FOSS ELECTRONICS

LAB NOTEBOOK

Investigation 1: Circuits

Investigation 2: Resistors 1

Investigation 3: Voltage

Investigation 4: Electronic Dissection

Investigation 5: Resistors 2

Investigation 6: Diodes

Investigation 7: Capacitors

Investigation 8: Current

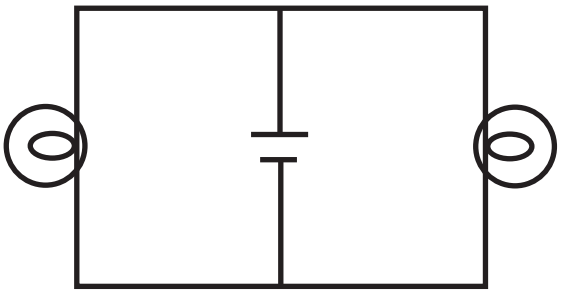
Name _____

Period _____ Date _____

RESPONSE SHEET—CIRCUITS

Willie drew a schematic diagram of a circuit he was planning to build. He looked at it and told his friend Rosa,

This is a perpendicular circuit. When I connect the components, the lights will be dim because the current will be going two ways at once.



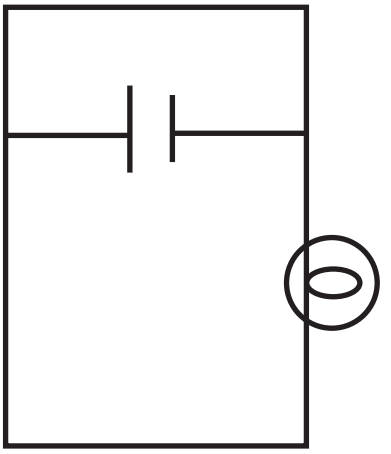
If you were Rosa, what would you tell Willie?

Name _____

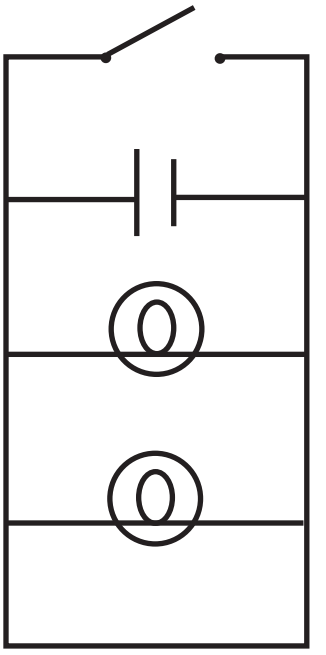
Period _____ Date _____

FINDING SHORT CIRCUITS

A.



B.



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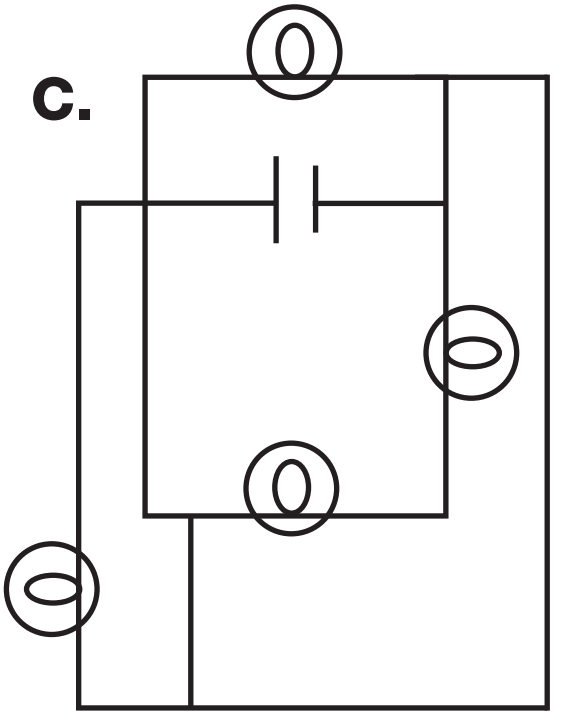
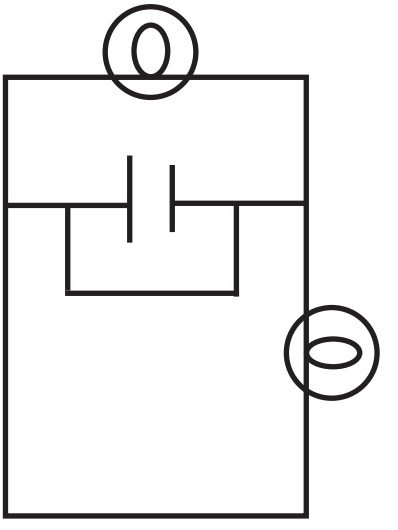


D.



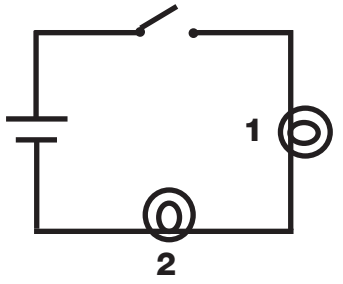
Name _____

Period _____ Date _____

SERIES AND PARALLEL SCHEMATICS

- Set up the circuits shown in the schematics.
- Label the positive and negative battery terminals.
- Draw arrows to show the path taken by the electricity.

1.



a. Schematic 1 shows a _____ circuit.

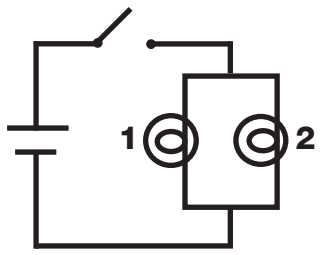
b. Predict whether the lamps will be bright or dim.

_____

_____

_____

2.



a. Schematic 2 shows a _____ circuit.

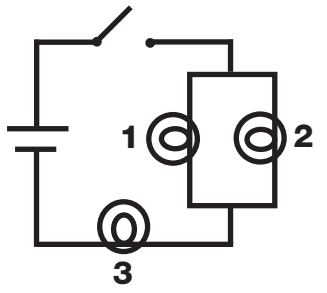
b. Predict whether the lamps will be bright or dim.

_____

_____

_____

3.



a. Schematic 3 shows a _____ circuit.

b. Predict whether the lamps will be bright or dim.

_____

_____

_____

Name _____

Period _____ Date _____

AQUARIUM-LIGHT PROBLEMS

Ms. Waters had two aquariums with beautiful tropical fish. She wanted to install in each tank some lights that she could turn on in the evening and off in the morning. Her small aquarium needed one light, and her large aquarium needed two lights. She had one battery, two switches, three lightbulbs, and eight pieces of wire.

