30. Ohm's Law

Driving Questions

What is a fundamental relationship between the voltage across a resistor, the current flowing through a resistor, and the resistance of the resistor?

Background

Georg Simon Ohm (1787-1854) discovered that when the voltage (potential difference) across a resistor changes, the current through the resistor changes. We will measure voltage and current through a circuit to determine that relationship.

Materials and Equipment

For each student or group:

- Data collection system
- Voltage sensor
- Current sensor
- Charge/discharge circuit board
- AA cell battery (2)
- Patch cord, 4-mm banana plug (5)

Safety

Follow all standard laboratory procedures.

Sequencing Challenge

The steps below are part of the Procedure for this lab activity. They are not in the right order. Determine the proper order and write numbers in the circles that put the steps in the correct sequence.

◯	◯	◯	◯
Connect the voltage /current sensor to the data collection system	Determine the slope of the best fit line of the Voltage versus Current data plot	Begin data collection, and then discharge the capacitor across the 10 ohm resistor.	Repeat twice more, once with a 33 ohm resistor, and then with a light bulb.

Procedure

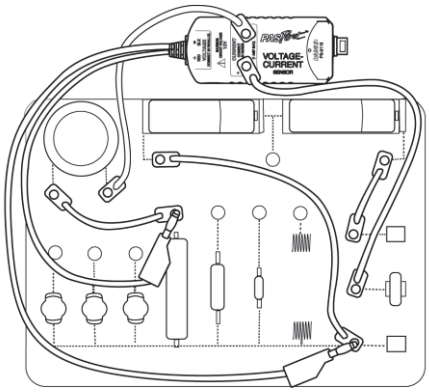
After you complete a step (or answer a question), place a check mark in the box (☐) next to that step.

Note: When you see the symbol "" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step. Your teacher will provide you with a copy of the instructions for these operations.

Part 1 – 10 Ω resistor

Set Up

1. ☐ Using the patch cords, circuit board, 2 AA batteries, and voltage/current sensor assemble the simple circuit seen in the figure below.



Note: With the circuit assembled correctly, the 1 F capacitor will act as a variable voltage source across the 10 Ω resistor, ranging from 0 to 1.5 VDC, while the voltage/current sensor simultaneously measures both voltage applied to the resistor, and current through the resistor.

2. ☐ Connect the voltage and current sensors to the data collection system. (2.2)

3. ☐ Start a new experiment on the data collection system. (1.2)

4. ☐ What is the proper placement of the leads from and to the voltage sensor and current sensor respectively when measuring the voltage and current associated with a resistor?

_____

_____

_____

5. ☐ Close the switch to the "charge" position for at least 15 seconds to charge the capacitor.

6. ☐ Display Voltage on the *y*-axis of a graph with Time on the *x*-axis, and then change the *x*-axis from Time to Current. (7.1.1) (7.1.9)

Collect Data

7. ☐ Move the switch on the circuit board to the "discharge" position.

8. ☐ Start data recording. (6.2)

9. ☐ What is the purpose of the capacitor in the circuit?

_____

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10. ☐ When the voltage and current are nearly equal to zero, stop data recording. (6.2)

11. ☐ Move the switch to the open (upright) position.

12. ☐ Add a note to the graph to indicate the data run was collected using the 10 Ω resistor. (7.1.5)

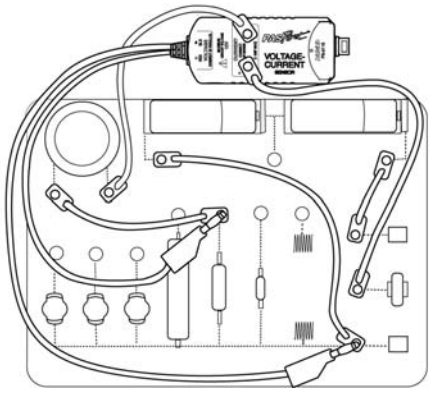
Analyze Data

13. ☐ On the data collection system, find the slope of a best-fit line for your data and record the slope in Table 1 in the Data Analysis section. (9.6)

Part 2 – 33 Ω resistor

Set Up

14. ☐ Replace the 10 Ω resistor in your circuit with the 33 Ω resistor by moving the 4 mm banana plugs just above the 10 Ω resistor to the terminal just above the 33 Ω resistor.



15. ☐ Close the switch to the "charge" position for at least 30 seconds to charge the capacitor.

16. ☐ How will the graph of Voltage versus Current for the 33 Ω resistor be different from the one for the 10 Ω resistor?

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Collect Data

17. ☐ Move the switch to the "discharge" position.

18. ☐ Start data recording. ◆(6.2)

19. ☐ When the voltage and current are nearly equal to zero, stop data recording. ◆(6.2)

20. ☐ Move the switch to the open (upright) position.

21. ☐ Add a note to the graph to indicate the data run was collected with a 33 Ω resistor. ◆(7.1.5)

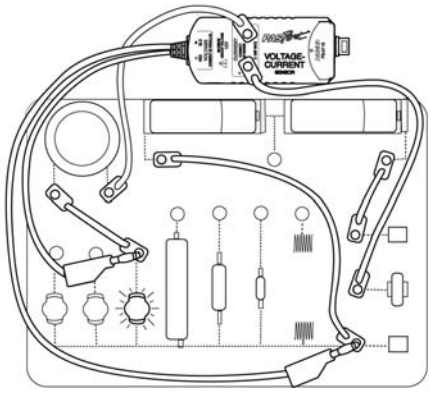
Analyze Data

22. ☐ On the data collection system, find the slope of a best-fit line for your data and record the slope in Table 1 in the Data Analysis section. ◆(9.6)

Part 3 – Light Bulb

Set Up

23. ☐ Replace the 33 Ω resistor in your circuit with one of the three light bulbs by moving the 4 mm banana plugs just above the 33 Ω resistor to the terminal just above any of the three light bulbs.



