circuit cubes

STEM STARTER KIT

Lesson Plans

LESSON 1

Getting to Know Your Circuit Cubes

APPROPRIATE FOR: Grades K – 8

STANDARDS FOR: Grades K – 2, 3 – 5

DIFFICULTY: Easy

PREP TIME: 5 Minutes

TOPIC: Tinkering

DURATION: 40 – 60 minutes

SUBJECT: Light

Student Focus Question

How can the Cubes create circuits?

Lesson Goal

Students will model, build, and draw diagrams of electric circuits.

Objective

Develop an understanding of circuits using the Cubes.

Prior Knowledge Required

None

Vocabulary

BATTERY CUBE: produces the power used to animate projects by turning chemical energy into electrical energy

LED CUBE: functions as a Light Emitting Diode (LED) that illuminates with less heat than other bulbs

MOTOR CUBE: turns electrical energy into mechanical energy by making a rotating motion

ELECTRIC CIRCUIT: a pathway for energy to flow

ELECTRONS: negatively charged particles that move through circuits creating electricity

POLARITY: the direction of a magnetic and electrical flow from one pole to another pole

VOLTAGE: the pressure from the power source that pushes charged electrons through the circuit

Background

What is an electric circuit? Through the exploration of Circuit Cubes, students can learn what an electric circuit is on their own! Each Cube in the Circuit Cubes STEM Kit has its own role to play in creating an electric circuit.

The Battery Cube

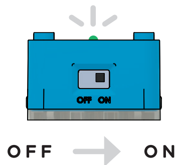
The blue Battery Cube has an on/off switch. When charged and turned on, this Cube creates the energy to power the electricity.

This battery is essentially a cell full of chemicals that produce electrons. The basic structure of the battery includes two terminals, or metal poles, on each side of the battery. One terminal is marked positive, while the other is marked negative. When the two terminals are connected, this allows electrons to flow from the negative to the positive terminal as fast as they can. When the other Cubes are connected to the Battery Cube using the poles or wires, it allows energy to flow to the LED light bulb or to the Motor Cube, creating an electrical circuit, which is a consistent flow of energy in a closed loop.

Inside the Battery Cube itself, a chemical reaction produces the electrons from the chemicals. Electrons flow from the battery into a wire, and must travel from the negative to the positive terminal for the chemical reaction to take place.

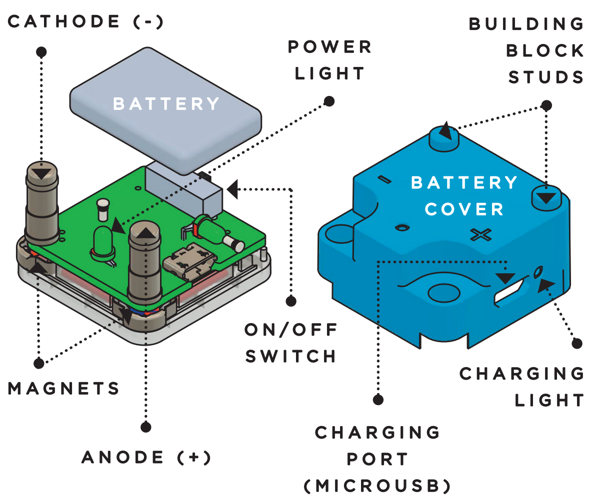
When the Battery Cubes are charged, they will have plenty of power—up to several hours' worth. Be sure to turn your Battery Cube off after use. Unless electrons are flowing from the negative to the positive terminal, the chemical reaction does not take place; therefore, the batteries will keep their charge. If they remain turned on, it will drain the power. The Circuit Cube Battery Cube is rechargeable; use the micro-

USB cable included and plug it into any USB port to charge it.



Your Battery Cubes are 160mAH at 3.7volts. “mAh” means “milliAmp hour” and is a unit that measures electric current over time. It is commonly used to measure the energy capacity of a battery. In general, the more mAh, the longer the battery capacity or battery life.

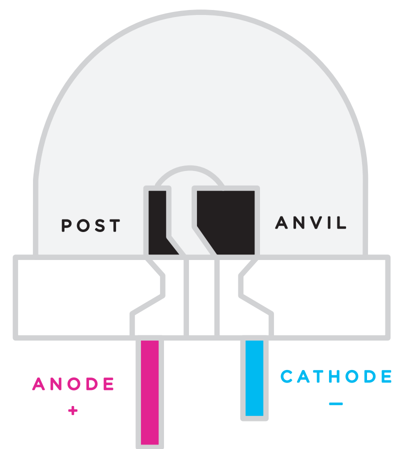
PLEASE REMEMBER: CIRCUIT CUBE BATTERY CUBES SHOULD NOT BE COMBINED. Doing so may damage them or other Circuit Cubes. Use only one battery at a time.



The LED Cube

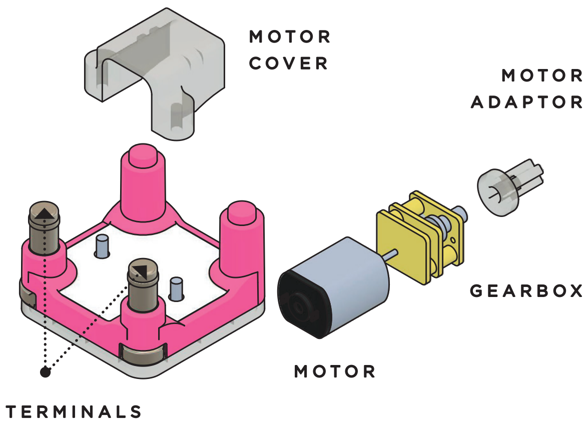
LEDs are **L**ight **E**mitting **D**iodes. They produce less heat and last longer than incandescent light bulbs and provide a diverse application. They are commonly seen around the house in flashlights, remote controls, and in the indicator lights of electric toothbrushes.

LEDs are easy to work with because of the two long wires, called diodes, that come off the lens. One wire is the positive (anode) and the other the negative (cathode). Diodes conduct electricity in one direction, so it is important to know the positive and negative side of the device. Circuit Cubes do not have visible wires. Students will need to learn more about the inside of the lens, so they can troubleshoot as they build. When connected with the Battery Cube, the LED Cube creates light energy. This light will not heat to a high temperature like incandescent light bulbs. It generates a super-bright light while staying cool to the touch. The LED light also has polarity, meaning that it only allows energy to flow in one direction. As a result, the LED Cube can be connected incorrectly. You’ll be able to tell because it will not light up; try reversing the wires if this happens.



The Motor Cube

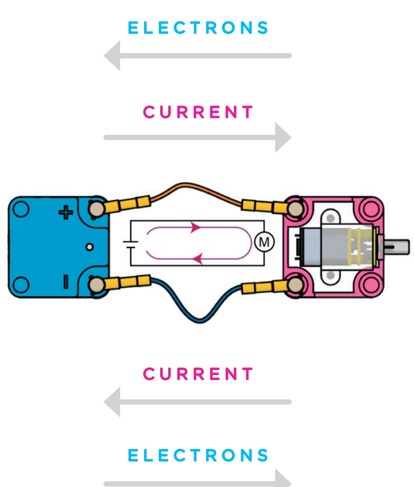
The Motor Cube uses the power from the Battery Cube to make mechanical energy. The spindle on the motor moves at 1,000 RPM (Revolutions Per Minute), but the gear box slows it down to 75 RPM. You can observe the gears inside the gearbox turning. One can reverse the direction of the motor by reversing the polarity. This can be done using wires. Try connecting the battery to the motor with wires and then switch the wires on the motor from one post to another post. When you do this, you will notice that the motion changes direction.



The Cubes • Background

Circuit Cubes can be used in different combinations to make electrical circuits. An electrical circuit is a pathway made of a conducting material that allows energy to flow. Metals like iron or copper are common conductors. The metal poles on the Circuit Cubes allow the flow of electricity from one to another. A battery or other power source gives the force (voltage) that makes the electrons move. When the electrons get to the LED Cube or the Motor Cube, they give it the power to make it work.

A circuit needs to be closed, or connected, to work. The metal contacts must be connected from the Battery Cube to the other Cubes and back again, so that the electrons can go out and come back to the source.

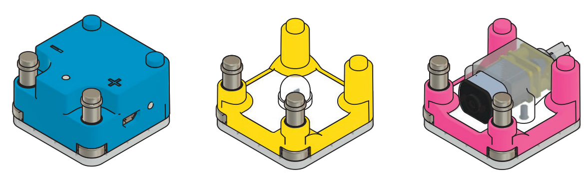


Circuit Cubes are stackable, so the poles can be touching from below as well as next to each other, depending on how one connects them. When the Battery Cube is switched off, it makes a gap in the circuit and the electrons are not able to flow around. When the switch is turned on, it closes the gap and the electricity can move and make the Cubes work again.

Have fun exploring Circuit Cubes! What combinations can you and your students make? We encourage your class to post photos of your creations using the hashtag #CircuitCubes so that others can see them.

Supplies

CUBES



MATERIALS

- Connection wires
- Wheels
- Chart paper
- Science journals or Student Observation & Reflection Sheet (included)

TOOLS

None

Lesson Procedure

Setup

❏ Decide how students will be partnered.
❏ Organize materials for easy group distribution.
❏ Read background information to familiarize yourself with batteries and how electrical circuits transfer energy.

Step 1 • Engage

- ❏ Begin this lesson with a student-driven exploration of the Cubes and wires. This is an open investigation and allows students to notice how the Circuit Cubes work.
- ❏ Students will discover that the Cubes are magnetic, that the Battery Cube has an on/off switch, and that an LED has polarity.

Step 2 • Notice & Wonder

- ❏ Ask students to notice what happens when the Cubes are connected.
- ❏ Instruct students to draw and make notes in their science journals or the Student Observation and Reflection Sheet about what happens when the Battery Cube is turned on and the other Cubes are connected (i.e., the LED lights up and/or the motor turns).
- ❏ Display large chart paper. As a whole class, make a drawing of a circuit, and label the parts and the direction the energy is flowing. Call on students to describe the parts as you label the diagram.
- ❏ **FOR EXAMPLE:** Have students connect the Battery Cube to the Motor Cube. Notice that when everything is connected, the circuit is closed, and electricity can flow from the battery to the motor and back again.
- ❏ Some students may offer prior knowledge on how circuits work. When students make an observation, pose questions such as:
  - What do you see that makes you say that?
  - What more can you find?
  - Show your neighbor (elbow partner) something that you discovered.
- ❏ Next, ask students to share observations from their journals or Student Observation and Reflection Sheets.
- ❏ Ask the students to write questions or wonderings that they have about the Cubes and how they create circuits.
- ❏ Ask the class to make the LED Cube light up.
- ❏ After 10 minutes of open investigation, ask the groups to document their findings in their science journals. Instruct students to use both pictures and words.
- ❏ They will need to include how they got the LED to work, and what was wrong if it did not work.
- ❏ Ask students: What questions do they have now?
- ❏ Have groups share their findings, either with another team or the whole class.
- ❏ Add details to the class chart to show how the wires can be used to connect the positive and negative side to the Battery Cube, and show the flow of energy in their own unique designs.

Step 3 • What would happen if...

- ❏ Have students explore possibilities for experiments by filling in the sentence starter: "What would happen if...?"
- ❏ The ideas could be recorded on the board, on the Student Observation and Reflection Sheet, or in a science journal.
- ❏ These ideas can be explored by making a plan and discussing predictions for what they think might happen.
- ❏ Provide time for students to test their own ideas, which will lead to their own designs.

Step 4 • Math Connection

- ❏ Have students write or orally present an addition/subtraction word problem to review their Cube interactions.

