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Ohm’s Law

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

Current and potential difference 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 |
| Potential Difference or Voltage | A measure of the energy difference per unit charge between two points in a circuit. | volt (V) | Difference in water pressure between two points |
| Current | A measure of the flow of charge in a circuit. | ampere (A) | Rate of water flow |
| Resistance | A measure of how difficult it is for current to flow in a circuit. | ohm (Ω) | A measure of how difficult it is for water to flow through a pipe. |

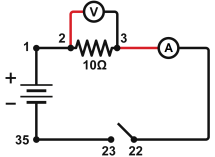


Figure 1

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.

MATERIALS

Chromebook, computer, or mobile device

Graphical Analysis 4 app

Go Direct Current

Go Direct Voltage

Extech Digital DC Power Supply

connecting wires with clips

light bulb (7.5 V)

Vernier Circuit Board 2 or switch and two resistors (about 10 and 50 Ω)

PRELIMINARY SEt up and QUESTIONS

1. Set up the sensors and data-collection app.
   1. Set the switch on the Current Probe to ±1 A.
   2. Launch Graphical Analysis. Connect Go Direct Current and Go Direct Voltage to your Chromebook, computer, or mobile device.
   3. Click or tap View, , and choose Meter.
2. Zero the sensors.
   1. Connect together the two voltage probe leads (red and black).
   2. When the voltage readings stabilize, click or tap the Voltage meter and choose Zero.
   3. When the current readings stabilize, click or tap the Current meter and choose Zero.
3. Set up the equipment.
   1. With the power supply turned off, connect the power supply to terminals J1 and J2. Connect the circuit with connecting wires as shown in Figure 1. Note: The numbers in the figure refer to the numbered terminals on the Vernier Circuit Board.
   2. Connect the current and voltage probes if they are not yet connected (see Figure 1). Note: The red leads from the current and voltage probes should be toward the positive terminal of the power supply.
   3. Set Switch 1, SW 1, located below the battery holder on the Vernier Circuit Board, to External.
4. Have your instructor check the arrangement of the wires before proceeding. Then, turn the control on the DC power supply to 0 V and then turn on the power supply. Close the switch and monitor the meter in Graphical Analysis. Slowly increase the voltage to 5 V. 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 predict exists between potential difference and current?

PROCEDURE

1. Set up the data-collection app.
   1. Click or tap Mode to open Data Collection Settings. Change Mode to Event Based.
   2. Change Event Mode to Selected Events, so that the potential and current will be recorded only at times you specify. Click or tap Done.
   3. Click or tap View, , and choose 2 Graphs.
2. Record the value of the resistor in the data table.
3. Collect your first point of current and potential data.
   1. Start data collection.
   2. Set the power supply to 0 V, and then click or tap Keep to record the current and potential.
4. Take additional data.
   1. Increase the potential on the power supply to approximately 0.5 V.
   2. Click or tap Keep to record another data pair.
   3. Increase the potential by about 0.5 V and click or tap Keep to record the data pair.
   4. 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.
   1. Click or tap View, , and choose 1 Graph.
   2. Click or tap the y-axis label and select Potential.
   3. Click or tap the x-axis label and select Current.
7. Are the potential difference and current proportional for this resistor? If so, fit a straight line to the data.
   1. Click or tap Graph Tools, , and choose Apply Curve Fit.
   2. Select Linear as the curve fit and click or tap Apply.
   3. Record the slope and y-intercept in the data table.
8. Repeat Steps 2–7 using a different resistor.
9. Are the potential difference, in volts, and current proportional for this resistor? If so, fit a straight line to the data.
   1. Click or tap Graph Tools, , and choose Apply Curve Fit.
   2. Select Linear as the curve fit and click or tap Apply.
   3. Record the slope and y-intercept in the data table.
10. Replace the resistor in the circuit with a 7.5 V light bulb. Repeat Steps 2–7, but this time increase the voltage in 0.1 V steps up to 5.0 V.
11. Click or tap the graph to examine the data. Is the slope constant? Compare slopes of data at different parts of the curve:
    1. Select the first three points on the graph.
    2. Click or tap Graph Tools, , and choose Apply Curve Fit.
    3. Select Linear as the Curve Fit and click or tap Apply.
    4. Record the slope in the data table.
    5. Select the last 10 points on the graph.
    6. Click or tap Graph Tools, , and choose Apply Curve Fit.
    7. Select Linear as the Curve Fit and click or tap Apply.
    8. Record the slope in the data table.

DATA TABLE

|  |  |  |
| --- | --- | --- |
|  | Slope  (V/A) | Y-intercept  (V) |
| Resistor  \_\_\_\_\_\_\_\_\_\_  Ω |  |  |
| Resistor  \_\_\_\_\_\_\_\_\_\_  Ω |  |  |
| Light bulb (first 3 pts) |  |  |
| Light bulb (last 10 pts) |  |  |

ANALYSIS

1. As the potential across the resistor increased, the current through the resistor increased. If the change in current is proportional to the potential difference, the data should be in a straight line and the y-intercept should be zero. In the two resistor examples how close is the y‑intercept to zero? Is there a proportional relationship between potential difference and current? If so, write the equation for each resistor data set in the form V = mI. Use a numerical value for the proportionality constant, m.
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 (Ω), where 1 Ω = 1 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 many common 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.

EXTENSIONS

1. Investigate Ohm’s law for reverse currents in resistors. Turn off the power supply and reverse the connections on the power supply. Turn the power supply back on and take data from 5.0 V to 0 V. Do not stop data collection. Turn off the power supply, restore the connections to the circuit to their original configuration, and turn the power supply back on. Take data from 0 to 5 V as before. Is the current still proportional to the potential across the resistor?
2. Investigate the behavior of other electrical devices such as diodes, LEDs, and Zener diodes. Make one run, then reverse the direction of the device and repeat.
3. Use a low-voltage AC power supply and measure current and potential difference, in volts, as a function of time in a simple circuit. Compare the two graphs. Create a graph of potential difference vs. current. Perform a linear regression over these data and compare to the resistance in the circuit.