UDL Teacher Guide: Beginning Electricity

"We believe that electricity exists, because the electric company keeps sending us bills for it, but we cannot figure out how it travels inside wires."
Dave Barry

Driving Question: What is electricity?

This unit will help you explore electricity.

Introduction

Using the UDL approach, students actively explore the science of electricity: from a fictional story to data collection with probes, and from hands-on inquiry to using computer models and simulations. Data collection, using probeware, is displayed using smart graphs, allowing students to dissect the elements of the graph to enhance their understanding. A variety of scaffolding helps are provided throughout the unit. The scaffolding allows student and teacher to work together so that students can demonstrate what they have learned through text and/or drawings. Coaches give prompts, hints, and models to engage students in the science content.

Technology

The technology used in the electricity unit is designed for students to discover the story told by the data as they circuits and electricity. A voltage sensor is used in the activities "Volts and Lights" and "Sum Volts." The probes allow students to collect and view data in real time on smart graphs. Smart graphs allow students to analyze data in a meaningful and supported way. The graphing tools are the same, regardless of the activity.

The technology in UDL does not supplant the teacher. Instead, students are individually supported throughout the unit. One example of this support is that students can highlight the text and the computer will vocalize the words. Definitions for highlighted words (in blue) are also built into the program. A complete glossary for the unit can be found at the bottom each page using the book icon. In some of the units you will also find three robot helpers. These robots help the student understand the material by asking them to make predictions, asking guided questions, and by clarifying or predicting what will happen next.

The teacher can manage certain features of the units for both the class and individual students. Once a class is set up the teacher can go to the UDL Portal-Info page and click on the "View a report on this class" icon. At the top of the report page there are two options, one that allows you to configure the parameters for students. This allows you to control the font size and set the initial scaffolding level for students. The option on the class report page allows you to enable/disable activities within the units.

The default setting for lesson order when setting up your classes will be a sequenced order of lessons. When students enter the menu page they will complete the Pre-test. When they have submitted the Pre-test they will be able to access the next lesson in the sequence. If you want to allow students to choose their own sequence you can set up your class so that once they have completed the Pre-test and Introduction they can move between lessons in whatever order they like. (A more detailed explanation can be found at http://udl.concord.org/share/teacher-guides/Dashboard.pdf)

Scaffolding in UDL Units

Scaffolding in education has traditionally been done by the teacher as a way to assist students as they are learning new skills or content. The scaffolding is done not to provide answers or do the work for them but as a way for the students to gain confidence and develop understanding of skills and concepts. The goal of scaffolding is that over time the level of assistance that a student needs will gradually be reduced until the minimal amount of support is needed and used. To use a cooking analogy: a chef will use a recipe the first few times he makes a dish. After he has made it several times, he may have the recipe out for reference and then after more time, it becomes so natural he no longer needs the recipe.

In the UDL units different levels of support are offered to students when answering questions. As with the cooking analogy, the scaffolding is intended to provide support for those students who need it with the goal that with time they will be able to work with minimal scaffolding. When scaffolding prompts are available they are accessed by clicking on the green question mark icon. Students may answer the open-ended question as presented. Or, if they are unable to do so, they can click on the question mark and access the first level of support. At this level they are given a hint that may lead them to the correct response. If the student is still unable to answer the question, they can click the question mark again for the answer with key words left out and they can fill in the blanks. If they need additional help, they receive a multiple-choice list. The final level of scaffolding offers the student a model response; they are given the answer and asked to provide their own ideas about the response.

Background Information

Electricity is a part of the modern life. Almost everyone uses electricity each day without ever thinking about where it comes from, what it is, or how it works. Because we see the results of what is happening with electrical current, but not the actual movement, understanding electricity can be an elusive topic to understand, especially in 3rd and 4th grade.

Atoms are made up of charged and uncharged particles, but only the charged particles have an effect on the electrical properties. The simplest charged subatomic particles are the electron and proton. Protons in the center of an atom have a positive charge of +1 while electrons, which are on the outer edges of an atom, have a negative charge of -1.

When an object has more positive than negative charges, the total electrical charge is positive. Conversely, when an object has more negative charges than positive, the total electrical charge is negative. When the positive and negative electrical charges are equal, the total electrical charge is zero.

In static electricity this change in charges results from the transfer of charges from one object to another (i.e., a piece of wool and a balloon). When you charge the balloon by rubbing it with a piece of wool, you change the charge of the balloon. You can see the results when you take the charged balloon and put it next to someone's hair—their hair will stick out.

