ENEE 303
SOLUTIONS FOR HOMEWORK 3
DUE: 26 SEPTEMBER 06
START READING CHAPTER 4 IN S&S – TRY TO GET BOUT HALF WAY THROUGH THE CHAPTER
DO: 3.3, 3.4, 3.17, 3.33, and 3.34.
CHAPTER 3 - PROBLEMS

3.1

![Diode Circuit Diagram]

The diode can be reverse-biased and thus no current would flow, or forward-biased where current would flow.

(a) Reverse biased \( I = 0 \) \( V_D = 1.5 \)V
(b) Forward biased \( I = 1.5 \)A \( V_D = 0 \)V

3.2

(a) Diode is conducting and thus has a 0V drop across it. Consequently
\[ V = -3V \]
\[ I = \frac{3 - (-3)}{10k\Omega} = 0.6 \text{mA} \]

(b) Diode is cut off.
\[ V = 3V \quad I = 0A \]

(c) Diode is conducting
\[ V = 3V \]
\[ I = \frac{3 - (-3)}{10k\Omega} = 0.6 \text{mA} \]

3.3

(a) Diode is cut off.
\[ V = -3V \quad I = 0A \]

(b) Diode circuit diagram
\[ +1V \quad D_1 \quad V = 3V \quad -3V \quad 2k\Omega \]
\[ I = \frac{3 - (-3)}{2k\Omega} = 3mA \]

3.4

(a) Diode circuit diagram
\[ +1V \quad D_1 \quad V = 1V \]
\[ +3V \quad D_2 \quad V = 3V \]

Diode is cut off.

\[ V_{p+} = 10V \quad V_{p-} = 0V \]
\[ f = 1kHz \]
**CHAPTER 3 PROBLEMS**

(f) \[ V_{p+} = 10V \quad V_{p-} = 0V \quad f = 1kHz \]
- Di is cutoff when \( V_x < 0 \)

(g) \[ V_{p+} = 0V \quad V_{p-} = -10V \quad f = 1kHz \]
Di shorts to ground when \( V_x > 0 \) and is cutoff when \( V_x < 0 \) whereby the output follows \( V_x \).

(h) \[ V_o = OV \]
- The output is always shorted to ground as Di conducts when \( V_x > 0 \) and Dz conducts when \( V_x < 0 \).

(i) \[ V_{p+} = 10V \quad V_{p-} = -5V \quad f = 1kHz \]
- When \( V_x > 0 \), Di is cutoff and \( V_o \) follows \( V_x \).

(b) \[ V_{p+} = 0V \quad V_{p-} = -10V \]
\( f = 1kHz \)

(c) \[ V_o = 0V \]
Neither Di nor Dz conducts so there is no output.

(d) \[ V_{p+} = 10V \quad V_{p-} = 0V \quad f = 1kHz \]
Both Di and Dz conduct when \( V_x > 0 \)

(e) \[ V_{p+} = 10V \quad V_{p-} = -10V \quad f = 1kHz \]
Di conducts when \( V_x > 0 \) and Dz conducts when \( V_x < 0 \). Thus the output follows the input.
When $V_2 < 0$, $D_1$ is conducting and the circuit becomes a voltage divider where the negative peak is

$$\frac{1k\Omega}{1k\Omega + 1k\Omega} \cdot 10V = -5V$$

$V_{p1} = 10V \quad V_{p2} = -5V \quad f = 1k\text{Hz}$

When $V_2 > 0$, the output follows the input as $D_1$ is conducting. When $V_2 < 0$, $D_1$ is cutoff and the circuit becomes a voltage divider.

$V_{p1} = 1V \quad V_{p2} = -9V \quad f = 1k\text{Hz}$

When $V_2 > 0$, $D_1$ is cutoff and $D_2$ is conducting. The output becomes 1V.

