

## LabQuest 22

# Ohm's Law

The fundamental relationship among the three important electrical quantities *current*, *voltage*, and *resistance* was discovered by Georg Simon Ohm. The relationship and the unit of electrical resistance were both named for him to commemorate his contribution to physics. One statement of Ohm's law is that the current through a resistor is proportional to the potential difference across the resistor. In this experiment you will test the correctness of this law in several different circuits using a Current Probe and a Voltage Probe.

These electrical quantities can be difficult to understand, because they cannot be observed directly. To clarify these terms, some people make the comparison between electrical circuits and water flowing in pipes. Here is a chart of the three electrical units we will study in this experiment.

Electrical Quantity	Description	Unit	Water Analogy
Voltage or Potential Difference	A measure of the Energy difference per unit charge between two points in a circuit.	Volt (V)	Water Pressure
Current	A measure of the flow of charge in a circuit.	Ampere (A)	Amount of water flowing
Resistance	A measure of how difficult it is for current to flow in a circuit.	Ohm ( $\Omega$ )	A measure of how difficult it is for water to flow through a pipe.

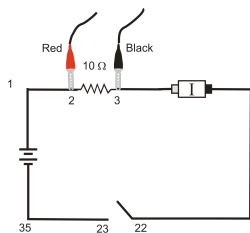


Figure 1

## OBJECTIVES

- Determine the mathematical relationship between current, potential difference, and resistance in a simple circuit.
- Compare the potential vs. current behavior of a resistor to that of a light bulb.

## LabQuest 22

### MATERIALS

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|--|---|
| LabQuest                               | clips to hold wires                       |
| LabQuest App                           | light bulb (6.3 V)                        |
| one Vernier Current Probe and          | adjustable 5 volt DC power supply         |
| one Vernier Differential Voltage Probe | two resistors (about 10 and 50 $\Omega$ ) |
| wires                                  |   |

### PRELIMINARY SETUP AND QUESTIONS

- Connect the Current Probe and the Differential Voltage Probe to LabQuest and choose New from the File menu. If you have older sensors that do not auto-ID, manually set up the sensors.
- With the power supply turned off, connect the power supply, 10  $\Omega$  resistor, wires, and clips, as shown in Figure 1. Take care that the positive lead from the power supply and the red terminal from the Current & Voltage Probe are connected as shown in Figure 1. **Note:** Attach the red connectors electrically closer to the positive side of the power supply. Have your instructor check the arrangement of the wires before proceeding.
- You need to zero both probes with no current flowing and with no voltage applied (power supply off).
  - With no current flowing and with no voltage applied, wait for the readings on the screen to stabilize.
  - Then, choose Zero ► All Sensors from the Sensors menu. The readings for both sensors should be close to zero.
- The current and voltage readings are shown on the screen, updated about once a second. Turn the control on the DC power supply to 0 V and then turn on the power supply. Slowly increase the potential to 5 V. Monitor the readings and describe what happens to the current through the resistor as the potential difference across the resistor changes. If the potential doubles, what happens to the current? What type of relationship do you believe exists between potential difference and current?

### PROCEDURE

- On the Meter screen, tap Mode. Change the data-collection mode to Selected Events so that the interface will record the potential and current only at times you specify. Select OK.
- Record the value of the resistor in the data table.
- Collect your first point of current and potential data.
  - Start data collection.
  - Check to see that your power supply is set to 0 V, and then tap Keep to record the current and potential.
- Take additional data.
  - Increase the potential on the power supply to approximately 0.5 V.
  - Tap Keep to record another data pair.
  - Increase the potential by about 0.5 V and tap Keep to record the data pair.
  - Repeat this process until you reach a potential of 5.0 V. After the last point stop data collection.

5. Set the power supply back to 0 V.
6. Two graphs are displayed on the screen. View a single graph of potential vs. current.
  - a. Choose Show Graph ► Graph 1 from the Graph menu.
  - b. Change the y-axis (the vertical axis) to Voltage.
  - c. Change the x-axis to Current.
7. Are the voltage and current proportional for this resistor? If so, fit a straight line to the data.
  - a. Choose Curve Fit from the Analyze menu.
  - b. Select Linear as the Fit Equation. The linear-regression statistics for these two data columns are displayed.
  - c. Sketch and label graph on separate sheet of paper
  - d. Record the slope and y-intercept of the regression line in the data table, along with their units.
  - e. Select OK.
8. Repeat Steps 2–7 using a different resistor.
9. Are the voltage and current proportional for this resistor? If so, fit a straight line to the data.
  - a. Choose Curve Fit from the Analyze menu.
  - b. Select Linear as the Fit Equation. The linear-regression statistics for these two data columns are displayed.
  - c. Record the slope and y-intercept of the regression line in the data table, along with their units.
  - d. Select OK.
10. Replace the resistor in the circuit with a 6.3 V light bulb. Repeat Steps 2–7, but this time increase the voltage in 0.1 V steps up to 1.0 V, 0.5 V steps from 1 to 4 V, and in 0.1 V steps again from 4 to 5 V.
11. To examine the graph, tap any data point. As you tap each data point, current and voltage values will be displayed to the right of the graph. Is the slope constant? To compare slopes of data at different parts of the curve, estimate the slope at the start of the graph (the low-current end) using the second and third points. Record the slope in the data table. Be sure to enter the units of the slope. In the same way estimate the slope using the last two points. Record this slope in the data table.

**DATA TABLE**

	Slope of regression line (V/A)	Y-intercept of regression line (V)
Resistor ____ Ω		
Resistor ____ Ω		
Light bulb (low current)		
Light bulb (high current)		

**ANALYSIS**

1. As the potential across the resistor increased, the current through the resistor increased. If the change in current is *proportional* to the voltage, the data should be in a straight line and it should go through zero. In these two examples how close is the y-intercept to zero? Is there a proportional relationship between voltage and current? If so, write the equation for each run in the form potential = constant × current. (Use a numerical value for the constant.)
2. Compare the constant in each of the above equations to the resistance of each resistor.
3. Resistance,  $R$ , is defined using  $R = V/I$  where  $V$  is the potential across a resistor, and  $I$  is the current.  $R$  is measured in ohms ( $\Omega$ ), where  $1 \Omega = 1 \text{ V/A}$ . The constant you determined in each equation should be similar to the resistance of each resistor. However, resistors are manufactured such that their actual value is within a tolerance. For most resistors the tolerance is 5% or 10%. Check with your instructor to determine the tolerance of the resistors you are using. Calculate the range of possible values for each resistor. Does the constant in each equation fit within the appropriate range of values for each resistor?
4. Do your resistors follow Ohm's law? Base your answer on your experimental data.
5. Describe what happened to the current through the light bulb as the potential increased. Was the change linear? Since the slope of the linear regression line is a measure of resistance, describe what happened to the resistance as the voltage increased. Since the bulb gets brighter as it gets hotter, how does the resistance vary with temperature?
6. Does your light bulb follow Ohm's law? Base your answer on your experimental data.