Another property of charged objects is how they attract or repel. If two objects have the same charge (+ + or - -) they will repel (push away) each other. If two objects have opposite charges (+ -) they will attract (pull together) each other.

When there is a difference in electrical charge between two objects an electric field is produced. This electric field produces a force on both the objects themselves and any charged particles near the objects. The voltage between the two objects is proportional to the difference in electrical charge and the force produced by the electric field. It is important to remember that voltage is a property associated with the difference in electrical charge between two separate locations.

While protons are tightly bound up in the nucleus of the atom, the outermost electrons in materials that are good electrical conductors are held very loosely. Some metals like copper,

aluminum, and gold are very good conductors. When there is a voltage difference between the two ends of a conductive wire, electrons will freely flow from the more negative end towards the more positive end.

The flow of electrical charge is called current and is measured in amperes. The charges that are flowing in the wires are electrons. Electrical charge is measured in coulombs. In the investigations that follow students need not understand how current and charges are measured. They need to understand that the charges flow. However, it will help if they visualize a battery pushing electrons around a circuit and speak of the flow of electrons or charge rather than the flow of current. While many people might use the phrase "the flow of electrical current," this can easily cause confusion in later studies.

It might help to use the analogy of a stream. Voltage is analogous to the difference in height from the high point to the low point, or the pressure at the faucet. Current is analogous to the flow of water. Charge is analogous to the water itself.

In non-rechargeable batteries, the electrochemical reactions are not reversible, and the ability of the battery to maintain a voltage is reduced as it is used. The electrochemical reactions in rechargeable batteries can be reversed with a battery charger, allowing it to be used again and again.

Students may ask why different size batteries (AAA, AA, C, D) can have the same voltage. Propose an addition to the analogy: Let's suppose you are watering a garden with your hose. Instead of connecting your hose to a faucet (which implies a non-ending source), you have the option of drawing water from two different ponds. One pond is twice the size of the other and of equal depth. Both ponds rest on a hill an equal distance from the garden. If you place the hose at the bottom of either of the ponds, the water will flow at equal pressure (representing the voltage drop) through the hose. Ask the students which pond they would use during a drought if they needed more water for their garden? The larger pond is like the bigger battery. The large pond stores more water. The larger battery stores more chemicals.

When the electrons flow through the circuit and meet resistance, for example, in the filament of a light bulb, the electrical energy is transformed into heat and light energy. At the atomic level, the electrons make the atoms in the filament heat up and glow. Thus a circuit transforms chemical energy in a battery into heat and light energy in a light bulb.

Standards

NSES Content Standard A

- Abilities necessary to do scientific inquiry.
  - Ask a question about objects, organisms, and events in the environment.
  - Plan and conduct a simple investigation.
  - Employ simple equipment and tools to gather data and extend the senses.
  - Use data to construct a reasonable explanation.
  - Communicate investigations and explanations.
- Understandings about scientific inquiry.
  - Use mathematics in all aspects of science inquiry. (5-8)

NSES Content Standard B

- Light, heat, electricity, and magnetism
  - Electricity in circuits can produce light, heat, sound and magnetic effects. Electrical circuits require a complete loop through which an electrical current can pass. (K-4)

Benchmarks for Science Literacy (AAAS)

- 4G Forces of Nature
  - Without touching them, material that has been electrically charged pulls on all other materials and may either push (repel) or pull (attract) other charged materials. (3-5)
  - A charged object can be charged in one of two ways, which we call either positively charged or negatively charged. Two objects that are charged in the same manner exert a force of repulsion (repel) on each other, while oppositely charged objects exert a force of attraction on each other. (6-8) (Atlas of Science Literacy; Volume 2)

- 8C Energy Sources and Uses
  - Electrical Energy can be produced from a variety of energy sources and can be transformed into almost any other form of energy. Moreover, electricity is used to distribute energy quickly and conveniently to distant locations. (6-8)

Alaska state standards (http://udl.concord.org/share/teacher-guides/TG_Electricity-Beginning-AK-Standards.pdf)

California state standards (http://udl.concord.org/share/teacher-guides/TG_Electricity-Beginning-CA-Standards.pdf)

Learning Goals

Students should understand that electricity is based on electric charges.

There are two kinds of charges: positive and negative. Matter is made up of lots of both kinds of electric charges.

