

ECE 320: Quiz #2 Name _____

Semiconductors, PN Junction, Diode Characteristics - January 28, 2016

- 1) Define the following terms

p-type semiconductor

$$\# \text{ holes} \gg \# \text{ electrons}$$

n-type semiconductor

$$\# \text{ electrons} \gg \# \text{ holes}$$

intrinsic silicon

$$\# \text{ electrons} \approx \# \text{ holes}$$

2a) Why don't diodes allow current to flow from n to p?

- reverse bias uses minority carriers
so $I \approx 0$
- depletion zone gets bigger
- potential energy barrier gets bigger

2b) Why is there a 0.7V drop across a silicon diode when it turns on? (i.e. why don't diodes turn on at 0V?)

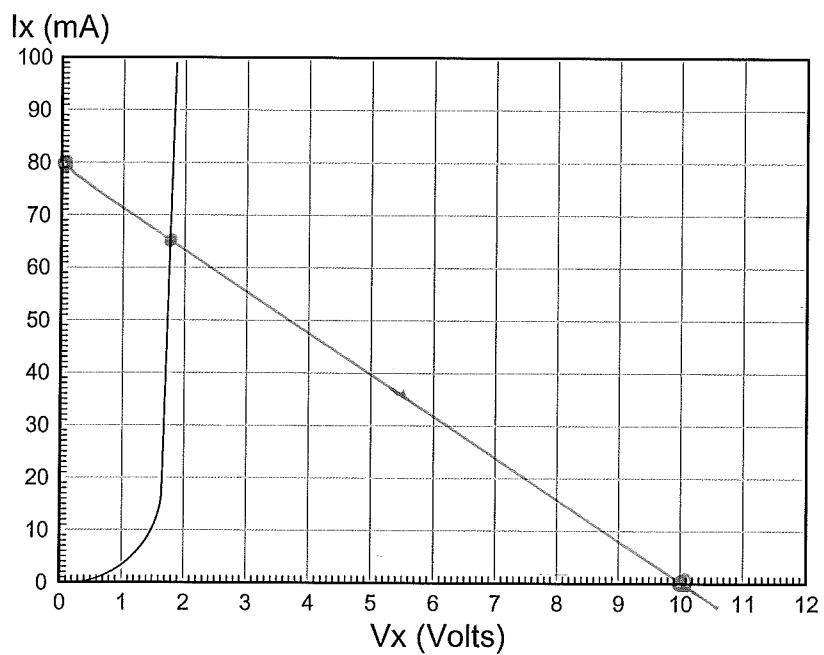
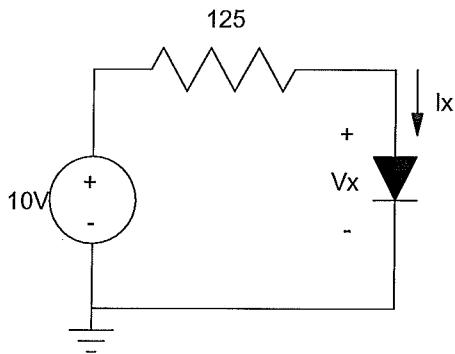
- it takes $\approx 0.7V$ to remove the depletion zone
- it takes $\approx 0.7V$ to overcome the potential energy barrier

3) The VI characteristics for a red LED are shown below. For the following circuit

- Draw the load line, and
- Determine the operating point

Determine the resistance between A and B

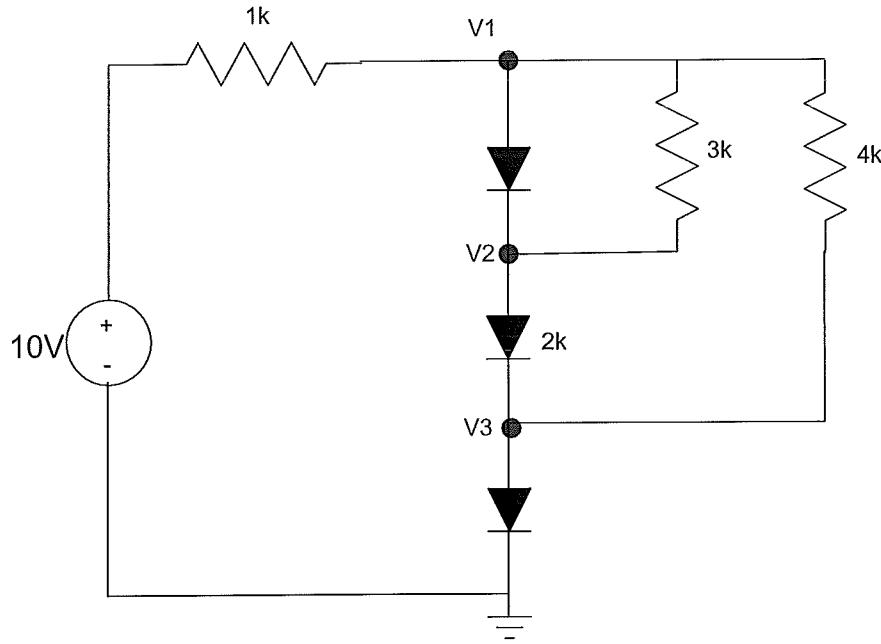
Load Line	I_x	V_x
show on graph	65 mA	1.8 V