Step 5 • Reflect

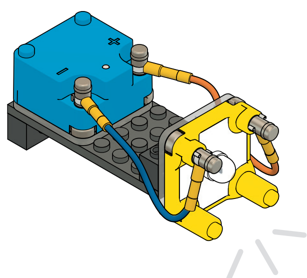
- ❏ Since students share the materials, it is important for them to reflect independently in their journals or on the Student Observation and Reflection Sheets. This is an opportunity to draw and write about the experience. Their entry may serve as a formative assessment of student understanding, or for the teacher to use as a reflection on what worked during the build.

Extension • Engineering Challenge

- ❏ Team up: Have students design an open circuit that doesn't work (e.g., the motor won't turn on, the LED won't light up, etc.) and ask another group to find the way to make it work.

LESSON 2

Make a Flashlight



APPROPRIATE FOR: Grades K – 8

STANDARDS FOR: Grades K – 2, Grades 3 – 5

DIFFICULTY: Easy

PREP TIME: 15 minutes

DURATION: 40 minutes

TOPIC: Light

Lesson Goal

This lesson focuses on how LEDs work. Students will use Circuit Cubes to build a flashlight from the STEM Kit supplies.

Objective

Deepen an individual's understanding of how Circuit Cubes transfer energy.

Prior Knowledge Required

Students would benefit from having experienced Lesson 1. During that lesson, they took a closer look at the parts of the Circuit Cubes and examined the LED Cube.

Vocabulary

ANODE: the positive side of the LED

ANVIL: larger side of the internal structure of the LED that attaches to the cathode side of the wire

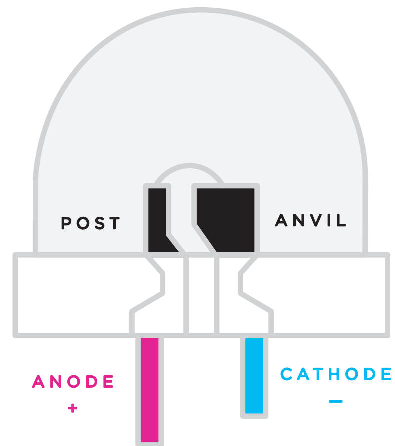
CATHODE: the negative side of the LED

DIODE: a semiconductor device with two terminals, typically allowing the flow of current in one direction only

LED: Light Emitting Diode— a diode that emits light when an electric current is passed through it

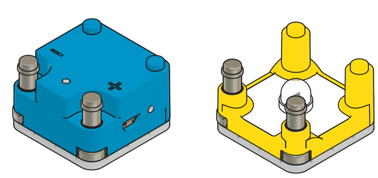
POST: small side of the internal structure of an LED that attaches to the anode side of the wire

Take a moment to view the inside of the LED. Notice that the Post (or small side) is attached to the anode (+) side of the LED wire. The Anvil (or large side) is attached to the cathode (-).



Supplies

CUBES



MATERIALS

- 4 x 8 plate
- 1 x 4 stud beam (2)
- pegs (2)
- connection wires (2)
- telescope tube

- science journals or Student Observation and Reflection Sheets

TOOLS

None

Lesson Procedure

Setup

❏ Decide how students will be partnered.

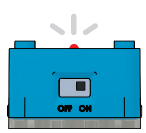
❏ Organize materials for easy group distribution.

❏ Read background information to familiarize yourself with LEDs and how they transfer energy.

Step 1 • Engage

❏ Students will recall that: the Cubes are magnetic, the Battery Cube has an on/off switch, and the LED has polarity.

❏ This is also a good time to discuss how to know if the Battery Cube needs to be recharged. When the Battery Cube is turned on, the small green indicator light stays on. When the Battery Cube needs to be recharged, this light will flash red.

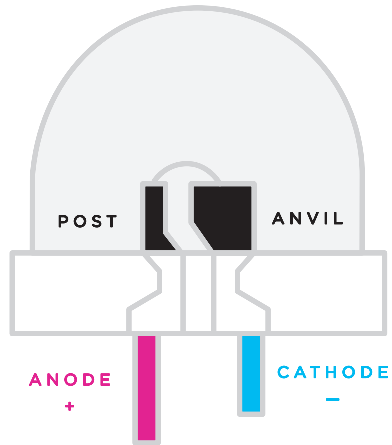


❏ Students can examine the LED Cube and make observations.

❏ **FOR EXAMPLE:** Look closely at the LED Cube to find the difference between the positive (Anode) and negative (Cathode) sides of the Post (+) and Anvil (-).

❏ Some students may offer prior knowledge about how the LED works.

❏ Share the diagram to explain the polarity.



❏ When students make an observation, pose questions such as:

- What do you see that makes you say that?
- What more can you find?
- Show your neighbor (elbow partner) something that you discovered.

Step 2 • Plan

❏ Instruct students to set aside the materials that are needed for the design. Students can place needed supplies on the STEM Starter Kit box to organize materials, and for a visual check to see that everyone is ready.

❏ Discuss the names and possible uses of the materials.

❏ For example, ask:

- What do the wires do?
- How can the wires change the design?

Step 3 • Make

❏ Display the instructions for building the flashlight. Instruct students to follow the directions to build a flashlight.

Step 4 • Notice and Wonder

❏ Once the flashlight is built, ask students to make observations as a group.

❏ Discuss such questions as:

- What worked, and when were they challenged?

- How did the wires add to the design?
- How could we use this design in future builds?

Step 5 • What would happen if…

- ❏ Have students explore possibilities for experiments by filling in the sentence starter: "What would happen if…?"
- ❏ The ideas could be recorded on the board, on the Student Observation and Reflection Sheet, or in a science journal.
- ❏ Students can explore these ideas by making a plan and discussing their predictions for what they think might happen.
- ❏ Provide time for students to test their own ideas, which will lead to their own designs.

Step 6 • Math Connection

- ❏ Have students calculate the intensity of light using a photometer or light meter (an app can be downloaded on your phone or tablet). Use this to measure the different intensities based on the distance of the light from the source. Students can write sentences explaining the relationship between the intensity of the light and the distance of the source. For reference, it varies as the inverse square of the distance from the light.

Step 7 • Reflect

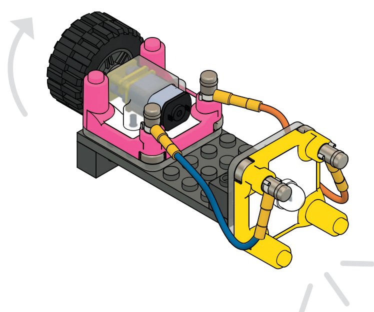
- ❏ Since students share the materials, it is important for them to reflect independently in their journals or on the Student Observation and Reflection Sheet. This is an opportunity to draw and write about the experience. Their entry may serve as a formative assessment of student understanding, or for the teacher to use as a reflection on what worked during the build.

Extension • Engineering Challenge

- ❏ Team up and have students design a flashlight, using the Cubes and common household materials, that will make the brightest light.

LESSON 3

Make a Hand-Crank Flashlight



Overview

APPROPRIATE FOR: Grades K – 8

STANDARDS FOR: Grades 2 – 4

DIFFICULTY: Easy

PREP TIME: 15 minutes

DURATION: 45 minutes

SUBJECT: Light

Student Focus Question

How can energy be transferred without the use of a battery?

Lesson Goal

Students will begin this activity by examining the Motor Cube. The goal is to see the gears. To experience the energy needed to power the light, students will build a Hand-Crank Flashlight.

Objectives

The purpose of this activity is to feel how much energy is needed to power an LED. We use kinetic energy to harness power. By creating a small hand crank, we can use the power from our bodies and convert it to electrical power.

Prior Knowledge Required

Students would benefit from experiencing Lesson 1, an investigation of the Cubes. These foundational activities allow students to gain prior knowledge with how the Cubes interact.

Vocabulary

ELECTRICAL ENERGY: energy absorbed or delivered by an electrical circuit

GEAR: a wheel with teeth that links with other gears and transmits rotational motion

LED: Light Emitting Diode—a device that emits light when an electric current is passed through it that conducts electricity in one direction

KINETIC ENERGY: energy associated with the motion of an object

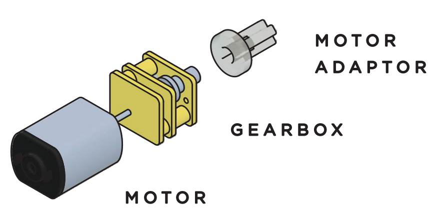
POTENTIAL ENERGY: energy stored by an object due to its position or state

Background

Gears are a set of toothed wheels that work together to make a smaller effort have more power. If you turn a larger gear that is connected to a smaller gear, you will cause the small one to spin quickly. Very little effort is needed to turn the gear. The energy is strong enough to power the light.

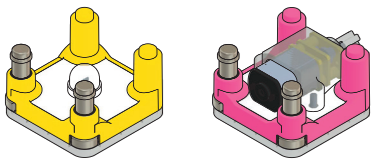
Remember, LEDs only allow current to flow in one direction. As a result, your hand-crank flashlight will only work in one of the two directions you turn it.

Energy from a person cranking the motor will spin the gears around a rotor. This rotor is connected to a shaft that when spun, creates electricity. Now, let's get cranking!



Supplies

CUBES



MATERIALS

- 4 x 8 plate
- 1 x 4 stud beams (2)
- Pegs (2)
- Connection wires (2)
- Wheel
- Science journal or Student Observation and Reflection Sheet

TOOLS

- Timer (optional)

Lesson Procedure

Setup

❏ Decide how students will be partnered.

❏ Organize materials for easy group distribution.

❏ Read Background Information to familiarize yourself with gears and how they transfer energy.

Step 1 • Engage

❏ Engage in a conversation about nutritious food with your students. Aside from it tasting good, why do we eat? What does food offer our bodies? Tell your students that today, they will use their stored energy to help power an LED.

Step 2 • Plan

❏ Students begin this activity with an investigation of the Motor Cube. Look closely at the parts and pay special attention to the gears. Elicit responses to questions such as:

- What do those gears do?
- How could we make them turn?
- What is happening when we turn them?
- What do the wires do?
- How can the wires change the design?

❏ Provide time for students to look, wonder, and ask follow-up questions.

Step 3 • Make

❏ Display the instructions for building the Hand-Crank Flashlight. Instruct students to follow the directions.

Step 4 • Notice & Wonder

❏ Once built, ask students to make observations as a whole group. Discuss questions such as:

- What worked, and when were they challenged?
- How did the wires add to the design?
- How could we use this design in future builds?
- How were the gears used to create electricity?

Step 5 • What would happen if...

❏ Have students explore possibilities for experiments by filling in the sentence starter: "What would happen if...?"

❏ The ideas could be recorded on the board, on the Student Observation and Reflection Sheet, or in a science journal.

❏ Students can explore these ideas by making a plan and discussing predictions for what they think might happen.

❏ Provide time for students to test their own ideas, which will lead to their own designs.

Step 6 • Remake

❏ If time allows, students could add to their designs.

- Using additional materials, challenge students to create a different type of crank.
- Using additional materials, challenge students to create a way to direct the light.

Step 7 Math • Connection

- ❏ Have students compete to see who can keep their Hand-Crank Flashlights lit the longest. Use a timer and graph the results as a class for each group.

Step 8 • Reflect

- ❏ Since students share the materials, it is important for them to reflect independently in their journals or on their Student Observation and Reflection Sheets. This is an opportunity to draw and write about the experience. Their entries may serve as a formative assessment of student understanding, or for the teacher to use as a reflection on what worked during the build.

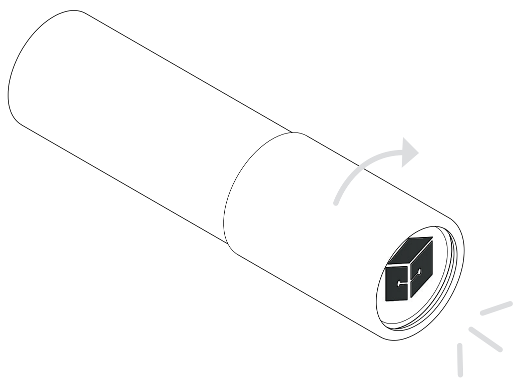
Extension • Engineering Challenge

- ❏ Have students team up and use the Hand-Crank Flashlight to send Morse Code messages across the sea. Ask students to develop a message and test it to see if the other team can translate it and send a message back.

