Homework Solution 2

\[ 4.20 \quad I = I_s e^{V_D/V_T} \]
\[ 10^{-3} = I_s e^{0.7/V_T} \]
For \( V_D = 0.71 \) V,
\[ I = I_s e^{0.71/V_T} \] (2)
Combining (1) and (2) gives
\[ I = 10^{-3} e^{(0.71 - 0.7)/0.025} \]
\[ = 1.49 \text{ mA} \]
For \( V_D = 0.8 \) V,
\[ I = I_s e^{0.8/V_T} \] (3)
Combining (1) and (3) gives
\[ I = 10^{-3} e^{(0.8 - 0.7)/0.025} \]
\[ = 54.6 \text{ mA} \]
Similarly, for \( V_D = 0.69 \) V we obtain
\[ I = 10^{-3} e^{(0.69 - 0.7)/0.025} \]
\[ = 0.67 \text{ mA} \]
and for \( V_D = 0.6 \) V we have
\[ I = 10^{-3} e^{(0.6 - 0.7)/0.025} \]
\[ = 18.3 \mu\text{A} \]
To increase the current by a factor of 10, \( V_D \) must be increased by \( \Delta V_D \).
\[ 10 = e^{\Delta V_D/0.025} \]
\[ \Rightarrow \Delta V_D = 0.025 \ln 10 = 57.6 \text{ mV} \]

\[ 4.28 \quad \text{We can write the following node equation at the diode anodes:} \]
\[ I_{D2} = 10 \text{ mA} - V/R \]
\[ I_{D1} = V/R \]
We can write the following equation for the diode voltages:
\[ V = V_{D2} - V_{D1} \]
We can write the following diode equations:
\[ I_{D2} = I_s e^{V_{D2}/V_T} \]
\[ I_{D1} = I_s e^{V_{D1}/V_T} \]
Taking the ratio of the two equations above, we have
\[ \frac{I_{D2}}{I_{D1}} = \frac{10 \text{ mA} - V/R}{V/R} = e^{(V_{D2} - V_{D1})/V_T} = e^{V/V_T} \]
To achieve \( V = 50 \) mV, we need
\[ \frac{I_{D2}}{I_{D1}} = \frac{10 \text{ mA} - 0.05/R}{0.05/R} = e^{0.05/0.025} = 7.39 \]
Solving the above equation, we have
\[ R = 42 \Omega \]

\[ 4.23 \quad \text{The voltage across three diodes in series is} \]
\[ 2.0 \text{ V; thus the voltage across each diode must be} \]
\[ 0.667 \text{ V. Using} \quad I_D = I_s e^{V_D/V_T} \text{, the required} \]
\[ \text{current} \ I \ \text{is found to be} \ 3.81\text{mA}. \]

If 1 mA is drawn away from the circuit, \( I_D \) will be
\[ 2.81\text{mA}, \] which would give \( V_D = 0.659 \text{V} \), giving an output voltage of 1.98 V. The change in output voltage is -20mV.
4.40 Refer to Example 4.2.

(a)

\[ I = 1.86 - 1 = \frac{10 \text{ kΩ}}{0.86 \text{ mA}} = 1 \text{ mA} \]

\[ V = 0 \text{ V} \]

(b)

\[ I_{D2} = \frac{10 - 0 - 0.7}{5} = 1.29 \text{ mA} \]

\[ V_D = -10 + 1.29 (10) + 0.7 = 3.6 \text{ V} \]

4.44

(a) \[ I = \frac{2.5 - 0.7}{5 + 20} = 0.072 \text{ mA} \]

\[ V = 0.072 \times 20 = 1.44 \text{ V} \]

(b) The diode will be cut off, thus

\[ I = 0 \]

\[ V = 1.5 - 2.5 = -1 \text{ V} \]