Senior 1

Cluster 3: The Nature of Electricity

Overview

The conceptual development of the particle model of electricity underlies an understanding of electrostatics and current electricity.

Students construct simple devices like an electrophorus to investigate electrostatic phenomena. A transition from static to current electricity enables the learner to:

- develop a model of electricity.
- construct simple devices, like an electroscope, to investigate electrostatic phenomena.
- investigate circuits and make connections to daily applications, including the cost of electrical energy and the safety and efficiency of electrical appliances.
- investigate hydroelectric power and address sustainability issues associated with the generation and transmission of electricity in Manitoba.

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-01 Demonstrate evidence for the existence of two types of charge.

GLO: A1, C2, C5

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

SUGGESTIONS FOR INSTRUCTION
(1 HOUR)

➢ Entry-Level Knowledge

In Grade 5, students were introduced to the phenomena of static and current electricity.

➢ Notes for Instruction

The goal of this cluster is to help students develop a conceptual model that answers the question: “What is electricity?” Conceptual models play an important role in science. A good model is simple and provides explanations and predictions for our observations. Students should understand that models in science are tentative. Moreover, a historical perspective permits students to consider early models, discrepant events which challenge the model, and the revision or rejection of the model.

➢ Student Learning Activities

Teacher Demonstration

Capture students’ attention with some simple but effective demonstrations (e.g., bend a stream of water or raise a 2" x 4" board with a charged rod). (See Appendix 3.1)

Class Discussion

Ask students to provide evidence for the existence of only two types of charge. (See Appendix 3.2) Related teacher support materials are also offered in the Appendix. After students provide evidence for the existence of two types of charge (positive and negative), establish a simple model that demonstrates that charge is a property that exerts electrical forces. Like charges repel and unlike charges attract.

Suggestions for Assessment

Prior Knowledge Activity

Students write a short story to describe their prior experiences with electricity using a RAFTS strategy. (See *SYSTH*, pages 13.23–13.28)

Visual Displays S1-0-2a, 5c

Students create a poster of their previous experiences with electricity. Other displays could include Concept Overviews or Concept Frames. (See *SYSTH*, pages 11.24, 11.25)

Written Quiz/Test

Students diagram and explain the evidence for the existence of only two types of charge.

Suggested Learning Resources

Science 9

Chapter 9, p. 268

Sciencepower 9

Chapter 9, p. 294

Appendices

3.1 Teacher Support Material
Pre-Model Activities

3.2 Student Learning Activity
An Introduction to Electrostatics — Home Experiment

5.2 Rubric for the Assessment of Class Presentations

SYSTH

11.24, 11.25 Developing Scientific Concepts Using Graphic Displays

13.23–13.28 Writing to Learn Science

Prescribed Learning Outcomes

Students will...

S1-3-02 Discuss early models of electricity to support the premise that models in science change.

Include: one-fluid model, two-fluid model, particle model.

GLO: A1, A2, A5, C8

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-2b. Evaluate the reliability, bias, and usefulness of information.
(ELA: S1: 3.2.3, 3.3.3) GLO: C2, C4, C5, C8; TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5; TFS: 1.3.1, 3.2.2

Suggestions for Instruction
(1/2 hour)

➢ Entry-Level Knowledge

In the previous outcome, students examined evidence that only two charges are possible.

➢ Notes for Instruction

Today, we accept the particle model of electricity because Thomson’s discovery of the electron, Millikan’s oil drop experiment, and Rutherford’s gold foil experiment provide consistency between this model and the atomic model of matter. Ask students to use these early models to explain electrostatic phenomena. Encourage students to examine these early models, and design their own tests to challenge them. For example, a student may suggest trying Plutarch’s model in a vacuum to see if air has any effect on electric force.

➢ Student Learning Activities

Collaborative Teamwork S1-0-4e, 5c

Student groups brainstorm an explanation for the charging of the transparent tapes in Appendix 3.2 using one of the models. Assign the following sample questions randomly by drawing them out of a hat.

- Using the one-fluid model, explain how the transparent tapes acquire their charge.
- Using Plutarch’s model, explain why the top tape attracts the bottom tape.
- Using the particle model, explain why both tapes are attracted to your finger.

Student Research S1-0-2a, 2b, 2c

Students research the major contributions to the conceptual development of electric charge including those of Plutarch, Gilbert, Gray, Franklin, Dufay, and Rutherford.

Suggestions for Assessment

Journal Writing

Students compare and contrast the early models of electricity (i.e., one-fluid, two-fluid models, particle model) using Compare and Contrast frames. (See *SYSTH*, pages 10.15, 10.24)

Visual Displays

Outline the role of models in science using a concept map. (See *SYSTH*, page 9.6)

Research Report/Presentation

Students research the major contributors to the conceptual development of electric charge. Reports can be presented as

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- multimedia presentations
- storytelling or dramatic presentations

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

Teacher-, peer-, or self-assessment can be used.

Teacher Background

Plutarch, a Greek philosopher, explained electrical attraction by suggesting that the electric (in his case, rubbed amber) heated the surrounding air. Then, the air swirled around tiny nearby objects (like bits of straw) and pushed them back to the electric. Gilbert, in his text *De Magnete*, proposed that a substance, called effluvium, emanated from the electric and attached itself to the nearby object. Franklin’s one-fluid model asserted that every object contained a “normal” amount of electric fluid. If an object gained fluid it became positively charged; if it lost fluid it became negatively charged. Dufay’s two-fluid model and the particle model of electricity are similar. An object becomes charged if you lose or gain one fluid (or particle).

Suggested Learning Resources

SYSTH

9.6 Tapping into Prior Knowledge

10.4 Building a Scientific Vocabulary

10.15 Building a Scientific Vocabulary

10.24 Building a Scientific Vocabulary

Appendices

5.2 Rubric for the Assessment of Class Presentations

5.3 Rubric for the Assessment of a Research Project

Prescribed Learning Outcomes

Students will...

S1-3-03 Explain how a discrepant event can be used to evaluate the particle model of electricity.

Include: the attraction of neutral objects to charged objects.

GLO: A1, A2, A3, C8

S1-3-04 Relate the particle model of electricity to atomic structure.

GLO: A1, A2, D3

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-2b. Evaluate the reliability, bias, and usefulness of information.
(ELA: S1: 3.2.3, 3.3.3) GLO: C2, C4, C5, C8; TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

Suggestions for Instruction

(1 hour)

➢ Notes for Instruction

Help students relate the positive and negative charges to the protons and electrons in the atomic model. Discuss the fixed nature of the nucleus of the atom including its positively charged protons, and the movement of its negatively charged electrons.

➢ Student Learning Activities

Student Research/Reports S1-0-2a, 2b, 2c

Students or student groups research and report on the contributions of Rutherford, Thomson, and Millikan to the particle model of electricity.

Class Discussion/Teacher Demonstration

Introduce the attraction of neutral objects as a discrepant event. Show that a neutral object is attracted to both positive and negative charges. Then ask students: “How do we know that the object is neutral and not a third kind of charge?” To guide students towards an answer, ask them: “What happens when neutral charges are brought near each other?” When students realize that neutral objects don’t demonstrate electrical effects, they can modify their idea of charge to explain the attraction of neutral objects to both positive and negative charges by the polarization of charge. (See Appendix 3.3)

It is important to explain the attraction of neutral objects before students begin related investigations. Emphasize the difference between “touching” and “nearby.” Discuss the idea of charge polarization (as in a neutral insulator where the charges align but do not move very far) versus charge separation (as in a neutral conductor where the charges are displaced by some distance). (See Figures 1 and 2 below)

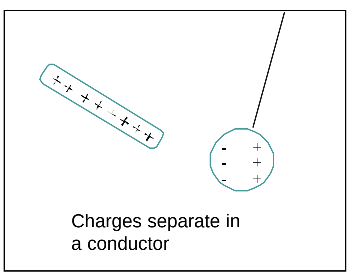

Figure 1: Charge Separation

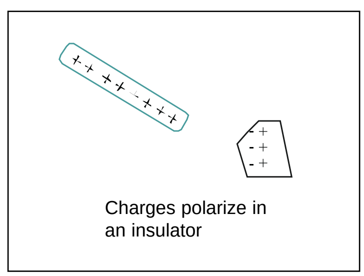

Figure 2: Charge Polarization

SUGGESTIONS FOR ASSESSMENT

Written Quiz/Test

Students summarize the particle model of electricity as follows:

- Two types of charge particles, positive (protons) and negative (electrons), exist.
- Charge cannot be created or destroyed — charge is conserved.
- Positive charges are fixed and negative charges are free to move.
- A neutral object has equal numbers of positive and negative charge.
- A negative object has an excess of negative charge. A positive object has a deficit of negative charge.
- Charge is shared by contact. Materials which allow charge to move easily are called conductors, and materials which do not allow charge to move easily are called insulators.
- Like charges repel; unlike charges attract.

