Topic 4.5
What are series and parallel circuits and how are they different?

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*
- **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)
- **E2.5** compare, on the basis of observation, the differences between series and parallel circuits
- **E3.5** explain the characteristics of electric current, potential difference, and resistance, in simple series and parallel circuits

Skills

- conduct inquiries to collect observations and data
- organize and record data using appropriate formats
- justify conclusions based on inquiry results and research findings, and justify their conclusions
- use appropriate numeric, symbolic, and graphic modes of representation, and appropriate units of measurement

Materials

Please see the teaching notes for each activity for a list of the materials required. Please see page TR-50 for a summary of the materials required in this topic.

Overview

In this topic, students will compare and contrast series and parallel circuits. They will carry out investigations to explore the characteristics of current and potential difference in an electric circuit.

Common Misconceptions

- **Some students may believe that when one component in a series circuit stops working the loads that come before it will work and those after it will not.** You can demonstrate that this belief is not true by constructing a simple circuit of four light bulbs connected to a battery in series. Unscrew the third bulb and students will see that all bulbs will go out.
- **Students may believe that when loads are connected in parallel, the total voltage from the source is divided among the loads (just as the total current is divided).** Use a circuit diagram to emphasize that individual electrons take only one pathway to return to the source. Since each electron begins with the same amount of energy (equivalent to the total battery potential), each will lose the same amount travelling across the load, regardless of the pathway taken. Or use the skier analogy that appears in the Starting Point activity to explain. Whether the skiers all go down one ski hill or five ski hills, the drop (potential difference) is the same.

Background Knowledge

In a series circuit, where there is only one path for electron flow, and the components are all connected end to end, the current remains the same throughout the circuit, no matter where it is measured. As more and more loads are connected in the series circuit, the current leaving the source decreases, and the potential difference across each load also decreases. The sum of the potential differences across the loads is equivalent to the voltage across the source.

In a parallel circuit, where there is more than one path on which electrons can flow and the components are connected parallel to each other, the potential difference remains the same across the loads. As more loads are connected in the parallel circuit, the current leaving the source increases. The sum of the current through the loads is equivalent to the current leaving the source.

Literacy Strategies

Before Reading

- Have students compare the electric circuits shown in Figure 4.26 and Figure 4.27. They each have a battery and three loads. Ask students what is different about their connection. Define the key terms *series* and *parallel circuits*. Help students draw connections between these meanings of series and parallel and other ways the words are used.
- Have students predict the relationships for current and potential difference as more loads are connected in series and in parallel. After reading the student textbook, ask students to compare or verify their predictions with what they learned.

During Reading

- Help students analyze the text, examine the diagrams, and summarize the key ideas. Have them summarize by reducing the passage under each heading to 20 words or less that capture the gist of the text, and include diagrams where appropriate. Encourage English language learners to make point-form notes and label diagrams to summarize each section. Students can use **BLM G-30 Summarizing** to help them create their summaries.
- Students could create these summaries as write-arounds. Students in groups of four each draft a summary of one of the sections. Group members then exchange summaries and add or revise to each one as needed. In the end, the group has four complete summaries they can share with the class.

After Reading

- Have students return to the graphic organizer that they completed in the Starting Point Activity. Ask them to add the differences they just learned onto the organizer.

Assessment FOR Learning		
Tool	**Evidence of Student Understanding**	**Supporting Learners**
Learning Check question 1, page 295 Investigation 4G, pages 298-299 Investigation 4H , pages 300-301	Students use words or diagrams to compare and contrast current in a series circuit and current in a parallel circuit.	• Return to the skier analogy, or another suitable analogy, to help students understand how current would be different in each type of circuit. • Refer students to Table 4.1 on page 281 to review symbols used to draw circuit diagrams. • Allow English language learners to respond to What Did You Find Out? questions orally; ask questions as needed.
Learning Check questions, page 297 Investigation 4G, pages 298-299 Investigation 4H , pages 300-301	Students use words, diagrams, and numerical relationships to compare and contrast potential difference in a series circuit and in a parallel circuit.	• Return to the skier analogy, or another suitable analogy, to help students understand how potential difference would be similar in each type of circuit. • Consider setting up the circuits in the Learning Check questions if students are having trouble visualizing them from the illustrations. • Allow English language learners to respond to What Did You Find Out? questions orally. Prompts may be needed.