LESSON 4

Make a GOBO Flashlight

(GOBO MEANS GOES BEFORE OPTICS)



APPROPRIATE FOR: Grades K – 8

STANDARDS FOR: Grades 2 – 4

DIFFICULTY: Easy

PREP TIME: 15 minutes

DURATION: 50 minutes

Student Focus Question

What effect does the distance of the LED to the GOBO disc have on the size on the projected image?

Lesson Goal

This activity has the students creating a flashlight, and then adding a template that shines through the device to project an image. Student teams will use Circuit Cubes to build a GOBO Flashlight.

Objectives

Through observations, teams will iterate their design. By asking questions and making observations, they will deepen their understanding of how the GOBO creates images with light and shadow, and how the size of the projected image can change.

Prior Knowledge Required

Students need to understand how the Battery Cube and the LED Cube work together to turn on the light.

Vocabulary

TRANSPARENT: material that allows light to travel through

TRANSLUCENT: material that allows some light to travel through

OPAQUE: material that blocks light from traveling through

ELECTROMAGNETIC SPECTRUM: the whole range of different kinds of light, from radio waves to gamma radiation

THERMAL ENERGY: energy associated with the vibration of molecules in a material

GOBO: (GOes Before Optics) is a template placed in front of a light source to produce light and shadow to make a design

PROJECTION: presentation of an image on a surface

Background

Objects vary in how they transmit light. Transparent objects allow light to travel through them. Materials like air, water, and clear glass are transparent. When light encounters transparent materials, almost all of it passes directly through them. Air, for example, is transparent to all visible light.

Translucent objects allow some light to travel through them. Materials like frosted glass and some plastics are translucent. When light strikes translucent materials, only some of the light passes through them. The light does not pass directly through the materials. It changes direction many times and is scattered as it passes through. Therefore, we cannot see clearly through them, and objects on the other side of a translucent object appear fuzzy and unclear.

Opaque objects block light from traveling through them and create a shadow. Most of the light is either reflected by the object or absorbed and converted to **THERMAL ENERGY**.

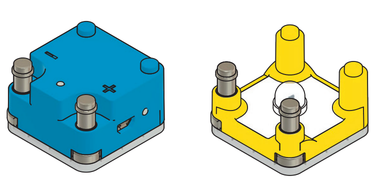
VISIBLE LIGHT is what you normally think of when you hear "light". There are lots of other kinds of "light", though, like microwaves, radio waves, ultraviolet, and infrared. The whole range of light is called the **ELECTROMAGNETIC SPECTRUM**. Just because something is transparent to one part of the spectrum, like visible light, doesn't mean that it is transparent to all kinds of light.

In a GOBO, a material is used to block the light and that material controls the shape and the sharpness of the emitted light. It's a lot like making shadow puppets. If the material is dark and/or thick, it will be more opaque and the image will be more distinct. If the material is light and/or thin, some of the light is able to pass through, which creates a light, fuzzy image. Students can also increase the size of the image by moving the GOBO tubes. Notice that if you extend the telescope tube, the beam pattern gets narrower and shines farther. What happens when you collapse the telescope tube? The area of the beam changes proportionally to the distance the telescope tube is moved.

Students can experiment with making GOBO images to find the best procedure and design!

Supplies

CUBES



MATERIALS

- telescope tubes
- connection wires
- 4 x 1 stud beam (2)
- 4 x 8 plate
- connectors (2)
- mylar discs for each student
- cardboard ring
- erasable markers
- clear transparent tape
- optional materials: felt, cardstock, or tissue paper
- instructions for assembling the GOBO
- science journals or Student Observation and Reflection Sheets

TOOLS

- Scissors (if using other materials for GOBO image)

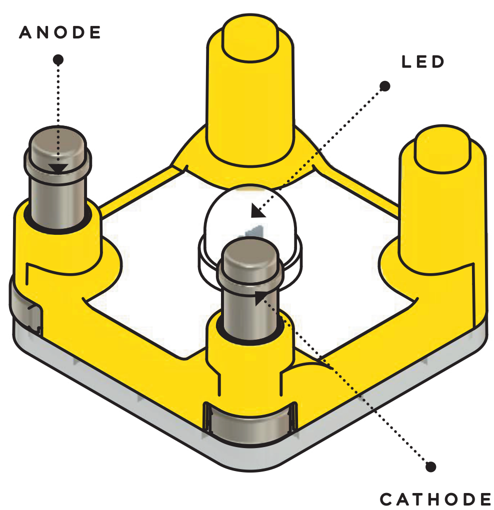
Lesson Procedure

Setup

❏ Decide how students will be partnered.

❏ Organize materials for easy group distribution.

❏ Read background information to familiarize yourself with LEDs and how they transfer energy.



Step 1 • Engage

❏ Begin this lesson with a student-driven exploration of the Cubes and wires. This is an open investigation and allows students to notice how the Circuit Cubes work.

Step 2 • Plan

- ❏ Begin this activity with a review of the parts for each of the Cubes. Students should be aware of the Battery Cube's on/off switch; that LEDs have polarity; that you can see the +/- parts of an LED by looking in the lens; and that the wires help extend the distance between the Cubes.
- ❏ Decide if you want to include other materials to use for the GOBO image, such as felt, cardstock, or tissue paper, and cut the materials into small strips for students to investigate.
- ❏ If you are using markers, test them ahead of time so you know they work and know how to clean the marker off the mylar discs.

Step 3 • Make

- ❏ Distribute instructions that illustrates how to assemble the inside of the flashlight using the Battery Cube, LED Cube, and wires.
- ❏ Once the flashlight is assembled, make observations.
- ❏ In students' science journals or informally, they should observe:
    - What happened when you or your group extended the tube?
    - What happened when you or your group contracted the tube?
- ❏ Ask your students to wonder why this device is called a GOBO. Explain the acronym (GOes Before Optics).
- ❏ Distribute the mylar discs and markers to each team, and instruct students to draw a simple image.
- ❏ Give students time to assemble the GOBO.

Step 4 • Notice & Wonder

- ❏ Have teams share their observations with another team: What do they notice when using their GOBO flashlight?
- ❏ As groups share their designs, take note of vocabulary used, challenges faced, and observations made.
- ❏ Have students write down their questions about their own design or others.
- ❏ Have student share their questions. Did they find students who had similar questions?
- ❏ What could they investigate together as a group?

Step 5 • What would happen if...

- ❏ Have students explore possibilities for experiments by filling in the sentence starter: "What would happen if...?"
- ❏ The ideas could be recorded on the board, on the Student Observation and Reflection Sheet, or in a science journal.
- ❏ Students can explore their ideas by making a plan and discussing predictions for what they think might happen.
- ❏ Provide time for students to test their own ideas, which will lead to their own designs.

Step 6 • Remake

- ❏ If time allows, students should create additional lenses. You can distribute the other optional materials listed at the beginning of the lesson for students to tape on the mylar discs. Ask students to consider:
    - How do the different materials affect the image that is projected?
    - How would you describe the materials? (e.g., translucent or opaque).
    - How did the length of the telescope tube change the image?
- ❏ Discuss what you heard each team mention. Ask for groups to share their observations.
- ❏ Provide an additional 10 minutes to remake.

Step 7 • Math Connection

- ❏ Use the GOBO flashlights to explore shapes by making some lenses of your own. Make designs with triangles, squares, rectangles, etc., and distinguish defining attributes of the shapes through observation and class discussion.

Step 8 • Reflect

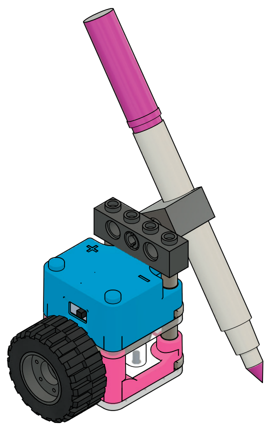
Since students share the materials, it is important for them to reflect independently in their science journals or on the Student Observation and Reflection Sheets. This is an opportunity to draw and write about the experience. Their entries may serve as a formative assessment of student understanding, or for the teacher to use as a reflection on what worked during the build.

Extension • Engineering Challenge

Have students team up and use the GOBO to make an original symbol to shine on the ceiling. Student could be given the example of calling Batman, and they could think of their own symbol to communicate. They can make the design and create a meaning, like to ask for help, invite others to celebrate, or to know where to meet up after an earthquake. Anything is possible!

LESSON 5

Make a 1-Marker Scribblebot



APPROPRIATE FOR: Grades K–8

STANDARDS FOR: Grades K – 2, Grades 3 – 5

PREP TIME: 5 minutes

DURATION: 45 minutes

TOPIC: Art

Student Focus Question

How can patterns help make predictions in work of art from a Scribblebot?

Lesson Goal

Students create a robot, and then make observations and predictions about the patterns it creates.

Objectives

Through observations, teams will iterate their design. By asking questions and making observations, they will deepen their understanding of patterns.

Prior Knowledge Required

None

Vocabulary

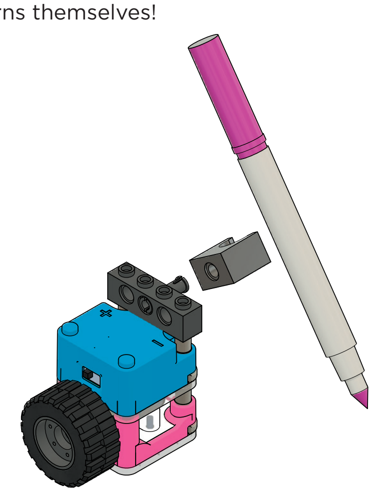
PATTERN: similarities and differences that can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena and designed products

SYMMETRY: the balance of proportion where the two halves are mirror images of each other

Background

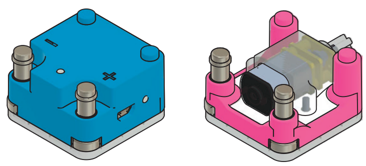
Patterns are similarities and differences that can be used to sort, classify, communicate, and analyze simple rates of change for natural phenomena and designed products. Pattern recognition is an important skill in science and engineering. Aesthetic patterns can be found in nature, including snowflakes, flower petals, crystals, and animal prints. Symmetry appears in nature and is a balance of proportion; it can be important with visual patterns. These natural designs have influenced designs made by engineers. When observing patterns, students can identify symmetry and detect when it's not consistent. Observations and investigations of patterns can help students be more conscience of what they are observing.

In order to understand patterns, students prompt questions about relationships and the factors that influence them. This activity boosts pattern awareness and recognition. It also encourages interest in how the patterns are formed and how to predict them in future testing. Most of the fun comes from creating the patterns themselves!



Supplies

CUBES



MATERIALS

- wheel
- 4 x 1 stud beam
- marker
- marker holder
- bushing
- axle
- white butcher paper to cover tables/desks for art creations
- tape
- science journals or Student Observation and Reflection Sheets

TOOLS

- video or digital image device to capture and document student engagement, processing, and learning

Setup

❏ Decide how students will be partnered.

❏ Organize materials for easy group distribution.

❏ Read background information to familiarize yourself.

Step 1 • Engage

❏ Begin this lesson with a student-driven exploration of the Cubes and wires. This is an open investigation and allows students to notice how the Circuit Cubes and the added materials work.

Step 2 • Plan

❏ Begin this activity with a review of the parts for each of the Cubes. Students should be aware of the Battery Cube's on/off switch; that the Motor Cube is 2-directional; and how the wheel and other materials are added to the Cubes.

❏ Students share observations and make predictions about how they think they will want to make their Scribblebot.

Step 3 • Make

❏ Distribute instructions that illustrates how to assemble the 1-Marker Scribblebot using the provided materials.

