Current Electricity

Electricity, currents, circuits, resistance, and magnetism all play a role in this segment.	
Student Science Performance	
Grade or course: Physical Science	**Title**
Topic: Current Electricity	Limit the Resistance to Learn about Electricity!

Performance Expectation for GSE:

SPS10. Obtain, evaluate, and communicate information to explain the properties of and relationships between electricity and magnetism.

a. Use mathematical and computational thinking to support a claim regarding relationships among voltage, current, and resistance.
b. Develop and use models to illustrate and explain the conventional flow (direct and alternating) of current and the flow of electrons in simple series and parallel circuits. (Clarification statement: Advantages and disadvantages of series and parallel circuits should be addressed.)
c. Plan and carry out investigations to determine the relationship between magnetism and the movement of electrical charge. (*Clarification statement*: Investigations could include electromagnets, simple motors, and generators.)

Performance Expectations for Instruction:

- Describe what is required for an electrical current to work (a complete circuit).
- Compare and contrast a series, parallel circuit, and explain the uses of each.
- Compare and contrast (as well as describe and model) direct and alternating current.
- Demonstrate that electrical currents can produce magnetic fields and that the opposite is also true.
- Support claims about the relationship between voltage, current and resistance in an electric circuit as it relates to the motion of charged particles across a conductor.
- Diagram and model circuit patterns.
- Make electromagnets and simple motors.

Additional notes on student supports

Materials

- Flashlight bulbs
- Different gauges and kinds of insulated and bare wires
- Wire cutter
- D cell batteries
- Magnets
- Iron nails (core of electromagnet)
- Multimeter
- Paper clips
- Switches
- Shoe boxes or circuit boards
- Electrical tape

Students will continuously obtain, evaluate, and communicate information. This is not a linear process. Students will communicate through writing and discussions to allow for formative assessment. This benefits the teacher, student, and whole group to guide instruction to clarify misconceptions or extend content.

Engaging Learners	**Phenomenon:** Electric cars require a relationship between electricity and magnetism in order to work. Consider showing pictures or videos of electric or hybrid vehicles.

	Have students brainstorm a list of questions about electric vehicles such as the ones listed: ● How is an electrical vehicle different from a regular car? ● What is a hybrid vehicle? ● What role to magnets play in electric vehicles? ● What are the advantages and disadvantages of each? ● What are the electrical components in each? How are they different? ● What is the cost difference? ● Why is there a cost difference? ● What is the fuel source? Alternatively, to focus more on electromagnetism, this claim-evidence-reasoning template could be used. Explain that the way cars and other electric powered appliances and vehicles work showing an understanding of electricity. *Teacher Notes: Students will work with circuits to better understand direct and alternating current, advantages and disadvantages of different types of circuits, electromagnetism in motors and generators, and the relationship of voltage, current and resistance.*
	Obtaining Ask: Where does this power come from to cause motors to work? What is electricity? Have students spend some time in small groups discussing and listing what they know about electricity. Provide materials to have them show their skill at making a complete circuit using wires, batteries, bulbs, and switches. Have them diagram and label the flow of electrons through the circuit and explain why the bulb won't light if there is a break in the circuit or the switch is left open. Explain that this type of circuit uses direct current. The energy flows directly from the battery through the wires to the bulb. Have students note the different energy transformations that occur as the complete circuit lights the bulb. Chemical paste in the battery, electric current, heat, light, etc. Give students various diameters of wire to see the difference the diameter of the wire causes in the brightness of the bulb. Wire has an electrical resistance. This resistance depends on the length and thickness of the wire. Even though the wire is a conductor, there is a tendency for a material to oppose the flow of electrons, transforming the electrical energy into thermal energy, and in the case of the light bulb, into light. Have students note the differences in the heat generated by the resistance of different wire. Ask: ● Why is the heat given off from the wire a safety issue? ● What is a short circuit? ● Why do short circuits sometimes cause fires and injuries? ● How can you protect yourself and your property from a short circuit?