Positive and negative charges together cancel each other out, so matter can have lots of electrical charges, but be neutral (uncharged) overall.

Opposite charges attract (pull together). Positive and negative attract.

Like charges repel (push apart). Positive and positive repel. Negative and negative repel.

To work, electric devices need a circuit, which is a conducting loop that allows the electric charges to flow in a continuous circle.

Batteries store electrical energy as chemical energy. Batteries can push electrical charges through a circuit, transferring the electrical energy from the battery to the device in the circuit, such as a light bulb.

Working with probeware, sensors, and computers

Probeware and sensors allow students to collect real-time data during an investigation. Probeware is a device that can be attached to a computer, handheld (Palm), graphing calculator, or similar tool to collect, display, and store data as it is collected. There are a variety of measurements that be collected using different probes, including temperature, humidity, voltage, and force.

The NSES include a section on *Understanding About Science and Technology* that deals with the use of technology and the connections to science. At the K-4 level the standards state, "Tools help scientists make better observations, measurements, and equipment for investigations. They help scientists see and do things that they could not otherwise see, measure, and do." As you begin using probeware with your students, make sure that you help them understand how the probes they are using in a particular lesson are enabling them to expand their ability to see, measure, or do the activities.

It is also important that you take the time to become familiar with the equipment and how it works. You will also need to be prepared for the unexpected. Whenever you are working with technology you may find yourself and your class in a situation where things don't work the way that you expect them to. Being flexible is the key.

In addition to making sure you are familiar with the probes and sensors and how they are used, you need to make sure that you are comfortable with the computer technology available at your site. Your school or district technology coordinator can be a valuable support as you are working with the UDL program.

Unit Overview

Activity Title	Time	Materials	Activity Overview
Pre-test	20 minutes	• Computer with Internet access	Students answer six questions (multiple choice and short answer) to establish prior knowledge.
Introduction	20 minutes	• Computer with Internet access	Students work in groups to consider the question "What things in your house use electrical energy to work?" They also think about which electrical devices make light, heat, motion, and noise.
Telegraph Story	two to three 45-minute periods	• Computer with Internet access • Printout of story (optional) (http://udl.concord.org/share/teacher-guides/Elec34-telegraph-v4.pdf) • Morse Code chart (optional) (http://udl.concord.org/artwork/elect_34/morse_code/morse_code.pdf)	Eduardo is sick and his sister Maria is bored, so Maria builds a telegraph so that they can still have some fun. Their mother shows them how to use Morse Code to send messages back and forth.
Conductors and Insulators	two 30-40 minute sessions	• AA or AAA size battery • 2 pieces of wire, each about 10 cm long • small holiday light with wire ends stripped • penny	Students first explore materials that act as conductors and insulators using a computer model. Then they use a battery and blub to test several common materials to

		• plastic spoon • rubber band • eraser • pencil lead • paper clip • wood • Computer with Internet access	find which ones conduct or insulate against the flow of electricity.
String Circuit	60 minutes	• piece of cardboard 25 x 50 cm (10 x 20 in) • 4 bendable straws • string (130 cm) • tape • scissors • marker • Computer with Internet access	Students build a model of an electrical circuit using straws and string. Then they compare the straw and string model to a computer simulation of a circuit.
Light a Bulb!	40 minutes	• Computer with Internet access	Students experience lighting a bulb with a single battery. The focus is on creating a circuit and thinking about what materials can be used to complete a circuit.
Volts and Lights	two 30-40 minute sessions	• Genecon hand generator • voltage sensor • two holiday lights • Computer with Internet access	Students are introduced to the concept of voltage and how to use a generator to light a bulb.
Sum Volts	30-45 minutes	• Computer and internet access • Voltage sensor • 4 AA or AAA batteries, some of them old or not fully charged • Masking tape • Binder clips, to hold batteries in series • Computer with Internet access	Students measure what happens when batteries are added together in a series.
Wrapping Up	Ongoing	• Computer with Internet access	Students can visit and revisit “Wrapping Up” during their completion of the unit activities. In Wrapping Up they have the opportunity to review and clarify their thinking.
Post-test	20 minutes	• Computer with Internet access	Students complete the post-test, which contains the same set of question as the pre-test, as well as student feedback questions.

