SNC1D/1P The Characteristics of Electricity/Electrical Applications

Student Activity: Series Circuits

Topics	Timing
current electricity series circuit	preparation: 5 min activity: 20 min

Specific Expectations

SNC1D

A1.1 formulate scientific questions about observed relationships, ideas, problems, and/or issues, make predictions, and/or formulate hypotheses to focus inquiries or research

A1.8 analyse and interpret qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis, identifying possible sources of error, bias, or uncertainty

A1.10 draw conclusions based on inquiry results and research findings, and justify their conclusions

A1.11 communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models)

E2.1 use appropriate terminology related to electricity, including, but not limited to: *ammeter, amperes, battery, current, fuse, kilowatt hours, load, ohms, potential difference, resistance, switch, voltmeter,* and *volts* [C]

E2.5 design, draw circuit diagrams of, and construct series and parallel circuits (e.g., a circuit where all light bulbs go out when one light bulb is removed; a circuit that allows one of several light bulbs to be switched on and off independently of the others), and measure electric current I, potential difference V, and resistance R at various points in the circuits, using appropriate instruments and SI units [IP, PR, AI, C]

E3.4 identify the components of a simple DC circuit (e.g., electrical source, load, connecting wires, switch, fuse), and explain their functions

E3.5 explain the characteristics of electric current, potential difference, and resistance in simple series and parallel circuits, noting how the quantities differ in the two circuits

SNC1P

A1.1 formulate scientific questions about observed relationships, ideas, problems, and/or issues, make predictions, and/or formulate hypotheses to focus inquiries or research

A1.8 analyse and interpret qualitative and/or quantitative data to determine whether the evidence supports or refutes the initial prediction or hypothesis, identifying possible sources of error, bias, or uncertainty

A1.10 draw conclusions based on inquiry results and research findings, and justify their conclusions

A1.11 communicate ideas, plans, procedures, results, and conclusions orally, in writing, and/or in electronic presentations, using appropriate language and a variety of formats (e.g., data tables, laboratory reports, presentations, debates, simulations, models)

E2.1 use appropriate terminology related to static and current electricity, including, but not limited to: *ammeter, ampere, battery, conductivity, current, energy consumption, fuse, kilowatt hours, load, ohm, potential difference, resistance, switch, voltmeter,* and *volts* [C]
E2.4 design, draw circuit diagrams of, and construct simple series and parallel circuits (e.g., circuits with: one light bulb; two light bulbs of the same brightness; one light bulb on and the other light bulb off) [IP, PR, C]
E2.5 compare, on the basis of observation, the differences between series and parallel circuits [PR, AI]
E3.3 identify the components of a simple direct current (DC) electrical circuit (e.g., electrical source, electrical load, switch, fuse), and describe their functions
E3.5 explain the characteristics of electric current, potential difference, and resistance, in simple series and parallel circuits

Introduction

In this demo, two circuits are constructed to enable comparison of the brightness of a light bulb placed in a circuit with one cell and the brightness of the same light bulb in a circuit with three cells connected in series. In Next Steps the potential differences of the two circuits are compared.

Materials

Each group of students will need:

5 alligator clips	light bulb; minimum 4.5 V
3 cells (AA batteries)	switch

Safety Considerations

- Light bulbs may become hot if left on for extended periods. Beware of burns. Allow the bulbs to cool before handling them.

Procedure

Part One - Circuit with one cell

1. Have students make a simple circuit by connecting a cell, a switch, and a light bulb with wires (Fig. 1).

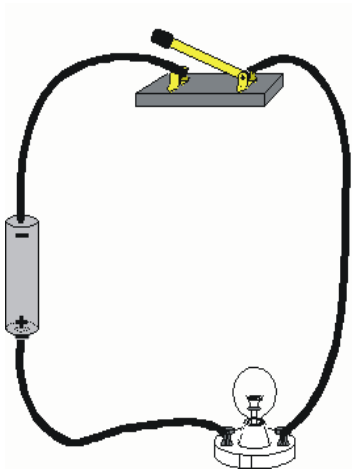

Fig.1 Set-up for Step 1 with one cell

2. **Observe**
   Have students observe the brightness of the light bulb.

Part Two - Circuit with three cells in series

3. Have students construct the circuit in Fig. 2. The cells should be added in series as shown, but ask students not to close the switch just yet.

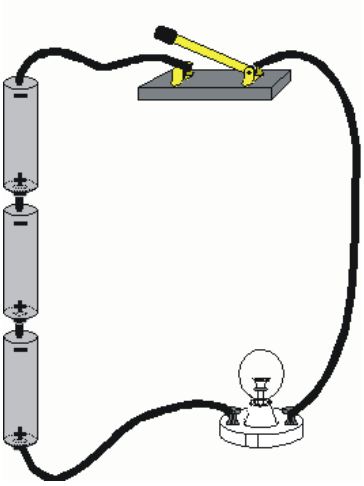

Fig.2 Set-up for Step 3, with three cells in series

4. **Predict**
   Ask students to predict how the brightness of the light bulb in the two circuits will compare when the final connection is made.
5. **Explain**
   Ask students to justify their predictions based on their knowledge of current electricity and the components of simple electrical circuits.
6. **Observe**
   Have students make the final connection in the circuit and make observations to test their predictions.
7. **Explain**
   Ask the students to review their predictions and see if they match what they have observed.

Disposal

Dispose of discharged cells by recycling them at a battery-recycling station in your school or in many home improvement stores (e.g., Home Depot, Canadian Tire).

Have a disposal plan for broken light bulbs that is consistent with school board protocol and appropriate for your municipality.

What happens?

A light bulb connected to three cells in series glows much brighter than the same light bulb connected to a single cell.

How does it work?

All else being equal, the greater the potential difference across a light bulb, the more brightly it glows. (See Next Steps.) When cells are connected in series, the total potential difference across the three cells is the sum of all the potential differences of the individual cells. For example, the potential difference across three 1.5 V cells is 4.5 V.

You could use a water column analogy (see Additional Resources) as a model for the increase in potential difference across cells in a series arrangement. Consider a water column of height *x* (to represent a single cell) with an opening at its base where water can flow out. The difference in gravitational potential energy between the top and bottom of the column depends on the height of the column. Similarly, the difference in electrical potential energy of a cell depends on the "height" or difference in electrical potential energy between the positive and negative compartments of the cell. Connecting three cells in series is analogous to using a water column that is three times the height of a water column of height *x*. Hence, the gravitational potential energy across the water column is three times that of a column with height *x*. Similarly, the potential difference of three cells arranged in series is three times that of a single cell.

Teaching Suggestions/Hints

1. Check all cells prior to the activity to ensure that their potential difference is almost identical.
2. Demonstrate the water column analogy using plastic tubing. This will help students understand why a series arrangement of cells in a circuit results in a brighter bulb because of a larger potential difference.

Next Steps

Repeat this activity using:

- a voltmeter to measure the potential difference across the cells and the light bulb. Relate these values to the brightness of the light bulb
- three cells connected in parallel

Additional Resources

1. A circuit-building interactive website - http://resources.schoolscience.co.uk/britishenergy/11-14/chal1.html
2. STAO resource: practical applications of cells connected in series - http://stao.ca/res2/elw/removing_covering_batt.php
3. STAO resource: a lesson on cells and batteries in series and parallel - http://stao.ca/res2/elw/L41.php
4. STAO resource: water column analogy - http://stao.ca/VLresources/2008/TheWaterModel.doc