Family Science Night

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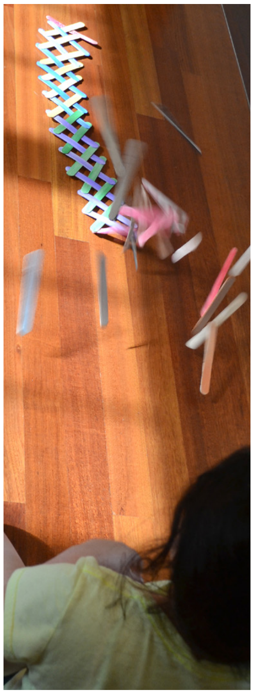
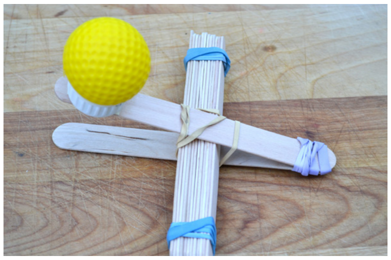




MAKE YOUR OWN ANEMOMETER

I wonder...
Can I measure how fast the wind is blowing?

An anemometer is a device used to measure wind speeds. Anemometers are essential for predicting weather changes, for research purposes, and for determining good locations for wind farms.

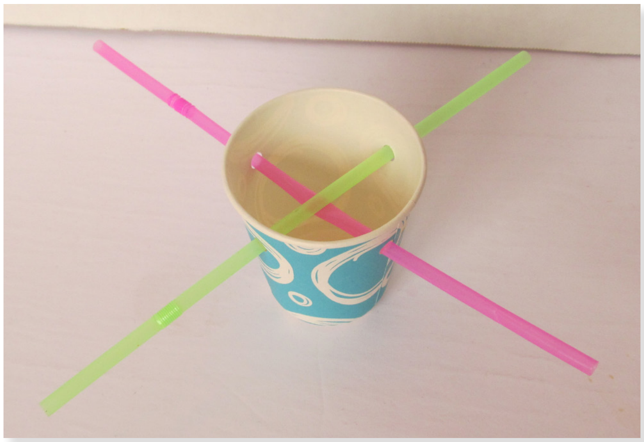
In this activity, you'll make your own anemometer and test it out in different wind conditions.

MATERIALS

- 5 paper cups, 5 oz size
  (optional: one cup in a different color)
- 2 straws
- 1 unsharpened pencil with eraser
- 1 pushpin
- 1 hole punch
- 1" piece of brightly colored tape
- Blob of clay, enough to support an upright pencil
- Stopwatch (or phone with stopwatch app)
- Fan
- Ruler

Make your anemometer:

1. Using a hole punch, punch out four holes (evenly spaced) just under the lip of one of the paper cups.
   This will be your center cup. (Note: If you have one cup in a different color, save it for use later.)
2. Using one end of the pencil, punch a hole in the center of the bottom of the center cup.
3. On each of the remaining four cups (including the cup in a different color), punch out two holes just under the lip, approximately 1 inch apart.
4. Thread one of the straws through two opposite holes in the center cup. Then thread the other straw so it lies crossways on the first straw.



5. Attach the four cups to each of the four ends of the straws by threading a straw end through both holes. Make sure the top of each cup is facing toward the bottom of the next cup.
6. Attach the colored tape to the bottom lip of one of the cups; if you used one cup in a different color, attach the tape to this cup. The tape and the different color make it easier to measure the rate at which the anemometer spins.
7. Insert the pencil, eraser end first, through the hole in the bottom of the center cup until it reaches the straws. Stick the pushpin gently through the 2 straws and into the eraser. Hold the pencil in one hand and push one of the cups to spin them. If the cups spin easily, you're ready for your experiment. If not, loosen the pushpin a little.
8. Stick the end of the pencil into the clay so your anemometer can be freestanding.

Make your predictions

If you hold your anemometer in front of a fan, what do you think will happen? What happens if you move your anemometer farther away from the fan? How can you measure how fast your anemometer is spinning?

Record your predictions in your Safety Smart® Science Investigator's Journal.

Observe

Position the anemometer a few inches away from the fan and turn on the fan. What happens? What if you move the anemometer farther away from the fan?