❏ Give students time to create their Scribblebots.

Step 4 • Notice & Wonder

❏ Once the Scribblebot is assembled, make observations.

❏ In students' science journals, on Student Observation and Reflection Sheet, or informally, they should observe and record:

- Is there a difference in the designs the pen makes when you change the location of the pen's attachment point on the bot?
- Can you predict the direction of the bot?
- Can you predict the pattern the pen will make?

❏ Have teams share their observations with another team. What do they observe?

Step 5 • What would happen if...

❏ Have students explore possibilities for experiments by filling in the sentence starter: "What would happen if...?"

❏ The ideas could be recorded on the board, on the Student Observation and Reflection Sheet, or in a science journal.

❏ Students can explore their ideas by making a plan and discussing predictions for what they think might happen.

❏ Provide time for students to test their own ideas, which will lead to their own designs.

Step 6 • Math Connection

- ❑ Have students recognize a line of symmetry for their design by folding it into matching parts and drawing the lines of symmetry. Identify if the drawing is not symmetrical and tell why.

Step 7 • Remake

- ❑ If time allows, students should redesign and modify their Scribblebots in order to change the art pattern.

Step 8 • Reflect

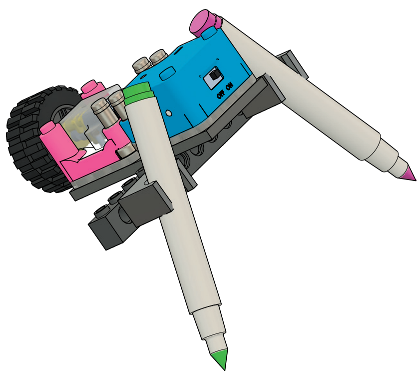
- ❑ Since students share the materials, it is important for them to reflect independently in their journals or on the Student Observation and Reflection Sheets. This is an opportunity to draw and write about the experience. Their entries may serve as a formative assessment of student understanding, or for the teacher to use as a reflection on what worked during the build.

Extension • Engineering Challenge

- ❑ Ask students to group up and try to create a bullseye with their Scribblebot. Set up a group testing area where each group member will use a different color to create each section.
- ❑ Have the students then compare how they changed their Scribblebots to make the design.

LESSON 6

2-Marker Scribblebot



APPROPRIATE FOR: Grades K-8

STANDARDS FOR: Grades K-2, Grades 3-5

DIFFICULTY: Moderate

PREP TIME: 5 minutes

DURATION: 50 minutes

SUBJECT: Art

Student Focus Question

How can you change the diameter in a work of art made by a Scribblebot?

Lesson Goal

Students create a Scribblebot, and then make observations about the diameter of the drawings it creates.

Objectives

Students test their ideas on how to change the diameter of the circles created by the Scribblebot.

Prior Knowledge Required

How to build a 1-Marker Scribblebot (from previous lesson).

Vocabulary

DIAMETER: the straight line passing through the center of circle

Background

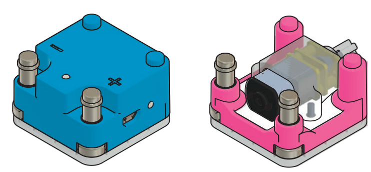
There are so many circles around us—hula hoops, clock faces, hub caps, tortillas, and more! How do you measure a circle? This activity helps you explore this question while engaging in some exciting art-making.

All the points on a circle are equally distant from the center point. The line passing straight through the center of a circle is called the **DIAMETER**. This is one of the attributes you can measure on a circle using a ruler or a meter stick.

In this activity, you can also count the number of circles the Scribblebot makes. The number of circles created in one minute will differ depending on the length of time the Scribblebot is in action and the size of the circles created. What can make the diameter of the circles longer or shorter?

Supplies

CUBES



MATERIALS

- wheel
- 12 x 1 stud beam
- 4 x 8 plate
- markers (2)
- marker holders (2)
- pegs (2)
- yarn (optional)
- science journals or Student Observation and Reflection Sheets

TOOLS

- Ruler or meter stick, digital device for recording

Lesson Procedure

Setup

- ❑ Bundle materials into sets, so that students can easily view them from their desk or table group.
- ❑ Determine how students will be partnered.

Step 1 • Engage

- ❑ Begin this lesson with a student-driven exploration of the Cubes and wires. This is an open investigation and allows students to notice how the Circuit Cubes work.

Step 2 • Plan

- ❑ Challenge your class to design and draw all their ideas for building a 2-Marker Scribblebot with a certain diameter for one or both of the circles created (e.g., 6 cm and 12 cm).
- ❑ Tell students that they will first brainstorm how they will change the diameter.
- ❑ They will later get into teams to plan, build, and test the design.
- ❑ Remind students that in order to make the pens create a pattern, they will need energy. Ask the class where the energy is being stored.
- ❑ Have each student brainstorm in their science notebook or on a sheet of paper and document their initial design process. Tell students that they will work quietly and independently for 10 minutes.
- ❑ They may touch the materials as they plan, but no building yet.
- ❑ Students will write and draw all their ideas for building a 2-Marker Scribblebot that can produce a 12-centimeter diameter.
- ❑ Once they have finished one design, they can create a second design with a 6-centimeter diameter.
- ❑ Remind students to draw pictures and label the parts.
- ❑ For visual learners and ELD students, create a Word Bank for the names of the materials and concepts.
- ❑ As students work on their designs, circulate and ask questions such as:
  - What direction do you think the bot will travel?
  - What do you see that makes you say that?
  - What type of pattern do you think 2 pens will make?
  - What do you think will happen if you move the pens to different locations on the axle?
- ❑ After 10 minutes, ask students to partner up to share their ideas. Instruct students to listen to their partner, and to ask clarifying questions when the purpose of a part is unclear. Collect the designs.

Step 3 • Make

- ❑ Using their Student Observation and Reflection Sheets and feedback from teammates, teams will determine which design(s) to build together and decide on the jobs or roles each team member will have.
- ❑ Allow 20–30 minutes for design investigations.
- ❑ Share the instructions that illustrate how to assemble the 2-Marker Scribblebot using the provided materials.
- ❑ Have students test their Scribblebots and use a ruler to calculate the diameter of their design. Be sure to have students measure their diameter consistently by modeling for them. They can also lay a piece of yarn over the design and cut it with scissors to the correct length. This piece of yarn can be measured to make the process more accurate.
- ❑ Circulate to document their processes with your digital device, and to ask open-ended questions.
- ❑ Resist solving issues for teams; instead, ask questions like:
  - What have you tried so far?
  - What worked, and when were you challenged?
  - How has your team decided that your jobs are fair and equal?

- What do you want your design to do?
- How will moving the pen(s) along the axle change your pattern?
- What did you notice about the 2-Marker Scribblebot?
- What have you discovered about the pattern(s) that your Scribblebot makes?

Step 4 • Notice and Wonder

❏ Once the Scribblebot is assembled, make observations.

❏ Have teams share their observations with another team. What do they notice?

❏ After the 20–30 minutes are over, ask each team to share something that surprised them or made their team struggle during this investigation.

❏ Then, have them show the class the pattern that their Scribblebot made.

❏ Have students write down their questions about their Scribblebot.

❏ Have student share their questions. Did they find students who had similar questions?

❏ What could students do to answer their questions?

Step 5 • What would happen if...

❏ Have students explore possibilities for experiments by filling in the sentence starter, "What would happen if...?"

❏ The ideas could be recorded on the board, on the Student Observation and Reflection Sheet, or in a science journal.

❏ Students can explore their ideas by making a plan and discussing predictions for what they think might happen.

❏ Provide time for students to test their own ideas, which will lead to their own designs.

Step 6 • Math Connection

❏ Have students compare their Scribblebot pattern to others in class, note similarities and differences in the designs, and construct a viable argument.

❏ Ask students: How do we measure the circumference of the design? What tool or tools are needed?

Step 7 • Remake

❏ Invite teams to redesign their Scribblebot after viewing the patterns made by the other Scribblebots.

❏ Once each team has had a chance to redesign their Scribblebot, remind them to note their design changes in their notebooks.

❏ After a few trials, student pairs choose their favorite Scribblebot design and let it loose on a section of butcher paper shared by the entire class. They sign their names next to their bot's design so that the end result is a colorful banner that can be hung in the classroom to showcase the work of each class.

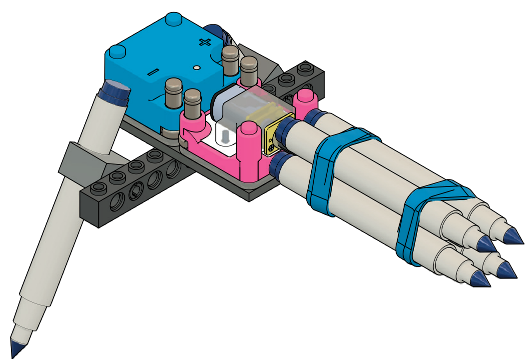
❏ If time allows, teams share their new findings and designs. Then, teams return all materials.

Step 8 • Reflect

❏ Since students share the materials, it is important for them to reflect independently in their journals or on the Student Observation and Reflection Sheet. This is an opportunity to draw and write about the experience. Their entries may serve as a formative assessment of student understanding, or for the teacher to use as a reflection on what worked during the build.

LESSON 7

Make a 6-Marker Scribblebot



APPROPRIATE FOR: Grades K–8

STANDARDS FOR: Grades K–2, Grades 3–5

DIFFICULTY: Moderate

PREP TIME: 5 minutes

DURATION: 50 minutes

SUBJECT: Art

Student Focus Question

What does the design process look like when creating a 6-Marker Scribblebot?

Lesson Goal

The focus of this lesson is on the design process, and students will use this experience to document their progress.

Objective

Students are challenged to create a 6-Marker Scribblebot based on their previous constructions.

Prior Knowledge Required

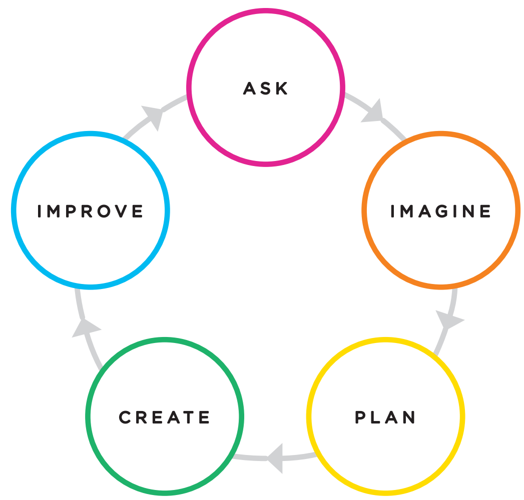
Students would benefit from having experienced building previous versions of Scribblebots in Lessons 5 and 6.

Vocabulary

DESIGN PROCESS: a series of steps an engineer uses to solve a problem by designing a solution

Background

The design process is an important procedure in engineering. Its purpose is to come up with a solution to a problem. The process can be long, because it's often the continuous iteration of ideas that leads to successful outcomes.



ASK

The first step of the process is to ask questions to clarify the problem and the purpose of the project. Often in engineering, there are also constraints, such as materials and time, that should be determined. This is important to know and factor in when designing solutions. Solutions need to be reasonable and within the means of the students to enact.

IMAGINE

The second step is where the creativity comes in. Students will imagine innovative solutions that they want to test. The brainstorming process should be conducted in a small group setting to allow students to bounce ideas around. This is also where teachers should lay some ground rules so that every group member is heard and everyone's input is included when choosing the best design idea to pursue.

PLAN

The plan involves drawing a sketch and deciding the materials needed for the agreed-upon design. This description of the product will be used later to discuss changes and tweaks for future prototypes.