Visual Displays

Students diagram and explain the attraction of neutral objects to either positively or negatively charged objects using the particle model of electric charge.

Research Report/Presentation

Students or student groups research and report on the contributions that led to the development of the particle model of electricity. Reports can be presented as

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- multimedia presentations
- storytelling or dramatic presentations

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

SUGGESTED LEARNING RESOURCES

Science 9

Rutherford: Chapter 3, p. 85

Thomson: Chapter 3, p. 84

BLM 9.2 A Model for the Electrical Nature of Matter

Sciencepower 9

Rutherford: Chapter 7, p. 239

Thomson: Chapter 9, p. 307

Appendices

3.3 Teacher Support Material Attraction of a Neutral Object

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-05 Investigate and explain electrostatic phenomena using the particle model of electricity.

Include: conservation of charge, conduction, grounding, attraction of a neutral insulator, induction.

GLO: A2, D3, D4, E4

Skills and Attitudes Outcomes

S1-0-1b. Select and justify various methods for finding the answers to specific questions. (Math: S1: A-1) GLO: C2

S1-0-3a. State a testable hypothesis or prediction based on background data or on observed events.
GLO: C2

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

SUGGESTIONS FOR INSTRUCTION

(3 HOURS)

➢ **Student Learning Activities**

Teacher Demonstration

Demonstrate conservation of charge by rubbing a glass rod with silk. (Negative charges are removed from the rod by friction, resulting in a net positive charge on the rod.) Hold another positively charged object near the rod. The rod will repel a positively charged object. The silk, on the other hand, has gained electrons and will attract a positively charged object, as it is now charged negatively. Help students infer that charge is not created or destroyed, but moved around.

Laboratory Activity S1-0-1b, 3a, 4e, 5c

Students investigate electrostatic phenomena using the lab described in Appendix 3.4. It is not necessary to use traditional materials, as most of the commercial plastic rods and pith balls are reliable and inexpensive. Different types of materials, such as vinyl or acetate, may replace glass and ebony rods. Try different types of cloth — whatever works best in your environment.

Students use a simple foil electroscope to test for charge. (See Appendix 3.5) Charge the electroscope positively. (Any object that repels the foil must also be charged positively. Any object which attracts the foil could be negative or neutral.) Students determine the only definitive test for a negative charge (i.e., charge the electroscope negatively and look for a repelling effect).

Visual Displays S1-0-5c

Students diagram electrostatic phenomena observed during their investigations, showing the movement of negative charges, the resulting net charge, and the effects of the net charges on the objects involved.

Suggestions for Assessment

Performance Assessment

Given an unknown charge, students demonstrate their ability to determine the charge using a pith ball and two rods or strips (for positive and negative charges).

Laboratory Report

Students investigate electrostatic phenomena. (See Appendix 3.4)

Student assessments should include diagrams that show the object, the movement of the negative charges, the net charge, and the resulting effects. For example, charging by conduction requires three diagrams.

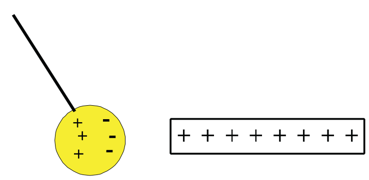

Diagram 1: Positive rod is brought nearby.

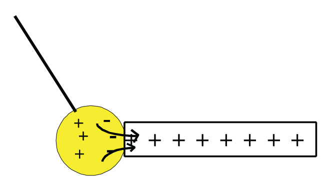

Diagram 2: Negative charges move onto the positive rod.

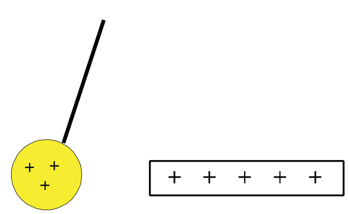

Diagram 3: The ball is more positive and the rod is less positive.

Figure 3: Charging by Conduction

Suggested Learning Resources

Sciencepower 9

BLM 9-11, 12, 19

Appendices

3.4 Student Learning Activity
Electrostatics Lab

3.5 Blackline Master
Electrostatic Devices — Background Information

Teacher Background

Students may wonder why a glass rod rubbed with silk is positive, an ebony rod rubbed with silk is positive, and an ebony rod rubbed with fur is negative. The terms positive and negative are arbitrary and were coined by Ben Franklin.

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-06 Investigate common electrostatic technologies and phenomena and describe measures which reduce dangers associated with electrostatics.

Examples: photocopying, static straps to reduce charge buildup, lightning, electrostatic spray-painting, electrostatic precipitator...

GLO: A5, B1, C1, D4

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-2b. Evaluate the reliability, bias, and usefulness of information.
(ELA: S1: 3.2.3, 3.3.3) GLO: C2, C4, C5, C8; TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-8d. Describe examples of how technologies have evolved in response to changing needs and scientific advances.
GLO: A5

SUGGESTIONS FOR INSTRUCTION

(1 HOUR)

➢ Student Learning Activities

Class Discussion

Students brainstorm and list the applications, problems, and solutions of everyday situations involving electrostatic charge. This discussion can form the content for the first column of a KWL frame (i.e., What do we know?). (See *SYSTH*, pages 9.8–9.10) Continue the discussion to allow students to express what they want or need to investigate further.

Student Research/Reports S1-0-2a, 2b, 2c, 8d

Using the list created in the previous activity, students or student groups research an item, and report their findings to the class. (See the examples in the learning outcomes column.)

Journal Writing

Students complete their KWL frames, describing what they know, wanted to know, and have learned.

SUGGESTIONS FOR ASSESSMENT

Rubrics/Checklists

Rubrics or checklists can be used for peer-, self-, or teacher-assessment.

Research Report/Presentation

Students or student groups research and report on everyday applications and problems/solutions involving electrostatic charge. Reports can be presented as

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- multimedia presentations
- storytelling or dramatic presentation

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations. (See *SYSTH*, page 3.13)

Teacher Background

Many useful everyday applications of electrostatic charge, including photocopy machines and electrostatic spray-painting, are based on the principle that opposites attract. The advent of computer technology and electronic storage devices has also raised awareness of the hazards of electrostatic charge (e.g., computer chips are extremely sensitive to static charge). It is common knowledge that before working on computer components, you should ground yourself by touching a metal or an electrostatic mat.

SUGGESTED LEARNING RESOURCES

Science 9

pp. 278–93

BLM 9.9 Build Your Own Electroscope

Sciencepower 9

pp. 310–18

Appendices

5.2 Rubric for the Assessment of Class Presentations

5.3 Rubric for the Assessment of a Research Project

SYSTH

3.13 Cooperative Learning and Science

9.8–9.10 Tapping into Prior Knowledge

9.24 Tapping into Prior Knowledge

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-07 Construct one or more electrostatic apparatus and explain how they function using the particle model of electricity.

Include: pieplate electrophorus.

GLO: A2, C3, D3, D4

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2;
TFS 2.2.1) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-2b. Evaluate the reliability, bias, and usefulness of information.
(ELA: S1: 3.2.3, 3.3.3) GLO: C2, C4, C5, C8;
TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6;
TFS: 2.2.2, 4.3.4

S1-0-4a. Carry out procedures that comprise a fair test. Include: controlling variables, repeating experiments to increase accuracy and reliability of results.
GLO: C1, C2 TFS: 1.3.1

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5a. Select and use appropriate methods and tools for collecting data or information.
GLO: C2; TFS: 1.3.1

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

S1-0-7a. Draw a conclusion that explains the results of an investigation.
Include: cause and effect relationships, alternative explanations, supporting or rejecting the hypothesis or prediction.
(ELA: S1: 3.3.4) GLO: C2, C5, C8

S1-0-8d. Describe examples of how technologies have evolved in response to changing needs and scientific advances.
GLO: A5

S1-0-8e. Discuss how peoples of various cultures have contributed to the development of science and technology.
GLO: A4, A5

SUGGESTIONS FOR INSTRUCTION

(1-1/2 HOURS)

➢ **Notes for Instruction**

An important component of Senior 1 Science is the active involvement of students in the construction of their own electrostatic equipment.