Topic 4.5 (Student textbook pages 292–303)

Using the Topic Opener (Student textbook pages 292–293)

- Begin with the Starting Point Activity. Have students compare the two pictures in the opener spread to complete the graphic organizer.
- Ask students to examine Picture A more closely. If this picture were to model an electric circuit, have students describe what parts would represent the source, charge, connecting wire, and so on.

Starting Point Activity (Student textbook page 293)

Pedagogical Purpose

Students will examine components of an analogy of simple series and parallel circuits to look for similarities and differences.

Planning	
Time	15–20 min in class

Skills Focus

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

Background Knowledge

Picture A shows an analogy of a series circuit. All of the skiers follow the same path to go down the hill and up the hill. Each skier retains position with respect to each other skier. If one skier falls, for example, it would hold up all of the skiers at the ski hill.

Picture B shows an analogy of a parallel circuit. There are multiple pathways for skiers to travel downhill, but only one path to go uphill. Each downhill path carries the same number of skiers. If a skier falls on one of the hills, it only holds up the skiers on that hill and not the others. Compared to Picture A, there are more skiers in Picture B.

Activity Notes and Troubleshooting

- Encourage students to count the number of skiers on each hill in each picture during the comparison.
- Ask what if questions, such as, "What would happen if a skier fell in picture A? How would this differ in Picture B?"

Additional Support

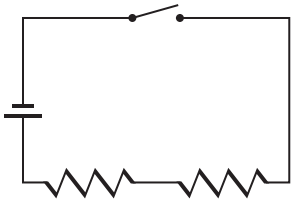
- ELL If there are several English language learners with the same first language in the class, consider grouping them together for this activity and allowing them to discuss in their first language. They can share their ideas in English during class discussions.
- Use multiple entry points and engage student interest with questions such as where would you rather ski? Why?
- DI Students could act this out by traveling circuits in your school, descending one staircase or several.

Instructional Strategies for Topic 4.5

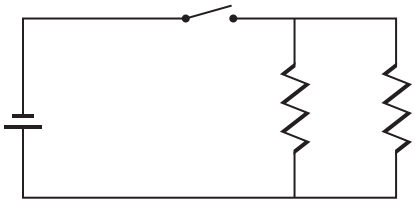
- Review the definitions or features of a series circuit and a parallel circuit. If you wish, refer to the analogy of the skiers in the Starting Point Activity to explain the difference between the two.
- Have students conduct Investigation 4G and Investigation 4H before continuing with the text. Doing so will give them the opportunity to analyze the data and use the questions to guide them to develop some of the relationships, without being given the "answers" first.
- When assigning the Investigations for this Topic, always partner English language learners with strong readers. Have the partners read the steps aloud and clarify vocabulary with the English language learners as they are working through the Inquiry. Expect active participation from English language learners in the procedural parts of the Inquiry, as this section is less linguistically demanding.
- Discuss their results from the Investigations and have students follow up by reading pages 294 to 297. Have students summarize the characteristics of series and parallel circuits in a graphic organizer of their choice.

Learning Check Answers (Student textbook page 295)

1. a)



b)



2. If one bulb burned out, the circuit would become open and the other lights would go out.

Learning Check Answers (Student textbook page 297)

1. 8 V

2. 2 A

3. 12 V

4. 9 A

Investigation 4G Observing Characteristics of Series Circuits

(Student textbook pages 298–299)

Pedagogical Purpose

Students will use an inquiry process to investigate the effects that changing resistance and changing potential difference will have on current in a simple series circuit.

