Homework #1 Solutions:

4.2 Refer to Fig. P4.2.
(a) Diode is conducting, thus
\[ V = -3 \text{ V} \]
\[ I = \frac{3 - (-3)}{10 \text{ k}\Omega} = 0.6 \text{ mA} \]
(b) Diode is reverse biased, thus
\[ I = 0 \]
\[ V = +3 \text{ V} \]
(c) Diode is conducting, thus
\[ V = +3 \text{ V} \]
\[ I = \frac{3 - (-3)}{10 \text{ k}\Omega} = 0.6 \text{ mA} \]
(d) Diode is reverse biased, thus
\[ I = 0 \]
\[ V = -3 \text{ V} \]

4.4
(a)
\[ V_p = 5 \text{ V} \quad V_n = 0 \text{ V} \quad f = 1 \text{ kHz} \]
(b)
\[ V_p = 0 \text{ V} \quad V_n = -5 \text{ V} \quad f = 1 \text{ kHz} \]

4.3
(c)
\[ v_o = 0 \text{ V} \]
Neither \( D_1 \) nor \( D_2 \) conducts, so there is no output.
(d)
\[ V_{p+} = 5 \text{ V} \quad V_{p-} = 0 \text{ V} \quad f = 1 \text{ kHz} \]
Both \( D_1 \) and \( D_2 \) conduct when \( v_I > 0 \)
(e)
\[ V_{p+} = 5 \text{ V} \quad V_{p-} = -5 \text{ V} \quad f = 1 \text{ kHz} \]
\( D_1 \) conducts when \( v_I > 0 \) and \( D_2 \) conducts when \( v_I < 0 \). Thus the output follows the input.
(f)
\[ V_{p+} = 5 \text{ V} \quad V_{p-} = 0 \text{ V} \quad f = 1 \text{ kHz} \]
\( D_1 \) is cut off when \( v_I < 0 \)
(g)
\[ V_{p+} = 0 \text{ V} \quad V_{p-} = -5 \text{ V} \quad f = 1 \text{ kHz} \]
\( D_1 \) shorts to ground when \( v_I > 0 \) and is cut off when \( v_I < 0 \) whereby the output follows \( v_I \).
(h) \( v_o = 0 \text{ V} \)

The output is always shorted to ground as \( D_1 \) conducts when \( v_I > 0 \) and \( D_2 \) conducts when \( v_I < 0 \).

(i) \( v_o \)

\( V_{P+} = 5 \text{ V, } V_{P-} = -2.5 \text{ V, } f = 1 \text{ kHz} \)

When \( v_I > 0 \), \( D_1 \) is cut off and \( v_o \) follows \( v_I \).

When \( v_I < 0 \), \( D_1 \) is conducting and the circuit becomes a voltage divider where the negative peak is

\[
\frac{1 \text{ k}\Omega}{1 \text{ k}\Omega + 1 \text{ k}\Omega} \times -5 \text{ V} = -2.5 \text{ V}
\]

(j) \( v_o \)

\( V_{P+} = 5 \text{ V, } V_{P-} = -2.5 \text{ V, } f = 1 \text{ kHz} \)

When \( v_I > 0 \), the output follows the input as \( D_1 \) is conducting.

When \( v_I < 0 \), \( D_1 \) is cut off and the circuit becomes a voltage divider.

(k) \( v_o \)

\( V_{P+} = 1 \text{ V, } V_{P-} = -4 \text{ V, } f = 1 \text{ kHz} \)

When \( v_I > 0 \), \( D_1 \) is cut off and \( D_2 \) is conducting. The output becomes 1 V.

When \( v_I < 0 \), \( D_1 \) is conducting and \( D_2 \) is cut off. The output becomes:

\( v_o = v_I + 1 \text{ V} \)

4.6

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\( X = AB, \quad Y = A + B \)

\( X \) and \( Y \) are the same for \( A = B \)

\( X \) and \( Y \) are opposite if \( A \neq B \)
4.9

(a) If we assume that both $D_1$ and $D_2$ are conducting, then $V = 0$ V and the current in $D_2$ will be $(0 - (-3))/6 = 0.5$ mA. The current in the 12 kΩ will be $(3 - 0)/12 = 0.25$ mA. A node equation at the common anodes node yields a negative current in $D_1$. It follows that our assumption is wrong and $D_1$ must be off. Now making the assumption that $D_1$ is off and $D_2$ is on, we obtain the results shown in Fig. (a):

$I = 0$
$V = -1$ V

(b) In (b), the two resistors are interchanged. With some reasoning, we can see that the current supplied through the 6 kΩ resistor will exceed that drawn through the 12 kΩ resistor, leaving sufficient current to keep $D_1$ conducting. Assuming that $D_1$ and $D_2$ are both conducting gives the results shown in Fig. (b):

$I = 0.25$ mA
$V = 0$ V

4.10:

(a) $5 \times \frac{10}{10 + 10} = 2.5$ V

$I = \frac{2.5}{5 + 20} = 0.1$ mA

$V = 0.1 \times 20 = 2$ V

(b) $V = 1.5 - 2.5 = -1$ V