ECE 320 - Quiz #2 - Name ____________________

Semiconductors, pn Junction, ideal diodes - Spring 2021

1) For semiconductors, current can flow using either holes or electrons.

1a) What are holes?

Holes are covalent bonds which are missing an electron. Holes act like a positively charged charge carrier.

1b) Why is the resistance of n-type silicon slighly less than the resistance of p-type silicon?

Electrons are physical particles. Any electron which is not tied up in a covalent bond is free to carry current.

Holes are not actual particles but a covalent bond which is missing an electron. A nearby electron that escapes its covalent bond can fill this spot in the covalent bond, making it look like the hole moved. Since this requires more things to happen, this shows up as having a lower mobility for holes and a higher resistance.

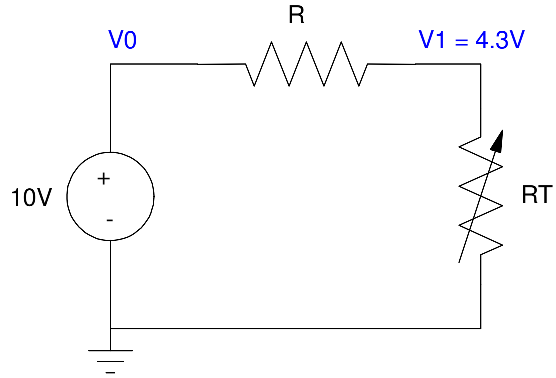
2) Thermistors: Assume the VI characteristics of a thermistor are

$$R_T = 1000 \exp\left(\frac{4440}{T+273} - \frac{4440}{298}\right)\Omega$$

where T is the temperature in degrees C. Determine RT and the temperature if V1 = 4.3V

Let R be 1000 + (your birth month) * 100 + your birthday. For example, March 14th would give R = 1514 Ohms.

R 1000 + 100*Month + Day	RT (Ohms) Thermistor	Temperature (C)
1514 varies	**1142.14** depends upon R	**+22.36 C** depends upon R



$$4.3V = \left(\frac{R_T}{R_T+R}\right)10V$$

$$R_T = \left(\frac{4.3}{10-4.3}\right)R = 1142.14\Omega$$

From the Thermistor equation

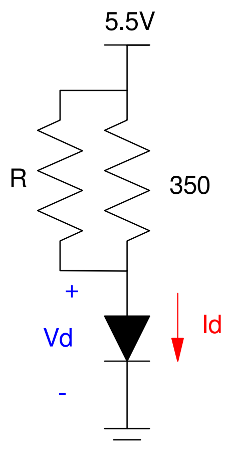
$$1142.14 = 1000 \exp\left(\frac{4440}{T+273} - \frac{4440}{298}\right)\Omega$$

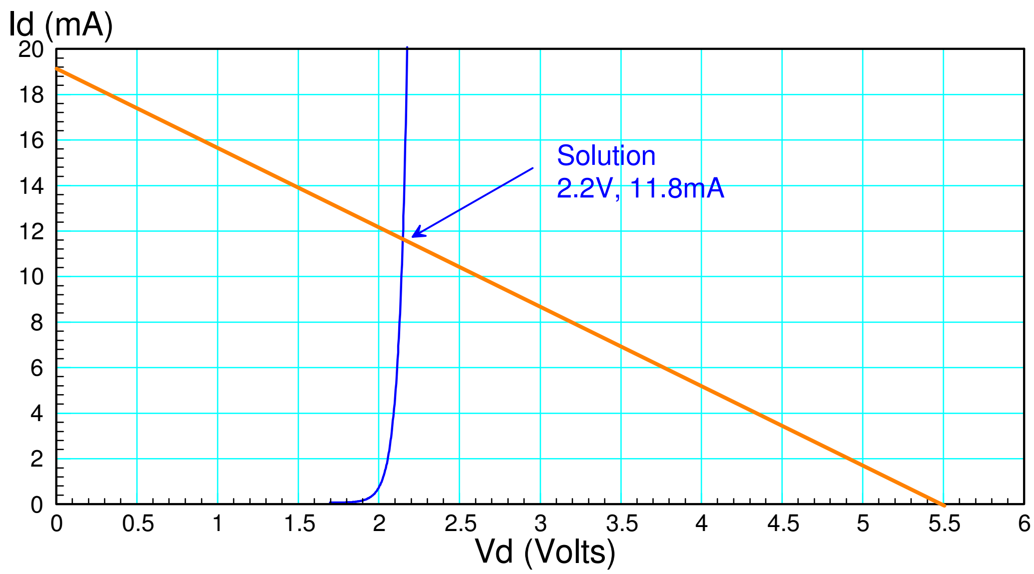
$$T = +22.365^0 C$$

3) Load Lines: The VI characteristic for a diode is show on the graph below. Draw the load line for the following circuit and from the graph, determine Vd and Id