Planning	
Materials	For each pair or group of students: - 1 power supply - 1 switch - 1 ammeter - 3 flashlight bulbs with bases - 3 voltmeters (or use one and move it for each measurement) - 12 wire leads with alligator clips **BLM 4-23 Observing Characteristics of Series Circuits** (optional) **BLM 4-24 Investigation 4G** (optional)
Time	40–50 min in class 10–15 min preparation
Safety	Insist that students follow these rules: • Disconnect any wire that gets too hot. • When using a power supply, always follow your teacher's instructions. • Always unplug or turn off a power supply before working on a circuit.

Skills Focus

- selecting appropriate instruments and materials
- conducting inquiry using instruments and materials safely, accurately, and effectively to collect data
- draw conclusions based on inquiry results
- use appropriate numeric and symbolic modes of representation

Background Knowledge

In a series circuit, the current through each of the components is the same, and the voltage across the components is the sum of the voltages across all the components. In a parallel circuit, the voltage across each of the components is the same, and the total current is the sum of the currents through all the components.

If a wire joins a 6.0 V power supply to one bulb, to the next bulb, and to the next bulb, then back to the power supply, in one continuous loop, the bulbs are said to be in series. If each bulb is wired to the battery in a separate loop, the bulbs are said to be in parallel.

If the three light bulbs are connected in series, the same current flows through all of them, and the voltage drop is 2.0 V across each bulb. If the light bulbs are connected in parallel, the current flowing through the light bulbs combine to form the current flowing in the power supply, while the voltage drop is 6.0 V across each bulb and the bulbs are about three times brighter.

In a series circuit, every device must function for the circuit to be complete. One bulb burning out in a series circuit breaks the circuit. In parallel circuits, each light has its own circuit, so all but one light could be burned out, and the last one will still function.

Activity Notes and Troubleshooting

- Have students work in groups of four. Assign each student a role so everyone feels accountable. Each student could perform a test for current, potential difference and brightness of bulbs for each circuit.
- Encourage students to proceed with caution when connecting instruments to the circuit.
- Insist that students use the power supply at only 6.0 V; accept no alternatives.
- The circuit diagram on page 299 of the student text is an excellent depiction of how to connect the elements of the circuit, voltmeters, and ammeter.
- DI The key expectation in this activity is for students to recognize that at a given potential difference, current decreases with each additional bulb connected.

Additional Support

- ELL Pre-teach vocabulary: ammeter, voltmeter, load, potential difference, power supply, alligator clips; ask students for other vocabulary that requires discussion.
- ELL Match English language learners with students who have strong communication skills.
- Students can use **BLM 4-23 Observing Characteristics of Series Circuits** to record their observations.
- Use multiple entry points and engage student interest with questions such as, "Were the light bulbs equally bright in each circuit?"
- DI Bodily-kinesthetic, spatial, and logical-mathematical learning is involved in this investigation. As much as possible, ensure that groups include students with strengths in these areas.

Answers

1. Adding more loads made the current reading go down.

2. a) Each additional bulb decreased the brightness of all the bulbs.

b) The brightness of the bulb is dependent on the current. As current increases, the bulbs will get brighter. As the current decreases, the bulbs will get dimmer.

3. Increasing the number of loads will decrease the potential difference across each individual load.

4. When the bulb was removed, all of the other bulbs went out.

5. As the number of loads increases in a series circuit, the current going through each load is reduced to the point where use of the circuit becomes impractical.

Investigation 4H Observing Characteristics of Parallel Circuits

(Student textbook pages 300–301)

Pedagogical Purpose

Students will use an inquiry process to investigate the effects that changing resistance and changing potential difference will have on current in a simple parallel circuit.

Planning	
Materials	For each pair or group of students: - 1 power supply - 1 switch - 1 ammeter - 3 flashlight bulbs with bases - 3 voltmeters (If there are not enough, use one and move it for each measurement.) - 13 leads with alligator clips **BLM 4-25 Observing Characteristics of Parallel Circuits** (optional) **BLM 4-26 Investigation 4H** (optional)
Time	40–50 min in class 10–15 min preparation
Safety	Insist that students follow these rules: • Disconnect any wire that gets too hot. • When using a power supply, always follow your teacher's instructions. • Always unplug or turn off a power supply before working on a circuit.