Directions:

Draw schematic diagrams to show your solutions to the problems.

1. How should Ms. Waters wire her aquariums to have one **bright** light in the small aquarium and two **bright** lights in the large aquarium?

2. How should she wire her aquariums to have one **dim** light in the small aquarium and two **dim** lights in the large aquarium?

3. How should she wire her aquariums to have one **bright** light in the small aquarium and two **dim** lights in the large aquarium?

Name _____

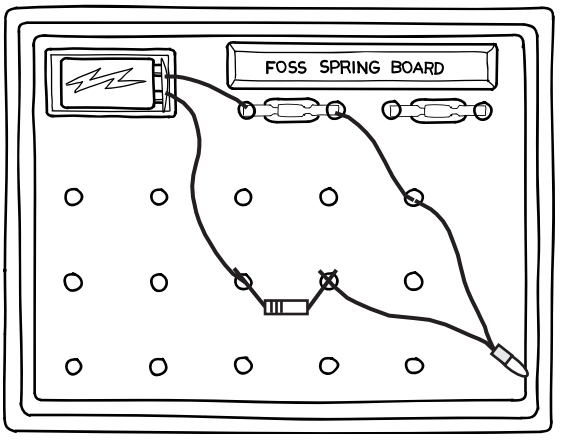
Period _____ Date _____

RESISTOR INVESTIGATION

1. Find four resistors in your component kit with the following colored bands:

   - brown/black/red
   - violet/green/black
   - brown/green/brown
   - orange/orange/brown

2. Set up the circuit pictured to the right.



3. Put the resistors into the circuit one at a time and close the switch. Observe the intensity of the light from the bulb.

4. List the resistors in order from brightest light to dimmest light.

	Resistor	Rated ohms	Measured ohms
brightest			
dimmest			

5. Decode the color bands and write the value of each resistor under "Rated ohms."

Mystery Resistors

Decode these six mystery resistors to discover their resistance.
Remember to include the units with your answers.

red/green/brown _____ gray/black/black _____

yellow/blue/green _____ black/orange/black _____

violet/black/red _____ brown/red/orange _____

Name _____

Period _____ Date _____

RESPONSE SHEET—RESISTORS 1

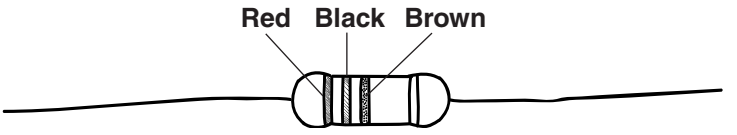
Thuy set up a circuit with a battery, a lamp, and a switch. When she closed the switch, the lamp glowed brightly. She also had the two resistors shown below. After thinking about it for a while, she said,

I'm going to put resistor A in series with the lamp and observe the brightness of the light. Then I'm going to take resistor A out of the circuit and put resistor B in its place.

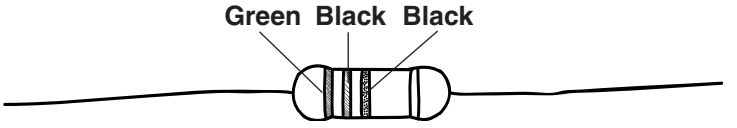
I predict that resistor A will make the light dimmer than resistor B.

Do you agree or disagree with Thuy's prediction? Explain your answer.

A.



B.



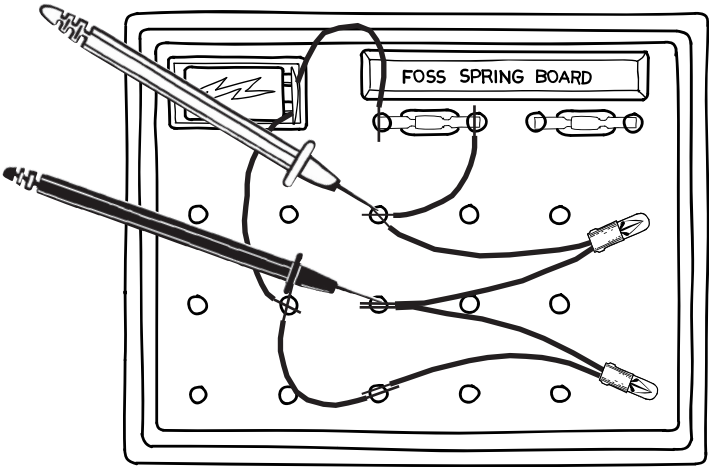
Name _____

Period _____ Date _____

MEASURING VOLTAGE DROPS IN FOUR CIRCUITS

Materials

1 Digital multimeter
1 Spring board and battery
1 150-Ω resistor
2 Lamps



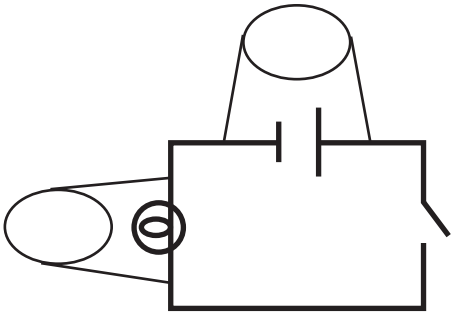
Investigation

Set up circuits A–D and measure the voltage drop across each component.

A. A switch and one lamp in series.
B. A switch, resistor, and one lamp in series.
C. A switch, resistor, and two lamps in series.
D. A switch and resistor in series with two lamps that are in parallel.

Draw schematics of the circuits and record the voltages of the components, using the method illustrated below—the voltage reading is written in an oval and the lines to the circuit show where the probes were placed.

A.



B.

C.

D.