Measure the **rate** (how many times the cups spin in a certain amount of time) of the anemometer. Place your anemometer approximately 12 inches away from the fan. Position your finger under your anemometer so that the tape lightly touches your finger. Keep your finger here and have a friend set the timer for 15 seconds. Count how many times the anemometer spins in 15 seconds by counting how many times the tape touches your finger. You can also count how many times you see the different-color cup pass in front of you. Record your results in your journal.

Leaving the fan speed the same, choose two other distances from your fan and measure the rate at which your anemometer spins for each one. Record your results.

Try taking your anemometer outside to run some experiments. What conclusions can you make about where the wind speed is highest and lowest?

What is going on here?

Anemometers are used around the world to measure wind speed. The cups catch the wind and the force from the wind moves the cups. The cups rotate around the center point; the stronger the wind, the faster the anemometer spins. Industrial anemometers are **calibrated** (adjusted to measure data accurately) to convert the speed of the rotating cups into a measure of wind speed. In this case, the anemometers are calibrated in such a way that a known number of rotations correlates to a known wind speed. Industrial anemometers also have cups that change the direction they are facing, to help measure wind direction.

Anemometers have many purposes. **Meteorologists** (scientists who study weather and atmospheric patterns) use anemometers to help predict the weather so they can warn residents of approaching storms. The aviation and marine industries rely on the information from meteorologists to assist with navigation.

Climatologists use anemometers to track climate changes over many years (whereas meteorologists track weather changes over many days). The National Oceanographic and Atmospheric Association (NOAA) tracks wind speed (among other data) and has data available about wind speed across the United States going back to 1950. Check it out at www.ncdc.noaa.gov/societal-impacts/wind.

Engineers use anemometers to help them decide where to build **wind farms** as they look for areas that see consistently high wind speeds. Wind farms are made up of multiple **wind turbines** that convert the **kinetic energy** (the energy in an object due to its movement) of the wind into electrical energy. An anemometer can be placed on top of a wind turbine so that the system that controls the turbine knows when it is windy enough to turn on.

When the wind is harnessed in this way **(wind energy)**, it is a form of **sustainable energy** because it depends on an energy source that doesn't run out and doesn't add pollutants to the environment. Other forms of sustainable energy are **solar energy** (using the sun's energy either by use of solar panels or heat, such as a solar oven), **hydroelectric energy** (using the energy from moving water to turn turbines that generate electricity) and **tidal energy** (harnessing the energy from moving tidal waters to generate electricity).

Think about this:

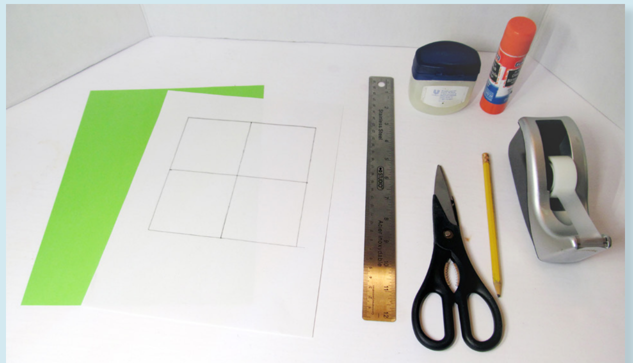
Air quality scientists monitor **air quality** (the amount of pollutants in the air) with information from satellites as well as from anemometers. When analyzing air quality, it's important to use anemometers to know the wind speed. The wind speed directly affects the **dispersion** of the pollutants (how the pollutants spread out into the air). By knowing the wind speed at the time of the air quality test, these scientists can estimate where the contaminants (polluting particles) are coming from. This also helps scientists and researchers predict where the contaminants might end up.

You can make your own air quality monitor to use with your anemometer at home or at school!

