Problem 1:

a) \[ I_X = \frac{1V - (-3V)}{2K} = 2mA = I_X \]

\[ V_X = 1V \]

Checks:
\[ I_{D1} = \frac{3V - 1V}{2K} = 1mA > 0 \rightarrow D_1 \text{ is forward-biased (FB)} \]
\[ I_{D2} = I_X - I_{D1} = 1mA \rightarrow D_2 \text{ is forward-biased (FB)} \]

b) \[ I_X = \frac{3V - (-2V)}{5K + 1K} = 1mA = I_X \]

\[ V_X = 3V - I_X \times 1K = 2V = V_X \]

Checks:
\[ V_{D2} = 1V - 2V = -1V < 0 \rightarrow D_2 \text{ is reverse-biased (RB)} \]
\[ I_{D1} = I_X = 1mA > 0 \rightarrow D_1 \text{ is forward-biased (FB)} \]

C) \[ V_X = 1V = V_X \]

\[ I_X = 0A \]

Checks:
\[ V_{D1} = 1V - 2V = -1V < 0 \rightarrow D_1 \text{ is reverse-biased (RB)} \]
Problem 2:

(a) $3V - 0.7V = 2.3V = V_x$

$I_x = \frac{0.3V - (3V)}{2K} = 1.65mA = I_X$

Checks:

$I_{D1} = \frac{3V - 0.7V - 0.3V}{2K} = 1mA > 0$ → $D_1$ is Forward-biased (FB)

$I_{D2} = I_X - I_{D1} = 0.65mA > 0$ → $D_2$ is Forward-biased (FB)

(b) $3V - 0.7V = 2.3V$

$I_x = \frac{3V - 0.7V}{1K + 5K} = 0.883mA = I_X$

$V_x = 3V - 0.7V - 1K \times I_X = 1.4167mV = V_x$

Checks:

$V_{D2} = V_x - 0.44 < 0$ → $D_2$ is Reverse-biased (RB)

$I_{D1} = I_X = 0.883mA > 0$ → $D_1$ is Forward-biased (FB)

(c) $1mA \downarrow$

$I_x = 0mA$

Checks:

$V_{D1} = V_x - 2V = -1V < 0$ → $D_1$ is Reverse-biased (RB)
Problem 3

KVL: \( 0 = -V_{ss} + R \cdot i_d + U_d \)

\[ i_d = \frac{V_{ss} - U_d}{R} = \frac{V_{ss}}{R} - \frac{U_d}{R} \]

With \( V_{ss} = 1 \text{V} \) and \( R = 500 \text{\Omega} \):
\[ i_d = \frac{1}{500} \text{mA} - \frac{U_d}{500} = 2 \text{mA} - 2 \text{mA} \cdot \frac{U_d}{500} \]

With \( V_{ss} = 0.5 \text{V} \) and \( R = 500 \text{\Omega} \):
\[ i_d = 1 \text{mA} - 2 \text{mA} \cdot \frac{U_d}{500} \]

\( \rightarrow \) slope of the load line in both cases:
\[ -\frac{2 \text{mA}}{1 \text{V}} = -\frac{1}{R} \]

\( \rightarrow \) No, the slope does not change when \( V_{ss} \) changes.

diode characteristics (Fig. 3.9d)

With \( V_{ss} = 1 \text{V} \) and the diode characteristics
\[ i_d \approx 0.55 \text{mA} \]
a) \(50^\circ C = 323 \text{ K}\)

*Equation 3.16 in the book:*

\[
V_T = \frac{k \cdot T}{q} = \frac{(1.38 \times 10^{-23}) \cdot (323)}{1.60 \times 10^{-19}} = 27.86 \text{ mV}
\]

*Equation 3.15 in the book:*

\[
I_0 = I_S \cdot [e^{\left(\frac{V_D}{n \cdot V_T}\right)} - 1] \quad \rightarrow \quad V_D = n \cdot V_T \cdot \ln\left(\frac{I_0}{I_S} + 1\right)
\]

Since \(\frac{I_0}{I_S} \gg 1\), is assumed here:

\[I_0 \approx n \cdot V_T \cdot \ln\left(\frac{I_0}{I_S}\right)\]

Using the two given measurement results to determine the emission coefficient:

\[
V_{02} - V_{01} = n \cdot V_T \cdot \ln\left(\frac{I_{02}}{I_S}\right) - n \cdot V_T \cdot \ln\left(\frac{I_{01}}{I_S}\right)
\]

\[
0.6 - 0.5 = n \cdot (27.86 \times 10^{-3}) \cdot \ln\left(\frac{120 \times 10^{-6}}{7 \times 10^{-6}}\right)
\]

\[\rightarrow \quad n = 1.263\]

b) Rearranging equation 1 above:

\[
I_S = \frac{I_0}{e^{\frac{V_D}{n \cdot V_T}}} = \frac{0.5}{e^{(0.263) \cdot (27.86 \times 10^{-3})}} \times 10^{-6}
\]

\[
I_S = 4.728 \times 10^{-12} \text{ A} = 4.728 \text{ pA}
\]
Problem 5:

(a) Using KVL

\[ 0.8V - I_1 \times 10K - 0.7V - I_1 \times 10K = 0 \]

\[ I_1 = 5 \text{mA} \]

\[ V_{\text{out}} = 0.8V - I_1 \times 10K = 0.75V = V_{\text{out}} \]

Checks:

\[ I_{D1} = I_1 > 0 \rightarrow D_1 \text{ is Forward-biased (FB)} \]

\[ V_{D1} + V_{D2} = 0.75V < 1.4V \rightarrow D_2, D_3 \text{ are Reverse-biased (RB)} \]
Problem 5, Part b)

Verification with $V1 = 0.8\text{V}$:

![Circuit Diagram]

Part c) Transfer characteristic:

![Graph]

The graph shows the transfer characteristic of the circuit with the following points:

- $R1 = 579.26\Omega$, $544.10\Omega$
- $F = 1.103$, $1.0019$
- $L = -1.1281$, $-537.94\Omega$

The graph plots $U(\text{OUT})$ against $U(V1\text{+})$.