Skills Focus

- selecting appropriate instruments and materials
- conducting inquiry using instruments and materials safely, accurately, and effectively to collect data
- draw conclusions based on inquiry results
- use appropriate numeric and symbolic modes of representation

Background Knowledge

In a series circuit, the current through each of the components is the same, and the voltage across the components is the sum of the voltages across all the components. In a parallel circuit, the voltage across each of the components is the same, and the total current is the sum of the currents through all the components.

If the light bulbs are connected in parallel, the current flowing through the light bulbs combine to form the current flowing in the power supply, while the voltage drop is 6.0 V across each bulb. In parallel circuits, each light has its own circuit, so all but one light could be burned out, and the last one will still function.

Activity Notes and Troubleshooting

- Have students work in groups of four. Assign each student a role so everyone feels accountable. Each student could perform a test for current, potential difference and brightness of bulbs for each circuit.
- Encourage students to connect instruments to the circuit with caution.
- Insist that students use the power supply at only 6.0 V; accept no alternatives.
- The circuit diagram on page 300 of the student text is an excellent depiction of how to connect elements of the circuit, voltmeters, and ammeter.
- The key expectation is for students to recognize that at a given potential difference, current increases for each additional bulb connected in parallel.

Additional Support

- ELL Pre-teach vocabulary: ammeter, voltmeter, load, potential difference, power supply, alligator clips
- ELL Match English language learners with students who have strong communication skills.
- Students can use **BLM 4-25 Observing Characteristics of Parallel Circuits** to record their results.
- DI Bodily-kinesthetic, spatial, and logical-mathematical learning are involved in this investigation. As much as possible, ensure that each group includes learners with strengths in these areas.
- Use multiple entry points and engage student interest with questions such as were the light bulbs equally bright in each circuit? Was the current always the same?

Answers

1. The current increases for each additional parallel circuit added.
2. The current passing through the power supply is the sum of the individual currents in each parallel circuit. Each additional parallel circuit adds its current to the total current passing through the power supply.
3. The brightness of the bulbs remains the same with the addition of each parallel circuit.
4. The potential difference across each bulb remains the same as each new bulb is added to the overall circuit.
5. The removal of one bulb did not affect the brightness of the other bulbs.
6. As each load is added in a parallel circuit, the amount of current increases, to the point where the current will be too great for safety.

Using Strange Tales (Student textbook page 302)

Literacy Support

Before Reading

- Have students look up definitions for the words in quotation marks: "spark" and "shocked". English language learners may be unfamiliar with the colloquial use of these words in the passage.

During Reading

- Ask students to write down facts about Nikola Tesla. (He lived from 1856–1943. He made over 500 inventions, mostly involving electricity; Thomas Edison was his main rival.)

After Reading

- Have students review what they have read and decide on three key words or phrases that they will use to conduct Internet or library research to answer the questions at the end of the feature. (for example, weird facts about Nikola Tesla; Tesla's electrical inventions; Tesla coils)

Instructional Strategies

- Have students examine the photo and describe what they see. Does the "large metal ball" remind them of something? (for example, the Van de Graaff generator at the Ontario Science Centre)
- Book the computer laboratory for students to conduct research on Nikola Tesla. Consider pairing English language learners with students who will be able to help them navigate Internet websites in English. Alternatively, allow English language learners to conduct research in their first language, then answer the questions in English.

Answers

1. The sparks from Tesla coils have a high frequency and low current. This means that even if one is shocked, it will be generally harmless.

2. Answers may vary. For example:

- Tesla was fascinated with pigeons, letting them stay in his hotel room and ordering special seeds for them.
- Tesla was very picky about other people's clothing. On many occasions, he sent his subordinates home demanding that they change their clothes.
- Tesla presented his innovations in a very spectacular fashion, refusing to hold conventions without his Tesla coil on and sparking the air.