EXTRA ACTIVITY: Make an air quality monitor

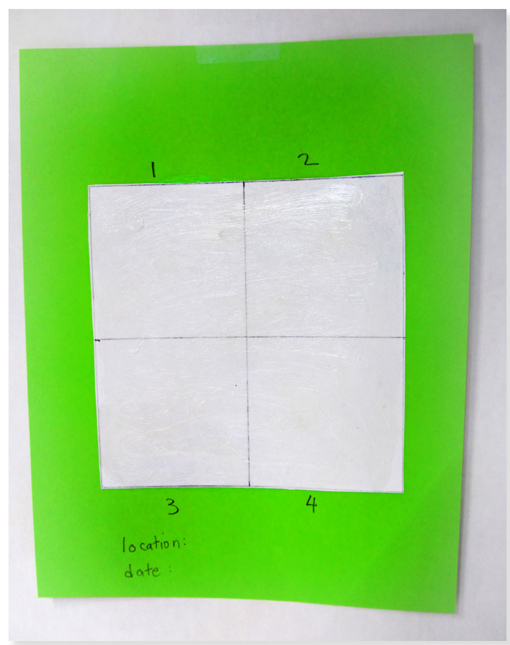
MATERIALS

- Card stock in a bright color (1 sheet per monitor)
- White graph paper or paper with four 3" squares drawn onto it
- Scissors
- Glue
- Petroleum jelly
- Tape
- Sharpened pencil
- Magnifying glass



Set up your air quality monitor:

1. Cut around the outside perimeter of the four squares together so the excess paper is trimmed away.
2. Glue the graph paper or paper with squares drawn on it to the card stock. Label the squares 1, 2, 3, and 4 and add the date and location of where the monitor will be placed.
3. Spread a thin layer of petroleum jelly over the white paper.
4. Using the tape, affix your air quality monitor in your home, in your classroom or school hallway, or outside.
5. Make multiple air quality monitors and hang them in various places. Look for high traffic vs. low traffic areas, indoors vs. outdoors, etc.
6. Use your anemometers to make observations about the wind speed in the areas that you placed your air quality monitors.
7. Let the monitors sit, undisturbed, for 3 to 5 days.
8. After 3 to 5 days, count up the particles in each square and record your results. (You might need to use a magnifying glass to help you see some of the smaller particles.) Record the results in your Safety Smart Science Investigator's Journal.



LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Physical Sciences
- Disciplinary core ideas:
  - PS3B Conservation of Energy and Energy Transfer
  - PS3C Relationship Between Energy and Forces
  - ESS2D Weather and Climate
- Cross-cutting concepts: Patterns, interdependence of science, engineering, and technology

Safety Smart Science Investigator's Journal:
Make Your Own Anemometer

Predictions

What do you think will happen when you hold the anemometer close to the fan? What will happen when you move the anemometer farther away from the fan?

____

____

How can you measure how fast your anemometer is spinning?

____

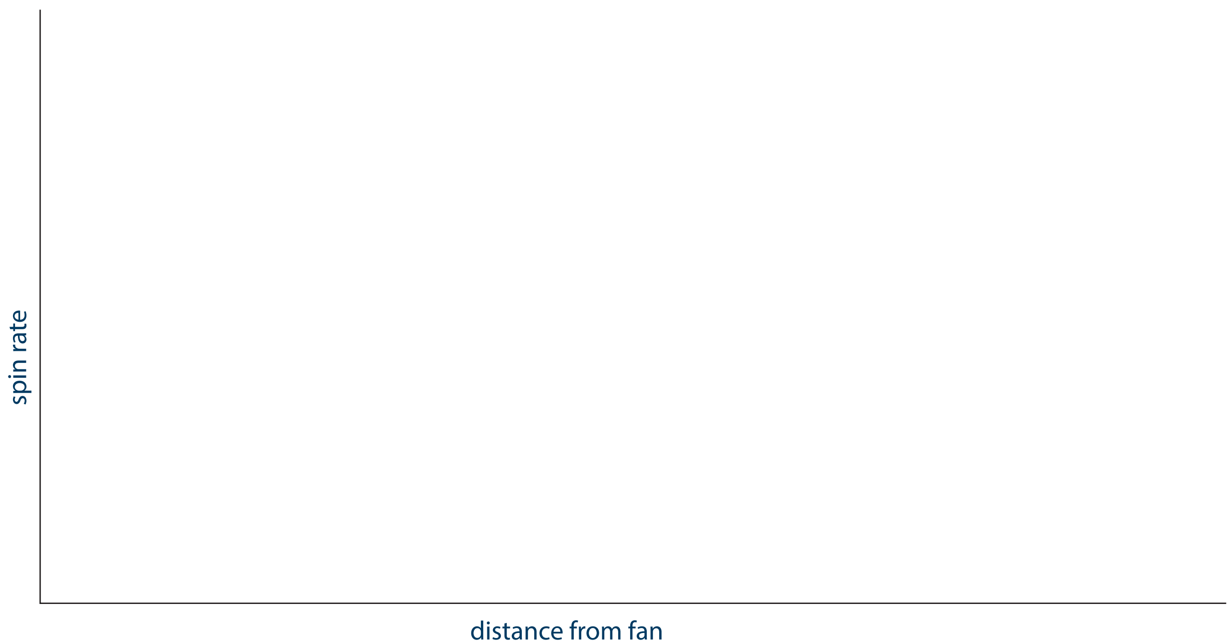
What does it mean when an industrial anemometer starts spinning faster? How is the weather changing?

