Topic 4.6
What features make an electrical circuit practical and safe?

Specific Expectations

- **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
- **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

Skills

- use appropriate modes of representation and units of measurement
- express the results of calculations accurately and precisely

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see page TR-51 for a summary of the materials required in this topic.

Overview

In this topic, students will learn how different safety devices, such as circuit breakers, fuses, and special outlets, work to provide electrical safety in the home.

Common Misconceptions

- **Many students think that when a device is turned off, electricity is not being used.** Unfortunately, this assumption is not true. For many appliances, some part of the appliance or device continues to consume energy when it is turned off. For example, the clock on the DVD player or the remote signal on the TV continues to operate in stand-by mode. This phenomenon, in which energy is still being used when the device is turned off, is called *phantom load*. The only way to completely turn off a device with phantom load is to unplug it.

Background Knowledge

Electrical safety in the home is an integral part of the practical application of electricity and electrical circuits. Safety features (circuit breakers, fuses, and so on) are installed in homes to prevent electrical hazards such as electrical fires (caused by overheating in the wires) or dangerous electric shocks. The chart summarizes some common safety features:

Safety device	How it works
circuit breaker	A strip made of two metals bends when it gets too hot and causes a switch to open which causes the current to stop flowing.
fuse	A small wire burns and breaks apart when the current gets too high, creating a gap in the circuit.
high voltage circuits (240 V outlet)	By doubling the potential energy to 240 V, a circuit can provide the same amount of energy while using half as much current.
larger cords or cables	Their size allows them to carry more current without becoming too hot
grounded wire	The grounded wire directs any excess current to the ground.
three-hole outlet	The third hole in a three-hole outlet grounds the third prong on the plug which is connected to the metal parts of an electrical device.
ground fault interrupter	The GFI immediately opens the circuit when it detects a difference between the current entering one hole and leaving the other.

Literacy Strategies

Before Reading

- Invite students to share any electrical safety tips that they are already familiar with. Discuss why these might be effective and important safety measures.
- Draw students' attention to the headings in this topic. Have them preview the headings and predict what they will learn.

During Reading

- Have students create a table similar to the one in Background Knowledge above, and use it to list each safety feature they read about and take notes about how it works as they read. Encourage students to use diagrams to record if they find them helpful.

After Reading

- Have students draw a Venn diagram to compare circuit breakers and fuses.

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Learning Check questions, page 309 Topic 4.6 Review question 2, page 313	Students explain in words or pictures how circuit breakers and fuses prevent fires.	• Students can use **BLM G-38 Venn Diagram** to answer Learning Check question 2 and **BLM G-34 Flowchart** to answer Learning Check question 3. • Bodily-Kinesthetic learners may benefit from acting out the situation in question 3. • Consider allowing English language learners to provide some responses orally.
Learning Check questions, page 311 Topic 4.6 Review question 5, page 313	Students describe several features that make an electrical ciruit safe.	• Students can use **BLM G-37 T-chart** to answer question 2. • Allow students to use labelled diagrams to answer if they wish.

Topic 4.6 (Student textbook pages 304–313)

Using the Topic Opener (Student textbook pages 304–305)

- Review previous learning about the difference between a series circuit and a parallel circuit.
- Assign the Starting Point Activity. The photo in the opener spread shows a family enjoying an evening watching television and using the computer.
- Have students suggest answers to the Topic Question: What features make an electrical circuit practical and safe? Use the discussion to gauge students' prior knowledge of the topic.

Starting Point Activity (Student textbook page 305)

Pedagogical Purpose

Students apply prior knowledge and use an inquiry process to examine common household circuits.

Planning	
Time	5–10 min in class

Skills Focus

- analyze and interpret qualitative data
- draw conclusions based on evidence

Background Knowledge

The scene on pages 304 and 305 depicts common household appliances connected in series, rather than parallel. As one might expect, this type of wiring does not commonly happen for several reasons. First, if one appliance in the series is turned off, then none of the other appliances can be used. Second, each appliance added to the circuit would cause a reduction in current and cause each appliance to function at suboptimal currents. The operation of one appliance would affect the operation of the others in the circuit.

