

# Kirchhoff's Laws Activity

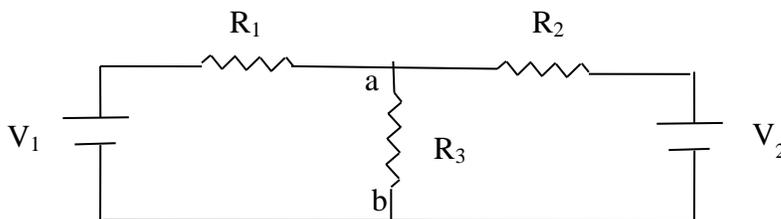
## Purpose

Students will explore Kirchhoff's Loop and Node rules. The students will also build circuits and verify voltages, currents, and resistances using a multimeter.

## Part I: Three Resistors & Two Power Supplies (50 pts total)

The resistors and power sources that you will be using both have tolerances. The tolerance of each resistor is +/- 1%. The tolerances of the power sources are approximately +/- 0.25V. Therefore you will need to measure each resistor and power source with a multimeter to determine its actual value.

After you have determined the actual values of your resistors and power sources, use Kirchhoff's Laws to theoretically determine the current passing through each resistor for the circuit drawn below. Since there are three unknown currents, you will need to generate three linearly independent equations to solve simultaneously. There are three loop equations and two node equations that can be created from the schematic below. You will need to choose three of these five equations in order to solve for  $I_1$ ,  $I_2$ , and  $I_3$ .



### Approximate Nominal Values

You will need to obtain the actual values of your components in order to compare the theoretical currents to the actual currents

$R_1$	$R_2$	$R_3$	$V_1$	$V_2$
100 $\Omega$	100 $\Omega$	200 $\Omega$	12.00 V	5.00 V

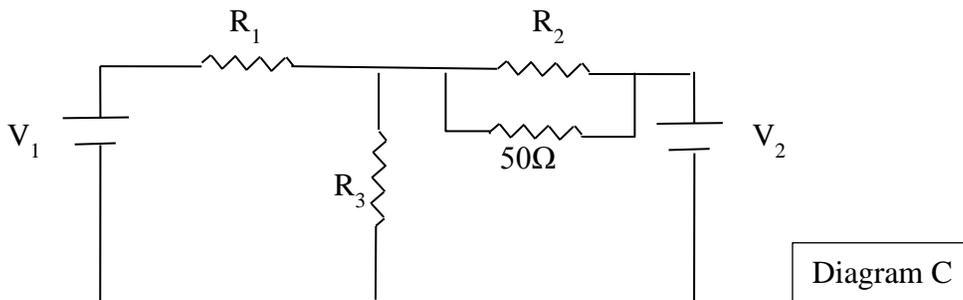
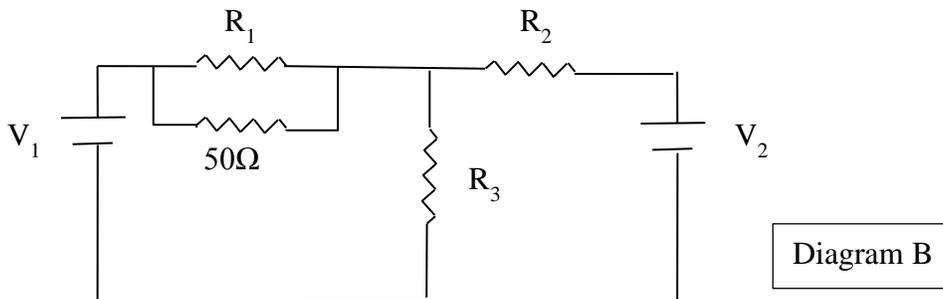
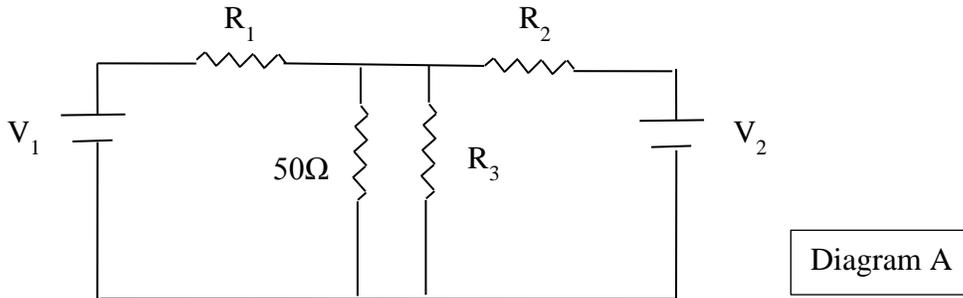
After you have theoretically calculated the currents going through each resistor, verify that your theoretical calculations are correct by building the circuit, and reading the currents with a multimeter. The currents flowing through the resistors will be in the milliamp range ( $10^{-3}$  Ampere). Therefore, you will need to use the (mA) and (COM) ports of the multimeter and the 200mA setting on the multimeter dial when using the multimeter as an ammeter.

Make sure each member of the group understands how to use a multimeter to measure voltage and current. A group member will be chosen at random to take measurements in Part II, and the group's score will depend on the ability of the group member to measure the voltage and/or the current using a multimeter. Also be aware that your group will be allowed to blow one fuse in the multimeter. After you have blown your first fuse, each additional fuse will result in a grade deduction. Specifically if an ammeter is connected in parallel with a resistor, the current reading will be ambiguous, and the multimeter fuse may be blown.