Name _____

Period _____ Date _____

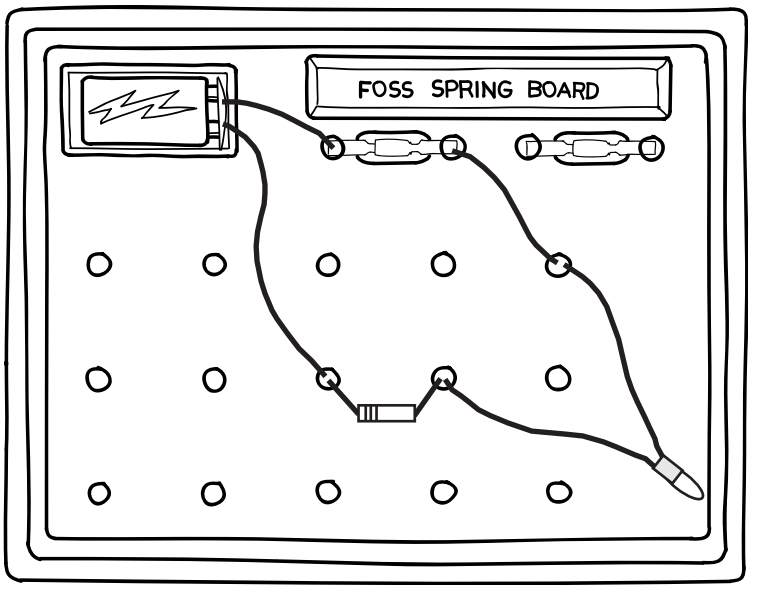
RESISTOR/VOLTAGE INVESTIGATION

1. Copy your *Resistor Investigation* data (see page 7) into the resistance and lamp-brightness columns below.

2. Set up the resistance investigation circuit (see below).

3. Use a voltmeter to gather the voltage-drop data to complete the table.

1	2	3	4	5
Resistor Code	**Resistance (ohms)**	**Lamp brightness**	**Lamp voltage drop**	**Resistor voltage drop**
bl/bl/bl				
v/gr/bl				
br/gr/br				
or/or/br				
br/bl/r				



Resistance investigation circuit

Name _____

Period _____ Date _____

PERCENTAGE OF RESISTANCE AND VOLTAGE

Materials

1 Spring board with battery
1 Digital multimeter
3 1000-Ω resistors

Investigation

When you have three resistors in a circuit, what share of the voltage drop does each resistor cause? Follow this procedure to find out.

1. Set up a circuit with three 1000-Ω resistors in series. Measure and record the voltage drop across each resistor.

2. Calculate the percentage of resistance imposed by each of the 1000-Ω resistors.

   - Add up the total resistance in the circuit. The total resistance in the circuit with three 1000-Ω resistors is 3000 Ω. In this circuit 3000 Ω is 100% of the resistance.

   - Calculate the percentage of resistance caused by each resistor.

$$\frac{1000\ \Omega}{3000\ \Omega} \approx 0.333 \approx 33.3\% \text{ of the resistance in the circuit}$$

3. Calculate the percentage of voltage drop contributed by each 1000-Ω resistor.

   - Measure the total voltage drop in the circuit. For example, if you put all three resistors in series and measure an 8-V drop across all three, then 8 V is 100% of the voltage drop in the circuit.

   - Calculate the percentage of the voltage drop caused by each resistor. In this example, the first 1000-Ω resistor dropped 2.7 V.

$$\frac{2.7\ \text{V}}{8\ \text{V}} \approx 0.333 \approx 33.3\%$$

4. Fill in the chart below with your voltage data and percentages.

	Resistor	% of resistance	Voltage drop	% of voltage drop
	R_1 (1000 Ω)	33.3		
	R_2 (1000 Ω)	33.3		
	R_3 (1000 Ω)	33.3		
Totals	3000 Ω	~100		

Name _____

Period _____ Date _____

RESISTANCE AND VOLTAGE WITH SIX RESISTORS

Materials

1 Spring board with battery
1 Multimeter
3 1000-Ω resistors
1 330-Ω resistor
1 150-Ω resistor
1 75-Ω resistor

Part 1: A toy company was planning to make a playhouse with several lights that glowed with different intensities. One of the toy makers had heard that there was a relationship between the amount of resistance imposed by a lamp and the amount of voltage it dropped. She decided to work with six resistors in series to figure out what share of the voltage each resistor will drop.

Can you guess which resistor will drop the largest percentage of the voltage? The smallest?

Largest _____ Smallest _____

Part 2: Conduct this investigation to answer the question below.

1. Set up one circuit with *all six* resistors in series.
2. Write the values of the six resistors in the "Resistance of the resistor" column in the table below. Calculate the total resistance in the circuit and record it in the table.
3. Calculate the percentage of resistance imposed by each resistor and record the percentages in the "% of total resistance" column in the table.
4. Measure and record the voltage drop across each resistor in the "Voltage drop" column.
5. Calculate the percentage of voltage drop used by each resistor and write the percentage in the "% of total voltage drop" column.

	Resistance of the resistor	% of total resistance	Voltage drop	% of total voltage drop
Total				

What is the relationship between resistance and voltage drop?

_____

_____

_____

Name _____

Period _____ Date _____

RESPONSE SHEET—VOLTAGE

Charles had just finished working with series circuits and the great truths. He told his friend Ray,

The rules for how series circuits work are called the great truths.

The first great truth says: The sum of the resistances in a series circuit always equals the resistance of the battery.

The second great truth says: The bigger the battery, the more voltage it has.

Ray thought a minute and then said,

I don't think that's quite right. Let me see if I can help you get these great truths straightened out.

What do you think Ray will tell Charles to help him understand the great truths?

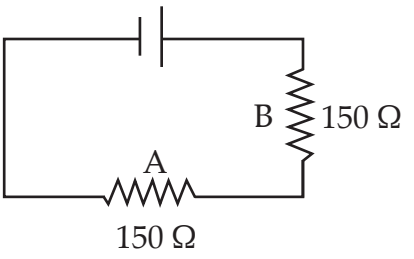
Name _____

Period _____ Date _____

HOW DO RESISTORS DIVIDE VOLTAGE?

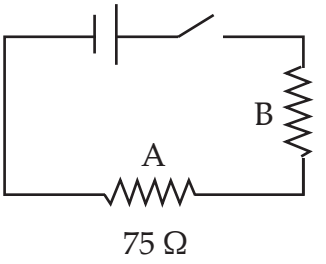
1. Study each of the four circuits.
2. Fill in the data tables with the information provided in the schematic.
3. Use the great truths of circuitry to fill in the rest of the data and answer the questions.

1.



	Resistance		Voltage	
	Amount	**%**	**Amount**	**%**
A	150 Ω	50		
B	150 Ω	50		
Total	300 Ω	100	9 V	

2.

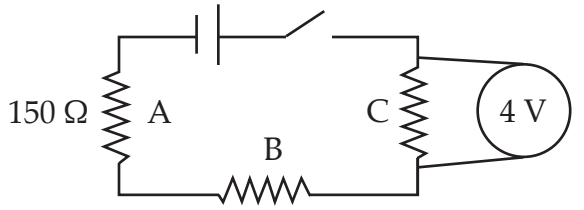


	Resistance		Voltage	
	Amount	**%**	**Amount**	**%**
A	75 Ω		3 V	
B				
Total	225 Ω			

Name _____

Period _____ Date _____

3.