- Let R be 1000 + 100*(Birth Month) + (Birthday)

R 1000 + 100*Month + Day	Load Line	Vd	Id
1514 varies	show on graph	**2.2V**	**11.8mA**





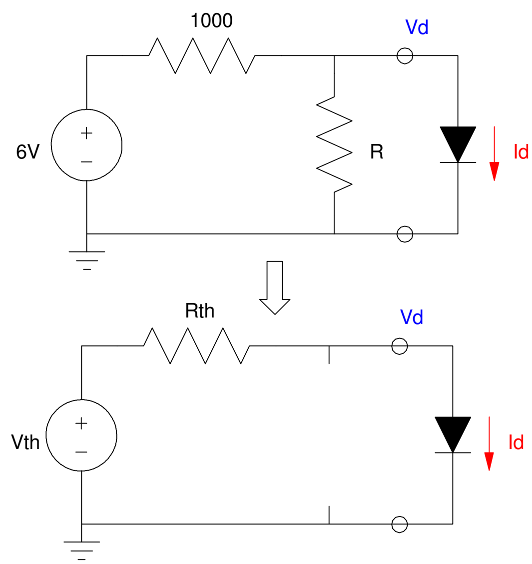
$$R||350 = 284.28\Omega$$

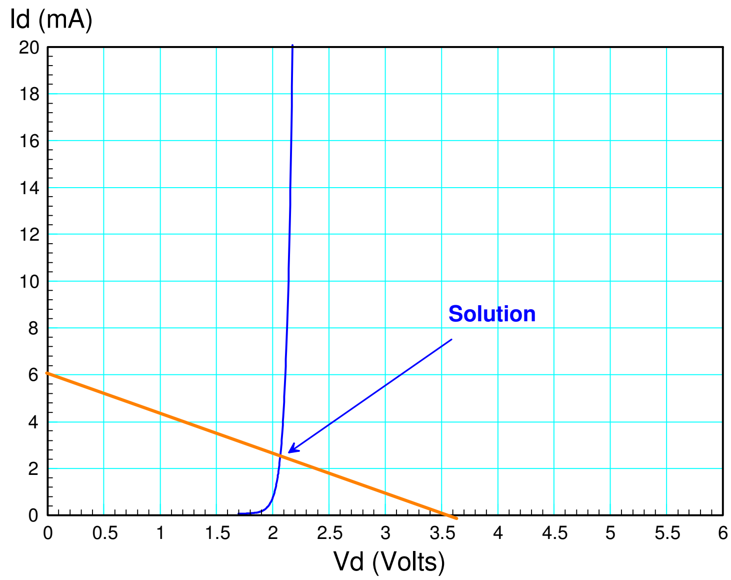
$$\max(Id) = \left(\frac{5.5V}{284.28\Omega}\right) = 19.3mA$$

4) More Load Lines: Determine the Thevenin equivalent for the circuit up top. Then, draw the load line and determine Vd and Id.

- Let R be 1000 + 100*(Birth Month) + (Birthday)

R	Vth	Rth	Vd	Id
1514	**3.613 V**	**606.2 Ohm**	**2.2V**	**2mA**





$$V_{th} = \left(\frac{R}{R+1000}\right) 6V = 3.613V$$

$$R_{th} = R||1000 = 602.2\Omega$$

Load Line: Y-Intercept

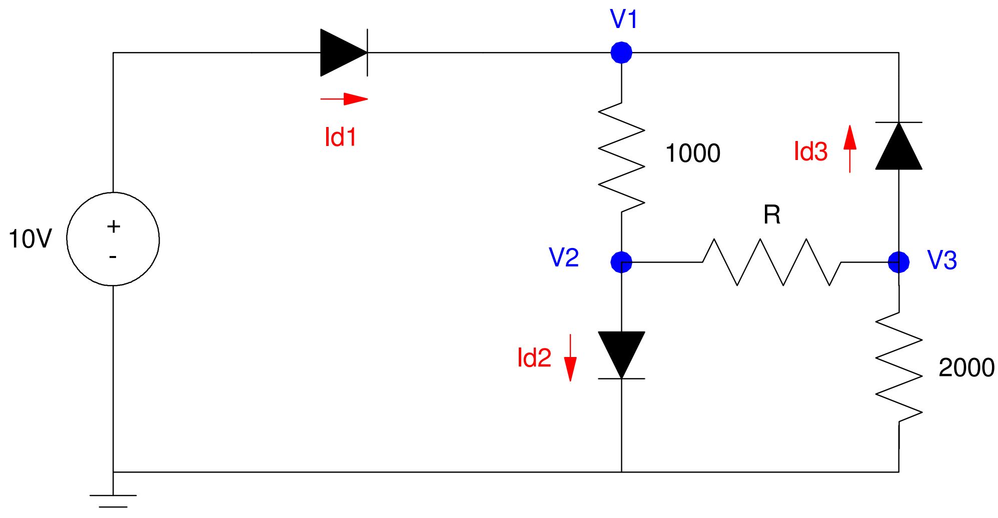
$$I = \frac{3.613V}{602.2\Omega} = 6.00mA$$