## Part II: Four Resistors & Two Power Supplies (40 pts total)

Your TA will assign your group one of the sets of conditions from the table below. Using the data conditions in the table, theoretically determine the current flowing through the  $50\Omega$  resistor. Remember that the conditions listed in the table are nominal values. You will need to use the actual values of the components at your station. The actual value of the  $50\Omega$  resistor will be posted on the blackboard. When you are confident that your group has theoretically calculated the current flowing through the  $50\Omega$  resistor, your TA will come to your station and provide your group with a  $50\Omega$  resistor and test your group.

	$R_1 (\Omega)$	$R_2 (\Omega)$	$R_3 (\Omega)$	$V_1 (V)$	$V_2 (V)$	Diagram
1	200	100	100	12	5	A
2	100	200	100	12	5	B
3	200	100	100	12	5	C
4	100	200	100	12	5	A
5	200	100	100	12	5	B
6	100	200	100	12	5	C



Individuals from your group will be randomly selected to use the multimeter to determine the current through the  $50\Omega$  resistor. The individuals selected will be responsible for properly setting and connecting the multimeter to the circuit, and the group will be given a score based on the individual's attempt. If the individual fails to properly set and connect the multimeter, another individual within the group will be given a chance, but the point value will incrementally be reduced. This process will continue until the point value is down to zero.

Name: \_\_\_\_\_

Banner ID #: \_\_\_\_\_

# Data Sheet

## Kirchhoff's Laws Activity

Hints:

1. Voltmeters and Ammeters must be used in such a way as not to alter the circuit. When a meter is inserted in a circuit, the meter should not allow a significant amount of current to be diverted from the component(s) to which the meter was connected. Remember that current is lazy, and current will take the path of least resistance.
2. A voltmeter will typically have a resistance on the order of a M $\Omega$ . Consider a 100  $\Omega$  resistor in parallel with a 1,000,000 $\Omega$  resistor. What percentage of the current will go through the 1,000,000  $\Omega$  resistor?
3. To read the voltage across a resistor with a voltmeter, connect the voltmeter in parallel with the resistor. This is true as long as the resistance of the resistor is much less than the resistance of the voltmeter.
4. An ammeter will typically have a resistance near zero ohms. What happens if you put a jumper wire across a resistor while it is in a circuit? Does the current want to flow through the resistor or the jumper wire?
5. To read the current through a resistor with an ammeter, connect the ammeter in series with the resistor.
6. Connecting an ammeter in parallel with a resistor will result in an ambiguous current reading, and the multimeter fuse may blow.
7. Solve for the system of equations in variable form.
8. For Part II, combine the resistors that are in parallel so that you start with three unknowns. See hint #7.

### Pre- Lab (Possible 10 Points)

### Part I (50 points total)

Three Loop Equations – in variable form – (5 points each)	Check the box if the equation was used to solve for $I_1$ , $I_2$ , and $I_3$ .
(Loop through $R_1$ and $R_3$ )	<input type="checkbox"/>
(Loop through $R_2$ and $R_3$ )	<input type="checkbox"/>
(Loop through $R_1$ and $R_2$ )	<input type="checkbox"/>

Two Node Equations – in variable form – (4 points each)	Check the box if the equation was used to solve for $I_1$ , $I_2$ , and $I_3$ .
(Node a)	<input type="checkbox"/>
(Node b)	<input type="checkbox"/>

Resistor ( $\Omega$ )	Theoretical Current [A]	Actual Current [B]	Percent Error	Score Based on Table Below
$R_1$	mA	mA		
$R_2$	mA	mA		
$R_3$	mA	mA		

$$\text{Percent Error} = \frac{|A - B|}{B} \times 100\%$$

Percent Error	$\leq 1\%$	$\leq 2\%$	$\leq 3\%$	$\leq 5\%$	$\leq 10\%$	$> 10\%$
Points	9	8	7	4	2	0

The point deduction for blown fuses is cumulative. (i.e. if three fuses are blown, a total of 15 points will be deducted)					
Blown Fuse	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>
Point Deduction	0 pts	5 pts	10 pts	10 pts	15 pts

Total Blown Fuse Deduction: \_\_\_\_\_

**Part I Score (0-50 pts):** \_\_\_\_\_

**Part II** (40 points total)

Attach all work done to determine the current through the 50 $\Omega$  Resistor

Assigned conditions from table (circle one): 1 2 3 4 5 6

Conditions from Table					
$R_1$ ( $\Omega$ )	$R_2$ ( $\Omega$ )	$R_3$ ( $\Omega$ )	$V_1$ (V)	$V_2$ (V)	Diagram

Sketch of Diagram (Include an ammeter that will read the current passing through the 50Ω resistor.)

Groups predicted value of current through the 50Ω resistor: \_\_\_\_\_ [A]

**Testing of the Circuit while witnessed by your TA:**

Student use of Multimeter to read current through 50Ω resistor (20, 15, 10, 5, or 0 pts): \_\_\_\_\_

**Turn the power supply off while connecting the multimeter.**

Actual current through 50Ω resistor read with multimeter: \_\_\_\_\_ [B]

$$\text{Percent Error} = \frac{|A - B|}{B} \times 100\%$$

Percent Error	<=1%	<=2%	<=3%	<=5%	<=10%	>10%
Points	20	19	17	14	12	8

Calculated Percent Error	Points per the Table

**Total Points for Part II:** \_\_\_\_\_

**Total Points for Activity:** \_\_\_\_\_