Synopsis: DC Circuits; Batteries, Bulbs and Beyond

In this activity we will construct a number of DC circuits using our test bread-boards. We will remake our flashlights. We will make parallel and series circuits with batteries, bulbs, resistors and simple electric motors.

Standards

4th Grade

1a. Students know how to design and build simple series and parallel circuits by using components such as wires, batteries, and bulbs.

1g. Students know electrical energy can be converted to heat, light, and motion.

9-12th Grade

5a. *Students know* how to predict the voltage or current in simple direct current (DC) electric circuits constructed from batteries, wires, resistors, and capacitors.

Optional with Quantification:

5b. *Students know* how to solve problems involving Ohm's law.

5c. *Students know* any resistive element in a DC circuit dissipates energy, which heats the resistor. Students can calculate the power (rate of energy dissipation) in any resistive circuit element by using the formula Power = IR (potential difference) × I (current) = $I^2 R$.

Driving Questions

1. What is a circuit? Open? Closed? Short?
2. What does a battery do?
3. What does it mean to have devices: in parallel? in series?

Learning Objectives

1.) Students will learn about DC circuits by making them and testing them. In particular, students will explore:

- Open vs Closed circuits
- Circuits with devices in series and in parallel
- Circuits with resistors in series and in parallel
- Circuits with batteries in series and in parallel
- Short circuits

Procedure

Work in groups of three

Make sure you have the following:

- DC circuit component kits
- Bread-boards
- Patience

Part A: Bread-Board Flashlight

1. Using your DC circuit components and bread-board, rebuild the flashlight you originally made in the "Flashlight Challenge". Sketch a circuit diagram for your bread-board flashlight in your notebook.

Optional: Use your multimeter to measure and record:

a. ΔV, I and R for each leg of the circuit.
b. What is ΔV for the whole circuit?
c. Does I change as you go around the circuit?

2. Add a single pole switch, so you can turn your flash light on and off. Sketch a circuit diagram with the switch in your notebook.

Optional: Use your multimeter to repeat the measurements in 1a with

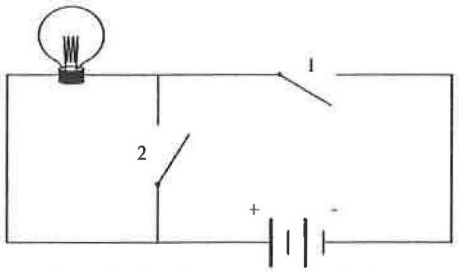
a. The switch open. (Open circuit)
b. The switch closed. (Closed circuit)
c. Can you explain your observations?
d. Can you make a general claim about open circuits?

3. Consider the circuit diagram depicted on the right.

BEFORE building the circuit make a few predictions.

What will happen to the bulb when:

a. Switch 1 is closed and Switch 2 is open?
b. Switch 1 is open and Switch 2 is closed?
c. Switch 1 is closed and Switch 2 is closed?



Two switch circuit for 3 & 4

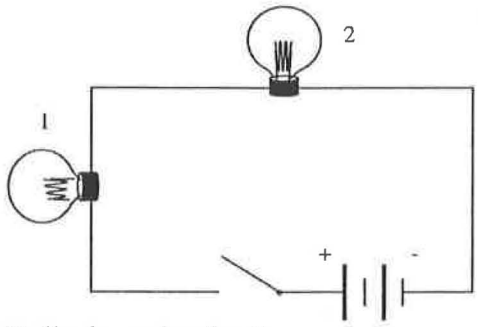
4. Adjust the switches to test your predictions in 3a, b and c. Record your observations in your notebook. Can you explain your observations? Any surprises?