	Resistance		Voltage	
	Amount	**%**	**Amount**	**%**
A				
B		25%		
C				50%
Total				

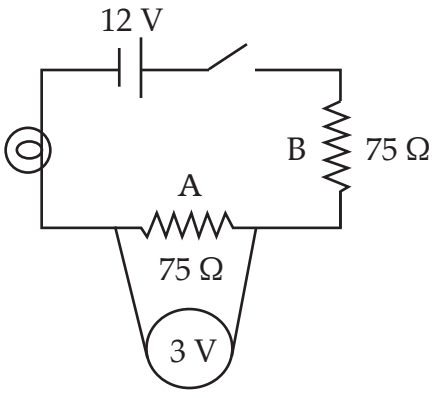
What can you say about the percentage of resistance contributed by a resistor and the percentage of voltage drop caused by that resistor? _____

_____

_____

_____

4. Lamps have very little resistance when there is no electricity flowing through them. They have more resistance when they are producing light. Because we cannot use our ohmmeter to measure resistance while electricity is flowing through the circuit, we need to find other ways to discover the resistance of lamps.



	Resistance		Voltage	
	Amount	**%**	**Amount**	**%**
A				25%
B				
Lamp				
Total				

I know that the lightbulb contributes _____ % of the resistance in a circuit.

Therefore the actual resistance of the lamp in the circuit is _____ .

Name _____

Period _____ Date _____

ELECTRONIC-DEVICE COMPONENT INVENTORY

Our device is a _____.

1. Use the *Electronic Component ID Guide* to identify the components.
2. Inventory (count) the components of each kind.
3. Record the number of each kind of component in the spaces below.
4. Draw little pictures to show what a typical component looks like (optional).
5. Draw pictures of mystery components on the back of this page.

Resistors	**Capacitors**
Diodes and LEDs	**Transistors**
Switches	**Integrated circuits**
Potentiometers and transformers	**Other components**

Name _____

Period _____ Date _____

TELEVISION FOCUS QUESTIONS

Television: Window to the World

1. What were the two competing methods of producing television signals? Which one succeeded?

2. Who were the inventors of television?

3. What was RCA, and for what primary purpose was it established?

4. Who was awarded the first patent for television, and what was the decision based on?

5. What was the theme of the 1939 World's Fair, and what products were introduced?

6. Why did most people get their first glimpse of television on a bar stool or a sidewalk?

7. What did Mr. Muntz do for television?

8. Why was the 1947 World Series important to the commercial spread of television?

9. What other electronic devices had as significant an impact on American life in the 20th century as television? Discuss one.

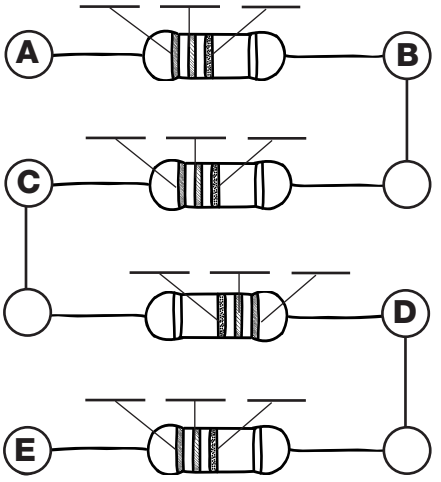
Name _____

Period _____ Date _____

CALCULATING RESISTORS IN SERIES

Part 1: Determining Resistance

1. Make up four different resistors between 0 Ω and 1000 Ω.
2. Record them on the "rated resistance" lines. Arrange them from lowest to highest resistance.
3. Write their color codes on the pictures of the resistors.
4. Record the total resistance of the series between the two letters indicated.

Color code	Rated resistance	Total resistance
	_____	from **A** to **B** _____
	_____	from **A** to **C** _____
	_____	from **A** to **D** _____
	_____	from **A** to **E** _____

Part 2: Resistors in Series

Determine the total resistance between points *X* and *Y*. Do it in your head, then check with a calculator.

1. *X* — 150 Ω — 330 Ω — Y Resistance equals _____
2. *X* — 510 Ω — 1000 Ω — Y Resistance equals _____
3. *X* — 150 Ω — 510 Ω — 1000 Ω — Y Resistance equals _____
4. *X* — 330 Ω — 150 Ω — 1000 Ω — Y Resistance equals _____

Part 3: Explain how you determined the total resistances.

_____

_____

_____

Name _____

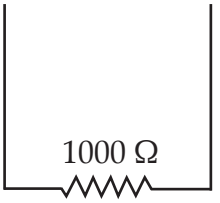
Period _____ Date _____

RESISTORS IN PARALLEL

The total resistance of resistors in parallel is calculated using the formula

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n},$$

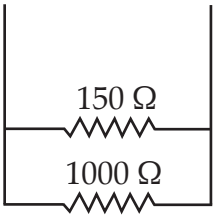
where R_t = the total resistance
R_1 = the first resistor
R_2 = the second resistor
R_n = the last resistor



Estimated resistance _____

Calculated resistance _____

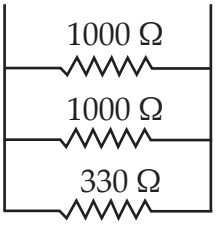
Measured resistance _____



Estimated resistance _____

Calculated resistance _____

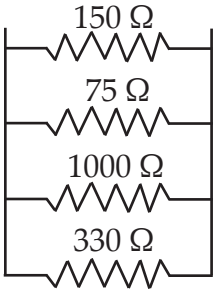
Measured resistance _____



Estimated resistance _____

Calculated resistance _____

Measured resistance _____



Estimated resistance _____

Calculated resistance _____

Measured resistance _____

Name _____

Period _____ Date _____

RESPONSE SHEET—RESISTORS 2

Mike and Delvon were finding out what happens when they connect more than one resistor together. Mike said,

This is easy. You can figure out the total resistance by adding up the resistances of all the resistors in the circuit.

Delvon responded,

That's not always true. Sometimes you have to add up the resistances and divide that number by the number of resistors in the circuit.

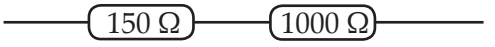
What would you tell Mike and Delvon to help them understand resistors better?

Name _____

Period _____ Date _____

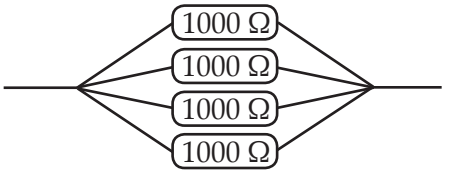
MAKING NEW RESISTORS

Making larger resistors is pretty easy; just put two resistors in series and they add together.