24. ☐ A light bulb acts like a resistor in a circuit, however, its resistance value changes as the filament in the bulb heats up. How will the graph of Voltage versus Current for the light bulb be different from either of your resistor curves?

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25. ☐ Close the switch to the "charge" position for at least five seconds to charge the capacitor.

Collect Data

26. ☐ Move the switch to the "discharge" position.

27. ☐ Start data recording. (6.2)

28. ☐ When the voltage and current are nearly equal to zero, stop data recording. (6.2)

29. ☐ Add a note to the graph to indicate the data run was collected with a light bulb. (7.1.5)

Analyze Data

30. ☐ Sketch a copy of your Voltage versus Current graph in the Data Analysis section. Be sure to correctly label the axes of the graph and indicate which run corresponds each resistor used, including the light bulb.

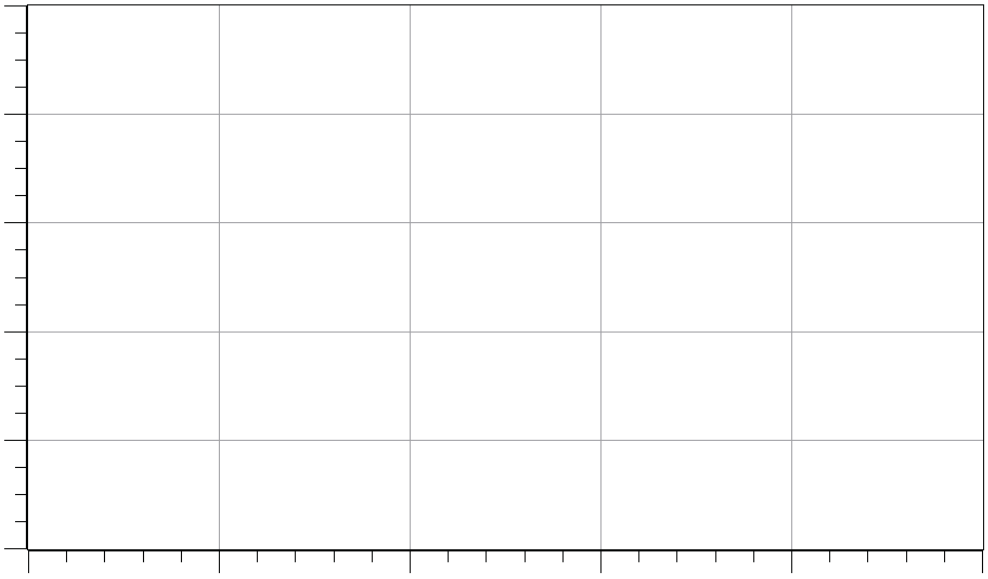
31. ☐ Save your experiment as instructed by your teacher. (11.1)

Data Analysis

Table 1: Voltage versus Current Slopes

Resistor (Ω)	Slope (V/A)

Voltage versus Current



Analysis Questions

1. Describe the Voltage versus Current curve for the 10 Ω resistor.

_____

_____

2. How does the slope of the Voltage versus Current curve for the 10 Ω resistor compare to the resistance value?

_____

_____

3. Describe the Voltage versus Current curve for the 33 Ω resistor.

4. How does the slope of the Voltage versus Current curve for the 33 Ω resistor compare to the resistance value?

5. Describe the Voltage versus Current curve for the 33 Ω resistor in comparison to the curve for the 10 Ω resistor.

6. How does the curve for the light bulb compare to the curve for either resistor?

Synthesis Questions

Use available resources to help you answer the following questions.

1. What can you conclude about the mathematical relationship between current and voltage for constant resistance?

2. What can you conclude about the relationship between current and resistance?

Multiple Choice Questions

Select the best answer or completion to each of the questions or incomplete statements below.

1. The voltage across a 580 Ω resistor is 120 V. How much current is going through the resistor?

A. There isn't enough information to answer this question.
B. 696 mA
C. 207 mA
D. 460 mA

2. The current through a 100 Ω resistor is 0.150 A. What voltage is being applied?

A. There isn't enough information to answer this question.
B. 15 V
C. 1.5 V
D. 666 V

3. A circuit with a 3 V battery pack and a resistor has a current of 0.06 A. What is the value of the resistor?

A. There isn't enough information to answer this question.
B. 18 Ω
C. 2 Ω
D. 50 Ω

Key Term Challenge

Fill in the blanks from the list of randomly ordered words in the Key Term Challenge Word Bank.

1. As the voltage across a resistor increases or decreases, _____ increases or decreases respectively, thus they are said to be _____ proportional. When resistance increases, current decreases and visa versa, thus they are said to be _____ proportional. This relationship is called _____ law.

2. The formula for Ohm's law is written as: _____. The plot of voltage versus current for a resistor with constant resistance is a _____ line with a slope about the same value as the _____.

Key Term Challenge Word Bank

Paragraph 1	Paragraph 2
Current	Capacitor
Conductivity	I = V/R
Directly	Resistor
Inversely	Straight
Ohm's	Q = CV
Resistance	
Voltage	