3. Answers may vary. For example:

- Alternating current systems
- Induction motors
- Systems for wireless communication

4. A Tesla coil is normally used to generate high voltage, low current, high frequency, alternating currents. Currently, there are no practical applications for a Tesla coil, but Tesla was hoping that this invention could one day transmit electrical power and information great distances wirelessly.

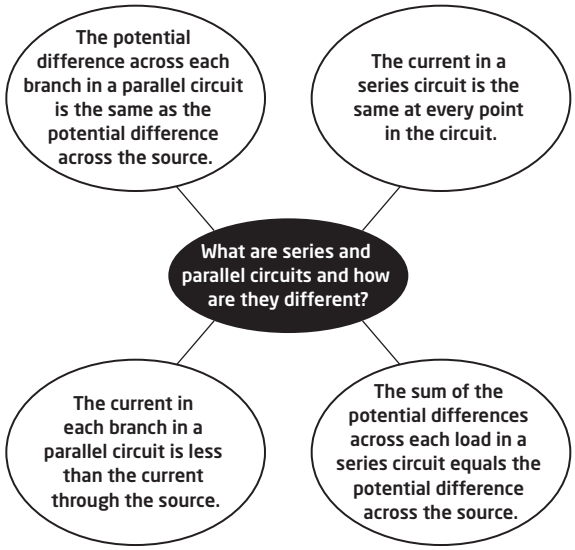
The Tesla coil receives a very high voltage input. The current goes through a capacitor, a few coils, and then into a final capacitor. When the capacitor is discharged, a substantial amount of energy sparks.

Topic 4.5 Review (Student textbook page 303)

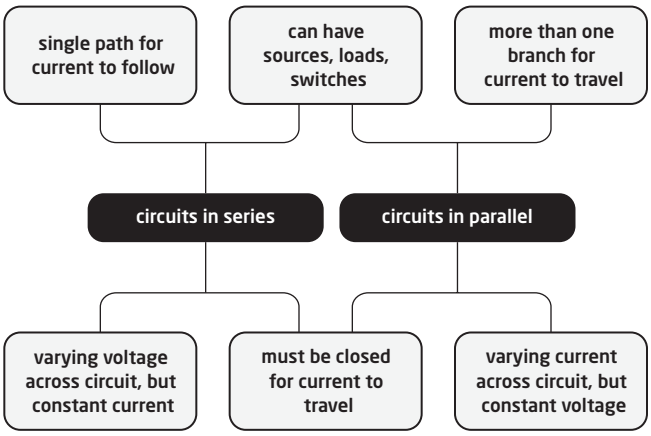
Please see also **BLM 4-27 Topic 4.5 Review (Alternative Format)**.

Answers

1. Answers may vary.



2. Answers may vary. For example:



3. a) This is a circuit in parallel with a 12 V source, 2 resistors, and 3 meters.

b) M must be a voltmeter because it is in parallel to the resistor. It will measure the potential difference across the resistor to its right. Since this is a parallel circuit, the potential difference across any resistor will be equal to the potential difference at the source, so it should read 12 V.

c) N must be an ammeter because it is in series with the rest of the circuit. It will measure the total current in the circuit. In a parallel circuit, the total current is equal to the sum of the currents across all resistors, so it should read 4 A.

4. a) This is a series circuit with a 12 V source, 2 resistors, and 3 meters.

b) X must be a voltmeter because it is connected in parallel with the resistor. It will measure the potential difference across the resistor beneath it. In a series circuit, the potential difference across the source is equal to the sum of the potential differences across all resistors, so it should read 6 V.

c) Y must be an ammeter because it is connected in series with the rest of the circuit. In a series circuit, the current is the same throughout so it should read 1 A.

5. The light bulbs would become dimmer because the potential difference is split in a series circuit across all loads, so by adding another load onto our circuit, the potential difference in all the bulbs must decrease and thus the bulbs would become dimmer.

6. A is a parallel circuit because the loads are on different branches. B is a series circuit because there is only one path for the current to follow.