ECE 320 - Quiz #2 - Name ____________________

Semiconductors, pn Junction, ideal diodes - Fall 2021

1a) When a silicon diode conducts current p to n, there is about a 0.7V drop across the diode. What causes this voltage drop?

At the pn junction

- *holes on the p-side diffuse to the n-side*
- *electrons on the n-side diffuse to the p-side*

This creates a depletion zone and a potential energy barrier (about 0.7V for silicon diodes). Any electron that crosses the pn junction has to expend 0.7V to overcome this.

1b) What are holes and electrons?

Electrons: We're not really certain. Current thought is that electrons are fundamental particles that can't be broken down into smaller parts (quarks).

Electrons are negative charged particles that surround the nucleus of an atom and are responsible for forming covalent bonds and for conducting charge (carrying current) in the conduction bands of a material (metals, n-type silicon).

Holes are a missing electron in a covalent bond. This can be caused by doping with Boron or from a thermal electron escaping its covalent bond, leaving a hole.

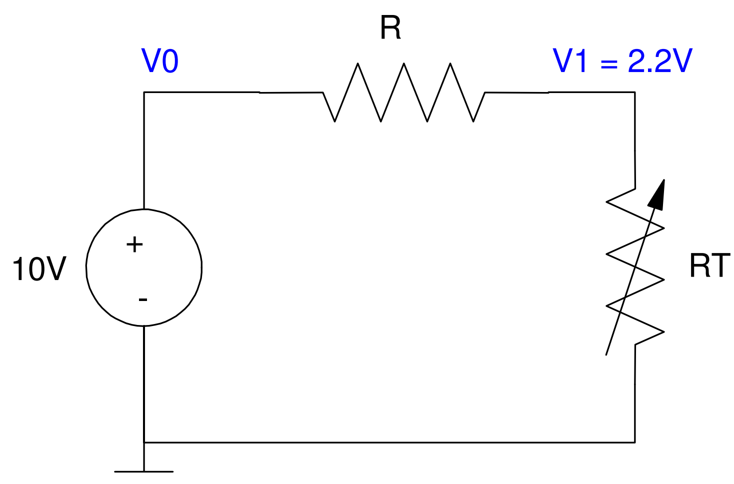
2) Thermistors: Assume the VI characteristics of a thermistor are

$$R_T = 1000 \exp\left(\frac{4200}{T+273} - \frac{4200}{298}\right)\Omega$$

where T is the temperature in degrees C. Determine RT and the temperature if V1 = 2.2V

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	**427 Ohms** varies with R	**44.15 C** varies with RT



$$V_1 = \left(\frac{R_T}{R_T+1514}\right)10V$$

$$R_T = \left(\frac{V_1}{10-V_1}\right)1514 = 427.026\Omega$$

From

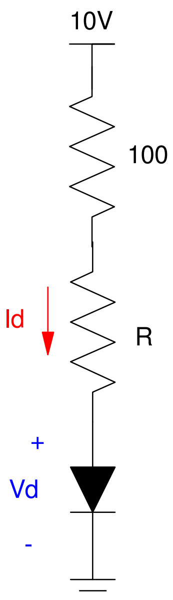
$$R_T = 1000 \exp\left(\frac{4200}{T+273} - \frac{4200}{298}\right)\Omega = 427.026\Omega$$

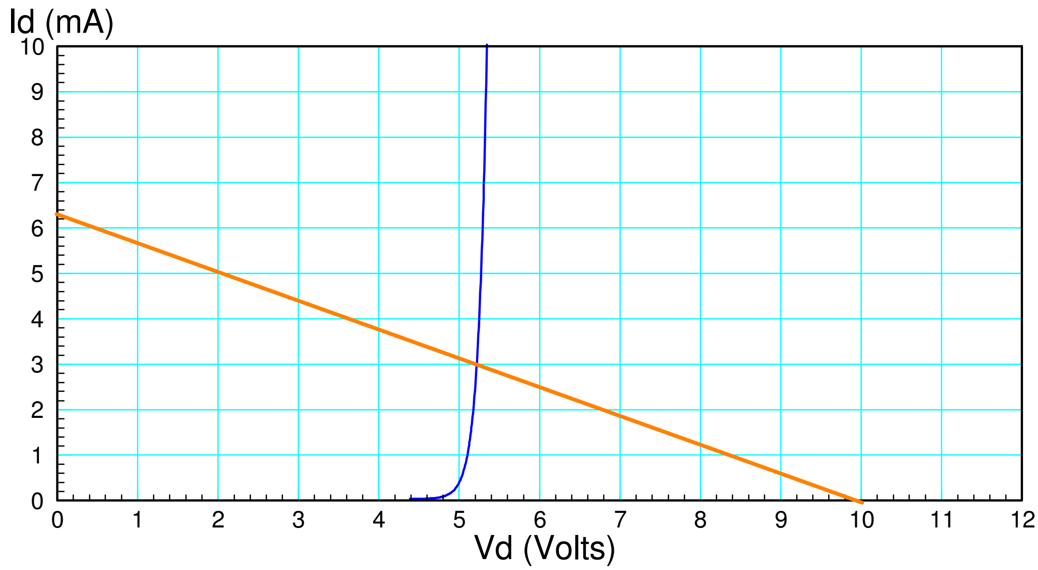
$$T = 44.148^0 C$$

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	x intercept = 10V y intercept = 6.196mA	**5.2V**	**3.0mA**