➢ **Student Learning Activities**

Laboratory Activity S1-0-4a, 4e, 5a, 5c, 7a

Students construct electroscopes, an electrophorus, and Leyden jars. (See Appendix 3.5) See the simple electrophorus shown below.

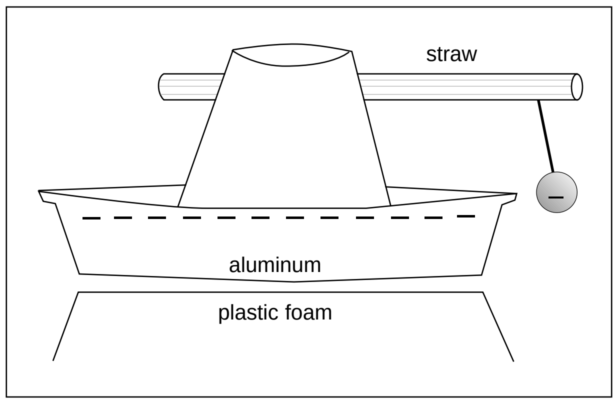

Figure 4: The Pieplate Electrophorus

Students use these devices to test for charge. See the Appendix for more learning activities with the electrophorus and other devices.

Teacher Demonstration

Demonstrate that the charges do not move from the plastic foam to the aluminum plate by putting wax paper between the plastic foam and aluminum.

Student Research S1-0-2a, 2b, 2c, 8d, 8e

Students research some of the early electrostatic devices built by scientists (e.g., Von Guericke's sulfur globe, Volta's electrophorus, Kelvin's water drop static generator) in order to make the connection among a particle model of electricity, new technologies, and their influence on the design of new experiments.

SUGGESTIONS FOR ASSESSMENT

Journal Writing S1-0-2c

Students complete a Compare and Contrast frame that distinguishes the charging of a conductor by conduction and induction. (See *SYSTH*, pages 10.15, 10.24)

Students prepare a Concept Overview outlining the characteristics of insulators and conductors. (See *SYSTH*, pages 11.25, 11.37)

Students explain some real-life phenomena that demonstrate the principle of induction (e.g., lightning formation, balloon sticking to a wall, the attraction of a stream of water to positive or negative charges, or the rotation of the 2" x 4" demonstration. (See Appendix 3.1)

Written Quiz/Test

Students

- diagram and explain the charging of an **electroscope** by conduction and induction.
- diagram and explain the charging of an **electrophorus** by induction.

Laboratory Report

Students explain how an electroscope, an electrophorus, and a Leyden jar function using the particle model of electricity.

Research Report/Presentation

Students or student groups research and report on early electrostatic devices. Reports can be presented as

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- multimedia presentations
- storytelling or dramatic presentations

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

SUGGESTED LEARNING RESOURCES

Appendices

3.1 Teacher Support Material Pre-Model Activities

3.5 Blackline Master Electrostatic Devices

3.7 Teacher Support Material Pieplate Electrophorus

5.2 Rubric for the Assessment of Class Presentations

SYSTH

10.15, 10.24 Building a Scientific Vocabulary

11.25, 11.37 Developing Scientific Concepts Using Graphic Displays

Other Resources

Morse, Robert, *Teaching Electrostatics*, American Association of Physics Teachers, College Park, MD: 1999
www.aapt.org

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-08 Demonstrate and explain the like nature of electrostatics and current electricity.

Include: discharge an electrophorus through a neon bulb.

GLO: C3, D4, E4

Skills and Attitudes Outcomes

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6;
TFS: 2.2.2, 4.3.4

SUGGESTIONS FOR INSTRUCTION

(1/2 HOUR)

➢ **Notes for Instruction**

Make a connection between electrostatics and current electricity (and ultimately the electrical outlets in your students' homes) by discharging an electrophorus through a neon bulb. Using the particle model for electric charge, explain how the negative charges flow from the ground (your finger) through the bulb, where they bump into neon atoms and give up some energy as heat and light. (See the diagram below and Appendix 3.7)

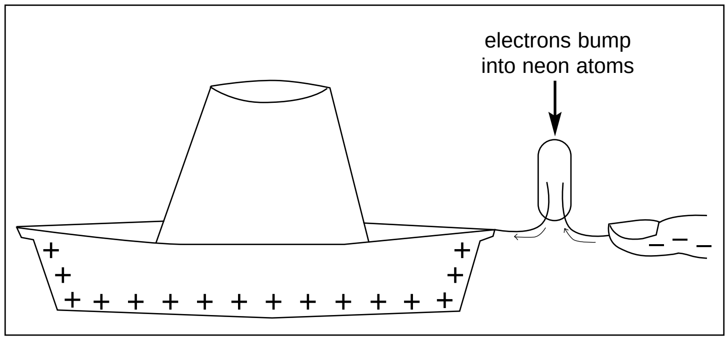

Figure 5: Discharging through a Neon Bulb

Note: Use NH-2 neon bulbs (available at local electronic supply stores).

➢ **Student Learning Activities**

Journal Writing

Students explain, using a Concept Overview frame, the like nature of electrostatics and electricity after viewing the demonstration above. (See *SYSTH*, pages 11.25, 11.37)

Suggestions for Assessment

Journal Writing S1-0-2c

Students describe the various kinds of electricity and some of their effects. The descriptions should include connections with chemistry and biology (e.g., biology — animal electricity contracts muscles).

Teacher Background

Historically, it was not apparent that electricity generated from various sources was of the same nature. Michael Faraday performed comprehensive investigations in the 1830s to show the "Identity of Electricities Derived from Various Sources." He demonstrated that electricity from batteries, magnetos, animals, and thermo sources produced shocks, deflected magnetic needles, and exerted forces of attraction and repulsion.

Suggested Learning Resources

Appendices

3.6 Teacher Support Material
Transition from Static to Current Electricity

3.7 Teacher Support Material
Pieplate Electrophorus

SYSTH

11.25, 11.37 Developing Scientific Concepts Using Graphic Displays

Other Resources

Arons, Arnold, *A Guide to Introductory Physics Teaching*. John Wiley and Sons, Toronto, ON: 1990, p. 164ff.

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-09 Define electric current as charge per unit time and solve related problems.

Include: $I = \frac{Q}{t}$.

GLO: C2, C3, D4

S1-3-10 Define voltage (electric potential difference) as the energy per unit charge between two points along a conductor and solve related problems.

Include: $V = \frac{E}{Q}$.

GLO: C2, C3, D4

Skills and Attitudes Outcomes

S1-0-1b. Select and justify various methods for finding the answers to specific questions. (Math: S1: A-1) GLO: C2

S1-0-2a. Select and integrate information obtained from a variety of sources. Include: print, electronic, specialists, other resource people. (ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-2b. Evaluate the reliability, bias, and usefulness of information. (ELA: S1: 3.2.3, 3.3.3) GLO: C2, C4, C5, C8; TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms. Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources. (ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-3b. Identify probable mathematical relationships between variables. *Examples: relationship between current and resistance...* GLO: C2

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise. (ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding. (ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION
(2 HOURS)

➢ **Notes for Instruction S1-0-3b**

Extend the particle model to a discussion of current electricity and define electric current as the number of charges (electrons) which pass a given point per unit time. (The coulomb is the unit for charge and 6.25×10^{18} electrons make up a coulomb. Thus, the unit for current is a coulomb/second, also known as an ampere [A]). Ask students to look on the side of a flashlight bulb for stamps, e.g., 2.2 V or 0.25 A, and then ask, "How many electrons pass through the bulb in one second?" Guide students through the following calculation:

I = q/t and q = I x t
Therefore, q = 0.25 A x 1 Second or 0.25 C
but 1 C = 6.25×10^{18}
Therefore, $0.25 \times 6.25 \times 10^{18} = 1.56 \times 10^{18}$ e
(That's a lot of electrons!)

