Section 1, Test 3 Solutions.

#1. Diodes are ideal.

Find $V$ if $i = 2A$

- $i = -2A$.

a) Assume $D_1$ on, $D_2$ off. The circuit becomes:

\[ V = iR = (2A)(2k\Omega) = 4kV. \]

Check: $i_{D1} > 0, i_{D1} = 2A$. $V_{D2} = -V = -4kV$, so $D_2$ is off.

So $D_1$ is on.

b) Assume $D_2$ on, $D_1$ off. The circuit becomes:

\[ V = iR = (-2A)(3k\Omega) \quad V = -6kV. \]

Check: $i_{D2} > 0$ so it is on. $V_{D1} = V = -6kV$ so it is off.
#2.

[Diagram of an electrical circuit with labelled components: \( V_i \), \( V_G \), \( V_o \), and \( V_{DD} = 12V \).]

a) Find the value of \( V_G \) required so that, when \( V_i = 0, \ V_o = 4V \).

When \( V_o = 4V \), \( V_R = 12V - V_o = 12V - 4V = 8V \).

\[ i_D = \frac{8V}{2k\Omega} = 4mA, \quad V_o = V_{OS}. \]

On the graph, we locate the point \( (V_{OS} = 4V, \ i_D = 4mA) \) it is on the \( V_{GS} = 3V \) curve. Since \( V_i = 0, \ V_{CC} = V_{GS} \).

b) With \( V_G \) as found above, and assuming now that \( V_i(t) = 1V \sin(2\pi \cdot 20t) \), find the peak to peak variation of \( V_o \).

We need to use the load line. \( I_D \) is a function of \( V_{OS} \) and \( V_{OS} \). The load line will take this into account.

KVL: \( V_{OS} + R \cdot i_D = V_{DD} \)

\[ i_D = \frac{V_{DD} - \frac{1}{R} V_{OS}}{R} = \frac{12V - \frac{1}{2k\Omega} V_{OS}}{2k\Omega} \]

\[ i_D = 6mA - \frac{1}{2k\Omega} V_{OS}. \]
Since $V_i$ varies between $+1V$ and $-1V$, $V_{GS}$ varies between $2V$ and $4V$.

Point A: $V_{GS} = 4V$, $i_D = 5mA$, $V_{DS} = 2.3V$.

B: $V_{GS} = 2V$, $i_D = 1mA$, $V_{DS} = 10V$.

$V_o = V_{OS}$, so the peak to peak variation is $10V - 2.3V = 7.7V$.

#3 $D = \overline{A} + \overline{B} + C$

$$\overline{A} + \overline{B} = \overline{AB} \leftarrow \text{NAND}.$$  

So now $D = \overline{AB} + C$
4. \( V_i \) appears to be composed of two signals: \( V_i = \sin(2\pi f_1 t) + \sin(2\pi f_2 t) \).

\[ f_1 = \frac{1}{1\text{ms}} = 1 \text{kHz} \quad f_2 = 20 f_1 = 20 \text{kHz} \]

At the output, the low frequency component appears nearly unchanged while the high frequency component is greatly reduced. This suggests a low-pass filter.

To find \( R_C \), make the cutoff between 1kHz and 20kHz, say \( f_c = 2 \text{kHz} \).

\[ f_c = \frac{1}{2\pi R C} \quad \text{so} \quad R C = \frac{1}{2\pi \times 2000} \]

If \( R = 1k\Omega \), \( C = 80\text{nF} \)

These values are not unique.