X-intercept = 10V

Y intercept:

$$I_d = \left(\frac{10V}{100\Omega + 1514\Omega}\right) = 6.196mA$$

4) Diodes (nonlinear equations): Assume

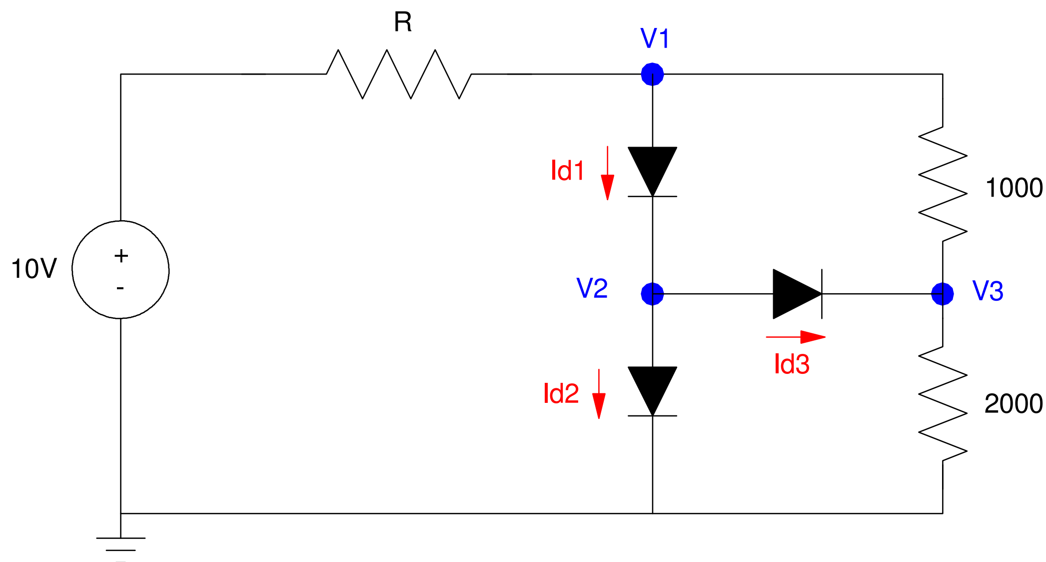
- The VI characteristics of a diode are

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

- R = 1000 + 100 * (your birth month) + (your birth date). For example, May 14th gives R = 1514 Ohms.

Write 6 equations so solve for {V1, V2, V3, Id1, Id2, Id3}

- note: don't solve.



$$I_{d1} = 10^{-8} \cdot \left(\exp\left(\frac{V_1 - V_2}{0.052} \right) - 1 \right)$$

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

$$I_{d3} = 10^{-8} \cdot \left(\exp\left(\frac{V_2 - V_3}{0.052} \right) - 1 \right)$$

Voltage node equations

$$\left(\frac{V_1 - 10}{1514} \right) + I_{d1} + \left(\frac{V_1 - V_3}{1000} \right) = 0$$

$$-I_{d1} + I_{d2} + I_{d3} = 0$$

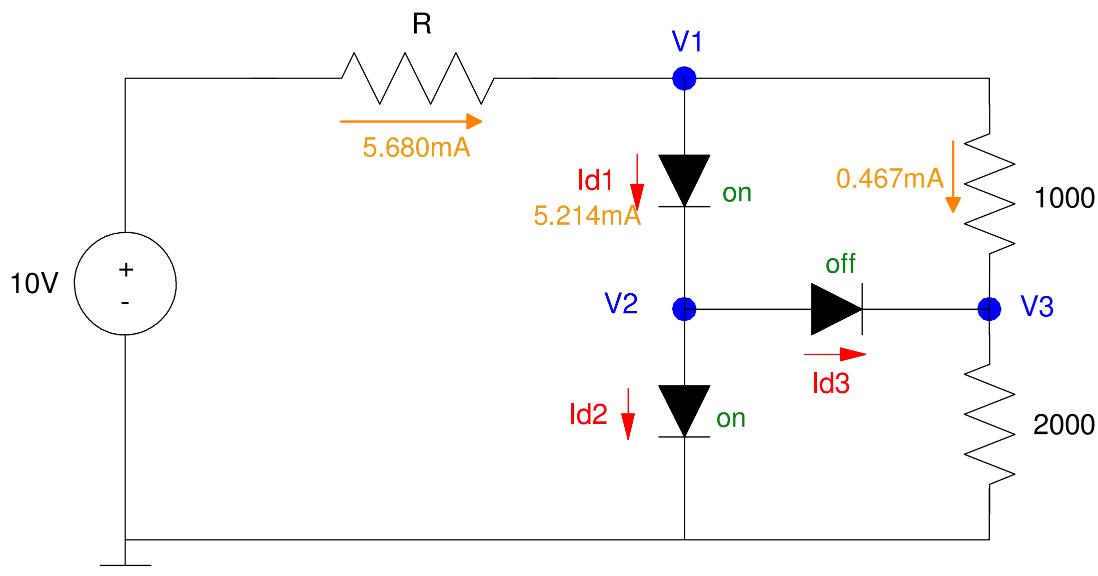
$$\left(\frac{V_3 - V_1}{1000} \right) - I_{d3} + \left(\frac{V_3}{2000} \right) = 0$$

5) Assume

- R = 1000 + 100 * (your birth month) + (your birth date). For example, May 14th gives R = 1514 Ohms.
- Ideal silicon diodes (Vf = 0.7V).