➢ **Student Learning Activities**

Collaborative Teamwork S1-0-4e

Student groups brainstorm to identify other forms of unit quantities (e.g., unit costs for grocery items) and make up questions to challenge other groups. Your total cost equals the unit cost times the number of items you buy. Similarly, electric energy is the unit energy (electric potential) times the number of charges you have.

Teacher Background

Electric potential (V) is a unit of energy. The units are joules/coulomb, commonly called volts. The volt is the energy of each charge. Therefore, if you have more charges you have more total energy (Energy = charge x potential [E = qV]). This concept is important when calculating energy in the home.

You don't pay for the amount of charge or the potential; instead you pay for the energy that is consumed.

Electric potential difference (ΔV), also called voltage, is the measure of the potential difference between two points. Electric potential is a difficult concept and should be related to the more familiar gravitational potential. If you lift an object above the Earth, the energy is stored as gravitational potential between two masses (the object and the Earth). If you release the mass, the energy is transformed into kinetic energy as the object accelerates towards the Earth. In electricity, you must also apply a force to separate charge. This energy is stored as electric potential and when the charges are released, the energy is transformed to kinetic energy as they accelerate. Therefore, to create an electric potential, we must accumulate and separate charge.

Suggestions for Assessment

Written Quiz/Test

Students

- solve problems using $I = q/t$.
- solve problems using $V = E/q$. Include questions that emphasize the unit nature of electric potential (i.e., $E = qV$).

Journal Writing S1-0-2c, 7e

Students

- use a water analogy to describe electric potential and current flow.
- compare and contrast electric and gravitational potential energy.
- use a Word Cycle to connect the electrical terms positive charge, negative charge, separation, electric potential difference, conductor, insulator, current, unit energy, total energy, electrophorus, time, joules, and coulomb. (See *SYSTH*, page 10.21)

Student Research S1-0-1b, 2a, 2b, 2c

Students

- investigate the physiological effects of electric current on the human body.
- compare the voltage ratings for different sources of electrical energy (e.g., wall outlet, battery, photocell, and animal electricity).

Teacher Background

Educational research clearly shows that students lack a conceptual background when studying current electricity. Therefore, this cluster has been written to help students develop a conceptual model of electricity using a particle. In an electric circuit, electrons are present in ALL PARTS of the circuit all the time. In order to move electrons in a wire, we need a potential difference between the ends of the wire. A potential difference is created by an accumulation of charge at the ends of the wire. As one electron is pushed into one end of the wire, ALL electrons in the wire move simultaneously and one electron moves off the other end. The electrons actually move through the wire relatively slowly, as they bump into the fixed particles in the wire. However, the signal (the electron moving off the other end) travels instantaneously (speed of light).

Suggested Learning Resources

Science 9

Chapter 10, p. 316 (S1-3-10)

Sciencepower 9

Chapter 10, p. 325 (S1-3-09)

Chapter 10, p. 331 (S1-3-10)

SYSTH

10.21 Word Cycle

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-11 Identify the five sources of electrical energy and some associated technologies.

Include: chemical, photo, thermo, electromagnetic, piezo.

GLO: B1, D4, E4

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

SUGGESTIONS FOR INSTRUCTION
(2 HOURS)

➢ **Notes for Instruction**

The five sources of electrical energy are chemical, photo (light), electromagnetic, thermo (heat), and piezo (crystals). Chemical sources accumulate charge through chemical processes; photoelectric materials emit electrons when they are struck by light; a wire moving in a magnetic field generates current; some dissimilar metals generate current when heated; and certain crystals generate current when they are stressed.

➢ **Student Learning Activities**

Teacher Demonstration

Demonstrate several sources of electrical energy such as

- chemical energy using a battery (e.g., a potato clock or a lemon battery).
- photo energy using a photocell (available in hobby stores or scientific catalogues). For a bright light, use your overhead.
- electromagnetic energy by pushing a magnet into a coil of wire or using a hand-held generator from commercial suppliers.
- thermoelectric energy by heating thermocouples.
- piezo electric energy using piezoelectric crystals (found in microphones) to change mechanical energy to electrical energy.

Note: Chemical (batteries), photoelectricity (photocells), and electromagnetic (generators) sources are readily available.

Student Research

Students research and identify a common application of electricity at home, work, or school.

Suggestions for Assessment

Research Report/Presentation S1-0-2a, 2c

Students research

- fuel cells, including their advantages over traditional sources of chemical energy, and their applications.
- ultrasonic waves. (In medicine, ultrasonic waves are produced by electrically stimulating a piezoelectric crystal. Alternating electric current applied to a piezoelectric crystal causes rapid deformations of the crystal. These vibrations cause compressions in the air surrounding the crystal, or ultrasonic waves.)
- guitar tuners and microphones (piezoelectricity), thermocouples (heat-sending switch), and photocells.

Reports can be presented as

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- multimedia presentations
- storytelling or dramatic presentations

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

Journal Writing S1-0-2a, 2c

Students compare the energy used when manufacturing batteries with the energy delivered by batteries.

Students examine the toxic chemicals involved in manufacturing batteries and discuss the environmental problems associated with their disposal.

Teacher Background

To create electric potential energy, we must accumulate and separate charge. As the negative charges move, the energy is transformed to kinetic energy. If we do not replace the negative charge, the potential reduces very quickly and no more current will flow. For a continuous flow of charge, we must maintain this accumulation of charge.

Suggested Learning Resources

Science 9

Chapter 11, pp. 342, 346

Sciencepower 9

Chapter 12, p. 380

Appendices

5.2 Rubric for the Assessment of Class Presentations

5.3 Rubric for the Assessment of a Research Project

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-12 Describe resistance in terms of the particle model of electricity.

GLO: A2, D3, E2

Skills and Attitudes Outcomes

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6;
TFS: 2.2.2, 4.3.4

SUGGESTIONS FOR INSTRUCTION

(1/2 HOUR)

➢ Notes for Instruction

According to our particle model of electricity, positive charges are fixed and the negative charges (electrons) move. As the electrons move through a conductor, they bump into the fixed particles (the atoms) in the conductor. When they bump into the atoms, the electrons slow down and give up their energy as heat and light. This opposition to the flow of electrons is called resistance.

The accepted unit of resistance is the Ohm (Ω). One Ohm is the resistance of a wire with a potential difference of one volt and a current of one ampere.

Encourage students to describe their understanding of resistance in their own words using analogies or creative writing.

➢ Student Learning Activities

Journal Writing

Using a RAFTS format, students describe the journey of the electrons in a wire. For example: You are an electron writing a letter of complaint to the atoms of a conductor who are always in the way. (See *SYSTH*, pages 13.23–13.28)

Alternatively, students use a water pump analogy to describe the energy changes in an electric circuit.

SUGGESTIONS FOR ASSESSMENT

Written Quiz/Test

Students describe the energy transfer in an electrical circuit in terms of the particle model.

Teacher Background

Traditionally, the unit of electrical resistance was the length of a standard wire. Conceptually, length is an excellent description of the resistance of a wire. A longer wire means there are more atoms for the electrons to bump into.

SUGGESTED LEARNING RESOURCES

Science 9

Chapter 10, p. 316

Sciencepower 9

Chapter 10, p. 337

SYSTH

13.23–13.28 Writing to Learn Science

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-13 Construct electric circuits using schematic diagrams.

Include: series, parallel.

GLO: C3, D4, E4

Skills and Attitudes Outcomes

S1-0-1b. Select and justify various methods for finding the answers to specific questions.
(Math: S1: A-1) GLO: C2

S1-0-3c. Plan an investigation to answer a specific scientific question.
Include: materials, variables, controls, methods, safety considerations.
GLO: C1, C2

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-6a. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

S1-0-7a. Interpret patterns and trends in data, and infer and explain relationships.
(ELA: S1: 3.3.1) GLO: C2, C5;
TFS: 1.3.1, 3.3.1

SUGGESTIONS FOR INSTRUCTION
(1 HOUR)

➢ **Notes for Instruction**

See Appendix 3.8: Batteries and Bulbs.

Class Discussion

Demonstrate the two-endedness of a light bulb by wrapping an ordinary household light in a towel and breaking the glass enclosure. (Exercise caution when breaking the bulb. The glass is sharp!) Students should identify the path of the electrons. (See Figure 7)

Teacher Demonstration

Introduce a second wire and the concept of a circuit loop. (See Figures 8 and 9) After drawing a picture of the circuit, introduce the convenience of schematics (symbols), including the symbols for cells, a switch, a bulb, and a resistance.