Activity Notes and Troubleshooting

- Students should analyze this scene in pairs or small groups and compare the scene with a room in their own home.
- Encourage students to make connections between common everyday experiences and what they have learned so far in their investigations of series and parallel circuits.

Additional Support

- ELL Students new to Canada may not be aware of household wiring. If that is the case, spend some time making connections with their experience.
- ELL Have each group begin by reading the activity aloud and ensuring that all group members understand the question.
- DI Ask students to compare this scene with a room in their home and make connections based on personal experience.

Answers

1. series circuit
2. The circuit is not practical because any appliances wired in this way would not work as designed.

Instructional Strategies for Topic 4.6

- Bring in some safety devices to show the students (for example, a fuse, heavy duty electrical cords, surge protectors, and so on.) Use them to introduce vocabulary.
- ELL Have English language learners look at the figures 4.32 and 4.33 and link these devices to each picture. Relate them to the diagram, to ensure they understand what a circuit breaker does. Use the diagram to explain the process described in the text and then have them read the text.
- As students read pages 308 to 311, have them complete a T-chart that lists different safety features in the first column, and describes how they help to make home circuits safe in the second column.
- Enrichment—Assign students a mini-project to create safety posters to make people aware of common electrical hazards in the home, and suggest safety tips to help avoid them.
- Assign Activity 4.13. Have students make connections to the picture from their own experience. Ask them where they have seen high-voltage wire and transformers like these in their community. As students read on, repeat key vocabulary and/or print the words on the chalkboard, and explain what each word means (for example, *conductor*, *transmission*, and so on). Consider pairing students who require support with mathematical tasks with someone who can help them.

Learning Check Answers (Student textbook page 307)

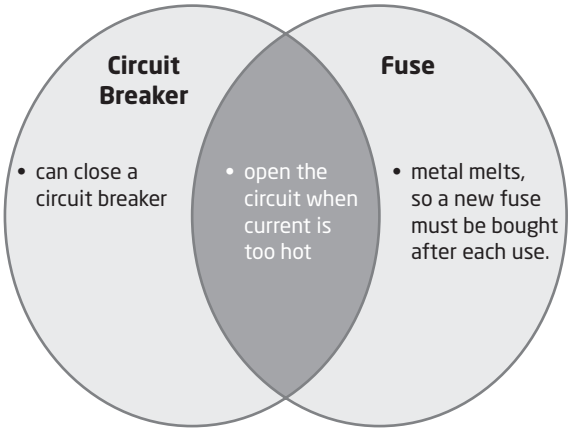
1. A switch can open or close a circuit. If the switch is open, then current cannot travel through and there will be no power supplied to the appliances.
2. Parallel circuits are useful because we can choose which appliances we want on and off and each appliance will get the maximum possible voltage. However, adding many branches would mean a greater current was needed which would make the wires extremely hot and cause a fire.
3. A circuit panel is the place in a building where large electrical cables connect the building to the electrical energy flowing from the power company. From the circuit panel, many smaller parallel circuits are wired throughout the building.

4. A building has many electrical outlets to ensure that one parallel circuit is not overloaded. By adding many electrical outlets, the current is spread amongst many different parallel circuits. If the current was focused on one parallel circuit, the current would become too high and it would cause a fire.

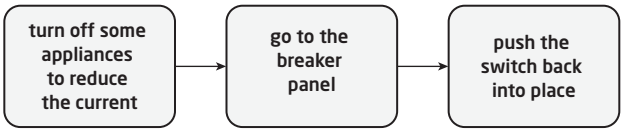
Learning Check Answers (Student textbook page 309)

1. Every device connected to an electrical outlet is connected in parallel. By adding more electrical devices, we are creating more branches in the parallel circuit. This will increase the current and the wires will become very hot, potentially starting a fire.

2.



3.



Activity 4.12 Make and Break the Circuit (Student textbook page 309)

Pedagogical Purpose

Students will investigate the role of circuit breakers by calculating loads that would cause a circuit breaker to open.