CREATE

It's time to create! Students can follow their plan to assemble their first prototype. As students build their Scribblebot, they will most likely experience challenges, and will be changing and tweaking their designs along the way. Circuit Cubes are designed to facilitate this part of the process. Students should be encouraged to freely design on the spot, if their plan doesn't work the way they expected. It is important to encourage students to engage and persist when they get frustrated or feel like giving up.

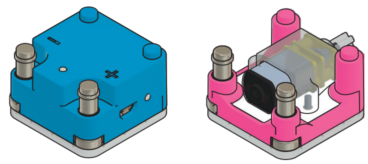
IMPROVE

The next step is for students to to improve their first design. This can happen after the groups have had time to problem-solve, and they are ready to stop and think about the process and their product so far. Often, groups will be at different stages at this point. Some may have a successful 6-Marker Scribblebot, others could still be working on a functional design. Regardless of the stage that they are in, students should document their process by sketching their new design or an improved design idea.

Once they have adequately documented their improved design, there are always opportunities to change it or make it better. This process can be endless and we encourage you to see it through! Reflection is key, so students should be given time to review their experiences and share.

Supplies

CUBES



MATERIALS

- 1 x 12 stud beams
- 4 x 8 plate
- pegs
- rubber bands
- markers (6)
- axles
- bushings
- wheels
- gears
- holders
- science journals or Student Observation and Reflection Sheets

TOOLS

The charts from previous investigations, fresh butcher paper for today's student Scribblebot patterns, video or digital image device to capture and document student engagement, processing, and learning, and pencils to use for brainstorming

Lesson Procedure

Setup

❏ Bundle materials into sets so that students can easily view them from their desk or table group, or use materials distribution procedures already established.

❏ Determine how students will be partnered.

Step 1 • Engage

❏ Begin this lesson with a student-driven exploration of the Cubes and wires. This is an open investigation and allows students to notice how the Circuit Cubes work.

- ❏ Introduce the challenge and inform student they will be coming up with their own design for a 6-Marker Scribblebot.
- ❏ Give students an opportunity to ask you questions about the purpose and the constraints.

Step 2 • Plan

- ❏ Share with students the design process: Ask, Imagine, Plan, Create, and Improve.
- ❏ Explain that students will be documenting throughout the design process with pictures and video.

Step 3 • Make

- ❏ Show the class the additional materials to use in today's investigation. Tell students that they will first brainstorm an idea on their own.
- ❏ Later, they will get into teams to plan, build, and test the design.
- ❏ Remind students that in order to make the pens create a pattern, they will need energy. Ask the class where the energy is being stored.
- ❏ Have each student brainstorm in their science notebooks or on sheet of paper that will be used to document their initial process of designing. Tell students that they will work quietly and independently for 5–10 minutes.
- ❏ They may touch the materials, but no building yet.
- ❏ Students will write and draw all their ideas for building a 6-Marker Scribblebot.
- ❏ Once they have finished one design, they will create a second design.
- ❏ Remind students to draw pictures and label the parts.
- ❏ For visual learners and ELD students, create a Word Bank for the names of the materials and concepts.
- ❏ As students work on their designs, circulate and ask questions such as:
    - Why did you choose to use the material in that way?
    - Where will you be able to access the power switch?
    - What direction do you think the bot will travel?
    - What do you see that makes you say that?
    - What type of pattern do you think that 6 pens will make?
    - What do you think will happen if you move the pens to different locations?
- ❏ After 10 minutes, ask students to join a small group or pair and share their ideas. Instruct students to listen to their partner(s) and ask clarifying questions when the purpose of a part is unclear.

Step 4 • Notice & Wonder

- ❏ Using their design sheets and feedback from teammates, teams are to determine which design(s) to build together, and establish equal jobs or roles; or, the teacher can assign partners (e.g., "A" and "B") to regulate shared build time.
- ❏ Allow 20–30 minutes for design investigations.
- ❏ Circulate to document students' processes with your digital device and to ask open-ended questions.
- ❏ Resist solving issues for teams; instead, ask questions like:
    - What have you tried so far?
    - How has your team decided that your jobs are fair and equal?
    - What do you want your design to do?
    - How will moving the pen(s) to different locations change your design?
    - What did you notice about the 6-Marker Scribblebot?
    - How does this pattern differ from the 1- and 2-Marker Scribblebots?
    - How are they the same?
    - What have you discovered about the pattern(s) that your Scribblebot makes?

- ❏ After the 20–30 minutes are over, ask each team to share something that surprised them or made their team struggle during this investigation.
- ❏ Then, teams show their classmates the pattern that their Scribblebot made.

Step 5 • What would happen if...

- ❏ Have students explore possibilities for experiments by filling in the sentence starter: "What would happen if...?"
- ❏ The ideas could be recorded on the board, on the Student Observation and Reflection Sheet, or in a science journal.
- ❏ Students can explore their ideas by making a plan and discussing predictions for what they think might happen.
- ❏ Provide time for students to test their own ideas, which will lead to their own designs.

Step 6 • Math Connection

Have students time how long their Scribblebot can turn without falling apart or going off the table. Graph the results.

Step 7 • Remake

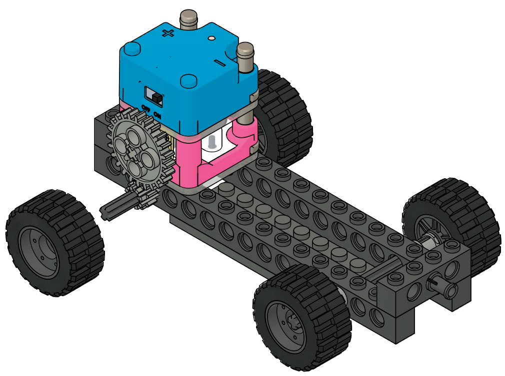
- ❏ Invite teams to redesign their Scribblebot after viewing the patterns made by the other Scribblebots.
- ❏ Once each team has had a chance to redesign their Scribblebots, remind them to note their design changes in their notebooks.
- ❏ If time allows, have teams share their new findings, then teams should return all materials.

Step 8 • Reflect

- ❏ Since students share the materials, it is important for them to reflect independently in their journals. This is an opportunity to draw and write about the experience. Their entries may serve as a formative assessment of student understanding, or for the teacher to use as a reflection on what worked during the build.

LESSON 8

Build the Chassis!



APPROPRIATE FOR: Grades K – 8

STANDARDS FOR: Grades K – 2, Grades 3 – 5

DIFFICULTY: Moderate

PREP TIME: 10 minutes

DURATION: 60 – 70 minutes

SUBJECT: Mechanics

Student Focus Question

How do gears affect the movement of a car?

Lesson Goal

Students will follow a plan to learn how gears interact and how they affect the movement of the car.

Objective

The goal of this lesson is for students to see how the speed of the car is affected by the gears.

Prior Knowledge Required

None

Vocabulary

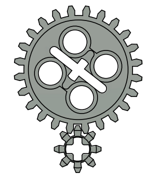
CHASSIS: the base frame of a motor vehicle

COG: tooth on the rim of a gear

GEAR: one of a set of toothed wheels that work together to make a smaller effort have more power

SIMPLE MACHINE: a mechanical device that makes work easier

SPEED: a way to measure motion by looking at how far something traveled compared to how long it took to get there



Background

When you think of simple machines, you may think of a screw, lever, wedge, pulley, or ramp. The simple machines that make our life easier also include gears, because gears harness force. This simple machine is basically a wheel with teeth, sometimes known as a cog. To create a gear, you must have two teeth that fit into another toothed wheel. There are vast arrays of differently sized gears to do various types of work. If you turn a larger gear that is connected to a smaller gear, you will cause the small one to spin quickly. Very little effort is needed to turn the gear. In contrast, by spinning the smaller gear, the larger one spins much slower. However, the force is stronger.

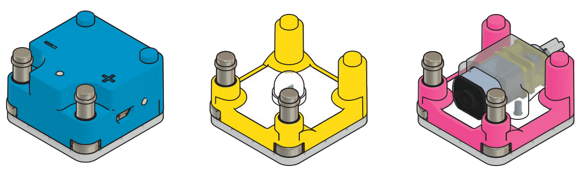
If a gear gives you more force, it gives you less speed at the same time. If it gives you more speed, it has to give you less force. Just as one gear can make another turn faster, it can also cause it to change direction. If you spin one gear to the right, it will turn the other to left. This can be important when machines need to change direction.

If don't want to sweat riding your bike up a steep hill, you will appreciate gears. Or, if you love roller coasters and Ferris wheels, you can thank the fine-tuned gear ratios that make this wonderful work happen. Whether it's for a watch or a gigantic crane, gears make our life much easier.

How would you describe the car's motion? Pay attention to how far has the car traveled and how long did it took to get to a fixed point. These observations can lead you to calculate the distance and the time. These two factors can be used to calculate the speed. Speed is measured by looking at how far something traveled compared to how long it took to get there. Speed = Distance/Time

Supplies

CUBES



MATERIALS

- gears (2)
- axles (2)
- 1 x 4 stud beam (2)
- 4 x 8 plate
- 1 x 16 stud beam (2)
- wheels (4)
- bushings (3)
- peg
- science journals or Student Observation and Reflection Sheets

TOOLS

- Meter stick or ruler
- Timer

Lesson Proceedure

Setup

❏ Organize materials for easy group distribution.

❏ Read background information to familiarize yourself with gears and how they transfer energy.

❏ Decide how students will be partnered and organize materials for easy group distribution.

Step 1 • Engage

❏ Begin this lesson with a student-driven exploration of the Cubes and wires. This is an open investigation and allows students to notice how the Circuit Cubes work.

Step 2 • Plan

❏ Begin this activity with a review of the parts for each of the Cubes. Students should be aware of the Battery Cube's on/off switch; that the wires help extend the distance between the Cubes; the gears affect how quickly the wheels will turn; and that the Cubes can be stacked.

Step 3 • Make

❏ Distribute instructions that illustrate how to assemble the chassis of the car using the supplied materials. Provide 15 minutes for students to build and observe how the car moves.

Step 4 • Notice & Wonder

❏ In students' science journals or informally, they should observe:

- What happened when you switch the gears?
- What did you notice about the gears?
- Do the gears need to be the same size?
- What happens when gears are not the same size?
- How did the gears help the car move?

❏ Challenge your students with the following questions:

- Can you make the car go faster or slower?
- Did you notice if both gears turn the same direction or not?
- How might you calculate the speed?

Step 5 • What would happen if...

❏ Have students explore possibilities for experiments by filling in the sentence starter: "What would happen if...?"

- ❏ The ideas could be recorded on the board, on the Student Observation and Reflection Sheet, or in a science journal.
- ❏ Students can explore their ideas by making a plan and discussing predictions for what they think might happen.
- ❏ Provide time for students to test their own ideas, which will lead to their own designs.

Step 6 • Math Connection

- ❏ Have students collect data and create a line plot to measure the distance of their car in x number of trials.
- ❏ Have students collect data and create a line plot to measure the speed of their car on an inclined plane.

Step 7 • ReMake

- ❏ If time allows, distribute an LED Cube to each group. Challenge your students to add this Cube to their car.

Step 8 • Reflect

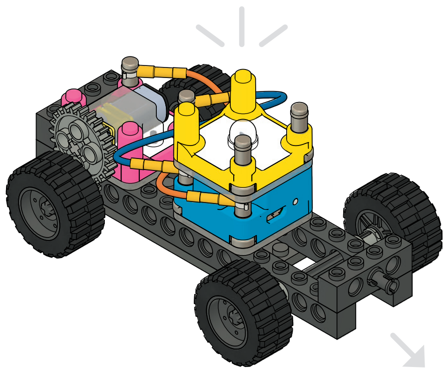
- ❏ Since students share the materials, it is important for them to reflect independently in their journals or on the Student Observation and Reflection Sheet. This is an opportunity to draw and write about the experience. Their entries may serve as a formative assessment of student understanding, or for the teacher to use as a reflection on what worked during the build.