5) Assume the VI characteristics of the diodes below are:

$$V_d = 0.052\ \ln\left(\frac{I_d}{10^{-8}} + 1\right) \qquad I_d = 10^{-8}\left(\exp\left(\frac{V_d}{0.052}\right) - 1\right)$$

Write the voltage node equations for the following circuit (don't solve).

- Let R be 1000 + 100*(Birth Month) + (Birthday)



$$I_{d1} = 10^{-8}\left(\exp\left(\frac{10-V_1}{0.052}\right) - 1\right)$$

$$I_{d2} = 10^{-8}\left(\exp\left(\frac{V_2-0}{0.052}\right) - 1\right)$$

$$I_{d3} = 10^{-8}\left(\exp\left(\frac{V_3-V_1}{0.052}\right) - 1\right)$$

$$-I_{d1} + \left(\frac{V_1-V_2}{1000}\right) - I_{d3} = 0$$

$$\left(\frac{V_2-V_1}{1000}\right) + \left(\frac{V_2-V_3}{1514}\right) + I_{d2} = 0$$

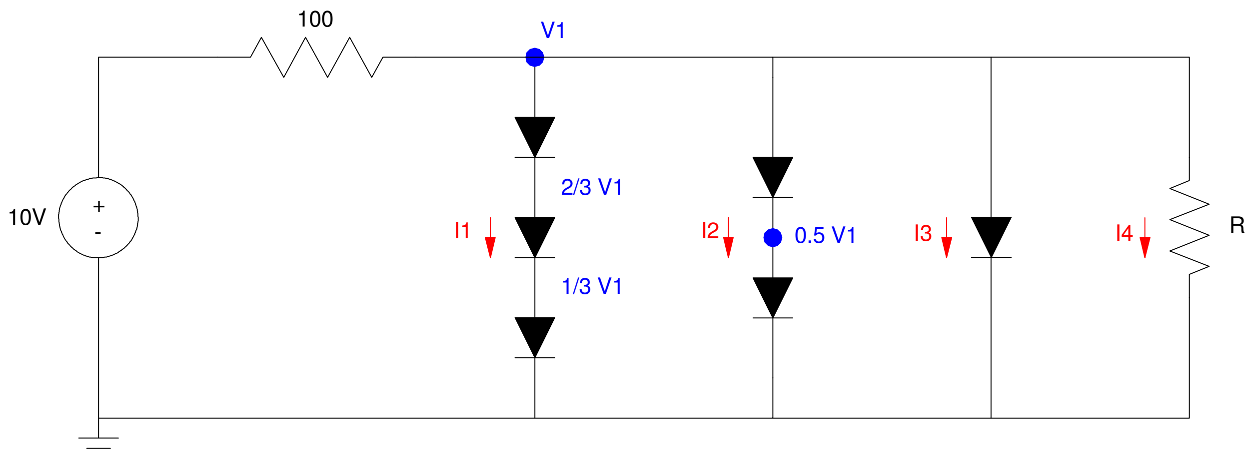
$$I_{d3} + \left(\frac{V_3-V_2}{1514}\right) + \left(\frac{V_3}{2000}\right) = 0$$

6) By symmetry, if you have three identical diodes in series, the voltage drop across each diode will be 1/3 of the total voltage. Assume the VI relationship for the diodes below are

$$V_d = 0.052 \ \ln\left(\frac{I_d}{10^{-8}} + 1\right) \qquad\qquad I_d = 10^{-8}\left(\exp\left(\frac{V_d}{0.052}\right) - 1\right)$$

Write the voltage node equations for the following circuit.

- Let R be 1000 + 100*(Birth Month) + (Birthday)



$$I_1 = 10^{-8}\left(\exp\left(\frac{\frac{1}{3}V_1}{0.052}\right) - 1\right)$$

$$I_2 = 10^{-8}\left(\exp\left(\frac{\frac{1}{2}V_1}{0.052}\right) - 1\right)$$

$$I_3 = 10^{-8}\left(\exp\left(\frac{V_1}{0.052}\right) - 1\right)$$

$$\left(\frac{V_1 - 10}{100}\right) + I_1 + I_2 + I_3 + \left(\frac{V_1}{1514}\right) = 0$$