Planning	
Time	15–20 min in class

Skills Focus

- analyze and interpret quantitative data
- draw conclusions based on data

Background Knowledge

A fuse or circuit breaker limits the amount of current in a circuit for safe operation. Students are probably unaware of the amount of current appliances use. This activity gives them a chance to see approximate values for the current used or "drawn" by certain appliances. Many circuits in households, especially those for large uses of current, e.g., clothes dryers, ovens, have circuit breakers or fuses with capacities of 20–30 A.

Activity Notes and Troubleshooting

- Students should analyze these values in pairs or small groups and look for similarities and differences, and look for combinations used within their own home.
- Encourage students to make connections between common everyday experiences and what they have learned so far in their investigations circuits.
- Ask students why the dishwasher does not cause the circuit breaker to open on its own (Dishwashers use their own, larger, circuit breaker.) and why the iron and the toaster oven can be used at the same time in most homes. (They are on separate circuits.)

Additional Support

- ELL Students new to Canada may not be familiar with some of these appliances or their names. Bring pictures to class and talk about the use of each appliance.
- ELL Read the activity aloud before students begin.
- Consider calculating one combination together as a model for students.
- DI Ask students to consider their own use of electricity and make conections based on personal experience.

Answers

Any combination that adds to 15 A or more will cause the circuit breaker to open.

Learning Check Answers (Student textbook page 311)

1. A 240 V outlet has a different shape than a 120 V outlet to prevent people from plugging appliances into the wrong outlet.
2.

Method	Where It Is Used
• Larger cables allow more current to travel without becoming too hot.	• Electrical wiring inside the home
• If a wire is grounded, excess current in the ground prevent a dangerous shock from accidental contact.	• One of the two wires in a parallel circuit • The third hole of an outlet
• Ground Fault Interrupters will open the circuit if the current leaving and entering the circuit are different.	• Outlets in bathrooms or near water faucets

3. In bathrooms, water can find is way onto many appliances and onto ourselves. This will cause our bodies to become conductors in the circuit, which could lead to a dangerous amount of current going through our bodies.

Activity 4.13 Delivering Electrical Energy to Your Home

(Student textbook page 98)

Pedagogical Purpose

Students will calculate the current, potential difference, and power lost as electrical energy is delivered to homes and consider the implications of this loss for power delivery.

Planning	
Materials	scientific calculator (one per group of 2 or 3 students) **BLM G-24 Using Scientific Notation** (optional)
Time	10–20 min in class

Skills Focus

- analyze and interpret quantitative data
- draw conclusions based on data
- communicate using appropriate units

Background Knowledge

Electric grids require transmission of power over long distances. Alternating current is normally preferred as its voltage may be easily stepped up by a transformer to minimize resistive loss in the conductors used to transmit power over great distances; another set of transformers is required to step it back down to safer or more usable voltage levels

at destination. The least amount of electrical energy is lost when transmission is at very high voltages. However, this also means that money and resources must be invested in transformers to step up the voltage at the source and step down the voltage at the destination.

Transmitting electricity at high voltage reduces the fraction of energy lost to heat. For a given amount of power, a higher voltage reduces the current and thus the resistive losses in the conductor. For example, raising the voltage by a factor of 10 reduces the current by a corresponding factor of 10 and therefore the I^2R losses by a factor of 100. Long distance transmission is typically done with overhead lines at voltages of 115 to 1200 kV.

Many students will have difficulty manipulating the numbers and units in this activity. The use of exponents and scientific notation is troublesome. Be prepared to review and teach use of exponents and scientific notation as part of this activity.

Activity Notes and Troubleshooting

- You may wish to conduct this as a whole-class activity with volunteers from the class working at the front completing each step in the calculations. Encourage other students to offer suggestions and help as required.
- The key point to get across is that high voltage is necessary to reduce line loss.
- A second important point to get across is that high voltage transmission lines and transformers are potentially dangerous and should be avoided.