	Explain that wires, batteries and bulbs come in different sizes to accommodate the differences in size of the apparatus, voltage and resistance. The length of wire and different gauges of wire cause different resistance. As the temperature of a metal wire decreases, its resistance also decreases. Have students brainstorm a list of appliances that use the temperature of a wire caused by resistance to work. (toaster, light bulb, hair dryer, etc.) *Teacher Notes: A possible extension for learning for some students could be introducing the concept of the Wheatstone Bridge. They can use these to calculate resistance and voltages on an electric circuit diagram.* *Additional teacher notes on topic, focus, and phenomenon.*
	Communicating Have students diagram and label parts of an electric circuit, a parallel circuit, and a series circuit using correct electric symbols. Basic Symbols for Electricity Diagrams
	Evaluating Have them test their diagrams and claims about relationships between voltage, resistance, and current using power source (dry cell), flashlight bulbs, wire, switches, and multimeters. *Teacher Notes: It is important for students to recognize the voltage of the battery and bulb to calculate how many batteries are needed to light multiple bulbs. Students should be shown the correct way to take voltage, current, and resistance measurements with a multimeter.*
Exploring .	***Obtaining*** Students need to test series and parallel circuits to determine advantages and disadvantages of each configuration using different configurations and make claims regarding the Ohm's Law relationship. ● Simple circuit with switch ● Series circuit with switch ● Series circuit with switch containing one bulb that doesn't work (burned out or not screwed in completely ● Parallel circuit with switch ● Parallel circuit containing one bulb that doesn't work. Have students diagram their circuits and explain the flow of energy through the circuit explaining what happens when a bulb doesn't light in each instance. This template could be used for students to construct claims about the relationships. Have them note the brightness of the bulbs in series and in parallel. Challenge them to do similar investigations using LEDs instead of flashlight bulbs.

	Communicating Have students determine when one type of circuit is preferred over a different type circuit and explain in a story about an electrician's dilemma.
	Evaluating Have students share their stories for edit and review and then revise their explanations before submitting them. *Teacher Notes: students should be generating claims about the Ohm's Law relationship and not simply given the equation; through building and testing various circuits, students will have data to make claims. In the template, students are asked to make analogies of V, I, and R; for example, voltage is water volume in a pipe, resistance is the pipe diameter, and current is the water speed. Connecting abstract concepts can help students build the conceptual understanding.* *Link this portion of the unit to the initial phenomenon and student claims by asking not only about the role of magnets in electric cars, but also the role of series and parallel circuits.* *LEDs are, effectively, gated. This means that when the current flows one direction through the diode, it will emit light. If the current flow is reversed, the diode will not produce light.* *If equipment is not readily available, there are numerous online simulations, such as PhET Circuit Construction, that allow students to explore these concepts* (Attribution: PhET Interactive Simulations, University of Colorado Boulder; https://phet.colorado.edu).
Explaining Finalizing Model	***Obtaining*** The War of the Currents AC vs. DC Power
	Evaluating Ask: How do vehicles use direct and alternating current? Do vehicles need both to operate? What are the advantages and disadvantages of each? Ask: What role do magnets and electromagnets play in the operation of a motor? How do they move an electrical charge?
	Communicating Have students research and diagram how each type of current (AC and DC) plays a role in the operation of a vehicle. *Teacher Notes: In this phase, student writing should be prevalent.*

Elaborating Applying Model to Solve a Problems	***Obtaining*** Challenge groups to design a shoe box or circuit board layout of 3 rooms with lights and switches to model what an electrician does when wiring a house. Challenge students to make electromagnets and simple motors to show the partnership of electric current and magnets to produce energy. Have them chart the data they produce by investigating using different number of coils, different size metal core, etc. to pick up paper clips. Have groups of students research different designs of electric motors and make one to share with the class. Have students research generators and where they are found and design models of generators explaining how magnets and electric current play a role in making the generator work.	
	Evaluating Have students explain their motor models, model generators, or electromagnet models with diagrams of how each work and then explaining design flaws, successes, and overcoming problems. Allow time for other teams to share ideas and revision strategies. Students should revisit their initial claims about magnets and electric cars and make any necessary changes.	
	Communicating Invite an electrician or other person who works with circuits to speak to the class about safety aspects, career and future projects.	
Evaluation	***Assessment of Student Learning***	
	Have students write an explanation of what an electrician that works with cars likely does. Use evidence from research and investigations to back up their claim. Student performances are assessed during each phase as students construct circuits and generate claims about electricity and magnetism concepts. Written responses and class discussion also determine student understandings and explanations.	
SEP, CCC, DCI	***Science Essentials***	
Science and Engineering Practices	• Develop and use models • Use mathematical and computational thinking • Plan and carry out investigations • Engage in argument from evidence • Construct explanations • Analyze and interpret data	
Crosscutting Concepts	• Energy and Matter • Systems and system models • Stability and Change	
Disciplinary Core Ideas	From A Framework for K-12 Science Education: PS2.B. Types of Interactions PS3.A. Definitions of Energy	

Additional Supports for struggling learners:

The following supports are suggestions for this lesson and are not the only options to support students in the classroom. These supports target students that struggle with science material, this lesson or a previous lesson. These are generalized supports and do not take the place of IEP accommodations as required by each student's Individualized Education Program.