Unit Activities

Pre-test

Time: 20 minutes

Materials: computer with Internet access

This unit begins with a short pre-test. The pre-test allows students to share what they know about the learning goals. Students must complete the pre-test and press the "Submit" button before proceeding to any activity. The post-test at the end of the unit contains the same set of questions and allows the student and teacher to see student growth after completing the activities in this unit.

Introduction

This section introduces the driving question for the unit, "What is electricity?" This question provides the framework for the activities in this unit. As you work with your students it is important to come back to it often. One way to do this is to post this question on a large piece of chart paper. Then, as students are working throughout the unit, add to the initial list of responses.

Time: 20 minutes

Materials: computer with Internet access

Telegraph Story *Story*

In this activity students read and summarize a story about communicating through a telegraph.

Time: two to three 45-minute sessions

Materials: computer with Internet access (or you can print a PDF version)

Student Activity:
In this story Eduardo is sick and his sister Maria is bored, so she builds a telegraph so they can still have some fun. With their mother's help they learn how to connect a battery and bulb to build and circuit. By connecting and disconnecting the wires they see that they can make the bulb flash on and off. Their mother shows them how to use Morse Code to send messages back and forth.

Scaffolding is available using the "robot" helpers, which provide prompts to help students understand the story.

Conductors and Insulators — *Hands-on & Computer model*

Discovery Question: What can conduct electricity?

Students test materials that conduct or insulate against the flow of electricity.

Time: two 30-40 minute sessions

Standards/Benchmarks:

NSES Content Standard A

- Abilities necessary to do scientific inquiry.
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  - Employ simple equipment and tools to gather data and extend the senses.
  - Use data to construct a reasonable explanation.
  - Communicate investigations and explanations.
- Understandings about scientific inquiry.

NSES Content Standard B

- Light, heat, electricity, and magnetism
  - Electricity in circuits can produce light, heat, sound and magnetic effects. Electrical circuits require a complete loop through which an electrical current can pass. (K-4)

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California state standards (http://udl.concord.org/share/teacher-guides/TG_Electricity-Beginning-CA-Standards.pdf)

Materials:

- computer with Internet access
- AA or AAA size battery
- 2 pieces of wire, each about 10 cm long
- small holiday light with wire ends stripped
- penny
- plastic spoon

- rubber band
- eraser
- pencil lead
- paper clip
- wood

Student Activity:
Students first explore materials that act as conductors and insulators using a computer model. Then they use a battery and bulb to test several common materials to determine which ones conduct or insulate against the flow of electricity.

Engage:
Students are introduced to conductors, those materials that allow an electrical charge to easily flow through them. They test materials and predict which they think are conductors.

Explore:
Students first use a computer model to see how putting a conductor or insulator in a circuit will change what happens when you try to light a bulb. They have a virtual grab bag of materials to use in their circuits.

Students then use a single battery, a holiday light, and a short piece of wire to make a circuit tester. Using their circuit tester they test common materials to see which are conductors and which are insulators.

Explain:
Students look back at the materials that were conductors and insulators and identify what is similar about conducting materials and what is similar about insulating materials.

Elaborate:
Students look at their holiday light and identify which part of the wiring is the conductor and which is the insulator. Using their ideas they explain why wires have the copper inside and the rubber or plastic around it.

Discussion:
Lead the whole class in a discussion using the question below to start the conversation. Allow students time to clarify their ideas and encourage them to explain their thinking.

"When a cord for a lamp or other electric appliance is damaged, why is it dangerous to keep using it?"

String Circuit — *Hands-on*

Discovery Question: How does electricity move through a wire?

Students build a model of an electrical circuit using straws and string. Then they compare the straw and string model to a computer simulation of a circuit.


Time: 60 minutes


Standards/Benchmarks:

NSES Content Standard A

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Materials:

- piece of cardboard 25 x 50 cm (10 x 20 in)
- 4 bendable straws
- string (130 cm)
- tape
- scissors
- paper
- marker
- computer with Internet access

Advance Preparation:
Cut cardboard (25 x 50 cm) and lengths of string (130 cm).

Student Activity:

Engage:
Students are introduced to the concept of an electrical circuit. In a brief reading students are introduced to key vocabulary, including battery, circuit, and heat. Then as a group the class models a circuit by linking arms. The teacher gives the circuit a charge by giving a little push to the person next to them; the class passes it on until it gets to the student who is the bulb.