Additional Support

- ELL This activity is reading intensive. Use newspaper clippings to capture interest and to share the big idea with English language learners: high voltages are necessary but dangerous. Go to the end of the passage and explain that they will read in order to explain why high voltages are used when transmitting over long distances. Give them a reading outline that summarizes the ideas discussed in each paragraph: the substation, transmission of power, minimizing lose of power calculating the loss of power using a formula. As you discuss these big ideas, use and write key vocabulary. Match English language learners with students who have strong communication skills. Have them read together and discuss what supports each idea in the outline. Do step 1 with the English language learners, to ensure they understand terms like formula and know the concepts represented by the formula.
- If you do have students work on this on their own or in groups, review Numeracy Skills Toolkit 1: Scientific Notation on page 366 of the student textbook, and **BLM G-24 Using Scientific Notation** with students.
- Ask students to consider their own use of electricity and make connections based on personal experience.

Answers

1. 2.0 A

2. 400 W

3. 0.04%

4. 50 A

5. 250 000 W

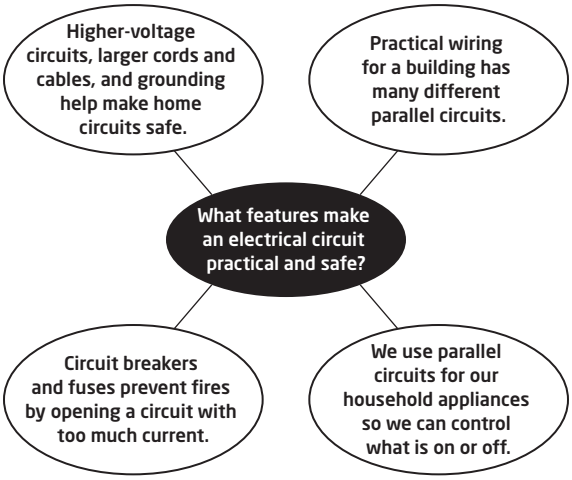
6. 25%

Topic 4.6 Review (Student textbook page 313)

Please see also **BLM 4-28 Topic 4.6 Review Answers (Alternative Format)**.

Answers

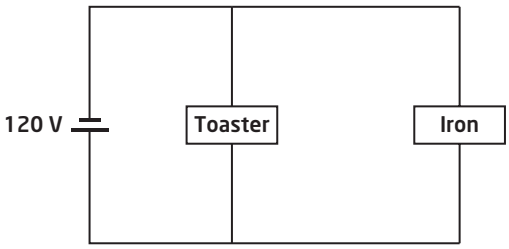
1. Answers may vary. For example:



2. a) When too much current flows through the circuit, it will heat the metals in the circuit breaker. The metal will bend and open the circuit before the temperature reaches a level in which the wires would cause a fire.

b) When too much current flows through the circuit, it will heat the metals in a fuse. The metal will melt and open the circuit before the temperature reaches a level in which the wires would cause a fire.

3. a)



b) $I_{total} = I_{toaster} + I_{iron}$

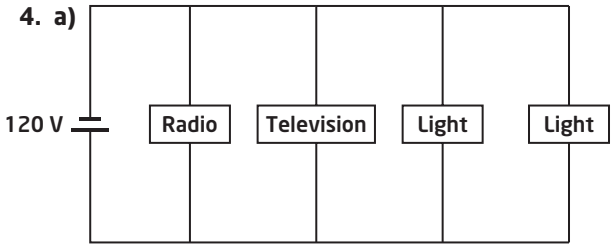
$I_{total} = 10 + 10$

$I_{total} = 20$

The total current in the circuit is 20 A.

c) Since the total current is 20 A, this will exceed the circuit breaker's limit and the circuit will be opened.

4. a)



b) $I_{total} = I_{radior} + I_{television} + I_{light} + I_{light}$

$I_{total} = 2 + 1 + 1 + 1$

$I_{total} = 5$

The total current in the circuit is 5 A.

c) Since the total current is less than 15 A, the circuit breaker will not react and the circuit will be closed.

5. The ground wire plug is a crucial safety feature to prevent a dangerous shock if the wire was accidentally touched. By removing this, instead of excess current going into the ground, it will go through her if an accident occurred.