

OHM'S LAW

LAB ELEC 25.CALC

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INTRODUCTION

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 this 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 (Ω)	A measure of how difficult it is for water to flow through a pipe.

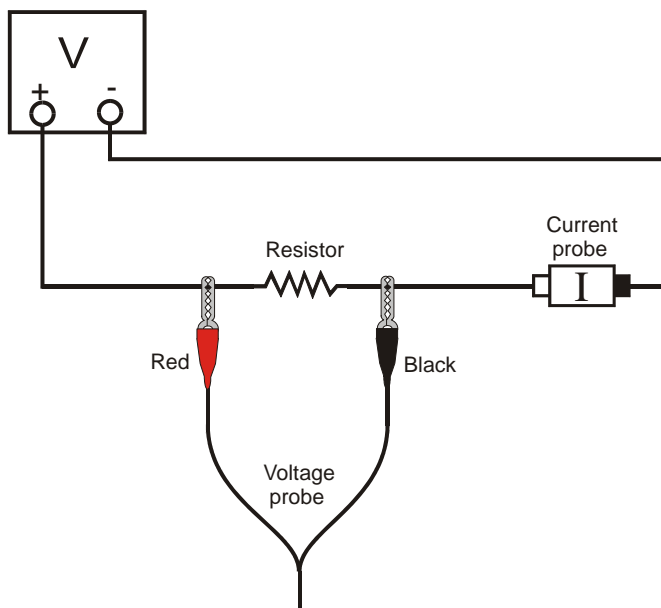


Figure 1

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

LabPro or CBL 2 interface	Vernier Circuit Board, or
TI Graphing Calculator	wires
DataMate program	clips to hold wires
one Vernier Current Probe and	light bulb (6.3 V)
one Vernier Differential Voltage Probe	adjustable 5-volt DC power supply
or, one Current & Voltage Probe System	two resistors (about 10 and 50 Ω)

PRELIMINARY SETUP AND QUESTIONS

1. Connect the sensors to the LabPro or CBL 2 interface:
 - If you are using the newer Current Probe and Differential Voltage Probe, connect the Current Probe to Channel 1 and the Differential Voltage Probe to Channel 2.
 - If you are using a Current & Voltage Probe System, connect DIN 1 on the Dual Channel Amplifier to Channel 1 of the LabPro or CBL 2 interface. Connect DIN 2 to Channel 2. Then connect a Current Probe to PROBE 1 on the Dual Channel Amplifier and a Voltage Probe to PROBE 2.
2. Use the black link cable to connect the interface to the TI Graphing Calculator. Firmly press in the cable ends.
3. Turn on the calculator and start the DATAMATE program. Press to reset the program.
4. If CH 1 displays the Current Sensor, proceed directly to Step 5. If it does not, set up your sensors manually. To do this:
 - a. Select SETUP from the main screen.
 - b. Press to select CH 1.
 - c. Select C V SYSTEM from SELECT SENSOR.
 - d. Select CV CURRENT (A) from C V SYSTEM.
 - e. Press to select CH2 and press .
 - f. Select C V SYSTEM from SELECT SENSOR.
 - g. Select CV VOLTAGE (V) from C V SYSTEM.
 - h. Select OK once to return to the main screen.
5. With the power supply turned off, connect the power supply, 10- Ω 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.

6. You need to zero both probes with no current flowing and with no voltage applied (power supply off).
 - a. Select SETUP from the main screen.
 - b. Select ZERO from the setup screen.
 - c. Select ALL CHANNELS from SELECT CHANNEL.
 - d. Press **ENTER** to zero the sensors.
7. The current and voltage readings are shown on the main 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 on your calculator 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

1. Set the data collection mode so that the interface will record the potential and current only at times you specify:
 - a. Select SETUP from the main screen.
 - b. Press **▲** to select MODE and press **ENTER**.
 - c. Select SELECTED EVENTS from the SELECT MODE menu.
 - d. Select OK to return to the main screen.
2. Record the value of the resistor in the Data Table.
3. To collect your first point of current and potential data,
 - a. Select START from the main screen.
 - b. Check to see that your power supply is set to 0 V, and then press **ENTER** to record the current and potential.
4. Take additional data:
 - a. Increase the potential on the power supply to approximately 0.5 V.
 - b. Press **ENTER** to record another point.
 - c. Increase the potential by about 0.5 V.
 - d. Repeat this process until you reach a potential of 5.0 V. After the last point, press **STO▶** to end data collection.
5. Set the power supply back to 0 V.
6. View a graph of potential vs. current.
 - a. Press **▲** to select CH2 VS. CH1.
 - b. Press **ENTER** to see a graph of potential vs. current.
7. Are the voltage and current proportional for this resistor? If so, fit a straight line to the data.
 - a. Press **ENTER** and select MAIN SCREEN to return to the main screen.
 - b. Select ANALYZE from the main screen.

- c. Select CURVE FIT from the ANALYZE OPTIONS.
 - d. Select LINEAR (CH2 VS CH1) from the CURVE FIT screen.
 - e. Record the slope and y-intercept of the regression line in the Data Table, along with their units.
 - f. Press **ENTER** to see your graph and the fitted line.
 - g. Press **ENTER** again and then select RETURN TO MAIN SCREEN.
8. Repeat Steps 2 – 7 using a different resistor.
 9. Replace the resistor in the circuit with a 6.3-V light bulb. Repeat Steps 3 – 6, 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.
 10. Trace across your graph using the cursor keys. 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 your 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 \times 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 (Ω), 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.

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 voltage as a function of time in a simple circuit. Compare the two graphs. Create a graph of voltage vs. current. Perform a linear regression over these data and compare to the resistance in the circuit.