LAB 3B: OHM'S LAW

INVESTIGATION: OHM'S LAW

What is the relationship between current and potential difference? You have already seen on several occasions that there is only a potential difference across a bulb when there is a current flowing through the bulb. The next question is how does the potential difference depend on the current? In order to explore this, you will need the following in addition to the equipment you have been using:

- regulated DC power supply (up to 3 volts and 0.5 amps)
- 10 ohm resistor

Examine the circuit shown below. A variable DC power supply is like a variable battery. When you turn the dial, you change the voltage (potential difference) between its terminals. Therefore, this circuit allows you to measure the current through the light bulb when different voltages are applied across it.

![Circuit Diagram]

Figure 3-10: Circuit with a variable power supply to explore the relationship between current and potential difference for a light bulb.

**Prediction 3-1:** What do you predict will happen to the brightness of the bulb as you turn the dial on the power supply and increase the voltage from zero? Explain.

**Prediction 3-2:** What do you predict will happen to the current through the bulb as you turn the dial on the power supply and increase the applied voltage from zero?

**Prediction 3-3:** What do you predict will happen to the potential difference across the bulb as the current through it increases from zero?

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Note: These materials may have been modified locally.
Prediction 3-4: What do you predict will be the mathematical relationship between the voltage across the bulb and the current through the bulb? Do you think it will be a proportional relationship or something else?

Activity 3-1: Current and Potential Difference for a Light Bulb

1. Open the experiment file called Ohm's Law.

2. Connect the circuit in Figure 3-10. Note that the current probe is connected to measure the current through the bulb, and the voltage probe is connected to measure the potential difference across the bulb.

3. Begin graphing current and voltage with the power supply set to zero voltage, and graph as you turn the dial and increase the voltage slowly to about 3 volts (DO NOT EXCEED 3 V OR YOU WILL BURN OUT THE BULB).

   Question 3-1: What happened to the brightness of the bulb as the power supply voltage was increased? Did this agree with your prediction?

   Question 3-2: What happened to the current in the circuit? Did this agree with your prediction?

   Question 3-3: How did the potential difference across the bulb change as the current through the bulb changed? Did this agree with your prediction?

   Question 3-4: How is the brightness of the bulb related to the potential difference across the bulb? To the current through the bulb?

4. The software will display three graphs: Current vs. Time, Voltage vs. Time, and Voltage vs. Current. Sketch the resulting data for the first and third of these graphs on the axes on the following page.

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5. Is there a linear relationship between voltage and current for the light bulb? In other words can you fit a line of the form \( y = mx + b \) precisely to the data on the voltage vs. current graph? You can experiment with the function plotter tool, which is available under the "analysis" menu.

**Question 3-5:** Based on your graphs, does the voltage across a bulb appear to be proportional to the current flowing through it? (This is the same as asking if their relationship is linear.)

In the last activity you explored the relationship between the potential difference across a light bulb and the current through the bulb. The actual quantitative relationship for a light bulb is rather complicated because the resistance of the bulb changes as the current flowing through it changes the temperature of the filament. Instead of a light bulb, you will now explore the simpler relationship between current and potential difference for a device called a **resistor**.

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**Activity 3-2 Relationship Between Current and Potential Difference for a Resistor**

1. Replace the light bulb by the 10-ohm resistor. Note that the zigzag line in Figure 3-11 is the symbol for a resistor.
Figure 3-11: Circuit with a variable power supply to explore the quantitative relationship between the current and potential difference for a resistor.

2. Begin graphing with the power supply set to zero voltage, and graph current and voltage as you turn the dial and increase the voltage slowly to about 3 volts.

   **Question 3-6:** What happened to the current through the resistor and the potential difference across the resistor as the power supply voltage was increased? Is this what you expected from your observations with the bulb in Activity 3-1?

3. Sketch the resulting data for Current vs. Time and Voltage vs. Time for the resistor on the axes below:

   ![Graph](image)
4. Use the function plotter tool to find the equation which represents the relationship between the potential difference across the resistor and the current through it.

**Question 3-7:** Compare your graph of voltage vs. current for the resistor to that for the bulb in the previous activity. In what ways are they similar, and in what ways are they different?

**Question 3-8:** In words, what is the mathematical relationship between potential difference and current for a resistor? Explain based on your graph.

The relationship between potential difference and current, which you have observed for a resistor, is known as Ohm's law. To put this law in its normal form, we must now define the quantity known as resistance. Resistance is defined by:

\[ R = \frac{\Delta V}{\Delta I} \]

If potential difference is measured in volts and current is measured in amperes, then the unit of resistance is the ohm, which is usually represented by the Greek letter \( \Omega \), "omega."

**Question 3-9:** State the mathematical relationship, which you found between potential difference and current for a resistor in terms of \( V \), \( I \), and \( R \).

**Question 3-10:** Based on your graph, what can you say about the value of \( R \) for a resistor—-is it constant or does it change as the current through the resistor changes? Explain.

**Question 3-11:** From the slope of your graph, what is the experimentally determined value of the resistance of your resistor in ohms? How does this agree with the value written on the resistor?

**Note:** Most circuit elements do not obey Ohm's law. The definition for resistance is still the same, but, as with the light bulb, the resistance changes as the current changes. Circuit elements which follow Ohm's law—like carbon resistors—are said to be ohmic, while circuit elements which do not—like a light bulb—are nonohmic.