____

____

Distance from fan (inches)	# revolutions in 15 sec
1. __12__ inches	
2. ______ inches	
3. ______ inches	

Try plotting your results on a graph!



Take your anemometer outside and record real-time data

Location *(by the flagpole, beside the slide etc.)*:	# revolutions in 15 sec
1.	
2.	
3.	

How does wind speed change the spin rate of an anemometer?

____

____

What did you learn about the wind speed in different locations around your school?

____

____

Air Quality Monitor

Location:		Location:		Location:	
Notes *(high traffic, indoors, etc.)*:		Notes *(high traffic, indoors, etc.)*:		Notes *(high traffic, indoors, etc.)*:	
Square #	# particles	Square #	# particles	Square #	# particles
1		1		1	
2		2		2	
3		3		3	
4		4		4	

BAKE S'MORES IN A SOLAR OVEN

I wonder...
Can I use the sun's energy to cook food?

All of the energy entering Earth's atmosphere comes from the sun. That's a lot of energy! Almost every country in the world harnesses this energy directly, using solar ovens to cook food or even **pasteurize** their water (the process of heating the water to a temperature to kill germs). Solar ovens are especially useful in places that receive a lot of sunlight year-round and that don't have an available source of clean drinking water or cooking fuel.

In this activity, we'll make a solar oven using household items, and you'll test it out by baking s'mores!

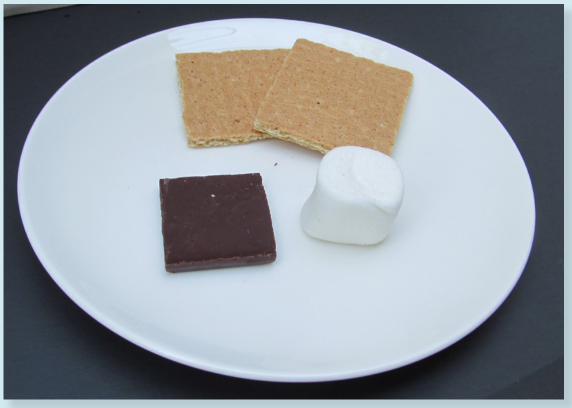
MATERIALS

- Shoebox or pizza box
- Scissors
- Tape
- White glue
- Wooden skewer
- Plastic wrap (same size as lid of box)
- Black construction paper or cardboard (same size as bottom of box)
- Aluminum foil (enough to line inside of box)
- Thermometer

S'mores ingredients

- 2 graham cracker squares
- 1 marshmallow
- 1 square of milk chocolate

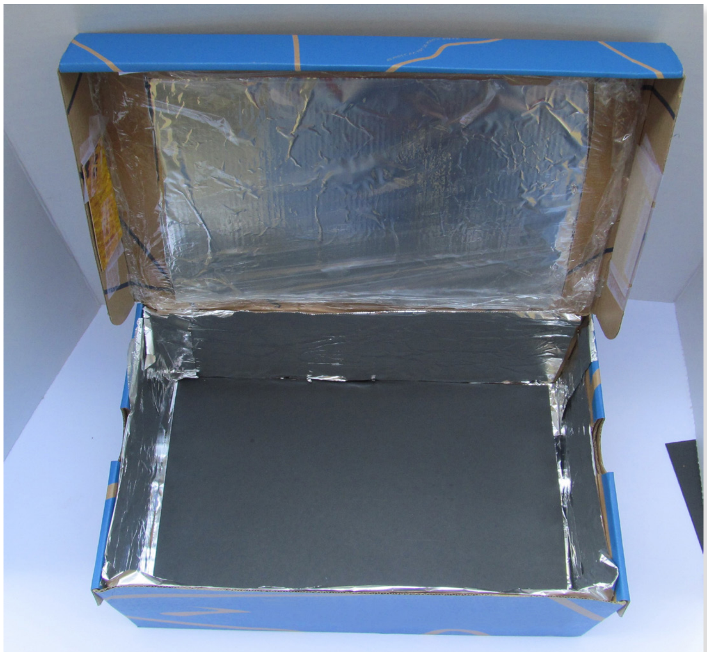
Optional: Materials to make a second solar oven, with white construction paper instead of black; this will let you make a scientific comparison of how effective each one is.