Explore:
Students use cardboard, bendable straws, and string to build a model of an electrical circuit. The model is used to explore how energy (the string) moves through a circuit (the straws). Students work in a small group with one being the battery (pulling string) and another being

the resistance created as the current moves through the filament of a light bulb (pushing gently on the opposite side of the string).

Explain:
Students are now introduced to the movement of electrons through a circuit. An animated image is used to model this movement. The concept of a switch is added to both models. On the chalkboard or on a sheet of paper have the students make a list of how the string model is like the real circuit and how the two are different. After students have had a chance to list their ideas they can refer to two charts in the Explain section.

Elaborate:
Students use what they have discovered to explain in their own words how the model and the circuit are the same and different.

Discussion:
Lead the whole class in a discussion using the questions below to start the conversation. Allow students time to clarify their ideas and encourage them to explain their thinking.

"Think about the string model again. What would happen if a thicker piece of string were used? Would the string move as easily? Can more electricity try to move through a wire than it can handle?"

Light a Bulb! — *Hands-on*

Discovery Question: How do you use batteries to light up a bulb?

In this activity students use a model in their first experience lighting a bulb with a single battery. The focus is on creating a circuit and thinking about what does and does not conduct electricity.


Time: 40 minutes


Standards/Benchmarks:

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Materials: computer with Internet access

Student Activity:

Engage:
Students begin by making a drawing of a battery using the drawing tools. They are then introduced to the idea that batteries have a positive and a negative end.

Explore:
Students are shown a circuit that includes a battery, bulb, and a switch. They manipulate the switch to turn the bulb on and off. With this information they use the drawing tools to show how they think the wires are connected to make a circuit light a bulb. Then, using their drawing as a guide, they use a battery, wires, and bulb to see if the bulb lights up. If the bulb doesn't light, students try another arrangement until it lights up.

Explain:
Using their experience with the battery and bulb, the students use the drawing tools to show their successful attempts. In the drawing they also are asked to show the direction of current flow.

Elaborate:
Having used the model to discover how to use a battery to light one bulb, students now are asked to use two batteries and two bulbs to create a circuit. The goal is to make a circuit where the batteries and bulbs form a single complete circuit.

Volts and Lights — *Hands-on (voltage sensor)*

Discovery Question: How do light bulbs work?

In this activity students are introduced to the concept of voltage and how to use a generator to light a bulb.

Time: two 30-40 minute sessions

Standards/Benchmarks:

NSES Content Standard A

- Abilities necessary to do scientific inquiry.
  - Ask a question about objects, organisms, and events in the environment.
  - Plan and conduct a simple investigation.

    - Employ simple equipment and tools to gather data and extend the senses.
    - Use data to construct a reasonable explanation.
    - Communicate investigations and explanations.
- Understandings about scientific inquiry.

Benchmarks for Science Literacy

- 8C Energy Sources and Uses
    - Electrical Energy can be produced from a variety of energy sources and can be transformed into almost any other form of energy. Moreover, electricity is used to distribute energy quickly and conveniently to distant locations. (6-8)

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California state standards (http://udl.concord.org/share/teacher-guides/TG_Electricity-Beginning-CA-Standards.pdf)

Materials:

- Genecon hand generator
- voltage sensor
- two holiday lights
- computer with Internet access

Technology note: The Genecon hand generator takes mechanical energy from the student turning the crank and converts it into electrical energy. It is important to monitor students while they are using the Genecon hand generator. Students need to crank slowly to get the bulb to light. If they crank too quickly, they may burn out the bulb.

Student Activity:

Engage:
Students are introduced to the structure of a light bulb, in particular to the filament, by reading about what the filament does and locating it on a picture of a holiday light. Then they are introduced to a smart graph that shows the voltage data from a student using a hand generator at three different speeds. They are asked to label events and record some of the values shown on the graph.

Explore:
Using a Genecon hand generator and holiday light students create a circuit and then crank the generator slowly to see if the bulb will light. Students record their work using the drawing tools. The exploration continues with the students using a voltage sensor that is connected to the generator-bulb circuit to measure the voltage produced. Several data sets are collected using the generator and a single bulb with students cranking at various speeds (slow, medium, fast).

Explain:
Having collected the data students now use it to describe the relationship between voltage and the brightness of the light.

Elaborate:
Students use their new understanding of voltage to make predictions about how the voltage might change with two holiday lights connected.

Quick Check for Understanding: To evaluate students, have them explain how to make a light bulb brighter. They can do this on a sheet of paper using pictures and words. The teacher can collect this.