➢ **Student Learning Activities**

Laboratory Activity S1-0-4e

Students build a simple circuit with a battery, one wire, and a mini lamp. Students perform lab exercises in simple circuits. (See Appendices 3.9–3.10)

Suggestions for Assessment

Journal Writing

Students compare and contrast the characteristics of series and parallel circuits.

Performance Assessment

Given a schematic diagram, students build an electric circuit, and draw a schematic diagram from a given electric circuit.

Laboratory Report

Students complete an investigation in series and parallel circuits.

Design Project S1-0-1b, 3c, 6a

Students design a circuit with two bulbs and a buzzer so that one bulb is always lit and the other only lights when the buzzer is turned on.

Teacher Background

A lamp is simply a wire (the filament) enclosed in a glass bulb. One end of the filament is connected to the shield and the other end touches the bottom contact.

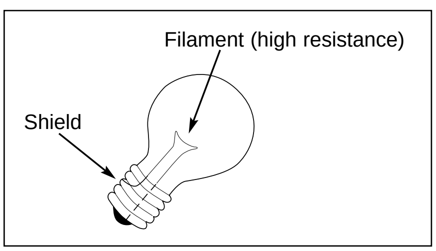

Figure 7: Bulb

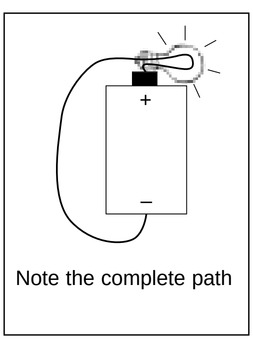

Figure 8: Battery and bulb

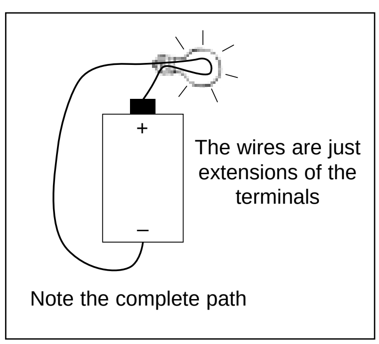

Figure 9: Simple circuit with battery and bulb

Suggested Learning Resources

Science 9

Chapter 10, p. 300

Skills, p. 544

Sciencepower 9

Chapter 10, p. 334

Chapter 11, p. 354

Appendices

3.8 Teacher Support Material Batteries and Bulbs

3.9 Student Learning Activity Simple Circuits Lab

3.10 Blackline Master DC Circuits and Schematic Diagrams

Other Resources

Evans, James. "Teaching Electricity with Batteries and Bulbs." *The Physics Teacher* (January 1978): 15.

Prescribed Learning Outcomes

Students will...

S1-3-14 Use appropriate instruments and units to measure voltage (electric potential difference), current, and resistance.

GLO: C2, C3, D4

Skills and Attitudes Outcomes

S1-0-3a. State a testable hypothesis or prediction based on background data or on observes events. GLO: C2

S1-0-3c. Plan an investigation to answer a specific scientific question.
Include: materials, variables, controls, methods, safety considerations.
GLO: C1, C2

S1-0-4a. Carry out procedures that comprise a fair test. Include: controlling variables, repeating experiments to increase accuracy and reliability of results.
GLO: C1, C2; TFS: 1.3.1

S1-0-4b. Demonstrate work habits that ensure personal safety of others, as well as consideration for the environment.
Include: knowledge and use of relevant safety precautions, WHMIS regulations, emergency equipment.
GLO: B3, B5, C1, C2

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5b. Estimate and measure accurately using Système International (SI) and other standard units.
Include: SI conversions.
GLO: C2

Suggestions for Instruction

(1 hour)

➢ Notes for Instruction

Use a multimeter or a voltmeter and an ammeter to measure voltage and current in circuits. Digital multimeters (numerical display) can be expensive; however, inexpensive analog meters can be found commercially. These have the additional advantage of providing students an opportunity to read a scale. The meter should be capable of measuring the voltage and current ranges that are required for simple circuits (e.g., flashlight batteries and bulb circuits require a range of about 5.0 V and 0.5 amperes).

➢ Student Learning Activities

Teacher Demonstration

Demonstrate that in order for an ammeter to measure current, it must be placed in series such that the current flows through the meter. (The meter is built with a very low resistance and does not affect the total resistance of the circuit.) Warn students what will happen if they place a meter in a circuit incorrectly (i.e., an ammeter placed in parallel behaves like a low resistance wire — it shorts the circuit). Using equipment and supporting schematics (See Figure 10) show that voltmeters are placed in a circuit in parallel and have a very high resistance. If a voltmeter is placed in series, the large resistance decreases the current (effectively to zero) and the circuit will not work. (See Appendix 3.11)

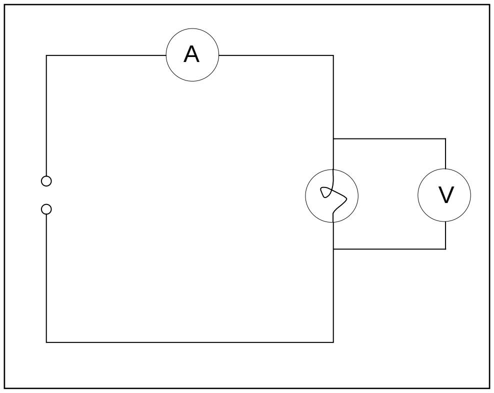

Figure 10: Correct Placement of Meters

Laboratory Activity S1-0-4a, 4b, 4e, 5b

Students perform a lab exercise, measuring voltage, current, and resistance. (See Appendix 3.11)

SUGGESTIONS FOR ASSESSMENT

Performance Assessment S1-0-3c

Students measure the current in a simple series or parallel arrangement.

Written Quiz/Test

Students

- draw schematic diagrams to show the placement of a voltmeter and an ammeter in a simple circuit.
- explain what happens to a circuit when the meter is placed incorrectly.

See examples below:

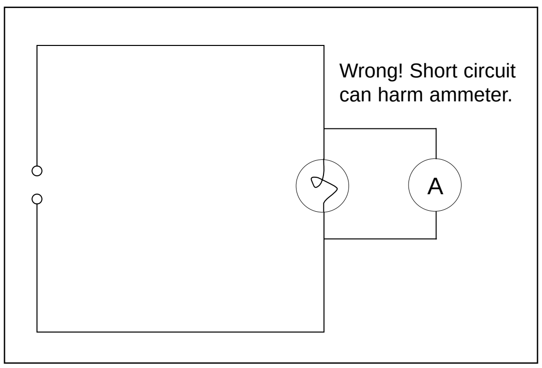

Figure 11: Ammeter is a small resistance

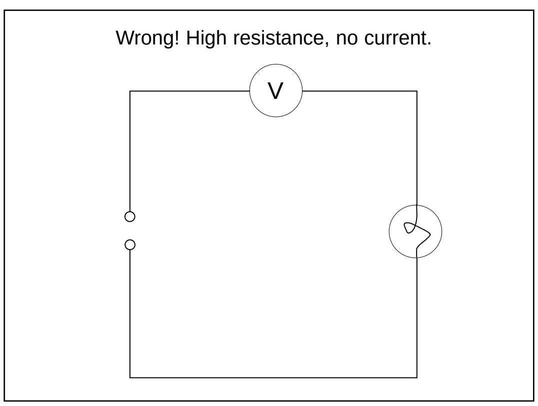

Figure 12: Voltmeter is a huge resistance

SUGGESTED LEARNING RESOURCES

Science 9

p. 546

Sciencepower 9

pp. 326, 332

Appendices

3.9 Student Learning Activity
Simple Circuits Lab

3.11 Student Learning Activity
Circuits Lab 2 — Measuring Current, Voltage, and Resistance

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-15 Compare and contrast voltage (electric potential difference) and current in series and parallel circuits.

Include: cells, resistance.