Set up the solar oven:

1. Leaving about a 1-inch margin, cut three sides around the lid of a shoebox to create a smaller flap in the lid.
2. Cut aluminum foil to the size and shape of the four vertical sides of the box and the smaller top flap. Glue the foil to the inside of the box sides and the underside of the top flap.

3. Cut and glue a piece of black construction paper or cardboard to the inside bottom of the box.
4. Cut and glue or tape plastic wrap to the underside of the larger lid of the box.



5. Prop the smaller lid flap open at about a 45-degree angle using the wooden skewer; tape in place.
6. Place the thermometer inside the box.

7. Place the solar oven in a sunny location and position it so the sun reflects off the flap.

   NOTE: Because solar ovens depend on sunlight, this activity works best on a sunny, non-windy day.

Observe

Using your thermometer, measure the outdoor temperature and the starting temperature of your oven as well as the time you started measuring it, and record your notes in your Safety Smart® Science Investigator's Journal. Once you have your data, plot it on a **line graph** (a type of graph that uses points on a line to show increases or decreases in your data measurements).

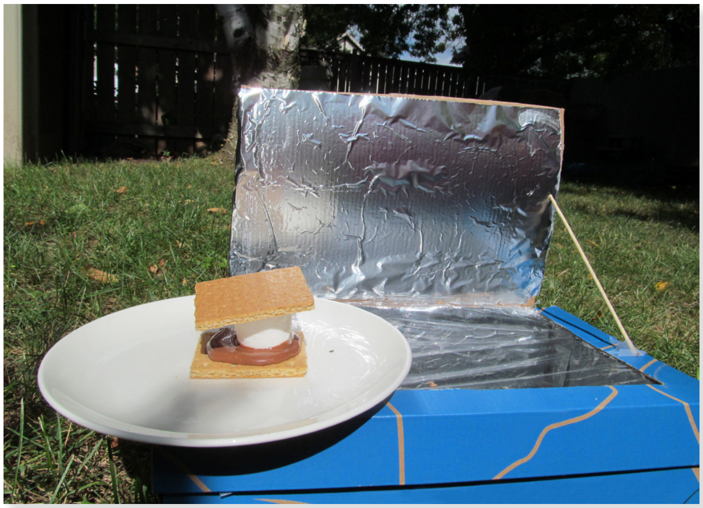
Place a marshmallow on one graham cracker square inside the solar oven. Depending on the strength of the sun, it might take 30 to 60 minutes for the marshmallow to get soft enough. Check on your solar oven every 5 to 10 minutes while you're baking your treat, and document the time and temperature in your journal.

After 30 to 60 minutes, put in the second graham cracker, this time with a square of chocolate on it.

Let the ingredients keep baking until the chocolate melts (another 5 to 10 min, depending on weather conditions).

Take photos when you measure the temperature, or even a time lapse video. What do you notice about how quickly the temperature rises? What happens to the temperature if a cloud covers the sun? What does the chocolate look like when it is melting?

When your chocolate is melted, remove the graham crackers from the oven, put them together as a sandwich, and enjoy your s'more!



What is going on here?

Sunlight contains a lot of energy; this is known as **solar energy**. This energy is carried by particles of light called **photons**. When these photons hit objects (like a solar oven or even air molecules), it causes the molecules in that object to vibrate. This vibration causes heat. In this activity, you are converting **light energy** into **heat energy**.

In the case of your solar oven, sunlight reflects off the aluminum foil and into the box, hitting the black paper at the bottom and the ingredients, causing the molecules in the construction paper, the food, and the air to vibrate and generate heat. That heat is trapped in the solar oven by the plastic wrap. On a sunny day, your small solar oven will trap enough of the sun's energy to bake the s'more.