150 Ω + 1000 Ω = 1150 Ω

Making smaller resistors is a little trickier. If the resistors are all the same value, you can put any number in parallel and divide the value of *one* resistor by the number of resistors in the set.



1000 Ω + 1000 Ω + 1000 Ω + 1000 Ω = 1000 Ω ÷ 4 = 250 Ω

If you have a collection of resistors of different values in parallel, you need to use the equation for calculating resistance in parallel.

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n},$$

The way to approach the problem is to estimate what resistors would combine in parallel to provide the required total resistance, plug them into the formula, and calculate. If the answer comes out right on or quite close to the desired resistance, you have succeeded.

Remember: The total resistance of a set of resistors in parallel will *always* be less than the smallest resistor in the set.

You have this set of resistors available to solve the problems below.

3 1000 Ω	**1 500 Ω**	**1 330 Ω**	**1 200 Ω**	**3 150 Ω**	**2 100 Ω**	**1 75 Ω**

1. Make a 850-Ω resistor.

2. Make a 4000-Ω resistor.

3. Make a 2925-Ω resistor.

4. Make a 50-Ω resistor.

5. Make a 125-Ω resistor.

6. Make a 111-Ω resistor.

7. Make a 37.5-Ω resistor.

8. Make a 2143-Ω resistor.

Name _____

Period _____ Date _____

DAY AND NIGHT LIGHT

Ms. Waters had a fine aquarium with fancy tropical fish from around the world. She had fitted the aquarium with a light that illuminated the tank brightly during the day. The setup had a switch to turn the light on and off, but she didn't really want to turn the light off at night—she wanted to be able to dim the light to half its brightness during the night.

She called her friend at the electronics store and described what she wanted to do. After thinking about it for a few minutes, her friend concluded that Ms. Waters needed to put 80–85 Ω of resistance in series with the lamp to cut its brightness in half.

Ms. Waters went to her electronics supply kit to see if she had an 80–85-Ω resistor, but she didn't. What she found in her resistor drawer was

1 1000 Ω	1 510 Ω	2 330 Ω	3 250 Ω	1 180 Ω	2 100 Ω	2 50 Ω

1. How can Ms. Waters solve her problem? Can you help her figure out how to use resistors from her kit to get 80–85 Ω of resistance in the circuit with her lamp? Show your work.

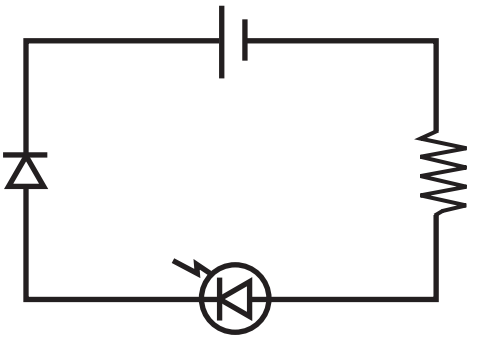
2. Draw a schematic showing how Ms. Waters might rewire her aquarium, so that the switch will change the light from full brightness to half brightness. (Hint: Think about how a short circuit works.)

Name _____

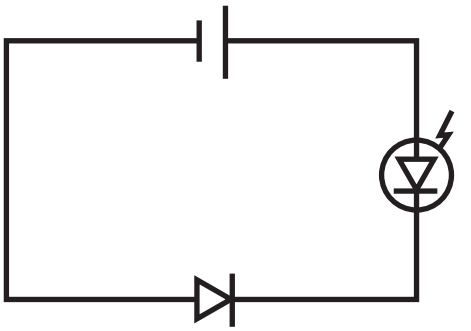
Period _____ Date _____

RESPONSE SHEET—DIODES

Josie and Ron worked together to explore diodes. They set up one circuit that used a diode and an LED in the same circuit. After they got their LED to light up, they each drew a schematic diagram of the successful circuit. Their schematics are shown below. Comment on each student's schematic.



Josie's schematic



Ron's schematic

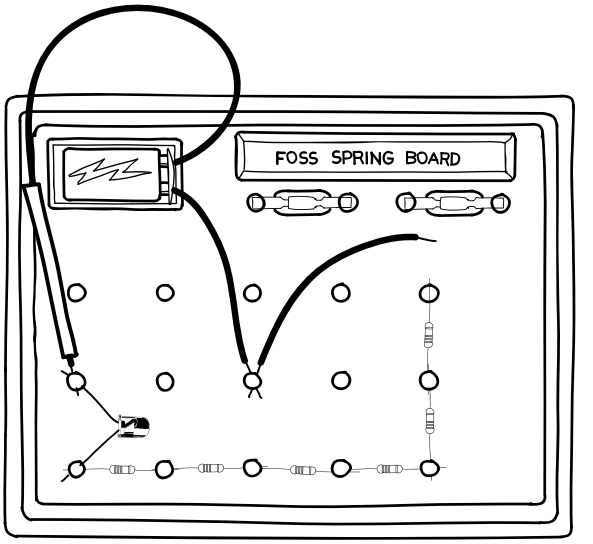
Name _____

Period _____ Date _____

RESISTORS IN SERIES WITH LEDs AND LAMPS

Part 1: Voltage Drops across an LED in Series with Resistors

Set up the circuit with six 1000-Ω resistors, as shown in the picture to the right. Measure the voltage drops across the LED when one 1000-Ω resistor, two 1000-Ω resistors, and so on are in series with the LED and the guardian resistor. Also measure the voltage drop across the LED when only the guardian is in series with the LED. Record the voltage drops in the table below.



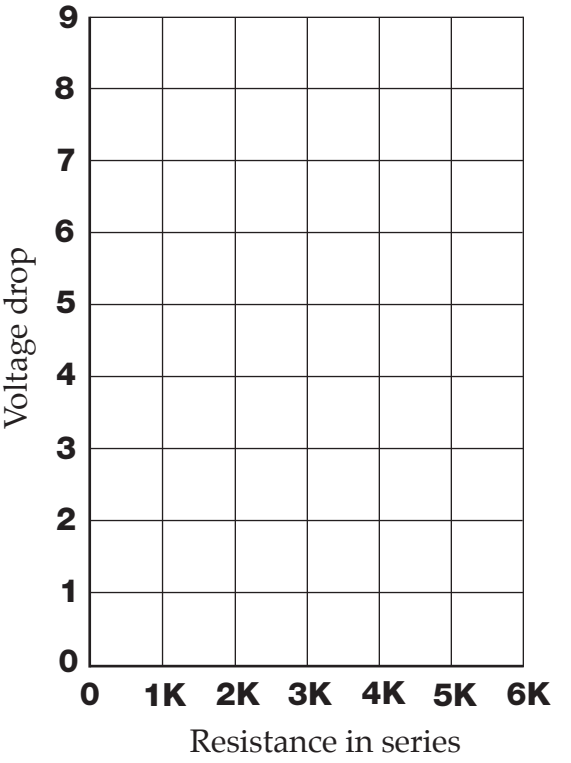
Part 2: Voltage Drops across a Lamp in Series with Resistors

Replace the LED with a lamp. Repeat the investigation and record the voltage drops in the table.