GLO: C3, D4

Skills and Attitudes Outcomes

S1-0-5b. Estimate and measure accurately using Système International (SI) and other standard units.
Include: SI conversions.
GLO: C2

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5;
TFS: 1.3.1, 3.2.2

S1-0-6a. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

S1-0-6b. Identify and suggest explanations for discrepancies in data.
Examples: sources of error...
(ELA: S1: 3.3.3) GLO: C2

S1-0-6c. Evaluate the original plan for an investigation and suggest improvements.
Examples: identify strengths and weaknesses of data collection methods used...
GLO: C2, C5

S1-0-7a. Interpret patterns and trends in data, and infer and explain relationships.
(ELA: S1: 3.3.1) GLO: C2, C5;
TFS: 1.3.1, 3.3.1

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION
(1 HOUR)

➢ **Notes for Instruction S1-0-5b, 5c, 6a, 6b, 6c, 7a, 7e**

After a brief demonstration of how to construct circuits in series and parallel, ask students to investigate the effects on current and voltage of these two types of circuits.

➢ **Student Learning Activities**

Class Discussion

Students manipulate equipment and construct circuits in series and in parallel according to circuit diagrams/schematics to compare and contrast current and voltage.

Single sources of electrical energy (cells) can be placed in series and in parallel. If cells are placed in series, the voltage increases proportional to the number of cells. In other words, the individual voltages add up to give the total voltage. For example, one flashlight battery (one cell) has a voltage of 1.5 volts. Three flashlight batteries in series have a voltage of 1.5 + 1.5 + 1.5 = 4.5 V. You can easily measure this using a voltmeter.

If the cells are placed in parallel, the voltages remain the same and each cell contributes a proportional amount of current. Cells in parallel also last longer.

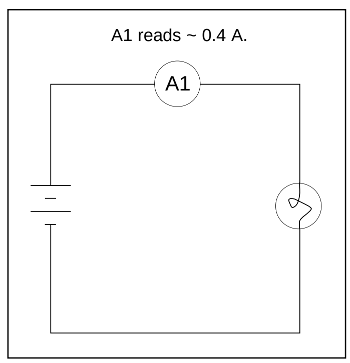

Figure 13: Current in a Simple Circuit

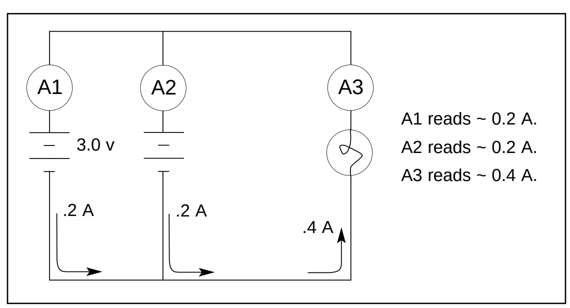

Figure 14: Current for Cells in Parallel

(continued)

SUGGESTIONS FOR ASSESSMENT

Journal Writing

Students compare and contrast

- the characteristics of voltage and current in series and parallel arrangements.
- resistance in series and resistance in parallel.

Written Quiz/Test

Students trace the path of the current in series and parallel circuits, and compare the brightness of bulbs in each case.

Teacher Background

It is a common belief that batteries are constant suppliers of current. Although each flashlight battery can deliver 0.2 A of current, the total current of three batteries in parallel is not necessarily 0.6 A. The amount of current in a circuit will also depend on the resistance of the circuit.

SUGGESTED LEARNING RESOURCES

Appendices

3.10 Blackline Master
DC Circuits and Schematic Diagrams

3.11 Student Learning Activity
Circuits Lab 2 — Measuring Current, Voltage, and Resistance

Other Resources

McDermott, L. and P. Schaffer. “Research as a Guide for Curriculum Development. Part I: An Example from Introductory Electricity.” *American Journal of Physics* 60 (11) (1992): 994–1003.

PRESCRIBED LEARNING OUTCOMES

Students will...

(continued)

S1-3-15 Compare and contrast voltage (electric potential difference) and current in series and parallel circuits.

Include: cells, resistance.

GLO: C3, D4

SUGGESTIONS FOR INSTRUCTION

(1 HOUR)

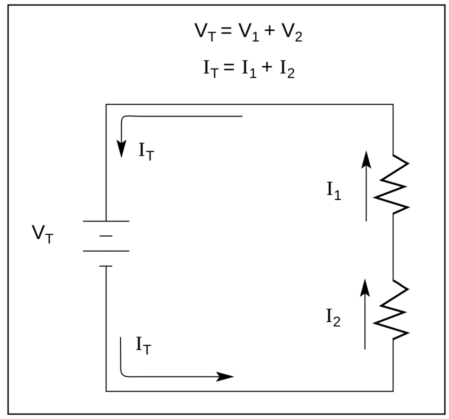

Figure 15: Resistance in Series

Resistance in parallel decreases the overall resistance of the circuit, since the electrons have an extra path to follow (it is like opening another door). Therefore, the current in the circuit increases. For example, a simple circuit with one bulb will have a current; two identical bulbs in parallel means the total resistance is halved and, therefore, the total current is doubled (less resistance, more current). However, this current must be shared by the two bulbs and the brightness of the bulbs remains the same. Resistances in parallel share current and have the same voltage. For resistances in parallel,

$V_T = V_1 = V_2$ and $I_T = I_1 + I_2$

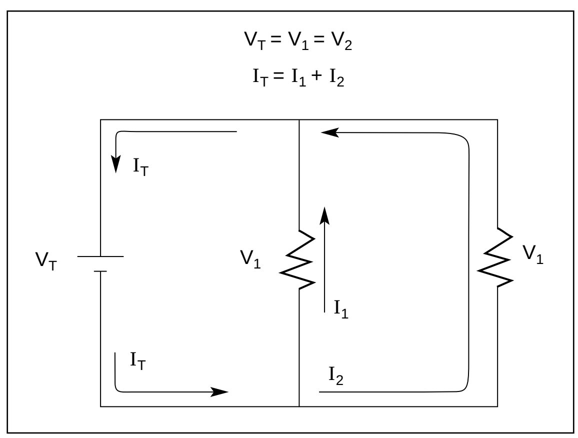

Figure 16: Current for Cells in Parallel

Resistance in series adds up to give the total resistance. Therefore, the current decreases and the brightness of bulbs in series will decrease compared to a single bulb. Resistances in series share the voltage and have the same current. For resistances in series we have, $V_T = V_1 + V_2$ and $I_T = I_1 = I_2$.

Suggestions for Assessment

Suggested Learning Resources

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-16 Investigate and describe qualitatively the relationship among current, voltage (electric potential difference), and resistance in a simple electric circuit.

GLO: C2, D4, E4

S1-3-17 Relate the energy dissipated in a circuit to the resistance, current, and brightness of bulbs.

GLO: D4

Skills and Attitudes Outcomes

S1-0-4e. Work cooperatively with group members to carry out a plan, and troubleshoot problems as they arise.
(ELA: S1: 3.1.3, 5.2.2) GLO: C2, C4, C7

S1-0-5b. Estimate and measure accurately using Système International (SI) and other standard units.
Include: SI conversions.
GLO: C2

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5
TFS: 1.3.1, 3.2.2

S1-0-6a. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

S1-0-7a. Interpret patterns and trends in data, and infer and explain relationships.
(ELA: S1: 3.3.1) GLO: C2, C5;
TFS: 1.3.1, 3.3.1

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION

(2 HOURS)

➢ **Notes for Instruction**

Help students relate the brightness of bulbs in a simple circuit to the current and resistance in the circuit. More current means more electrons bumping into things and giving up more energy, thereby causing the bulbs to burn brightly. More resistance means less current and, therefore, the bulbs burn less brightly. Demonstrate this by placing two identical bulbs in series. As a result, the brightness of the bulbs in a circuit is a qualitative measure of current. Use meters to verify quantitatively that current (I) is inversely proportional to resistance (R).

More voltage means more current when resistance is constant. Demonstrate this by comparing a simple circuit with one battery and bulb to a simple circuit with two batteries in series (more voltage) and the same bulb. The brightness of the bulb increases, indicating that the current has increased. Use meters to quantitatively measure the voltage and current. These results suggest that $I \propto 1/R$ and $V \propto I$. Combining them yields $I = V/R$ (Ohm's law). This approach should prepare students to investigate Ohm's law quantitatively.

