NSTA 2024
Denver, CO

Bright Ideas: Investigating Light Bulbs and Simple Circuits through Guided Inquiry

Experiments

Measuring Electric Current

- Go Direct Current Probe
- Vernier Circuit Board 2

Conservation of Charge

- Go Direct Current Probe
- Vernier Circuit Board 2

Voltage in a Circuit

- Differential Voltage Probe

Workshop Presenter

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Measuring Electric Current

Let's see if we can figure out how to measure current!

PRELIMINARY OBSERVATIONS

Observe the following electricity demonstrations:

- How to measure the current in a simple circuit consisting of a power supply, current probe, and a light bulb.
- What happens when the current is varied.

Your challenge is to build the circuit in Figure 1 and determine how to connect another current probe or ammeter to measure the current in Bulb #1 and Bulb #2. You can *observe* the brightness of the test bulb and the value of the Test Current Probe, but you must not attempt to measure the current in the left side of the circuit (as shown in Figure 1).

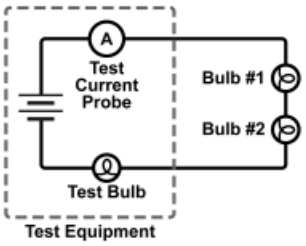

Figure 1 Experimental setup for measuring current in Bulbs #1 and #2

PROCEDURE

1. Brainstorm with your lab partners and determine as many methods as possible to measure the current in Bulb #1 and Bulb #2.

2. Carry out the investigation, and record your data and observations. Make sure all group members have access to the data.

ANALYSIS

1. Use your data and observations to explain how to measure current for a given component in a circuit. Write a brief description of your method. Propose an explanation as to why electric current should be measured this way.

This section to be handed out after the investigation.

2. Consider the circuits in Figure 2. Which of these circuits more accurately measures the current in Bulb #1? Explain why.

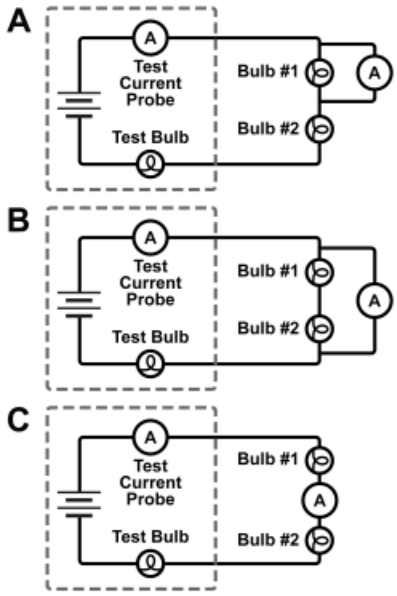

Figure 2

3. Predict what you will observe for the circuits that do not accurately measure the current through Bulb #1. Specifically, comment on the relative brightness of the three bulbs in the circuit. What will be the effect on the current flowing through the circuit as measured by the Test Current Probe and the second current probe/ammeter?

EXTENSIONS

1. Once you have correctly connected the current probe to measure current through Bulb #1, reverse the leads and observe what happens to the measurement. Trace the circuit from one end of the power source to the other and write a description regarding the direction of current flow.

2. Place a wire across the connections to Bulb #1 and observe what happens to the other light bulbs. How is this similar to the previous observations? What does this imply about an ammeter?

3. Add another light bulb in "parallel" with the other two. Ask your instructor for guidance on how to accomplish this, if necessary. Determine how to measure current through Bulb #2.

Conservation of Charge

Imagine you are canoeing down a river. Downstream you notice a large island. As you approach, it is not entirely clear which side of the island the river current will carry you. What do you experience/observe about the river as you approach and pass by the island?

PRELIMINARY OBSERVATIONS

Observe the following electricity demonstrations:

- A single light bulb connected to a battery, then additional lights added in series
- A single light bulb connected to a battery, then additional light bulbs added in parallel

Your task is to design an experiment that focuses collecting data to develop a model that explains the nature of current in circuits. Your model should be valid for series circuits, parallel circuits and combinations of the two.