Resistance in series	Voltage drop across the LED	Voltage drop across the lamp
6075 Ω		
5075 Ω		
4075 Ω		
3075 Ω		
2075 Ω		
1075 Ω		
75 Ω		

Part 3: Graph the Results

Graph the results of both investigations. Use different-colored lines for the LED and the lamp.



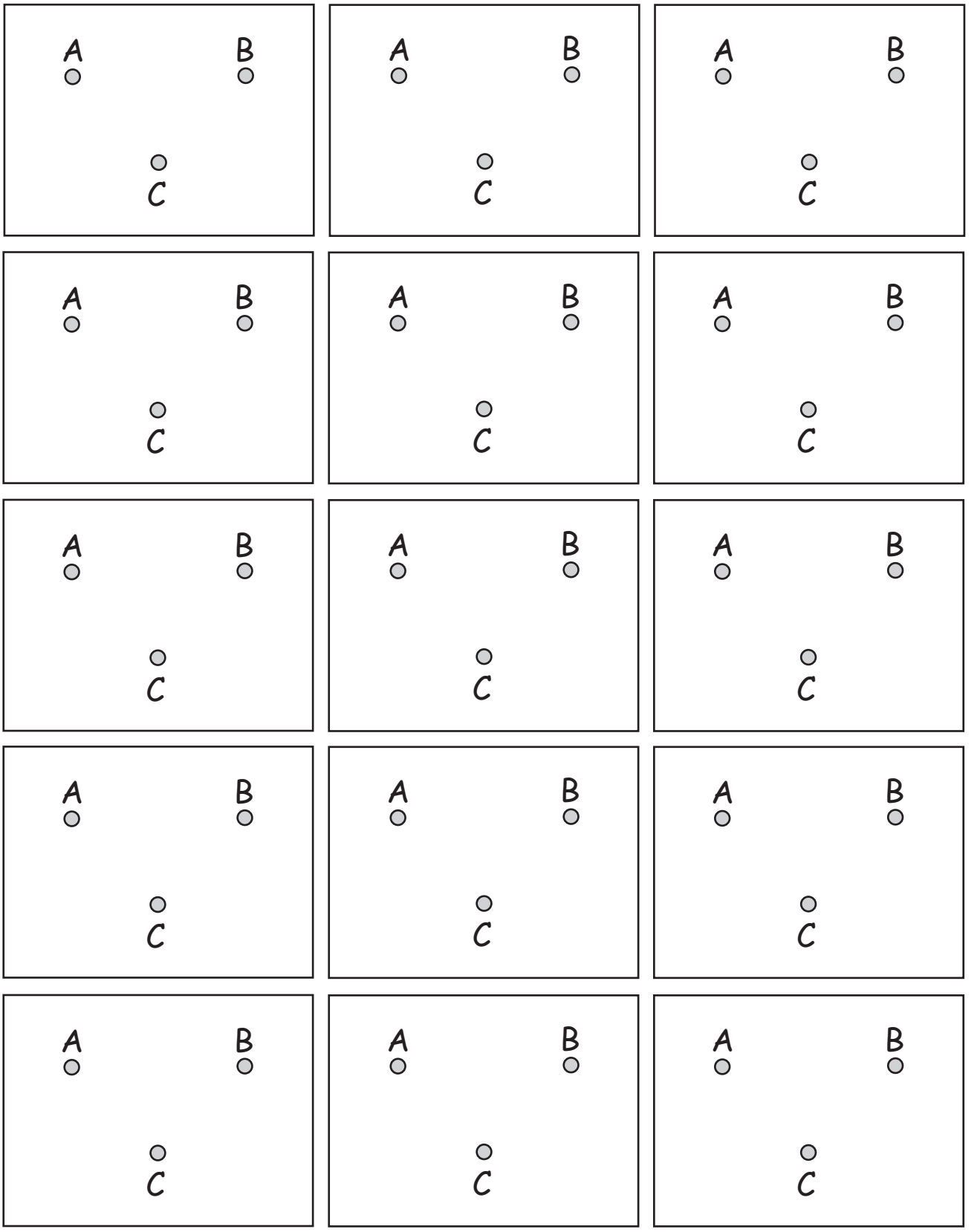
Part 4: Comparing the LED and the Lamp

Compare the voltage drops across LEDs and lamps as the resistance in series increases.

Name _____

Period _____ Date _____

WONDER-CARD RECORDS



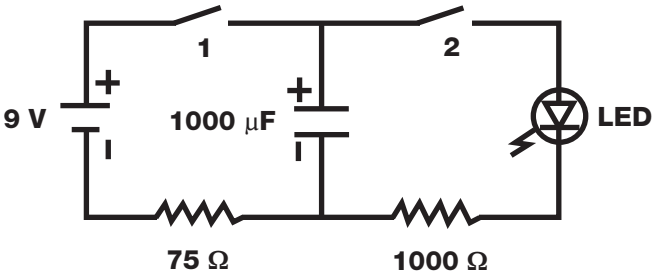
Name _____

Period _____ Date _____

RESPONSE SHEET—CAPACITORS

Karen was studying capacitors in her electronics course. She showed her friend Jill this schematic and told her,

This is a schematic of a charge/discharge device we made in class today.



Jill studied the schematic for a moment and then asked,

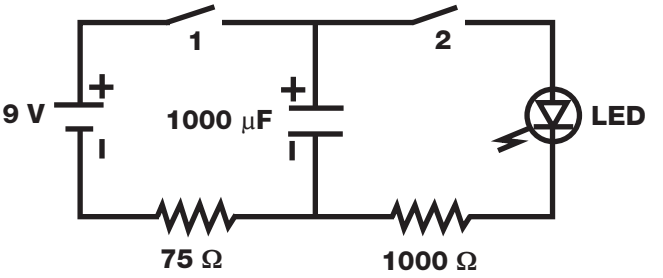
Why is it called a charge/discharge device? How does it work?

What should Karen tell her friend about the charge/discharge device?