Sum Volts — *Math*

Discovery Question: What is the voltage of combinations of batteries?

In this activity, students measure what happens when batteries are added together in a series.

Time: 30-45 minutes

Standards:

NSES Content Standard A: Science as Inquiry (grades 5-8)

- Understand about scientific inquiry.
  - Mathematics is important in all aspects of scientific inquiry.
  - Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.

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California state standards (http://udl.concord.org/share/teacher-guides/TG_Electricity-Beginning-CA-Standards.pdf)

Materials:
- Computer with Internet access
- Voltage sensor
- 2 AA or AAA batteries, some of them old or not fully charged
- Masking tape
- Binder clips, to hold batteries in series

Optional Materials:
- Flashlight that uses more than one battery

Safety Note: Do not mix the sizes of batteries. Students should use all AA or AAA in their testing series, not a combination of available batteries.

Engage:
Students consider the affect of using multiple batteries with electrical devices.

Explore:
Using the voltage sensor students measure the voltages of each battery. On a piece of masking tape they make a label showing the voltage measurement. Positive and negative poles of the battery are also recorded on the masking tape. Using the measurements they recorded, students predict the total voltage of the battery series. Consider having students share their predictions, recording if students predict the voltage to increase, decrease, or stay the same.

Students line up the batteries, positive pole to negative pole and test their predictions, calculating the difference between actual and observed voltage (measured vs. predicted). If the difference was more than 0.5 volts, students should retest their battery series and check connections.

Quick Check for Understanding: Predict what would happen to the total voltage reading if the red and black leads were reversed.

Explain:
Students then working with another group combine their batteries so that there are four lined up pointing in the same direction. They again measure the voltage of the batteries. Using their data from the four bulbs students record the total voltage written on the batteries and compare this to the measured voltage.

Elaborate:
Students are presented with an image of three batteries lighting a bulb and are asked to calculate the voltage based on the voltage on the individual batteries. They also predict which battery is the oldest based on the voltage measurements.

Quick Check for Understanding: Why do battery manufacturers say that it is not a good idea to mix old and new batteries?

Wrapping Up

Driving Question: What is electricity?

Time: Ongoing

Materials: computer with Internet access

Having completed the activities in this unit, students review what they have learned about electricity and respond to the discovery question for each activity with text, drawings, snapshots, or data they have collected. Students can revisit any activity except the pre-test. When students are ready, they need to input a password to unlock the post-test.

The password is: **electricity**

Post-test

Time: 20 minutes

Materials: computer with Internet access

In the post-test, students have an opportunity to rethink their answers to the same set of questions as the pre-test. Once the post-test has been unlocked, students will not be able to revisit any previous activities.

Note: When the students finish the post-test, a box comes up saying they have finished and should tell the teacher. At that moment, their data is *not yet saved*. They must close the unit for the data to be saved. The student cannot just walk away. Students can close the unit by going to the File menu and selecting Exit or by simply clicking the red circle (upper left).

Additional Resources

Vocabulary

Atom: a very small piece of matter. Several atoms joined together are called molecules.

Attract is when two things pull toward each other.

Battery creates voltage with a chemical reaction to run electrical devices.

Circuit is a continuous path that can carry an electric current.

Conductor is a material that allows the free passage of charges, such as metals like iron, copper, and aluminum.

Electric current is the flow of electric charges.

Electric charge is a basic property of the tiny particles that make up matter. Particles can have positive, negative, or no charge.

Electricity is a form of energy that is made up of positive and negative charges.

Electron is a tiny part of an element. An electron has a negative charge.

Energy is a property of materials that can be used to heat things. The total amount of energy in a system doesn't change.

Filament is the glowing wire inside a light bulb.

Generator is a device that converts mechanical energy to electrical energy.

Heat is a form of energy that consists of wiggling or motion of molecules. The faster the molecules wiggle, the hotter the material.

Insulator is a material that does not allow the passage of charges, such as wood, plastic, and air.

Motor is a device that converts electrical energy to mechanical energy.

Neutral means having no net electrical charge because the number of positive and negative charges is equal.

Predict is to make a careful guess about how something will happen.

Prediction is a careful guess about how something will happen.

Repel is when two things push away from each other.

Resistance is the measure of how much a material opposes the flow of electric current.

Temperature is the measure of how fast molecules in a material are wiggling or vibrating.

Voltage is a measure of how much force is pushing charges through a circuit.