Extension • Engineering Challenge

- ❏ Students will use their chassis designs to make a car that can travel the slowest, for safety, and carry the most pencils without them falling out.

LESSON 9

Hack Your Ride!



APPROPRIATE FOR: Grades K – 8

STANDARDS FOR: Grades K – 2, Grades 3 – 5

DIFFICULTY: Moderate

PREP TIME: 10 minutes

DURATION: 60 minutes

SUBJECT: Mechanics

Student Focus Question

What is the relationship between the electronic interactions and polarity occurring in the car?

Lesson Goal

This activity allows students to use what they know about the Motor Cube to build a car that can be motorized, uses gears, can be turned on and off, and uses the LED Cube as a light source. The design also addresses the polarity of the motor and how that affects movement.

Objective

The goal of this lesson is for students to ask questions to determine cause-and-effect relationships of polarity of the Motor Cube.

Prior Knowledge Required

"Building a Chassis" (Lesson 8) would be helpful to do before this lesson.

Vocabulary

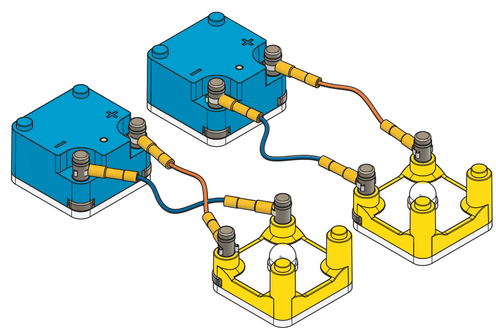
POLARITY: the position of the poles and the direction of the magnetic or electric field

Background

The electric currents and magnetism of the Motor Cube are fundamentally interrelated, meaning that an electric current in the motor will induce a corresponding magnetic field having a certain polarity. If the direction of the current in the motor is reversed, the polarity of the magnetic field is reversed.

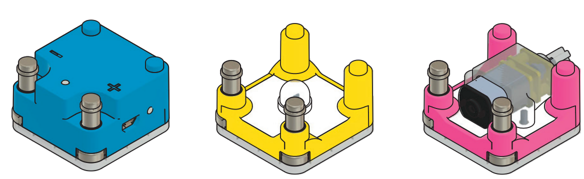
The current from a battery flows out from the "Positive" terminal, through the circuit and then back into the "Negative" terminal of the battery. All batteries have a "+" and a "-" symbol that indicate the correct polarity. To reverse the motor, you can reverse the connection of the battery by switching the wires to different terminals.

Let's experiment using this new car design!



Supplies

CUBES



MATERIALS

- gears (2)
- axles (2)
- 1 x 4 stud beam (2)
- 1 x 16 stud beam (2)
- connection wires (2)
- wheels (4)
- 4 x 8 plate
- pegs (4)
- science journals or Student Observation and Reflection Sheets

TOOLS

- Timer
- Meter stick or ruler

Lesson Proceedure

Setup

- ❏ Decide how students will be partnered.
- ❏ Organize materials for easy group distribution.
- ❏ Read background information to familiarize yourself with gears and how they transfer energy.

Step 1 • Engage

- ❏ Begin this lesson with a student-driven exploration of the Cubes and wires. This is an open investigation and allows students to notice how the Circuit Cubes work.

Step 2 • Plan

- ❏ Review of the parts for each of the Cubes. Students should be aware of the Battery Cube's on/off switch; that the wires help extend the distance between the Cubes; that the gears affect how quickly the wheels will turn; and that the Cubes can be stacked.
- ❏ If you have not yet had an open investigation with the LED Cube, it is recommended that students have a chance to play with this Cube before offering this investigation.
- ❏ Once students have had the opportunity to investigate all three Cubes, provide the challenge: How can you design the car to make the wheels turn in the opposite direction?

Step 3 • Make

- ❏ Build the vehicle by following the instructions. Students will need to incorporate the Battery Cube, Motor Cube, and LED Cube.

Step 4 • Notice & Wonder

- ❏ Ask students to make note of the direction of the Motor Cube's spindle when it is attached to the Battery Cube and turned on.
- ❏ Challenge students to see what would happen if they changed different aspects of the design.
  - What works to change the direction of the car, and why?
  - What doesn't work, and why?
  - What would change the speed of the car? Why?

Step 5 • What would happen if...

- ❏ Have students explore possibilities for experiments by filling in the sentence starter: "What would happen if...?"
- ❏ The ideas could be recorded on the board, on the Student Observation and Reflection Sheet, or in a science journal.
- ❏ Students can explore their ideas by making a plan and discussing predictions for what they think might happen.
- ❏ Provide time for students to test their own ideas, which will lead to their own designs.

Step 6 • Remake

- ❏ Based on observations and team sharing, teams revise their designs and change the way the wires are attached switching the polarity.
- ❏ Teams use their science journals or Student Observation and Reflection Sheet to record how the energy is flowing. Bring the investigation to a

close with final observations prior to the return of materials.

Step 7 • Math Connection

- ❏ Have students calculate the speed of their vehicle by measuring the distance and the time.
- ❏ Add friction to the track and see how it slows down the movement of the car, using a set distance and a timer.

Step 8 • Reflect

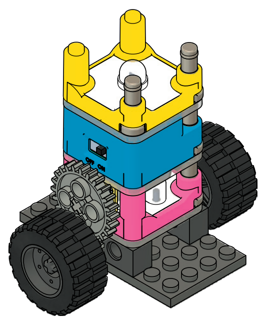
Since students share the materials, it is important for them to reflect independently in their journals or on the Student Observation and Reflection Sheet. This is an opportunity to draw and write about the experience. Their entries may serve as a formative assessment of student understanding, or for the teacher to use as a reflection on what worked during the build.

Extension • Engineering Challenge

Time for the Backwards Race! Make a straight path with a starting line and finish line in the classroom. Set up all the cars at the starting line, turn on the Battery Cubes, and hold the cars in place until the countdown ends and you yell “Go!” See which car can stay on track without running into others and make it to the finish line. Which cars didn’t make it, and why? Change the design or set-up to make it a close race.

LESSON 10

Build a Tower



APPROPRIATE FOR: Grades K–8

STANDARDS FOR: Grades K–2, Grades 3–5

DIFFICULTY: Moderate

PREP TIME: 5 minutes

DURATION: 60 minutes

SUBJECT: Movement

Student Focus Question

How does the pathway of energy differ in the Tower design from previous designs?

Lesson Goal

This activity allows students to use what they know about the Cubes to build a tower that is motorized, uses the LED Cube as a light source, uses gears, and uses the Battery Cube as the energy source. Students will explore how this design is different from others they have made due to the multiple pathways available for energy to travel.

Objective

The goal of this lesson is for students to understand the electronic interactions in a parallel circuit.

Prior Knowledge Required

Experience with exploring circuits in Lesson 1 will be helpful in the design process.

Vocabulary

BALANCE: an even distribution of weight to make something upright and steady

CAUSE AND EFFECT: a relationship that is used to explain change

PARALLEL CIRCUIT: a closed loop that has several paths for energy to flow

SERIES CIRCUIT: a closed loop where there is only one path for energy to flow

SYMMETRY: the balance of proportion in which the two halves are mirror images of each other

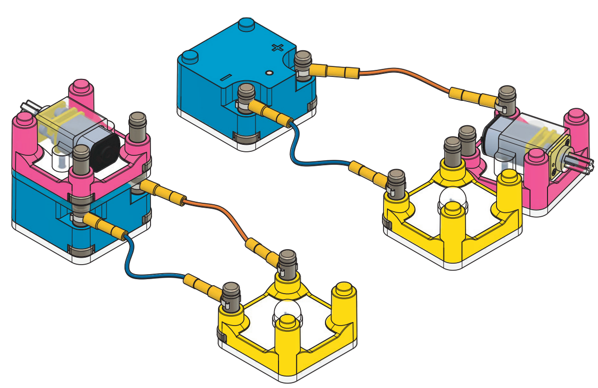
VOLTAGE: electromotive force or potential difference as expressed in volts

RESISTANCE: electrical quantity that measures how the device or material reduces the electric current flow through it

Background

An electrical circuit is a pathway made of metal that allows energy (electrons) to flow. There are two main kinds of circuits: series circuits and parallel circuits.

A series circuit provides one continuous path for electrons to flow through the circuit.



A parallel circuit is one with several different paths for the electricity to travel. Imagine it being like the circulatory system where the blood flows through veins and arteries, but they all come back to the heart.

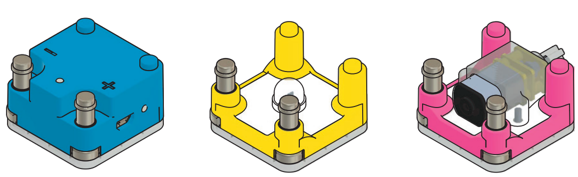
The parallel circuit has very different characteristics than a series circuit. For one, the total resistance of a parallel circuit is not equal to the sum of the resistors (as with a series circuit). The total resistance in a parallel circuit is always less than any of the branch resistances. Adding more parallel resistances to the paths causes the total resistance in the circuit to decrease. As you add more branches to the circuit, the total current will increase because the lower the resistance, the higher the current.

The voltage drops across a resistor in series. Not so with a parallel circuit. The voltage will be the same anywhere in the circuit.

Students do not need to know specific vocabulary related to parallel circuits and series circuits, however it is valuable for them to see different examples of how energy is transferred.

Supplies

CUBES



MATERIALS

- gears (2)
- axle (1)
- 1 x 4 stud beam (2)
- 4 x 8 plate
- wheels (2)
- bushing
- instructions
- science journals or Student Observation and Reflection Sheets, pennies (optional)
- clear tape (optional)

TOOLS

- Meter stick (optional)

Lesson Procedure

Setup

- ❏ Decide how students will be partnered.
- ❏ Organize materials for easy group distribution.
- ❏ Read background information to familiarize yourself with circuits and how they transfer energy.

Step 1 • Engage

- ❏ Begin this lesson with a student-driven exploration of the Cubes and wires. This is an open investigation and allows students to notice how the Circuit Cubes and wires work.

Step 2 • Plan

- ❏ Review the parts for each of the Cubes discovered in previous investigations. Students should be aware of the Battery Cube's on/off switch; that the gears affect how quickly the wheels will turn; and that the Cubes can be stacked.
- ❏ If you have not yet had an open investigation with the LED Cube, it is recommended that students have a chance to play with this Cube before continuing with this investigation.
- ❏ Explain that today's investigation is to stack the cubes to create a moveable Tower.
- ❏ Have students make observations of the image of the Tower, and discuss and describe the balance and symmetry in the design.
- ❏ Students share observations and make predictions about how they think the energy moves in the stacked Tower.
- ❏ Direct teams to decide how to assign tasks equally, or assign roles.
- ❏ Give teams access to kit materials.

Step 3 • Make

- ❑ Teams collect their materials and begin to build using the instructions.
- ❑ Circulate to document students' processes with your digital device and ask open-ended questions such as:
  - What have you tried so far?
  - Have you succeeded in getting your Tower to work?
  - How do you know you succeeded?

Step 4 • Notice & Wonder

- ❑ How are the Cubes lined up in the design?
- ❑ Is there a difference in the pathway of energy when the Cubes' orientation is changed?
- ❑ How is the energy flowing? Draw the pathways where the energy can flow.
- ❑ Ask teams to share their discoveries.
- ❑ Students record observations, sketches, and unanswered questions in their science journals.

Step 5 • What would happen if...

- ❑ Have students explore possibilities for experiments by filling in the sentence starter: "What would happen if...?"
- ❑ The ideas could be recorded on the board, on the Student Observation and Reflection Sheet, or in a science journal.
- ❑ Students can explore their ideas by making a plan and discussing predictions for what they think might happen.
- ❑ Provide time for students to test their own ideas, which will lead to their own designs.

Step 6 • Math Connection

- ❑ Once a design is fully functional, have students measure the height of the Tower using a ruler.
- ❑ Ask students: How can you make the Tower taller? Add to it and measure the difference.