General supports for the following categories:

Reading:	Writing:	Math:
1. Provide reading support by reading aloud or doing partner reads 2. Have the teacher model what they are thinking when reading the text 3. Annotate the text with students so that they may refer to it as they work through the lab	1. The teacher can provide a sentence starter for the students. 2. The teacher can give students an audience to write to (i.e. Write a letter to your sibling explaining this topic). 3. The teacher can provide constructive feedback during the writing process to help students understand the expectations.	1. Provide calculators as needed. 2. Provide graph paper as needed.

Supports for this specific lesson if needed:

Performance expectations for instruction:

1. The teacher should provide information to students in various formats to reach as many students as possible.
2. The students should be given adequate time to complete each part of the lesson.
3. The students should be allowed to express their knowledge in various formats.
4. The teacher should be sure to provide multiple ways for the students to communicate their knowledge of the material.

Engage:

1. The teacher should consider using both videos and pictures to explain the phenomena to students.
2. The teacher should record the questions that students are brainstorming on the board for use later as the class moves through the lesson.
3. The teacher can then help students determine which questions are the most important to research.
4. The teacher should give the CER template to students for students to record their initial claim.
5. The teacher should have clear and consistent guidelines established for working in small groups to

provide a safe environment for all students to participate.

6. The teacher should have students draw the circuit once they have correctly set up the complete circuit.
7. The teacher should consider giving struggling students sentence starters to get them started in the explain portion of the circuit.
8. The teacher should consider giving struggling students the questions in advance of any discussion that the class may have. This will allow struggling students to formulate responses prior to the classroom discussion. This should help some struggling students feel more comfortable and allow them to participate in the discussion.
9. The teacher should consider showing videos, doing demos and showing diagrams to help students see the different things that can impact how well a circuit works.
10. The teacher should consider reminding students of the correct symbols to use for electricity.
11. The teacher should provide multiple ways for the students to communicate their knowledge of the material. This can include writing, drawing or designing a play.

Exploring:

1. The teacher should provide a data sheet for the students to make observations of the different types of circuits.
2. Have students make claims about the flow of energy and explain why the bulb lights up or why it does not light up. The teacher should consider using a CER for this assignment.
3. The teacher should provide multiple ways for the students to communicate their knowledge of the material. This can include writing, drawing or designing a play.
4. Students may need additional time to formulate and revise their claims.

Explaining:

1. The teacher should consider giving students an organizer to record observations, research, diagrams and claims.
2. The teacher should provide multiple ways for the students to communicate their knowledge of the material. This can include writing, drawing or designing a play.

Elaborating:

1. The teacher should use flexible and intentional grouping.
2. The teacher should provide students with a template to record observations, notes and diagrams as they work on their circuit board layout.
3. The teacher should consider providing resources to students to for their research in the elaborate section.
4. The students may need additional time to complete these activities.

Evaluating:

1. The teacher should be sure to check for understanding throughout the lesson and build in re-teaching, review and enrichment as needed by each student.
2. The teacher should provide tangible and constructive feedback for students throughout the lesson.
3. The teacher should provide multiple formats for students to express their knowledge. These formats could include writing, drawing or designing a play.
4. Students may need additional time to complete their CER.

Magnets and Electric Cars? Claim-Evidence-Reasoning Template

Guiding Question: Why are magnets so important for electric vehicles?	
Additional Questions:	
Initial Claim	
Initial Evidence	
Initial Reasoning	