Your initial investigation will be made using the circuit in Figure 1:

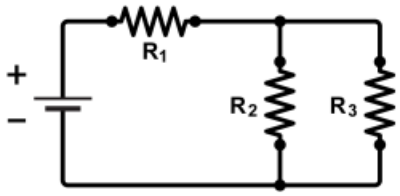

Figure 1

PROCEDURE

1. Discuss and decide what variables you will consider in the process of constructing a model for describing the current flow in a circuit.
    - Consider any knowledge you have gained from previous coursework.
    - Conduct research as needed.
2. Develop a purpose and a procedure for your investigation.
    - Your purpose should ask a question or propose a model related to the nature and properties of current in simple circuits.
    - Include an explanation of the equipment you will use.
    - Decide how much data and what observations to take in order to have enough information to satisfy your purpose and stand up to questioning by your peers.
3. Carry out the investigation and record your data and observations. Make sure all group members have access to the data.

ANALYSIS

Evaluate your data and develop a model based on this data to explain the phenomena you have observed. The model should allow you to predict the amount of current through any portion of a circuit consisting of resistors in series and parallel.

Use your model to explain the demonstrations conducted during the Preliminary Observations.

Construct a new circuit that contains both series and parallel elements. Predict the values of the current through each component. Measure the current through each component to verify your model. If your prediction does not match your measured values, revisit your model and adjust it as necessary.

EXTENSIONS

1. Compare the time required to deplete a battery when applied to a circuit in series and in parallel. Explain this in the context of conservation of charge and other observations in this investigation.

2. Starting with two bulbs in series with a battery, place an additional wire so that each end is in contact with the terminals of one of the bulbs. Describe your observations terms of current flow and explain in terms of your model. Is this a “short circuit” or an “open circuit”? Explain.

3. Research fuses and circuit breakers to provide a comparison of these two safety mechanisms and explain how that relates to the phenomena noted in the circuit in Extensions 1 and 2.

Voltage in a Circuit

Imagine you are at the top of a ski slope, looking down over the run. You point your skis down the hill and take off. You feel the pull of gravity as you ski down the run. Finally you end up at the bottom of the run. How do you get back up to the top of the run?

PRELIMINARY OBSERVATIONS

Observe the following electrical circuit demonstrations:

- Measure the voltage of a single battery.
- Predict the total voltage you would expect to see if you stack two batteries together. Then, test your prediction by stacking two batteries and measuring the voltage.
- What happens when you turn one of the batteries around? Test your prediction.

PROCEDURE

Your task is to create a circuit that consists of a single loop. The circuit will contain five components: three batteries and two resistors. Investigate the voltages of the components, changing their order and orientation in order to try to understand how voltage behaves in a circuit. Develop a model that explains your results.

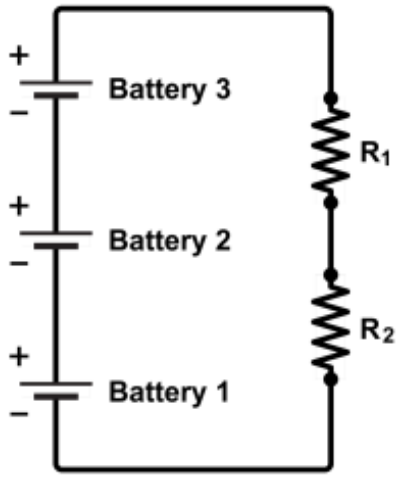

Figure 1 Schematic of initial circuit

1. Discuss and decide how you will conduct your investigation of the voltage in a circuit. Consider any knowledge you have gained from previous coursework while making your plan.

2. Develop a purpose and a procedure for your investigation.
    - Your purpose should ask a question or propose a model related to the nature and properties of voltage in simple circuits.
    - Include a list of equipment and an explanation of how the equipment will be used.
    - Decide how much data and what observations to take in order to have enough information to satisfy your purpose and stand up to questioning by your peers.
3. Carry out the investigation and record your data and observations. Make sure all group members have access to the data.

ANALYSIS

Evaluate your data and develop a model based on this data to explain your data and observations. The model should address how you might predict the amount of voltage across any component in a simple circuit.

Change one of the resistors in your circuit so that you have resistors of unequal resistance. Are the results consistent with your model? If not, modify your model to account for this new data.

Re-read the first paragraph in the introduction to this investigation. How is the content of that paragraph related to your model?

EXTENSIONS

1. Consider circuits with multiple current pathways, and determine how voltage behaves in this scenario.

2. Investigate both current and voltage in a variety of circuits in order to develop a comprehensive explanation of voltages and current in simple circuits with multiple paths.

3. Research voltage dividers and how they are used in modern electronics. Build a voltage divider circuit that will allow you to determine the resistance of an unknown resistor.

4. Replace each of the light bulbs in this investigation with LEDs. Add a single (approximately) 100 Ω resistor in series with each LED. Note how the LEDs behave as you test different battery configurations.