# ECE 320 - Quiz 1:  Name __Solution__

January 29, 2015  -  Semiconductors, PN Junction, Diode Equation

1)  Semiconductors can be p-type, n-type, or intrinsic.

1a)  What is meant by the term 'p-type semiconductor'?  (4 points)

*The majority of charge carriers are holes*

*Current travels by electrons hopping hole-to-hole (missing electrons in the covalent bonds)*

*Silicon doped with Boron is how you make p-type silicon ( -2 points )*

1b)  What is meant by the term 'n-type semiconductor'? (4 points)

*The majority of charge carriers are electrons*

*(more accurate):  The majority of charge carriers are electrons traveling in the conduction bands*

*Current travels by electrons flowing in the conduction bands (i.e. not in covalent bonds)*

*Silicon doped with Phosphorous is how you make n-type silicon ( -2 points )*

1c)  What is meant by the term 'intrinsic semiconductor'? (2 points)
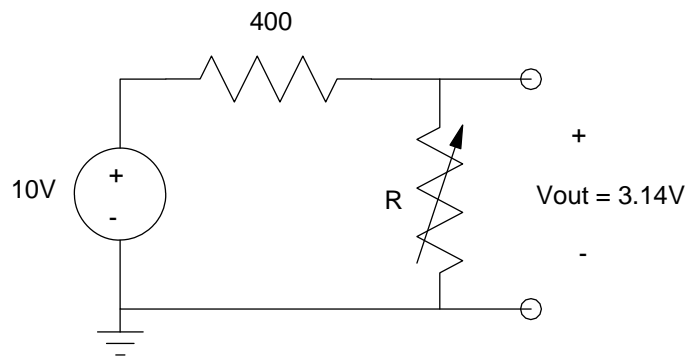
*Sillicon which  is neither p-type nor n-type*

*The number of holes and electrons are approximately the same*

2) Determine the resistance and temperature of the thermistor if the output voltage is 3.14V. Assume the temperature-voltage relationship is as follows where T is the temperature in degrees C

$$R = 1000 \cdot e^{-0.04(T-25)} \Omega$$

| R (Ohms) | T (degrees C) |
|:---:|:---:|
| **183 Ohms** | **67.44 C** |



$$V_{out} = \left( \frac{R}{R+400} \right) 10V$$

$$R = \left( \frac{V}{10-V} \right) 400\Omega$$

$$R = 183\Omega$$

$$R = 1000 \cdot e^{-0.04(T-25)} \Omega$$
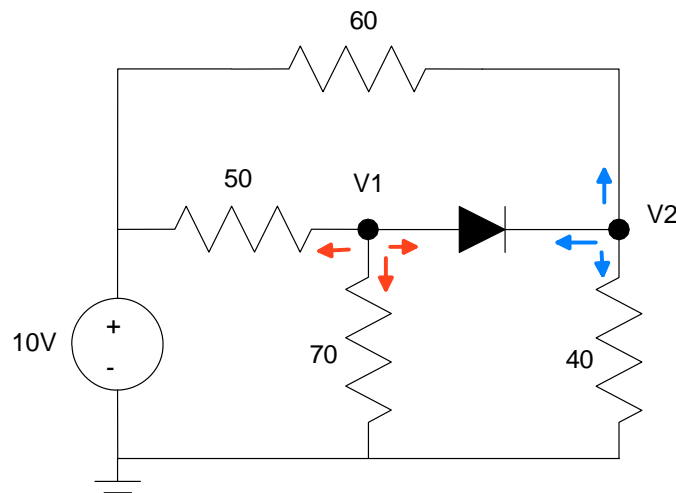
$$T = 25 - 25 \ln \left( \frac{R}{1000} \right)$$

$$T = 67.44$$

3) Write the voltage node equations at nodes V1 and V2. Assume silicon diodes with

$$I_d = I_{dss}(e^{20V_d} - 1)A \qquad\qquad V_d = 0.05 \ln\left(\frac{I_d}{I_{dss}} + 1\right)V$$
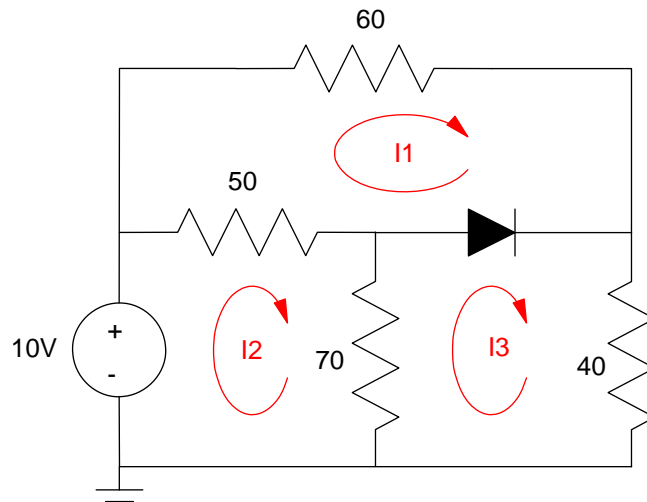
| | |
|---|---|
| Node V1 (orange) | $\left(\frac{V_1-10}{50}\right) + \left(\frac{V_1}{70}\right) + I_{dss}(e^{20(V_1-V_2)} - 1) = 0$ |
| Node V2 (blue) | $\left(\frac{V_2-10}{60}\right) + \left(\frac{V_2}{40}\right) - I_{dss}(e^{20(V_1-V_2)} - 1) = 0$ |

4) Write the current-loop equations for I1, I2, and I3.  Assume silicon diodes with

$$I_d = I_{dss}(e^{20V_d} - 1)A \qquad\qquad V_d = 0.05 \ln\left(\frac{I_d}{I_{dss}} + 1\right)V$$

| | |
|---|---|
| Loop I1 | $50(I_1 - I_2) + 60I_1 - 0.05 \ln\left(\frac{I_3 - I_1}{I_{dss}} + 1\right) = 0$ |
| Loop I2 | $-10 + 50(I_2 - I_1) + 70(I_2 - I_3) = 0$ |
| Loop I3 | $70(I_3 - I_1) + 0.05 \ln\left(\frac{I_3 - I_1}{I_{dss}} + 1\right) + 40I_3 = 0$ |

5) The following circuit is used to power a white LED where the VI characteristics are shown on the following graph.

110

9V

Id
+
Vd
-
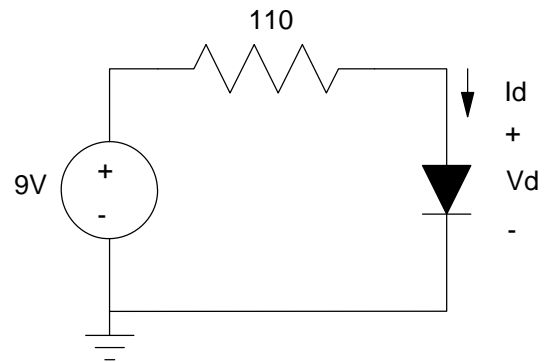
a) Draw the load-line for the following circuit

b) Determine Vd and Id

| Vd (Volts) | Id (mA) |
|------------|---------|
| **1.8 V**  | **66 mA** |