# Homework from Chapter 3

## 3.31

$V_T = (kT/q) = 26.1\ mV$

Using the diode V-I relation: $V_D = V_T \ln\left(1 + \frac{I_D}{I_o}\right) = 0.757\ V$

$\Delta V = (-1.8\ mV/K)(50-30) = -36\ mV$

$\Rightarrow V_D = 0.757 - 0.036 = 0.721\ V$

## 3.70

A) a. Diode is forward biased

$\Rightarrow V = -5+0 = -5\ V$, $I = \frac{5-(-5)}{100K} = 100\ \mu A$

b. Diode is reverse biased

$\Rightarrow I = 0$, $V = +7\ V$ (no voltage drop across the resistor)

c. Diode is forward biased

$\Rightarrow V = 3V$, $I = \frac{3-(-7)}{100K} = 100\ \mu A$

d. Diode is reverse biased

$\Rightarrow I = 0$, $V = +5\ V$

B) a. Forward biased $\Rightarrow V = -5+0.6 = -4.4\ V$, $I = \frac{5-(-4.4)}{100K} = 94\ \mu A$

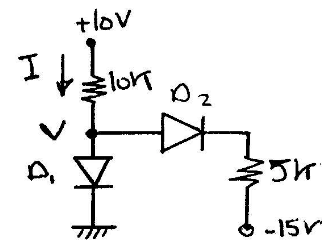
b. Reverse biased $\Rightarrow I = 0$, $V = +7V$

c. Forward biased $\Rightarrow V = 3-0.6 = +2.4V$, $I = \frac{2.4-(-7)}{100K} = 94\ \mu A$

d. Reverse biased $\Rightarrow I = 0$, $V = -5\ V$

## 3.71

A) For such kind of circuits, when the diode on/off status isn't clear, we need to put an assumption, then verify its validity. I'll apply this for the first circuit, then solve the others directly using same methodology.




a. Assume $D_1$ is on & $D_2$ is off

In this case $V = 0$

but this will mean that $D_2$ is forward biased & should be on, so we've a wrong assumption.

Now assume both $D_1$ & $D_2$ are on. $\Rightarrow V = 0$

$\therefore I = \frac{10V}{10K} = 1mA$ , $I_{D_2} = \frac{0-(-15)}{5K} = 3\ mA$

For Kirchoff's current law to be satisfied $I_{D_1} = I - I_{D_2} = -2mA$ but the current can't flow from N to P, so the assumption is also wrong.

Now, let's assume $D_1$ is off & $D_2$ is on $\Rightarrow I = I_{D_2}$ , $I_{D_1} = 0$

$\therefore I = \frac{10-(-15)}{10K+15K} = 1.67\ mA$ , $V = 10 - 10K(1.67mA) = -6.67\ V$

So the diodes operating points will be:

$D_1$ : (0 A, -6.67 V) $D_2$ (1.67 mA, 0V)

b. $D_1$ & $D_2$ are both on. $\Rightarrow V = 0$

$I = \frac{15}{5K} = 3mA$ , $I_{D_2} = \frac{0+10}{10K} = 1mA$ , $I_{D_1} = I - I_{D_2} = 2mA$

$D_1$ (2 mA, 0V) $D_2$ (1 mA, 0V)

c. Both $D_1$ & $D_2$ are on $\Rightarrow$ $V=0$ , $I = \frac{10-0}{10k} = 1mA$

$I_{D_2} = \frac{0-(-15)}{5k} = 3\,mA$ $\Rightarrow$ $I_{D_1} = 2\,mA$

$D_1$ (2mA, 0V) $D_2$ (3mA, 0V)

d. $D_1$ is on & $D_2$ is off $\Rightarrow$ $V=0$ , $I = 1\,mA$

$I_{D_2}=0$ $\Rightarrow$ $I_{D_1} = I = 1mA$

$D_1$ (1 mA, 0V) $D_2$ (0 mA, -15V)

B) Same way of solution is applied, but taking care that the on diode has a voltage drop of 0.75 V

a. $D_1$ is off & $D_2$ is on $\Rightarrow$ $I = \frac{10-(0.75)-(-15)}{10k+5k} = 1.62\,mA$ .

$V = 10 - 10k\,(1.62mA) = -6.2\,V$

$D_1$ (0 mA, -6.2 V) $D_2$ (1.62 mA, 0.75 V)

b. $D_1$ & $D_2$ are on $\Rightarrow$ $V=0.75V$ , $I = \frac{15-0.75}{5k} = 2.85\,mA$

$I_{D_2} = \frac{0.75-0.75-(-10)}{10k} = 1mA$ , $I_{D_1} = 1.85\,mA$

$D_1$ (1.85 mA, 0.75V) $D_2$ ( 1mA, 0.75V)

c. $D_1$ & $D_2$ are on $\Rightarrow$ $V=-0.75V$ , $I = \frac{10-(-0.75)}{10k} = 1.075\,mA$

$I_{D_2} = \frac{-0.75-0.75-(-15)}{5k} = 2.7mA$ , $I_{D_1} = I_{D_2} - I = 1.625\,mA$