Determine {V1, V2, V3, Id1, Id2, Id3}

V1	V2	V3	Id1	Id2	Id3
1.4V	**0.7V**	**0.933V**	**5.214mA**	**5.214mA**	**0**



Diode #3 must be off. Otherwise, V3 = 0V

Assume diodes #1 and #2 are on

V2 = 0.7V

V1 = 1.4V

by voltage division

$$V_3 = \left(\frac{2000}{2000+1000}\right) V_1 = 0.933V$$

Solve for Id1

$$\left(\frac{V_1 - 10}{1514}\right) + I_{d1} + \left(\frac{V_1}{3000}\right) = 0$$

$$I_{d1} = 5.214mA$$

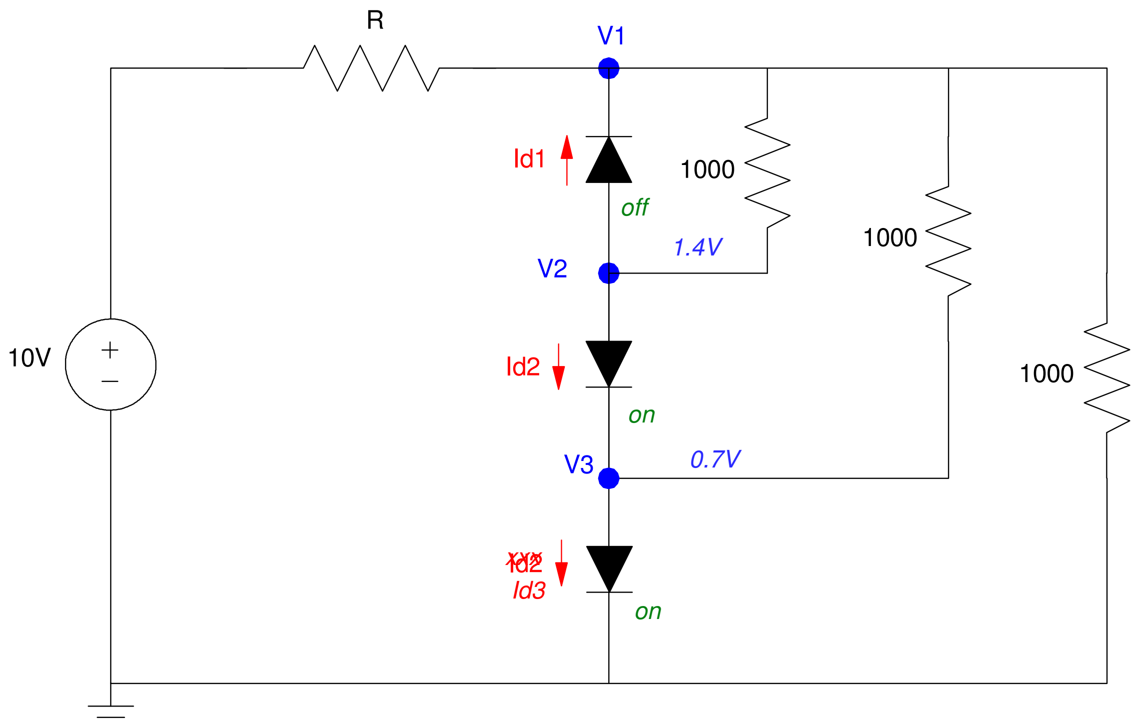
$$I_{d2} = I_{d1}$$

6) Assume

- R = 1000 + 100 * (your birth month) + (your birth date). For example, May 14th gives R = 1514 Ohms.
- Ideal silicon diodes (Vf = 0.7V).

Determine {V1, V2, V3, Id1, Id2, Id3}

V1	V2	V3	Id1	Id2	Id3
2.378V	**1.4V**	**0.7V**	**0**	**0.978mA**	**2.656mA**



To find V1, write the voltage node equation

$$\left(\frac{V_1-10}{1514}\right)+\left(\frac{V_1-1.4}{1000}\right)+\left(\frac{V_1-0.7}{1000}\right)+\left(\frac{V_1}{1000}\right)=0$$

$$V_1 = 2.378V$$

$$I_{d1} = 0$$

$$I_{d2} = \left(\frac{V_1-1.4}{1000}\right) = 0.978mA$$

$$I_{d3} = I_{d2} + \left(\frac{V_1-0.7}{1000}\right) = 2.656mA$$