➢ **Student Learning Activities S1-0-4e, 5b, 5c, 6a, 7a, 7e**

Laboratory Activity

Students investigate and describe qualitatively the relationship among current, voltage, and resistance in a simple electric circuit. (See Appendix 3.11)

SUGGESTIONS FOR ASSESSMENT

SUGGESTED LEARNING RESOURCES

Written Quiz/Test

Students

- rank the brightness of the bulbs in a circuit from least bright to brightest. For example:

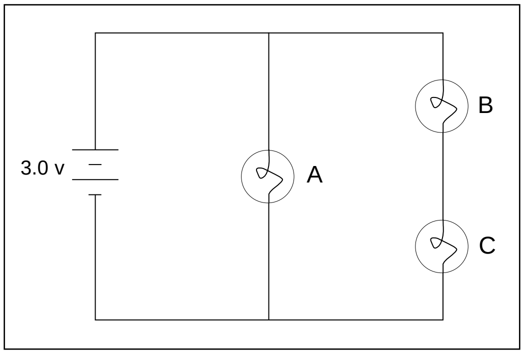

Figure 17: Bulb Brightness Ranking Exercise

(*Answer: The brightness of the bulbs is A > B = C*)

- explain changes in brightness of a bulb in a circuit when different characteristics of the circuit change. For example:

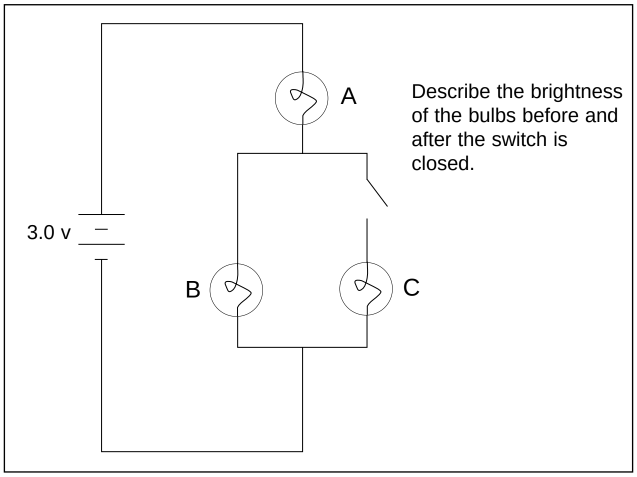

Figure 18: Circuit Changes and Effects on Brightness

Appendices

3.8 Teacher Support Material
Batteries and Bulbs

3.11 Student Learning Activity
Circuits Lab 2 — Measuring Current, Voltage, and Resistance

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-18 Explain the parallel circuits, the components, and the safety aspects of household wiring.

Include: switches, fuses, circuit breakers, outlets.

GLO: A5, B1, B2, C1

Skills and Attitudes Outcomes

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print, electronic, specialists, other resource people.
(ELA: S1: 3.1.4, 3.2.3; Math: S1-B-1, 2; TFS 2.2.1) GLO: C2, C4, C6; TFS: 2.2.2, 4.3.4

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.
(ELA: S1: 3.3.2) GLO: C2, C4, C6;
TFS: 2.2.2, 4.3.4

SUGGESTIONS FOR INSTRUCTION

(1 HOUR)

➢ **Notes for Instruction**

Help students recognize the components and parallel circuitry of household wiring.

Teacher Background

A household circuit is a circuit with many resistances in parallel. The source of electrical energy is the electricity supplied by the power company to the electrical panel in the house. The resistances are your lights and the electrical appliances, like the stove and refrigerator. Since electrical energy is converted to heat in a circuit, the wires in a circuit can burn and pose a safety hazard. Each time we add a resistance in parallel, the total resistance decreases and the total current increases. The resistances share this current and generally function properly. However, there is a portion of the circuit that must carry ALL the current. If too much resistance is added and the current exceeds the capacity of this wire, then the wire burns.

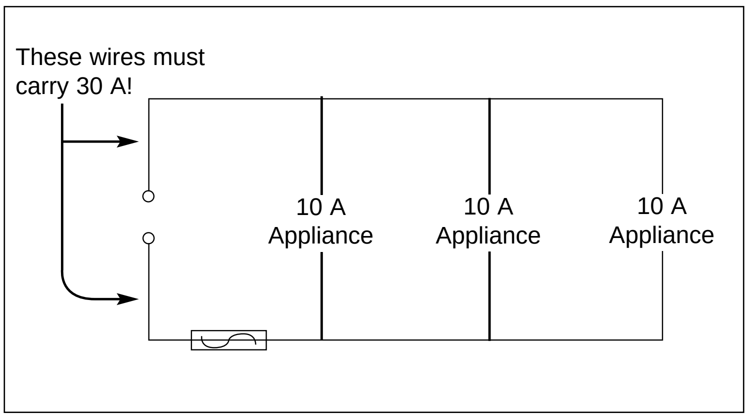

Figure 19: Fuse Placement in a Household Circuit

To protect the wires from burning, a fuse is added to this part of the circuit. A fuse is a small wire enclosed in a case. The wire in the fuse is chosen so that it will burn at a set current (like 1A). If the current exceeds the fuse's rating, the fuse "blows" and the circuit ceases to work.

Circuit breakers in homes protect the circuit and are located in the electric panel. Fuses must be replaced, but circuit breakers can be reset. If too many appliances are plugged into a household circuit, the breaker cuts off the power. The breaker cannot be reset until one or more of the appliances is unplugged.

➢ **Student Learning Activities**

Visual Displays

Students draw a household wiring diagram including all components (such as appliances, fuses, or breakers, etc.) and explaining parallel circuits.

SUGGESTIONS FOR ASSESSMENT

Research Report/Presentation S1-0-2a, 2c

Students research the safety features of ground fault circuit interrupter (GCFI) outlets.

Students compare and contrast fuses and circuit breakers.

Written Quiz/Test

Students draw a schematic diagram of a household electrical system.

SUGGESTED LEARNING RESOURCES

Science 9

BLM 12.2 Electrical Meter and Distribution Panel

Appendices

5.2 Rubric for the Assessment of Class Presentations

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-19 Explain safety considerations of some common household appliances.

Examples: kettle, heater, toaster...

GLO: A5, B1, C1, D4

S1-3-20 Define electrical power as energy per unit time, and solve related problems.

Include: $P = \frac{E}{t}$.

GLO: C2, C3, D4

Skills and Attitudes Outcomes

S1-0-3e. Determine criteria for the evaluation of an STSE decision.
Examples: scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; sustainability...
GLO: B5, C1, C3, C4

S1-0-3f. Formulate and develop options which could lead to an STSE decision.
GLO: C4

S1-0-5c. Record, organize, and display data using an appropriate format.
Include: labelled diagrams, graphs, multimedia
(ELA: S1: 4.1.1, 4.1.2) GLO: C2, C5
TFS: 1.3.1, 3.2.2

S1-0-5d. Evaluate, using pre-determined criteria, different STSE options leading to a possible decision.
Include: scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; sustainability.
(ELA: S1: 3.3.3) GLO: B5, C1, C3, C4;
TFS: 1.3.2, 3.2.3

S1-0-6a. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

S1-0-7e. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

SUGGESTIONS FOR INSTRUCTION
(2 HOURS)

➢ Entry-Level Knowledge

In previous learning outcomes, students determined that the total energy depends on the amount of charge ($E = qV$).

➢ Notes for Instruction

Help students see, through mathematical manipulation, that power is the rate at which energy is delivered to a circuit (i.e., $P = E/t$). (See Figure 20) The energy delivered to a circuit must be used in the circuit of the wires. Otherwise, the resistance in the circuit will not be able to dissipate the energy and the wires will burn.

$E = qV$	divide both sides by time
$\frac{E}{t} = \frac{q}{t} \cdot V$	since $P = E/t$ and $I = q/t$
$P = IV$	The power depends on the current and the voltage.

Figure 20: From Energy to Power

➢ Student Learning Activities S1-0-5c

Problem Solving

Students solve electrical power problems. (See Appendix 3.12)

Suggestions for Assessment

Visual Displays

Students design a poster display to describe how common household appliances work.

Journal Writing

Students compare and contrast

- the total power delivered in a series circuit to the power dissipated in each resistance.
- the total power delivered in a parallel circuit to the power dissipated in each resistance.
- the power dissipated in electric heaters connected in series and in parallel.

