this approximation.

Second, to find the value of R for given V, you need to find I through D_1 and R.
From circuit theory, $I = I_1 + I_2$; $V_{D_2} = V_{D_1} + V_R = V_{D_1} + 0.05V$

$I_1 = I_{D_1} = I_R$

We can write the equation for currents, substituting $V_{D_1} + 0.05V$ instead of V_{D_2} into that equation.

$$\underbrace{I_s \exp\left(\frac{V_{D_1} + 0.05V}{n \cdot V_T}\right)}_{I_2} + \underbrace{I_s \exp\left(\frac{V_{D_1}}{n \cdot V_T}\right)}_{I_1} = I$$

or $$10^{-9}A \cdot \exp\left(\frac{V_{D_1} + 0.05V}{1.739 \; 0.025V}\right) + 10^{-9}A \cdot \exp\left(\frac{V_{D_1}}{1.739 \; 0.025V}\right) = 10^{-2}A$$

and we are able to solve for V_{D_1}:

$$\exp\left(\frac{V_{D_1}}{1.739 \cdot 0.025V}\right) \cdot \left(1 + \exp\left(\frac{0.05V}{1.739 \cdot 0.025V}\right)\right) = 10^{7} \quad \text{or}$$

$$\exp\left(\frac{V_{D_1}}{1.739 \cdot 0.025V}\right) = \frac{10^{7}}{4.158} \Rightarrow V_{D_1} = 2.3\, n V_T \left(7 - \log_{10} 4.158\right) =$$

$$\approx \underline{\underline{0.638\ V}}$$

If you solve for V_{D_2}, substituting $V_{D_1} = V_{D_2} - 0.05V$, you should get $\underline{0.688\ V}$.

Now, we are able to find the current I_1:

$$I_1 = I_s \exp\left(\frac{V_{D_1}}{n \cdot V_T}\right) = 10^{-9}A \cdot \exp\left(\frac{0.638V}{1.739 \cdot 0.025V}\right) = 10^{-9}A \cdot \exp(14.67) =$$

$$\approx 10^{-9}A \cdot 10^{6.38} \approx \underline{\underline{2.4\ mA}}$$

$$R = \frac{V_R}{I_1} = \frac{0.05V}{2.4 \cdot 10^{-3}A} \approx \underline{\underline{20.82\ \Omega}}$$

$$\boxed{\text{Answers: } n = 1.739;\ I_s = 10^{-9}A,\ R = 20.82\ \Omega}$$