Part B: Parallel and Series

For each circuit in the part of the activity, we are going to follow a Think, Do, Understand, Grow approach. We will:

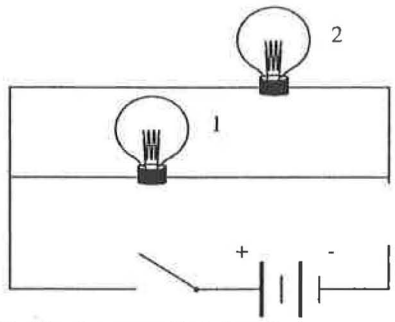
a. Make predictions
b. Build the circuit to test our predictions
c. Explain our observations and assess the accuracy of our original predictions
d. Make deductions based on your observations

5. Consider the circuit diagram with two bulbs **in series** depicted on the right.
   a. Which of the following do you predict will occur when the switch is closed?
      i. Bulb 1 will be brighter than Bulb 2.
      ii. Bulb 2 will be brighter than Bulb 1.
      iii. Bulbs 1 and 2 have roughly the same brightness.
   b. Make the circuit. What do you see? Record your observations.
   c. Can you explain your observations? Do they match your prediction?
   d. From your observation, what can you say about the current felt in Bulb 1 vs current in Bulb 2? (To feel smug, test your deduction with a multimeter).
   e. Draw an alternative circuit diagram that depicts the same circuit.



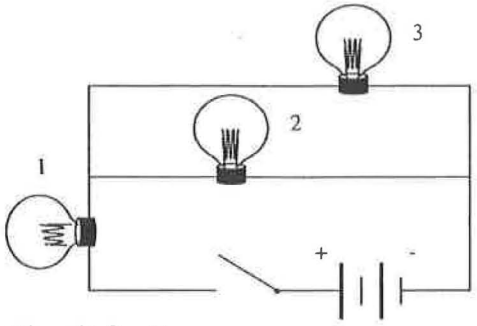
Bulbs in series for 5.

6. Consider the circuit diagram with two bulbs **in parallel** depicted on the right.
   a. Which of the following to you predict will occur when the switch is closed?
      i. Bulb 1 will be brighter than Bulb 2.
      ii. Bulb 2 will be brighter than Bulb 1.
      iii. Bulbs 1 and 2 have roughly the same brightness.
   b. Make the circuit. What do you see? Record your observations.
   c. Can you explain your observations? Do they match your prediction?
   d. From your observation, what can you say about the current felt in Bulb 1 vs current in Bulb 2? (To feel smug again, test your deduction with a multimeter).
   e. Draw an alternative circuit diagram that depicts the same circuit.
   f. How do your observations from 6 compare to those from 5?



Bulbs in parallel for 6.

7. Consider the circuit diagram with three bulbs depicted on the right. Which bulbs are in parallel? Which bulbs are in series?
   a. Which inequality will best describe the relative brightness of Bulbs 1, 2 and 3?
      i. $1 > 2 > 3$
      ii. $1 < 2 < 3$
      iii. $1 > 2 = 3$
      iv. $1 < 2 = 3$
      v. $1 = 2 = 3$
   b. Make the circuit. What do you see? Record your observations.
   c. Can you explain your observations? Do they match your prediction?
   d. From your observation, what can you say about the current felt in Bulb 1 vs current in Bulb 2? (To feel smug yet again, test your deduction with a multimeter).



Circuit for 7.

e. Draw an alternative circuit diagram that depicts the same circuit.

Follow up Deep thoughts for Parts A-D

1.) Did you see general rules for adding devices in
   a. Series?
   b. Parallel?

Sum up your findings.

Instructor Notes: DC Circuits; Batteries, Bulbs and Beyond

This activity is looooong. It could easily be broken up into a series of small activities that could be accomplished over many days. Getting quantitative with and adding resistors in parallel to determine total resistance is a good way to get students to add fractions in a real world[tm] context.

Safety

This activity has little to no risk associated with it. Students may be a little apprehensive, thinking they may get a shock from the battery. They will not be shocked by a D cell or any other 1.5 V battery. Batteries may get warm when in operation.

Materials

- DC circuit component kit
  - 1 Motor
  - 4 Velcro Sheets
  - 2 Medium Jumpers
  - 2 Single Switches
  - 1 Voltmeter
  - 3 Battery Holders
  - 3 Light Bulb Holders
  - 16 Nuts
  - 2 - 5 Ohm Resistors Red
  - 1 -15 Ohm Resistor White
  - 1 Potentiometer
  - 4 Short Jumpers
  - 2 Long Jumpers
  - 2 Double Switches
  - 3 D Batteries
  - 3 Light Bulbs
  - 16 Screws
  - 16 Washers
  - 1 -10 Ohm Resistor Green
- Bread-board

Notes