Teacher Background

Most small appliances, like kettles, heaters, and hair dryers, are just special forms of resistances which give off heat. They are built to work in a specific voltage and current range. They also wear out over time. Old, cracked, or frayed wires can cause an appliance to short circuit. In a short circuit, a wire may bypass the resistance of the circuit. The small resistance of the "short" causes an increase in the current. If the path cannot handle the increase in current, it will burn. If the path is your body, you will feel an electric shock. In household circuits, this shock can be lethal.

Suggested Learning Resources

Appendices

3.12 Student Learning Activity
Power Calculations

Prescribed Learning Outcomes

Students will...

S1-3-21 Develop a formula for domestic power consumption costs, and solve related problems.

Include:

$$\text{Cost} = \frac{\text{Power x time x unit price}}{\text{kWh}}.$$

GLO: B2, C2, C3, D4

S1-3-22 Analyze the electrical energy consumption of a household appliance.

Include: calculate consumption using Energuide labels, read hydro meter, interpret monthly hydro bill.

GLO: B5, C4, C5, C8

Skills and Attitudes Outcomes

S1-0-5a. Select and use appropriate methods and tools for collecting data or information.
GLO: C2; TFS: 1.3.1

S1-0-5b. Estimate and measure accurately using Système International (SI) and other standard units.
Include: SI conversions.
GLO: C2

S1-0-6a. Reflect on prior knowledge and experiences to develop new understanding.
(ELA: S1: 4.2.1) GLO: C2, C3, C4

S1-0-7a. Interpret patterns and trends in data, and infer and explain relationships.
(ELA: S1: 3.3.1) GLO: C2, C5;
TFS: 1.3.1, 3.3.1

Suggestions for Instruction

(3 hours)

➢ **Notes for Instruction**

Help students develop the calculation used by power companies to charge for energy consumption. Discuss household energy consumption and encourage students to become aware of how they can make wise decisions based on information from Energuide labels, hydro bills, etc.

➢ **Student Learning Activities**

Laboratory Activities S1-05a, 5b, 6a, 7a

Energy Awareness and the Energy Audit: Students classify the appliances in the home as low, medium, or high consumers of electricity.

Students perform an energy audit to determine the household energy requirements and habits of their families. Students tally household energy consumption by reading the electric meter at the same time every day. They keep a log of the family's use of appliances, and track other factors, like the weather, which may influence consumption. Students then analyze the audit to address the ways of conserving energy in the home, school, or workplace. (See Appendix 3.12)

Teacher Background

Homeowners pay a power company for energy. The cost of energy is calculated as follows: Cost = Power x time x unit cost/kWh. Since the power company measures energy in kilowatt hours (kWh), the units of power must be kilowatts and the units of time must be hours.

The Energy Efficiency Act and Regulations outline the standards for energy-using products, like major appliances, that we use in our homes. Each major appliance must be sold with an Energuide label that displays the estimated annual energy consumption of the household appliance in kilowatt hours and identifies the most and least energy-efficient models in the same category. This allows the consumer to compare efficiencies of different manufacturers before making a purchase.

Suggestions for Assessment

Journal Writing

Students compare the unit energy costs throughout Canada and the world. They also answer the question: "How does geography and the mode of production (hydro, coal, nuclear) relate to the unit cost?"

Research Report/Presentation

Students compare the cost of operating a portable appliance (like a CD player) with batteries or with hydroelectric power.

Home Assignment

Using a hydro bill, students calculate the cost of using an appliance for 24 hours.

Research Report/Presentation

Students research and report on the different types of bulbs (i.e., incandescent, fluorescent, halogen, compact fluorescent) and compare them for initial cost of purchase versus cost of operating. Reports can be presented as

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- multimedia presentations
- storytelling or dramatic presentations

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

Written Quiz/Test

Students read and record meter readings from diagrams and calculate the cost of energy from the information on a hydro bill.

Home Assignment

Students perform an energy audit.

Suggested Learning Resources

Science 9

BLM 12.5a	Sample Electricity Bill
BLM 12.6a	Energy Usage Table
BLM 12.6b	How to Read Your Meter

Sciencepower 9

BLM 11-14	Reading Meters
BLM 11-15	Practice Meters
BLM 11-16	The Price of Energy
BLM 11-18	Conserving Electricity

Appendices

3.12 Student Learning Activity Power Calculations

5.2 Rubric for the Assessment of Class Presentations

5.3 Rubric for the Assessment of a Research Project

PRESCRIBED LEARNING OUTCOMES

Students will...

S1-3-23 Recognize and explain the importance of incorporating principles of electrical energy conservation into the decision-making process.

GLO: B2, B5, C4, C8

S1-3-24 Use the decision-making process to address an issue associated with the generation and transmission of electricity in Manitoba.

Include: hydroelectric power, sustainability.

GLO: B2, B5, C4, C8

Skills and Attitudes Outcomes

S1-0-1c. Identify STSE issues which could be addressed. GLO: C4

S1-0-1d. Identify stakeholders and initiate research related to an STSE issue.

S1-0-2a. Select and integrate information obtained from a variety of sources.
Include: print and electronic sources, specialists, and other resource people.

S1-0-2b. Evaluate the reliability, bias, and usefulness of information.

S1-0-2c. Summarize and record information in a variety of forms.
Include: paraphrasing, quoting relevant facts and opinions, proper referencing of sources.

S1-0-2d. Review effects of past decisions and various perspectives related to an STSE issue.
Examples: government's, public, environmentalists', and First Nations' positions on hydroelectric development; religious, social, and medical views on genetic screening...

S1-0-3e. Determine criteria for the evaluation of an STSE decision.
Examples: scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; sustainability...

S1-0-3f. Formulate and develop options which could lead to an STSE decision.

S1-0-4d. Use various methods for anticipating the impacts of different options.
Examples: test run, partial implementation, simulation, debate...

S1-0-4f. Assume the responsibilities of various roles within a group and evaluate which roles are most appropriate for given tasks.

S1-0-5d. Evaluate, using pre-determined criteria, different STSE options leading to a possible decision.
Include: scientific merit; technological feasibility; social, cultural, economic, and political factors; safety; cost; sustainability.

SUGGESTIONS FOR INSTRUCTION
(3 HOURS)

➢ **Notes for Instruction**

Help students recognize and explain the importance of electrical energy conservation and its influence on our decisions.

➢ **Student Learning Activities S1-0-1c, 1d, 2a, 2b, 2c, 2d, 3c, 3f, 4d, 4f, 5d**

Role Playing Activity (Town Hall Meeting): Student groups role play a town hall meeting to decide if an electric generating station should be built in their community. Groups could include

- the mayor and councillors who preside over the meeting and vote on the motion
- concerned residents
- environmentalists
- engineers
- business representatives

Each stakeholder group presents its case, and the floor is open for questions and debate. The meeting concludes when the mayor and councillors reach a decision.

Student Research/Reports S1-0-2a, 2b, 2c, 2d

Students

- review the public affairs information available from Manitoba Hydro and report on the location of the electric generating stations and transmission wires in Manitoba.
- investigate and report on the public's knowledge and concerns with electric and magnetic fields.
- interview (or email) a resident of northern Manitoba to discuss sustainability issues from his or her perspective.
- research and report on the sustainability issues for nuclear and fossil fuel production of electricity.

Suggestions for Assessment

Research Reports

Students or student groups research and report on early electrostatic devices. Reports can be presented as

- written reports
- oral presentations
- posters
- pamphlets
- information technology presentations
- multimedia presentations
- storytelling or dramatic presentations

Textbooks, library reference materials, Internet sites, and other print and electronic media can be used for research and presentations.

Teacher Background

Electrical energy is an essential component of our everyday lives. Worldwide consumption of electrical energy is increasing, but the resources we use to generate this energy are not always sustainable. The term sustainability is used to mean that the social, economic, and environmental concerns must be considered for present and future use of electrical energy. Hydro generating stations (usually in the North) produce 99% of the electrical energy in Manitoba. Social, economic, and environmental issues include land claims, flooding, and alternative sources of energy.

Suggested Learning Resources

Science 9

BLM 11.5 Sources of Electricity

BLM 12.5b Making Energy Conservation Choices

Appendices

5.2 Rubric for the Assessment of Class Presentations

5.3 Rubric for the Assessment of a Research Project

5.4 Rubric for the Assessment of a Decision-Making Process Activity

NOTES