Step 7 • ReMake

- ❑ Based on observations and team sharing, teams revise their designs. Use questions from Step 4 to guide teams in the redesigning process.
- ❑ Teams use their science notebooks or Student Observation and Reflection Sheet to record new designs. Then, they can build and test their new ideas.
- ❑ Bring the investigation to a close with final observations prior to the return of materials.

Step 8 • Reflect

- ❑ Since students share the materials, it is important for them to reflect independently in their journals or on the student observation and reflection sheet. This is an opportunity to draw and write about the experience. Their entries may serve as a formative assessment of student understanding, or for the teacher to use as a reflection on what worked during the build.

Extension • Engineering Challenge

- ❑ If this Tower needed to cart as much cargo as possible to a distance of 5 meters away, how would the load be carried? Have students add weight to their Tower by attaching pennies to it with tape, and see which Tower can carry the most pennies and why. How much weight can your Tower hold without losing balance? Where should the cargo be taped to the Tower? How does the extra weight affect the movement?

Student Observation & Reflection Sheet (1 / 3)

FOCUS QUESTION

SKETCHES

Make drawings, labels, and notes. What are the parts? Label them.

How do the parts interact? Write ideas or share orally with the class.

What is happening? Write ideas or share orally with the class.

Student Observation & Reflection Sheet (2 / 3)

I notice:

I wonder:

What would happen if...

What worked?

What didn't work?

Student Observation & Reflection Sheet (3 / 3)

I learned:

This made me think of:

What would happen if...

I am excited to:

I am still unclear about:

Curriculum Standards

Next Generation Science Standards

LESSON 1 • Getting to Know Your Circuit Cubes

SCIENCE AND ENGINEERING PRACTICES

- Planning and Carrying Out Investigations
- Asking Questions and Defining Problems
- Obtaining, Evaluating, and Communicating Information
- Developing and Using Models

CROSSCUTTING CONCEPTS

SYSTEMS AND SYSTEM MODELS

- Can describe a system in terms of its components and their interactions
- Models can be used to represent systems and their interactions

PATTERNS

- Can observe patterns and use them to describe phenomena and evidence

CAUSE AND EFFECT

- Understands connections by identifying the reasons behind an occurrence, and what that occurrence results in

ENERGY AND MATTER

- Identifies the flow of energy in and out of a system, and how it influences its function

DISCIPLINARY CORE IDEAS

- **K-2-ETS1-2** Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps its function as needed to solve a given problem.
- **3-5-ETS1-1** Define a simple design reflecting a need or want that has criteria for success and constraints.
- **2-PS1-3** Make observations to construct an evidence based account of how an object made of a small set of pieces can be disassembled and made into a new object.
- **3-PS2-3** Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.
- **4-PS3-4** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

LESSON 2 • Make a Flashlight

SCIENCE AND ENGINEERING PRACTICES

- Planning and Carrying Out Investigations
- Asking Questions and Defining Problems
- Obtaining, Evaluating, and Communicating Information
- Developing and Using Models

CROSSCUTTING CONCEPTS

SYSTEMS AND SYSTEM MODELS

- Can describe a system in terms of its components and their interactions
- Models can be used to represent systems and their interactions

PATTERNS

- Can observe patterns and use them to describe phenomena and evidence

CAUSE AND EFFECT

- Understands connections by identifying the reasons behind an occurrence, and what that occurrence results in

ENERGY AND MATTER

- Identifies the flow of energy in and out of a system, and how it influences its function

DISCIPLINARY CORE IDEAS

- **K-2-ETS1-2** Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps its function as needed to solve a given

problem.

- **3-5-ETS1-1** Define a simple design reflecting a need or want that has criteria for success and constraints.
- **2-PS1-3** Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.
- **3-PS2-3** Ask questions to determine cause

and effect relationships of electric or magnetic interactions between two objects not in contact with each other.

- **4-PS3-4** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

LESSON 3 • Make a Hand-Crank Flashlight

SCIENCE AND ENGINEERING PRACTICES

- Planning and Carrying Out Investigations
- Asking Questions and Defining Problems
- Obtaining, Evaluating, and Communicating Information
- Developing and Using Models

CROSSCUTTING CONCEPTS

SYSTEMS AND SYSTEM MODELS

- Can describe a system in terms of its components and their interactions
- Models can be used to represent systems and their interactions

PATTERNS

- Can observe patterns and use them to describe phenomena and evidence

CAUSE AND EFFECT

- Understands connections by identifying the reasons behind an occurrence, and what that occurrence results in

ENERGY AND MATTER

- Identifies the flow of energy in and out of a system, and how it influences its function

DISCIPLINARY CORE IDEAS

- **K-2-ETS1-2** Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps its function as needed to solve a given problem.
- **1-PS4-4** Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.
- **3-5-ETS1-1** Define a simple design reflecting a need or want that has criteria for success and constraints.
- **2-PS1-3** Make observations to construct an evidence based account of how an object made of a small set of pieces can be disassembled and made into a new object.
- **3-PS2-3** Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.
- **4-PS3-4** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

LESSON 4 • Make a GOBO Flashlight

SCIENCE AND ENGINEERING PRACTICES

DEVELOPING AND USING MODELS

- Develop and use models to describe phenomena

CROSSCUTTING CONCEPTS

SYSTEMS AND SYSTEM MODELS

- Can describe a system in terms of its components and their interactions
- Models can be used to represent systems and their interactions

PATTERNS

- Can observe patterns and use them to describe phenomena and evidence

CAUSE AND EFFECT

- Understands connections by identifying the reasons behind an occurrence, and what that occurrence results in

ENERGY AND MATTER

- Identifies the flow of energy in and out of a system, and how it influences its function

DISCIPLINARY CORE IDEAS

- K-2ETS1-3 Analyze the design of two objects and compare the strengths and weaknesses of how they perform.
- 3-5-ETS1-1 Define a simple design reflecting a need or want that has criteria for success and constraints.
- 3-5ETS1-3 Plan and carry out fair tests to identify aspects that can be improved.

- MS.ETS1-2 Evaluate competing design solutions using a systematic process to determine how well the designs meet criteria.
- K-PS2-2 Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.
- 2-PS1-2 Determine which materials are best suited for the purpose.
- 3-PS2-3 Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.
- 4-PS3-4 Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
- 1-PS4-3 Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light.
- 1-PS4-4 Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.

LESSON 5 • Make a 1-Marker Scribblebot

SCIENCE AND ENGINEERING PRACTICES

DEVELOPING AND USING MODELS

- Develop and use models to describe phenomena

CROSS CUTTING CONCEPTS

SYSTEMS AND SYSTEM MODELS

- Can describe a system in terms of its components and their interactions
- Models can be used to represent systems and their interactions

PATTERNS

- Can observe patterns and use them to describe phenomena and evidence

CAUSE AND EFFECT

- Understands connections by identifying the reasons behind an occurrence, and what that occurrence results in

ENERGY AND MATTER

- Identifies the flow of energy in and out of a system, and how it influences its function

DISCIPLINARY CORE IDEAS

- K-2ETS1-1 Define a simple problem that can be solved with the design of a new or improved object.
- K-2-ETS1-2 Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps its function as needed to solve a given problem.
- K–2ETS1-3 Analyze the design of two objects and compare the strengths and weaknesses of how they perform.
- **3-5-ETS1-1** Define a simple design reflecting a need or want that has criteria for success and constraints.
- **3-5-ETS1-2** Generate and compare multiple possible solutions based on how likely they will meet constraints.
- **3-5ETS1-3** Plan and carry out fair tests to identify aspects that can be improved.
- **MS.ETS1-2** Evaluate competing design solutions using a systematic process to determine how well the designs meet criteria.
- **3-PS2-3** Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.
- **4-PS3-4** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

LESSON 6 • Make a 2-Marker Scribblebot

SCIENCE AND ENGINEERING PRACTICES

DEVELOPING AND USING MODELS

- Develop and use models to describe phenomena

CROSSCUTTING CONCEPTS

SYSTEMS AND SYSTEM MODELS

- Can describe a system in terms of its components and their interactions
- Models can be used to represent systems and their interactions

PATTERNS

- Can observe patterns and use them to describe phenomena and evidence

CAUSE AND EFFECT

- Understands connections by identifying the reasons behind an occurrence, and what that occurrence results in

ENERGY AND MATTER

- Identifies the flow of energy in and out of a system, and how it influences its function

DISCIPLINARY CORE IDEAS

- **K-2ETS1-1** Define a simple problem that can be solved with the design of a new or improved object.
- **K-2-ETS1-2** Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps its function as needed to solve a given problem.
- **K-2ETS1-3** Analyze the design of two objects and compare the strengths and weaknesses of how they perform.
- **3-5-ETS1-1** Define a simple design reflecting a need or want that has criteria for success and constraints.
- **3-5-ETS1-2** Generate and compare multiple possible solutions based on how likely they will meet constraints.
- **3-5ETS1-3** Plan and carry out fair tests to identify aspects that can be improved.
- **MS.ETS1-2** Evaluate competing design solutions using a systematic process to determine how well the designs meet criteria.
- **2-PS1-2** Determine which materials are best suited for the purpose.
- **3-PS2-3** Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.
- **4-PS3-4** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

LESSON 7 • Make a 6-Marker Scribblebot

SCIENCE AND ENGINEERING PRACTICES

DEVELOPING AND USING MODELS

- Develop and use models to describe phenomena

CROSSCUTTING CONCEPTS

SYSTEMS AND SYSTEM MODELS

- Can describe a system in terms of its components and their interactions
- Models can be used to represent systems and their interactions

PATTERNS

- Can observe patterns and use them to describe phenomena and evidence

CAUSE AND EFFECT

- Understands connections by identifying the reasons behind an occurrence, and what that occurrence results in

ENERGY AND MATTER

- Identifies the flow of energy in and out of a system, and how it influences its function

DISCIPLINARY CORE IDEAS

- **K-2ETS1-1** Define a simple problem that can be solved with the design of a new or improved object.
- **K-2-ETS1-2** Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps its function as needed to solve a given problem.
- **K-2ETS1-3** Analyze the design of two objects and compare the strengths and weaknesses of how they perform.
- **3-5-ETS1-1** Define a simple design reflecting a need or want that has criteria for success and constraints.
- **3-5-ETS1-2** Generate and compare multiple possible solutions based on how likely they will meet constraints.
- **3-5ETS1-3** Plan and carry out fair tests to identify aspects that can be improved.

- **MS.ETS1-2** Evaluate competing design solutions using a systematic process to determine how well the designs meet criteria.
- **2-PS1-2** Determine which materials are best suited for the purpose.
- **3-PS2-3** Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.
- **4-PS3-4** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

LESSON 8 • Build the Chassis!

SCIENCE AND ENGINEERING PRACTICES

- Planning and Carrying Out Investigations
- Asking Questions and Defining Problems
- Obtaining, Evaluating, and Communicating Information
- Developing and Using Models

CROSSCUTTING CONCEPTS

SYSTEMS AND SYSTEM MODELS

- Can describe a system in terms of its components and their interactions
- Models can be used to represent systems and their interactions

PATTERNS

- Can observe patterns and use them to describe phenomena and evidence

CAUSE AND EFFECT

- Understands connections by identifying the reasons behind an occurrence, and what that occurrence results in

ENERGY AND MATTER

- Identifies the flow of energy in and out of a system, and how it influences its function

DISCIPLINARY CORE IDEAS

- **K-2ETS1-3** Analyze the design of two objects and compare the strengths and weaknesses of how they perform.
- **3-5-ETS1-1** Define a simple design reflecting a need or want that has criteria for success and constraints.
- **2-PS1-2** Determine which materials are best suited for the purpose.
- **3-PS2-3** Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.
- **4-PS3-4** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

LESSON 9 • Hack Your Ride

SCIENCE AND ENGINEERING PRACTICES

- Planning and Carrying Out Investigations
- Asking Questions and Defining Problems
- Obtaining, Evaluating, and Communicating Information
- Designing and Using Models

CROSSCUTTING CONCEPTS

SYSTEMS AND SYSTEM MODELS

- Can describe a system in terms of its components and their interactions
- Models can be used to represent systems and their interactions

PATTERNS

- Can observe patterns and use them to describe phenomena and evidence

CAUSE AND EFFECT

- Understands connections by identifying the reasons behind an occurrence, and what that occurrence results in

ENERGY AND MATTER

- Identifies the flow of energy in and out of a system, and how it influences its function

DISCIPLINARY CORE IDEAS

- **K-PS2-1** Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.
- **K-PS2-2** Determine if a design solution works as

intended to change the speed or direction of an object with a push or a pull.