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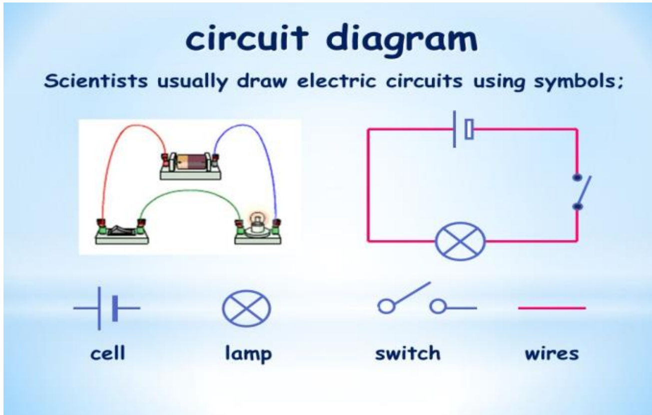
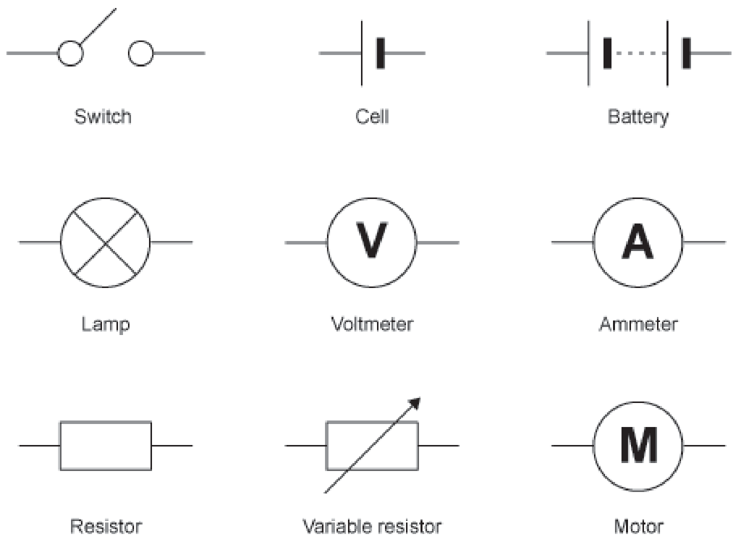
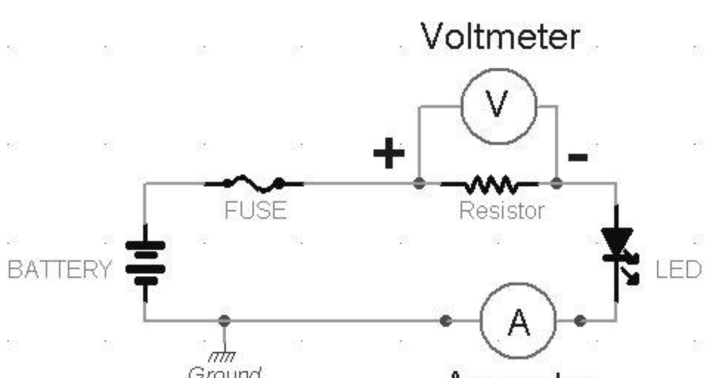
Basic Symbols for Electricity Diagrams





Showing LED and other symbols in a diagram:



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Voltage—Current—Resistance Relationships

Circuit Diagrams: Draw two different circuits that were constructed		
Voltage	**Current**	**Resistance**
Symbol: Unit:	Symbol: Unit:	Symbol: Unit:
What is real-world analogy for voltage?	What is real-world analogy for current?	What is real-world analogy for resistance?
Claims: When voltage increases (and current stays the same) the resistance: ____________ When voltage increases (and resistance stays the same) the current: ____________	**Claims:** When current increases (and voltage stays the same) the resistance: ____________ When current increases (and resistance stays the same) the voltage: ____________	**Claims:** When resistance increases (and current stays the same) the voltage: ____________ When resistance increases (and voltage stays the same) the current: ____________
Data to support above claims:	**Data to support above claims:**	**Data to support above claims:**
What is the mathematical relationship between these variables? Support with evidence		

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Energy and Matter GSE: SPS10 a, b, c			
Anchoring Phenomenon: The interaction of electricity and magnets in electric cars			
Topic	**Focus**	**Phenomenon**	**GSE/Notes**
Electricity and Magnetism	• Students will understand the relationship between voltage, current and resistance in an electric circuit as it relates to the motion of charged particles across a conductor. • Students will describe what is required for an electrical current to work (a complete circuit). • Students will compare and contrast a series, parallel circuit, and explain the uses of each. • Students will compare and contrast (as well as describe and model) direct and alternating current. Students can demonstrate that electrical currents can produce magnetic fields and that the opposite is also true.	*Possible additional phenomenon: Copper affects the motion of a magnet.* -When a magnet falls through a copper pipe it induces a current. The current creates a magnetic field that opposes the magnet, so it falls more slowly than expected.	SPS10a. Use mathematical and computational thinking to support a claim regarding relationships among voltage, current, and resistance. SPS10b. Develop and use models to illustrate and explain the conventional flow (direct and alternating) of current and the flow of electrons in simple series and parallel circuits. (Clarification statement: Advantages and disadvantages of series and parallel circuits should be addressed.) SPS10c. Plan and carry out investigations to determine the relationship between magnetism and the movement of electrical charge. (Clarification statement: Investigations include electromagnets, simple motors, and generators.) Equations- Voltage

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