When $V_2 < 0$, $D_1$ is conducting and $D_2$ is cutoff. The output becomes:

$$U_0 = U_2 + 1V$$

**CHAPTER 3 PROBLEMS**

3.5

- When $U_2 < 4.5V$, $D_1$ conducts and $D_2$ is cutoff so $i_B = 0A$. For $U_2 > 4.5V$, $D_2$ conducts and $D_1$ is cutoff thus disconnecting the input $U_2$. All of the current then flows through the battery.

$$10\sin\theta = 4.5V$$

$$\theta = \sin^{-1}(4.5/10)$$

Conduction angle = $\pi - 2\theta$

Fraction of cycle that $i_B = 100mA$ is given by:

$$\chi = \frac{\pi - 2\theta}{2\pi} = 0.35$$
\[
\left[ -\frac{14 \cdot 83 \cos \phi - 12 \phi}{R} \right]_{\phi = 0.3 \pi} = 0.1
\]

\[ R = 3.75 \Omega \]

Peak diode current = \( \frac{A - 12}{R} = 0.75A \)

Peak reverse voltage = \( A + 12 = 26.83V \)

- Resistors specified to only one significant digit and peak-to-peak voltage to the nearest volt then choose \( A = 15 \) so peak-to-peak sine wave voltage = 30V and \( R = 3 \Omega \).
- Induction starts at \( U_s = A \sin \theta = 12 \)
  \( \sin \theta = 12 \)
  \( \theta = 0.93 \) rad
- Induction stops at \( \pi - \theta \)
- Fraction of cycle that current flows is \( \frac{\pi - 2\theta}{2\pi} \times 100 \approx 20\% \)
- Average diode current =
  \[
  \frac{1}{\pi} \left[ -\frac{15 \cos \phi - 12 \phi}{3} \right]_{\phi = 0.93} = 1.36mA
  \]
- Peak diode current
  \[ \frac{15 - 12}{3} = 1A \]
- Peak reverse voltage
  \[ A + 12 = 27V \]

\[ V = \text{RED} \quad \text{GREEN} \]

\[
\begin{array}{ccc}
V & \text{RED} & \text{GREEN} \\
3V & \text{ON} & \text{OFF} & -D_1 \text{ conducts} \\
0 & \text{OFF} & \text{OFF} & -\text{No current flows} \\
-3V & \text{OFF} & \text{ON} & -D_2 \text{ conducts} \\
\end{array}
\]

\[ V_T = \frac{kT}{q} \]
where \( k = 1.38 \times 10^{-23}J/K \)
\[ T = 273 + x^\circ C \]
\[ q = 1.6 \times 10^{-19} C \]

\[ x [^\circ C] \quad V_T [mV] \]
\[
\begin{array}{cc}
-40 & 20 \\
0 & 23.5 \\
40 & 27 \\
150 & 36.5 \\
\end{array}
\]

For \( V_T = 2.5mV \)
\[ T = 16.8^\circ C \]

\[ 3.18 \]
\[
I = I_s e^{\frac{V}{2x0.025}}
\]
\[ \phi_0 \quad 1000 I_s = I_s e^{\frac{V}{0.05}} \]
\[ V = 0.345V \]

at \( V_R = 0.7V \)
\[ I = I_s e^{0.7/0.05} = 1.2 \times 10^6 I_s \]
Comparing the graphical results to the exponential model gives:

At \( i = 0.337 \text{ mA} = 10^{-2} \text{ } e^{0.25 \times 0.025} \)

\[ \Rightarrow 5 = 0.63 \cdot 6 \text{ mV} \]

which is only \((6.63 - 6.63.4) = 0.2 \text{ mV}\) greater than the value found graphically!

3.33

Iterative Analysis:

\[ \frac{i}{I_s} = e^{V/NU} \]

\[ I_s = 10^{-12} \text{ A} \]

\[ n = 1 \]

\[ V = 0.7 \text{ V} \]

\[ i = \frac{1 - 0.7}{1} = 0.3 \text{ mA} \]

\[ i = 0.6607 \text{ mA} \]

\[ n = 2 \]

\[ \frac{i}{I_1} = \frac{V - V_i}{0.05} \]

\[ V_2 = V_1 + 0.05 \ln \frac{i_2}{i_1} \]

\[ i = 1.5 \text{ mA} \]

\[ V = 0.7 + 0.05 \ln \frac{1.5}{1} \]

\[ i = \frac{1 - 0.720}{0.2} = 1.4 \text{ mA} \]

\[ i = 0.720 + 0.05 \ln \left( \frac{1.4}{1.5} \right) \]

\[ i = \frac{1 - 0.716}{0.2} = 1.42 \text{ mA} \]

\[ i = 0.716 + 0.05 \ln \left( \frac{1.42}{1.5} \right) \]

\[ i = 0.716 \text{ mA} \]