Name _____

Period _____ Date _____

VOLTAGE IN A CHARGE/DISCHARGE DEVICE



1. What happens to the voltage across the capacitor when switch 1 is closed?

2. What happens to the voltage across the capacitor when switch 2 is closed?

3. What happens to the voltage across the capacitor when a wire is used to short out the two sides of the capacitor?

4. After the capacitor is charged, what happens to the voltage across the 1000-Ω resistor when switch 2 is closed?

5. What happens to the voltage across the LED when switch 2 is closed?

6. What do you think happens in the discharge side of the circuit when switch 2 is closed?

7. **Extra credit:** What happens to the voltages across all of the components when both switches are closed? Explain your observations.

Name _____

Period _____ Date _____

INVESTIGATING RESISTANCE AND CURRENT

Remember

- Set your meter to measure 200 milliamps.
- Use the 75-Ω guardian resistor in all circuits.
- To measure current, put the probes of your meter into the circuit in series with the other components in the circuit.

Part 1: Current and Lamps in Series

1. Test a circuit with one lamp. What is the current? _____
2. Test a two-lamp series circuit. What is the current? _____
3. Test a three-lamp series circuit. What is the current? _____
4. What happens to the current with each added lamp? _____

   _____

5. Test the current at several locations in the three-lamp circuit. Is it the same everywhere, or does it vary from place to place? _____

   _____

Part 2: Current and Resistors in Series

1. Test a circuit with one 150-Ω resistor. What is the current? _____
2. Test a series circuit with two 150-Ω resistors. What is the current? _____
3. Test a series circuit with three 150-Ω resistors. What is the current? _____
4. What happens to the current with each added resistor? _____

   _____

5. Test the current at several locations in the three-resistor circuit. Is it the same everywhere, or does it vary from place to place? _____

   _____

Name _____

Period _____ Date _____

Part 3: Current and Resistors in Parallel

1. Set up a circuit with one 150-Ω resistor. Predict what will happen to the current in the circuit when a second 150-Ω resistor is put in *parallel* with the first. After you predict, measure the current.

   Current prediction _____ Current measurement _____

2. Predict and measure the current with three 150-Ω resistors in parallel.

   Current prediction _____ Current measurement _____

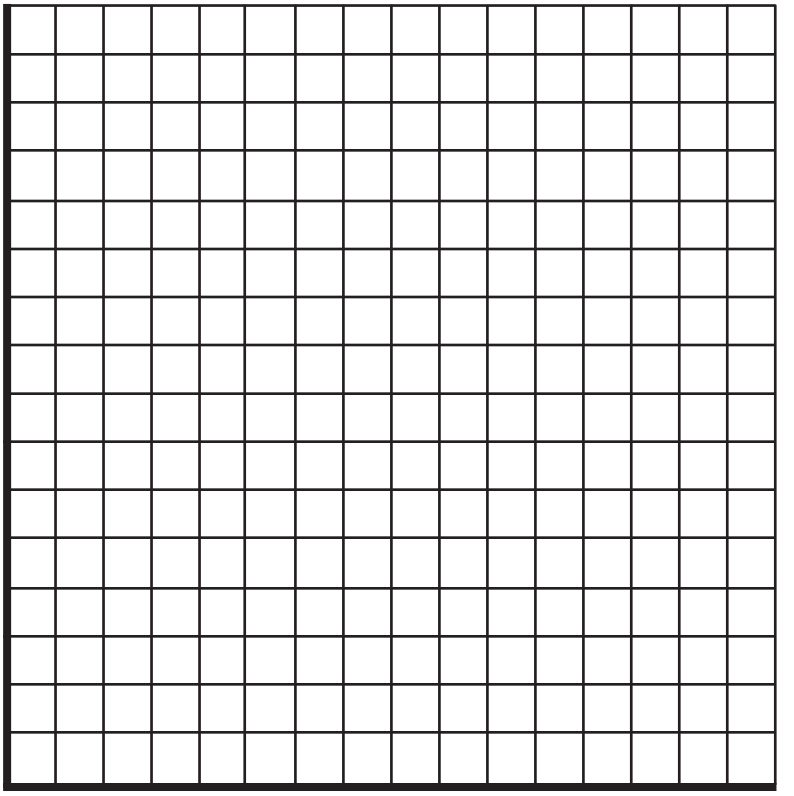
3. What happens to the current with each additional resistor placed in parallel?

   _____

Part 4: Resistance/Current Relationship

What happens to the current in a circuit as the resistance gets greater and greater? Use all the resistors in your kit to gather at least ten pairs of data. Graph the results.

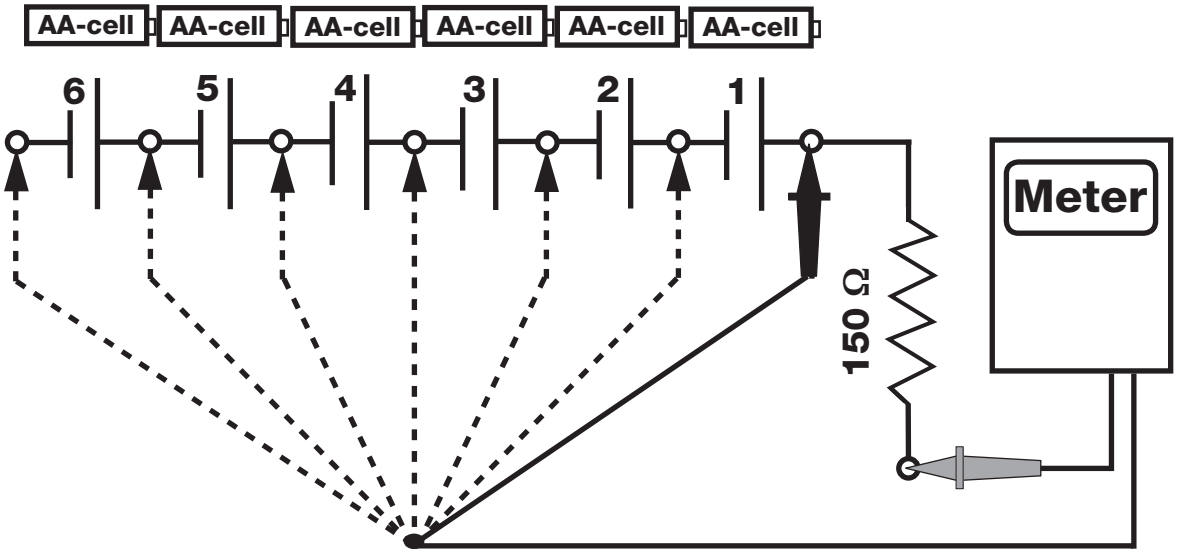
Resistance	Current



Name _____

Period _____ Date _____

INVESTIGATING VOLTAGE AND CURRENT



1. Include a 150-Ω resistor in your test circuit.
2. Record the total voltage available after you add each AA-cell to the series.
3. Measure and record the current flowing in the circuit after you add each AA-cell to the series.
4. Graph the results.