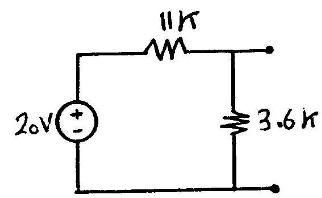
$D_1$ (1.625 mA, 0.75V) $D_2$ (2.7mA, 0.75V)

d. $D_1$ is on & $D_2$ is off $\Rightarrow$ $V = 0.75V$ , $I = \frac{10-0.75}{10k} = 0.925\ mA = I_{D_1}$

$D_1$ (0.925mA, 0.75V) $D_2$ ( 0 mA , −15.75V)

## 3.78

To solve this problem, we need to find the Thevenin eq. of the circuit first.




$$V_{th} = 20V \frac{3.6k}{11k + 3.6k} = 4.93V$$

$$R_{th} = 11k \parallel 3.6k = 2.71\ k\Omega$$

$\because V_{th} > V_Z$ , then the diode is working in the breakdown region

$$I_Z = \frac{4.93-4}{2.71k} = 0.343\ mA$$

$$Q_Z\ (0.343\ mA\ ,\ 4V)$$

## 3.127

Before solving such problems, we need to consider the following:

1. An ideal capacitor with no connected resistance charges immediatly.

2. When no current flows through the capacitor, any voltage rise or drop at one of its plates appears immediatly on the other plate.

3. We need to follow the problem at each point in time in order to be able to solve the problem correctly.

I'll apply those rules on the following circuits.

a. $V_s = 0 \rightarrow 3V$ ∴ The diode is off & no current flows in the capacitor
∴ The same voltage is transferred to $V_o$

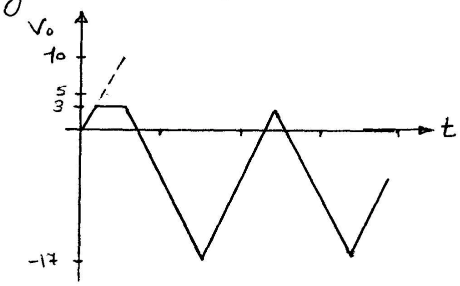
$V_s = 3 \rightarrow 10V$ The diode is on & so the capacitor charges from $0 \rightarrow 7V$
∴ $V_s = 3V$

~~$V_s = 10 \rightarrow 3V$ same as above ⇒ $V_s = 3V$~~

$V_s = 10 \rightarrow 3V$ ∵ $V_{cap} = 7V$ ⇒ $V_o = (10-7) \rightarrow (3-7)\,V = 3 \rightarrow -4\,V$

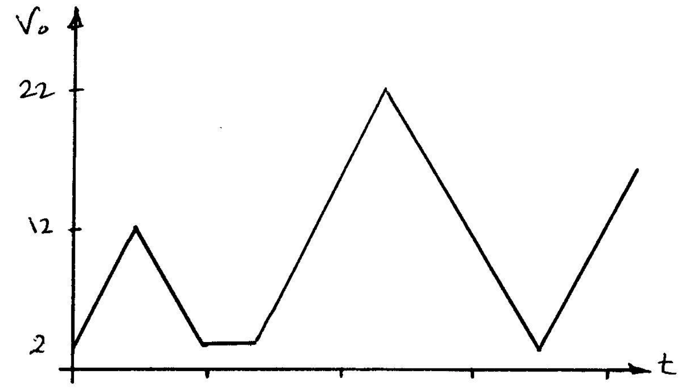
$V_s = 3 \rightarrow -10V$ The diode remains off & so the o/p voltage follows the i/p voltage but shifted down by $V_c = 7V$

So finally, the o/p voltage will be as follows:




b. ~~$V_s = 0 \rightarrow 2V$ The diode is on, the capacitor starts charging to 2V~~
~~⇒ $V_o = 2V$~~
~~$V_s = 2 \rightarrow 10V$ The diode is off & $V_o = V_s + 2V$~~
~~$V_s = 10 \rightarrow 2V$ The diode is still off & $V_o = V_s + 2V$~~
~~$V_s = -2 \rightarrow -10V$~~

$V_s = 0V$ The diode is on & it charges to $-2V$ & $V_o = 2V$
$V_s = 0 \rightarrow 10V$ The diode is off & $V_o = V_s + 2V$
$V_s = 10 \rightarrow 0V$ The diode is off & $V_o = V_s + 2V$
$V_s = 0 \rightarrow -10V$ The diode is on & so the capacitor charges to $-12V$ & $V_o = 2V$
$V_s = -10V \rightarrow 0V$ The diode is off & $V_o = V_s - (-12) = V_s + 12V$
$V_s = 0 \rightarrow 10V$ The diode is off & $V_o = V_s + 12V$
$V_s = 10 \rightarrow 0V$ The diode is still off & $V_o = V_s + 12V$
$V_s = 0 \rightarrow -10V$ The diode remains off & $V_o = V_s + 12V$




## 3.129

For both diodes to be conducting, $V_o = V_Z + V_{ON} = 5.7\,V$

$V_S = 0 \rightarrow 5.7V$ Both diodes are off & so $V_o = V_S$

$V_S = 5.7 \rightarrow 10V$ Diodes are conducting & the cap charges to 4.3V & $V_o = 5.7V$

$V_S = 10 \rightarrow 0 \rightarrow -10V$ Diodes are off again & $V_o = V_S - 4.3V$

$V_S = -10 \rightarrow 0 \rightarrow 10V$ Diodes remain off & $V_o = V_S - 4.3V$

Diodes remain off forever & $V_o = V_S - 4.3V$