4) Write the voltage node equations for the following circuit. Assume the diode equations are

$$V_d = 0.052 \ln(10^8 I_d + 1)$$

$$I_d = 10^{-8} \left(\exp\left(\frac{V}{0.052}\right) - 1 \right)$$



$$\frac{V_1 - 10}{1k} + \frac{V_1 - V_2}{3k} + \frac{V_1 - V_3}{4k} + 10^{-8} \left(e^{\frac{V_1 - V_2}{0.052}} - 1 \right) = 0$$

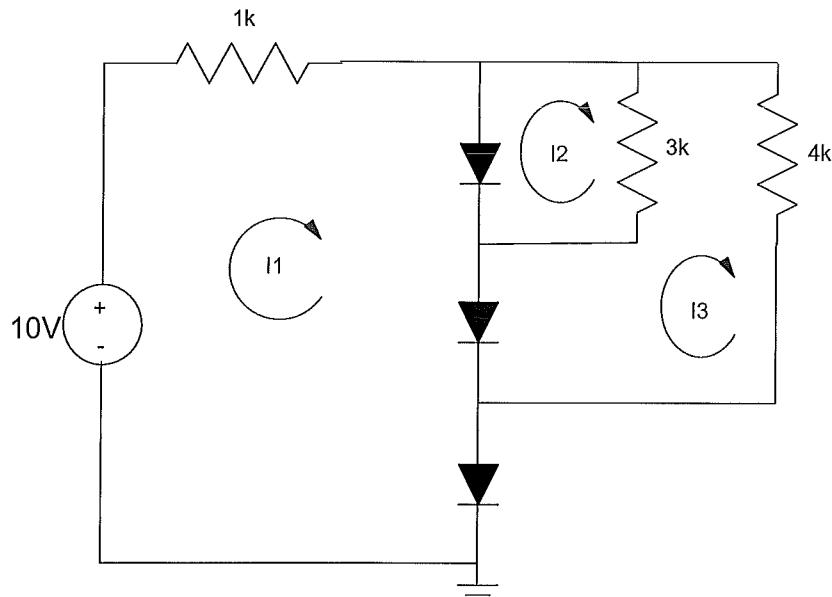
$$\frac{V_2 - V_1}{3k} + 10^{-8} \left(e^{\frac{V_2 - V_3}{0.052}} - 1 \right) - 10^{-8} \left(e^{\frac{V_1 - V_2}{0.052}} - 1 \right) = 0$$

$$\frac{V_3 - V_1}{4k} + 10^{-8} \left(e^{\frac{V_3}{0.052}} - 1 \right) - 10^{-8} \left(e^{\frac{V_2 - V_3}{0.052}} - 1 \right) = 0$$

5) Write the current loop equations for the following circuit. Assume the diode equations are

$$V_d = 0.052 \ln(10^8 I_d + 1)$$

$$I_d = 10^{-8} \left(\exp\left(\frac{V}{0.052}\right) - 1 \right)$$



$$-10 + 1000I_1 + .052 \ln((I_1 - I_2) \cdot 10^8 + 1) + .052 \ln(10^8(I_1 - I_3) + 1) + .052 \ln(10^8 I_1 + 1) = 0$$

$$3k \cdot I_2 - .052 \ln(10^8(I_1 - I_2) + 1) = 0$$

$$3k(I_3 - I_2) + 4k \cdot I_3 - .052 \ln(10^8(I_1 - I_3) + 1) = 0$$

Bonus! Is 1mA a lot? Assume each person in the United States leaves a single LED on, which draws 1mA at 3V (3mW). How many pounds of coal has to be burned to keep all 300 million of these LEDs turned on for one year? (note: 1 pound of coal produces about one kWh of electricity).

$$3\text{mW} \cdot 30\text{million people} = 900\text{kW}$$

* 8760 hours/year

$$= 7,844,000 \text{ kWh}$$

$$= 7,844,000 \text{ lb of coal}$$

$$= 3942 \text{ tons of coal}$$

$$\approx 1971 \text{ m}^3 \text{ of coal}$$

$$12.5\text{m} \times 12.5\text{m} \times 12.5\text{m}$$