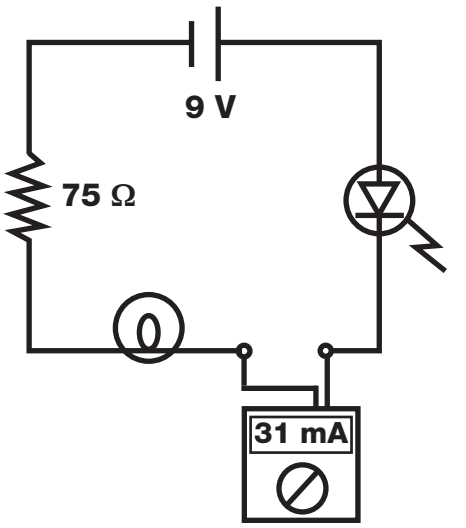
Cells	Volts	mA
0		
1		
2		
3		
4		
5		
6		

Name _____

Period _____ Date _____

OHM'S LAW PRACTICE

Rosa and Jamaica were working with the circuit diagrammed to the right. Their task was to figure out how much resistance the lamp imposed in the circuit. They used their ammeter to measure the current. It was 31 mA.



Rosa said,

Now we need to measure the voltage drop across the lamp so we can use Ohm's law to calculate the resistance.

Jamaica said,

No, we don't have to measure the voltage drop of the lamp because we know the battery supplies 9 volts of potential to the circuit. We can just calculate using Ohm's law.

Who do you think had the better idea? Why do you think so?

Name _____

Period _____ Date _____

OHM'S LAW PROBLEMS

$V = I \times R$ $I =$ $R =$

Show the form of Ohm's law you will use, and show your math. **Include the units in your answer: volts (V), ohms (Ω), or amps (A).**

1. Alan has a battery that measures 4.5 V. His friend is using it to run the motor of a remote-control car. The current flow in the motor circuit is 67 mA. What is the resistance of the motor?

$V =$
$I =$
$R =$

2. Mathew has a portable tape player that uses two 1.5-V batteries in series. The resistance imposed by the speaker is 15 Ω. What is the current flowing in the speaker circuit?

$V =$
$I =$
$R =$

3. The battery in Latoya's family car has a 12-V battery. The car horn imposes 33 Ω of resistance. What is the current flowing through the horn circuit when Latoya honks the horn?

$V =$
$I =$
$R =$

4. Ms. Waters had two 75-Ω resistors in series with the lightbulb in one of her aquariums. She measured the current at 0.06 A. What is the voltage drop across the two resistors?

$V =$
$I =$
$R =$

5. Mr. Jordan was working on a toaster oven that had two resistors in series. One was a 330-Ω resistor. The other resistor was unmarked. He measured the voltage at its source to be 110 V, and the current in the circuit was 250 mA. What was the resistance of the unmarked resistor?

$V =$
$I =$
$R =$

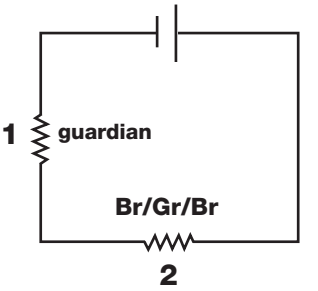
Name _____

Period _____ Date _____

TESTING OHM'S LAW

Test Ohm's law to see if it really works.

Part 1: Calculate a Known Resistance



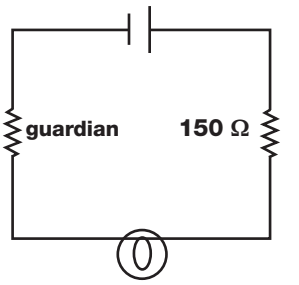
1. Set up a circuit with two resistors in series, the guardian resistor (violet/green/black) and brown/green/brown.
2. Measure the voltage drop across each resistor.
3. Measure the current in the circuit.
4. Calculate the resistance of each resistor, using Ohm's law. Compare your calculated resistance to the measured value (using the ohmmeter) and the rated value (decoded from the color bands) for both resistors.

Calculated value (Ohm's law) resistor 1 _____ resistor 2 _____

Measured value (ohmmeter) resistor 1 _____ resistor 2 _____

Rated value (color bands) resistor 1 _____ resistor 2 _____

Part 2: Calculate the Resistance of a Glowing Lamp



1. Set up a series circuit with a 150-Ω resistor and a lamp.
2. Measure the voltage drop across the lamp. _____
3. Measure the current in the circuit. _____
4. Calculate the resistance of the glowing lamp, using the appropriate form of Ohm's law.

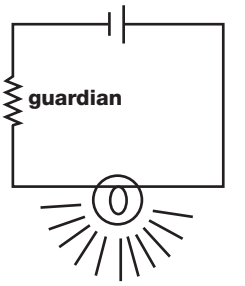
The lamp in series with a 150-Ω resistor has _____ of resistance.

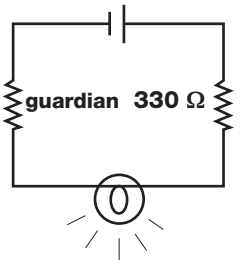
Name _____

Period _____ Date _____

Part 3: Compare the Resistance of Medium and Dim Lamps

1. Set up a circuit with one lamp glowing with medium intensity.
2. Measure the voltage drop across the lamp. _____
3. Measure the current in the circuit. _____
4. Set up a circuit with one lamp and a 330-Ω resistor.
5. Measure the voltage drop across the lamp. _____
6. Measure the current in the circuit. _____
7. Calculate the resistance of the medium lamp and the dim lamp.





Resistance of medium lamp _____

Resistance of dim lamp _____

Part 4: Explain the Resistance of Lamps

Write a paragraph explaining what you discovered about the brightness of lamps. Discuss current and resistance in your explanation.

STUDENT SCORING GUIDE

4 **The answer or task is completed correctly and demonstrates understanding of concepts and connections beyond the mastery level.**

3 **Mastery Level. The question or task is complete and correct. All important information is included in the answer.**

2 **The answer or task has essentially correct elements; there are only minor mistakes, or minor pieces of information left out.**

1 **The answer or task contains related information, but has significant mistakes or misconceptions.**

0 **The student does not respond to the question or task, or gives an answer that has nothing to do with what was asked.**

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