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Teacher Notes

Parallel versus Series Circuits Introduction

After students have discovered how to create simple circuits using a single bulb, they naturally begin to wonder about adding more bulbs or batteries. Lighting more bulbs or making them brighter seems to be an innate drive for middle school students! Their creativity and inventiveness provides an opportunity to compare two basic circuit patterns, series and parallel. First students should be given a non-directed time period to experiment with various circuit arrangements. Later they should compare these arrangements in an organized fashion and make careful note of the arrangement of the components of their circuits. They will note two primary differences:

1. In one arrangement, a series circuit, there is a single pathway for electricity. If students trace the pathway of the electrical flow they will notice that it flows from the battery through each bulb in turn and then back to the battery. They will also observe that the bulbs in a series circuit are noticeably dimmer than a single bulb. In a series circuit, if one bulb is removed or broken all the bulbs go out.

2. In an alternate arrangement, a parallel circuit, each bulb has an independent pathway to the battery. The bulbs are significantly brighter than in the series circuit and about the same brightness as a single bulb circuit. In a parallel circuit if one bulb is removed or broken the others will remain lit.

This activity is focused on exploring the differences in brightness. These observations should give rise to students developing mental models of what is occurring in each situation that might explain the difference in brightness. Some students may develop a hypothesis that the brighter bulbs in the parallel circuit are receiving "more" electricity. In this activity, students will use a CC DMM (digital multimeter) to test this hypothesis by observing the differences in voltage readings in a parallel and series circuit. Using the CC DMM (digital multimeter) will also afford them the opportunity to compare voltage output as more lights are added either end-to-end or in new branches.

Students will use spreadsheet and graphing computer applications to record and compare data.

Students will develop a number of key concepts related to electrical current including:

1. Electric circuits require an energy source and a complete loop through which an electric current can pass. The number and arrangement of batteries affects the brightness of a bulb or speed of a motor.

2. The force of an electric current can be measured in volts using a CC DMM (digital multimeter).

In addition students will gain experience with inquiry skills, including:

1. identifying variables that can affect the outcome of an experiment.

2. gaining skills and confidence in using a scientific measurement tool, the CC DMM (digital multimeter), as well as the spreadsheet and graphing capacity of a computer to represent and analyze data.

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Discussion Guide

Review a basic circuit with the students by having them construct one within their groups. Have the students use wires, a switch, a battery, and a bulb. After students have met with some success, ask each group to make a drawing of their circuit on paper. Students may use either representational drawings of actual components or circuit diagrams. Each group should be invited to present their drawing to the class and to trace the path of the electric current. Next, the students should be invited to compare circuits. A number of questions might be appropriate:

1. What do you notice about the difference in circuit arrangements?
2. What do you notice about the brightness of the bulbs in the different circuit arrangements?
3. Do you notice any differences in the circuits that might explain the difference in the brightness of the bulbs?
4. What happens in each circuit arrangement when you remove one bulb?
5. Does this give you any clues about the differences in brightness in different circuit arrangements?

At this point some students may have developed the hypothesis that the brighter bulbs are getting "more" electricity. Ask the class how they might test this idea.

Indicate that scientist use a tool to measure electric current and voltage. Tell the class that electricity is measured using a variety of kinds of units. Direct their attention to their batteries and ask them to report on the voltage rating. Tell the class that volts are a unit to measure the force or "push" of an electric current. Show the class the CC DMM (digital multimeter). Demonstrate how to test the voltage across the bulb with the multimeter.

Direct the students to "Thinking About the Question". After about 10 minutes allow the students to share their lists and reasoning. At this point the students should have had multiple experiences with building and identifying parallel and series circuits, if not demonstrate how to build and identify parallel and series circuits.

Direct the students to "Investigation I".

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Additional Teacher Background

Some students may question the concept of voltage. It is not necessary that they develop a sophisticated understanding of electrical units of measure. You might propose the following analogy: An electrical circuit is much like water running through a hose from a faucet. In this model the water represents the current flowing through the hose that represents the wire. If you turn the faucet on full, the pressure needed to push the water through the hose is at maximum. The pressure need to push the water represents the **voltage**. The hose offers **resistance** to flow. How much resistance is dependent on the length or the narrowness of the hose. (In electrical components resistance is also dependent on the nature of the conducting material.) The resistance of the hose and the pressure from the faucet will determine how much water (**current**) passes out of the end of the hose in a unit of time. This quantity is measured in amps.

Every time you add a bulb to a series circuit, you add more obstacles, or resistance, to the flow of electricity in the circuit. A series circuit has elements connected one after another along a single path. On the other hand in a parallel circuit there is an independent pathway for the electricity that flows through each bulb. A parallel circuit has elements connected in a branched path. In such a circuit, electric current may pass through any one of the paths. This model assumes that there is sufficient initial "pressure" or voltage produced by the battery to carry the current along two pathways. Adding more branches to a circuit results in a decrease in resistance in your circuit. As a result, the flow of electrical current is sufficient to maintain more than one bright bulb.

When in the presence of resistance (bulbs), electricity in the circuit experiences a voltage drop. The **sum** of all of the voltage drops across bulbs in a *series circuit* are equal to the voltage of the power source (battery). It is important to note, that each individual voltage drop across bulbs in a *parallel circuit* is **equal** to the voltage of the power source (battery).

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Parallel versus Series Circuits Suggested Timeline

The amount of time you spend on introductory discussions, data collection, and analysis, will determine your overall timeline. The following represents a possible timeline.

- One class period - Introductory Discussion
- One class period - Investigation I: Testing a two bulb circuit
- One class period - Investigation II: Testing a series circuit
- One class period - Investigation III: Testing a parallel circuit
- One class period - Analysis

Additional days can be used for further investigations.

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