- **2-PS1-1** Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
- **2-PS1-2** Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.
- **2-PS1-3** Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.
- **3-PS2-1** Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.
- **4-PS3-2** Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents.
- **4-PS3-4** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
- **K-2ETS1-3** Analyze the design of two objects and compare the strengths and weaknesses of how they perform.
- 3-5-ETS1-1 Define a simple design reflecting a need or want that has criteria for success and constraints.

LESSON 10 • Build a Tower

SCIENCE AND ENGINEERING PRACTICES

- Planning and Carrying Out Investigations
- Asking Questions and Defining Problems
- Obtaining, Evaluating, and Communicating Information
- Developing and Using Models

CROSSCUTTING CONCEPTS

SYSTEMS AND SYSTEM MODELS

- Can describe a system in terms of its components and their interactions
- Models can be used to represent systems and their interactions

PATTERNS

- Can observe patterns and use them to describe phenomena and evidence

CAUSE AND EFFECT

- Understands connections by identifying the reasons behind an occurrence, and what that occurrence results in

ENERGY AND MATTER

- Identifies the flow of energy in and out of a system, and how it influences its function

DISCIPLINARY CORE IDEAS

- **K-PS2-1** Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.
- **K-PS2-2** Determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.
- **2-PS1-1** Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
- **2- PS1-2** Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.
- **2-PS1-3** Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.
- **3-PS2-1** Plan and investigate to provide evidence of the effects of balance and unbalanced forces on the motion of an object.
- **4-PS3-2** Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electrical currents.
- **4-PS3-4** Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.
- **K-2ETS1-3** Analyze the design of two objects and compare the strengths and weaknesses of how

they perform.

- **3-5-ETS1-1** Define a simple design reflecting a need or want that has criteria for success and constraints.

Common Core State Standards Connections

LESSON 1 • Getting to Know Your Circuit Cubes

ELA/LITERACY

- W.2.8 Recall information from experiences or gather information from provided sources to answer a question. (K-2-ETS1-1) (K-2-ETS1-3)
- SL.2.5 Create audio recordings of stories or poems: add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings. (K-2-ETS1-2)
- SL.K.3 Ask and answer questions in order to seek help, get information, or clarify something that is not understood. (K-PS2-2)
- W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2) (4-PS3-3) (4-PS3-4) (4-ESS3-1)
- W.4.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (4-PS3-1)
- W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of resources. (3-5-ETS1-1) (3-5-ETS1-3)

CALIFORNIA ENGLISH LANGUAGE DEVELOPMENT STANDARDS

- K-5
- Interacting in Meaningful Ways
- Modes of Communication:
  Collaborative
  Interpretative
  Productive

MATHEMATICS

- MP.4 Reason abstractly and quantitatively (3-5-ETS1-1) (3-5-ETS1-2) (3-5-ETS1-3)
- MP.4 Model with mathematics (K-2-ETS1-1) (K-2-ETS1-3) (3-5-ETS1-1) (3-5-ETS1-2) (3-5-ETS1-3)
- MP.5 Use appropriate tools strategically (1-PS4-4) (3-5-EST1-1) (3-5-EST1-2) (3-5-EST1-3)

LESSON 2 • Make a Flashlight

- ELA/Literacy
- W.2.8 Recall information from experiences or gather information from provided sources to answer a question. (K-2-ETS1-1) (K-2-ETS1-3)
- SL.2.5 Create audio recordings of stories or poems: add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings. (K-2-ETS1-2)
- SL.K.3 Ask and answer questions in order to seek help, get information, or clarify something that is not understood. (K-PS2-2)
- W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2) (4-PS3-3) (4-PS3-4) (4-ESS3-1)
- W.4.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (4-PS3-1)
- W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of resources. (3-5-ETS1-1) (3-5-ETS1-3)

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MATHEMATICS

- MP.4 Reason abstractly and quantitatively (3-5-ETS1-1) (3-5-ETS1-2) (3-5-ETS1-3)
- MP.4 Model with mathematics (K-2-ETS1-1) (K-2-ETS1-3) (3-5-ETS1-1) (3-5-ETS1-2) (3-5-ETS1-3)
- MP.5 Use appropriate tools strategically (1-PS4-4) (3-5-EST1-1) (3-5-EST1-2) (3-5-EST1-3)

LESSON 3 • Make a Hand-Crank Flashlight

ELA/LITERACY

- W.2.8 Recall information from experiences or gather information from provided sources to answer a question. (K-2-ETS1-1) (K-2-ETS1-3)
- SL.2.5 Create audio recordings of stories or poems: add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings. (K-2-ETS1-2)
- SL.K.3 Ask and answer questions in order to seek help, get information, or clarify something that is not understood. (K-PS2-2)
- W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2) (4-PS3-3) (4-PS3-4) (4-ESS3-1)
- W.4.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly. 4-PS3-1)
- W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of resources. (3-5-ETS1-1) (3-5-ETS1-3)

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MATHEMATICS

- MP.4 Reason abstractly and quantitatively (3-5-ETS1-1) (3-5-ETS1-2) (3-5-ETS1-3)
- MP.4 Model with mathematics (K-2-ETS1-1) (K-2-• ETS1-3) (3-5-ETS1-1) (3-5-ETS1-2) (3-5-ETS1-3)
- MP.5 Use appropriate tools strategically (1-PS4-4) (3-5-EST1-1) (3-5-EST1-2) (3-5-EST1-3)

LESSON 4 • Make a GOBO Flashlight

ELA/LITERACY

- W.2.8 Recall information from experiences or gather information from provided sources to answer a question. (K-2-ETS1-1) (K-2-ETS1-3)
- SL.2.5 Create audio recordings of stories or poems: add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings. (K-2-ETS1-2)
- SL.K.3 Ask and answer questions in order to seek help, get information, or clarify something that is not understood. (K-PS2-2)
- W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2) (4-PS3-3) (4-PS3-4) (4-ESS3-1)
- W.4.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (4-PS3-1)
- W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of resources. (3-5-ETS1-1) (3-5-ETS1-3)

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MATHEMATICS

- MP.4 Reason abstractly and quantitatively (3-5-

ETS1-1) (3-5-ETS1-2) (3-5-ETS1-3)

- MP.4 Model with mathematics (K-2-ETS1-1) (K-2-ETS1-3) (3-5-ETS1-1) (3-5-ETS1-2) (3-5-ETS1-3)
- MP.5 Use appropriate tools strategically (1-PS4-4) (3-5-EST1-1) (3-5-EST1-2) (3-5-EST1-3)

LESSON 5 • Make a 1-Marker Scribblebot

ELA/LITERACY

- W.2.8 Recall information from experiences or gather information from provided sources to answer a question. (K-2-ETS1-1) (K-2-ETS1-3)
- SL.2.5 Create audio recordings of stories or poems: add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings. (K-2-ETS1-2)
- SL.K.3 Ask and answer questions in order to seek help, get information, or clarify something that is not understood. (K-PS2-2)
- W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2) (4-PS3-3) (4-PS3-4) (4-ESS3-1)
- W.4.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (4-PS3-1)
- W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of resources. (3-5-ETS1-1) (3-5-ETS1-3)

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MATHEMATICS

- MP.4 Reason abstractly and quantitatively (3-5-ETS1-1) (3-5-ETS1-2) (3-5-ETS1-3)
- MP.4 Model with mathematics (K-2-ETS1-1) (K-2-ETS1-3) (3-5-ETS1-1) (3-5-ETS1-2) (3-5-ETS1-3)
- MP.5 Use appropriate tools strategically (1-PS4-4) (3-5-EST1-1) (3-5-EST1-2) (3-5-EST1-3)

LESSON 6 • Make a 2-Marker Scribblebot

ELA/LITERACY

- W.2.8 Recall information from experiences or gather information from provided sources to answer a question. (K-2-ETS1-1) (K-2-ETS1-3)
- SL.2.5 Create audio recordings of stories or poems: add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings. (K-2-ETS1-2)
- SL.K.3 Ask and answer questions in order to seek help, get information, or clarify something that is not understood. (K-PS2-2)
- W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2) (4-PS3-3) (4-PS3-4) (4-ESS3-1)
- W.4.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly. (4-PS3-1)
- W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase i nformation in notes and finished work, and provide a list of resources. (3-5-ETS1-1) (3-5-ETS1-3)

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MATHEMATICS

- MP.4 Reason abstractly and quantitatively (3-5-ETS1-1) (3-5-ETS1-2) (3-5-ETS1-3)
- MP.4 Model with mathematics (K-2-ETS1-1) (K-2-

ETS1-3) (3-5-ETS1-1) (3-5-ETS1-2) (3-5-ETS1-3)

- MP.5 Use appropriate tools strategically (1-PS4-4) (3-5-EST1-1) (3-5-EST1-2) (3-5-EST1-3)

LESSON 7 • Make a 6-Marker Scribblebot

ELA/LITERACY

- W.2.8 Recall information from experiences or gather information from provided sources to answer a question. (K-2-ETS1-1) (K-2-ETS1-3)
- SL.2.5 Create audio recordings of stories or poems: add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings.(K-2-ETS1-2)
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- W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2) (4-PS3-3) (4-PS3-4) (4-ESS3-1)
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- MP.5 Use appropriate tools strategically (1-PS4-4) (3-5-EST1-1) (3-5-EST1-2) (3-5-EST1-3)

LESSON 8 • Build the Chassis!

ELA/LITERACY

- W.2.8 Recall information from experiences or gather information from provided sources to answer a question. (K-2-ETS1-1) (K-2-ETS1-3)
- SL.2.5 Create audio recordings of stories or poems: add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings. (K-2-ETS1-2)
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- MP.5 Use appropriate tools strategically (1-PS4-4) (3-5-EST1-1) (3-5-EST1-2) (3-5-EST1-3)

LESSON 9 • Hack Your Ride

ELA/LITERACY

- W.2.8 Recall information from experiences or gather information from provided sources to answer a question. (K-2-ETS1-1) (K-2-ETS1-3)
- SL.2.5 Create audio recordings of stories or poems: add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings. (K-2-ETS1-2)
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- MP.4 Model with mathematics (K-2-ETS1-1) (K-2-ETS1-3) (3-5-ETS1-1) (3-5-ETS1-2) (3-5-ETS1-3)
- MP.5 Use appropriate tools strategically (1-PS4-4) (3-5-EST1-1) (3-5-EST1-2) (3-5-EST1-3)

LESSON 10 • Build a Tower

ELA/LITERACY

- W.2.8 Recall information from experiences or gather information from provided sources to answer a question. (K-2-ETS1-1) (K-2-ETS1-3)
- SL.2.5 Create audio recordings of stories or poems: add drawings or other visual displays to stories or recounts of experiences when appropriate to clarify ideas, thoughts, and feelings. (K-2-ETS1-2)
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- W.4.7 Conduct short research projects that build knowledge through investigation of different aspects of a topic. (4-PS3-2) (4-PS3-3) (4-PS3-4) (4-ESS3-1)
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Curriculum Credit

Original curriculum created by:

- Patricia Amend-Ehn
- Carinne Paddock

Curriculum Editor:

- Helen Carmena