Around the world, solar ovens are used every day by families and businesses. Solar ovens are used regularly in some communities in India, China, and Africa. These countries have ideal conditions for solar ovens because they receive a lot of sunlight. Communities that don't have easy access to clean water or resources for cooking also use solar ovens. Some of these solar ovens are big enough to feed 20,000 people per day!

Solar oven baking cakes in Dampha Kunda, Gambia; photo credit: Ikiwaner

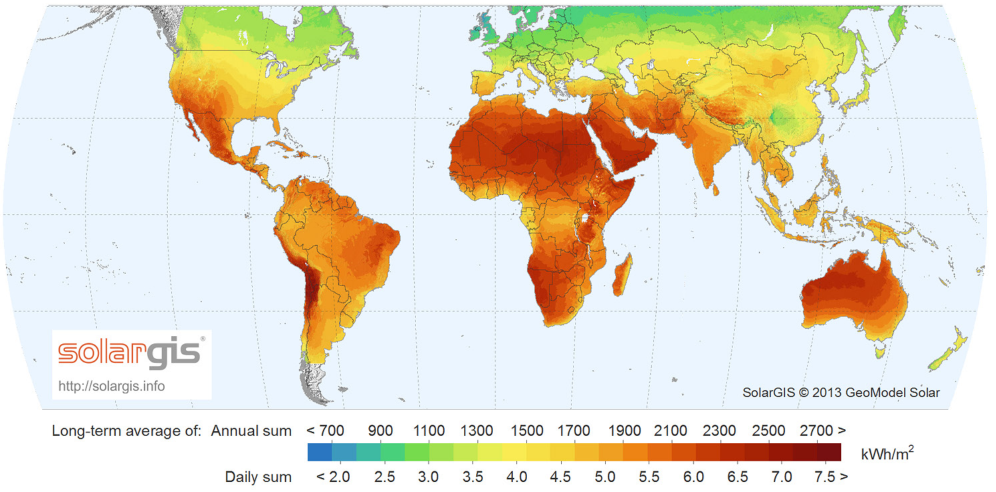


photo credit: SolarGIS © 2013 GeoModel Solar

This map shows the hours of solar energy each location receives in a day. The areas that are darker red receive more sunlight on a daily basis and are better suited for solar ovens.

Professionally built solar ovens can get hot enough to **pasteurize** water (kill harmful organisms in the water) to make it safe for drinking, cooking meals, and sterilizing medical equipment. Because solar ovens only need sunlight to work, they don't cost anything to use and they don't add any pollution to the environment. Solar ovens are an excellent example of **sustainable energy**, or energy production that can last for the foreseeable future.

Think about this:

What would happen if you used a color other than black at the bottom of your solar oven? Try running your experiment with a second oven that has white paper at the bottom. Does the solar oven heat up as quickly as it did with the black paper? Why or why not?

What happens if you try the experiment on a cloudy or windy day? How dependent is your solar oven on sunlight? Test it out!

What else can you cook in your solar oven: Can you boil water? Can you melt cheese? Other foods? Why or why not?

What more should I know?

Across North America, there are many contests and competitions that challenge students to build their own solar ovens. Now that you have the basics of how a solar oven works, you can improve upon your design and enter a contest on your own or with your class.

For inspiration, check out the Solar Oven Challenge from Re-Energy at www.re-energy.ca/solar-oven-challenge. Maybe you can start your own challenge in your school, or find a similar local challenge. Good luck!

LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Physical Sciences
- Disciplinary core ideas:
  - PS3B Conservation of Energy and Energy Transfer
  - PS3D Energy in Chemical Processes and Everyday Life
- Cross-cutting concepts: Energy and matter, cause and effect

Safety Smart Science Investigator's Journal: Bake S'mores in a Solar Oven

Clock time	Elapsed time (min)	Outdoor temp (°F)	Solar oven temp (°F)		Observations
			Black paper	White paper *(optional)*	
	0 min				

Plot your time and temperatures for your solar oven with black paper. If you have a second solar oven with white paper, use a different color to plot those, too!

temperature in solar oven

elapsed time (min)

What else can I cook in a solar oven?

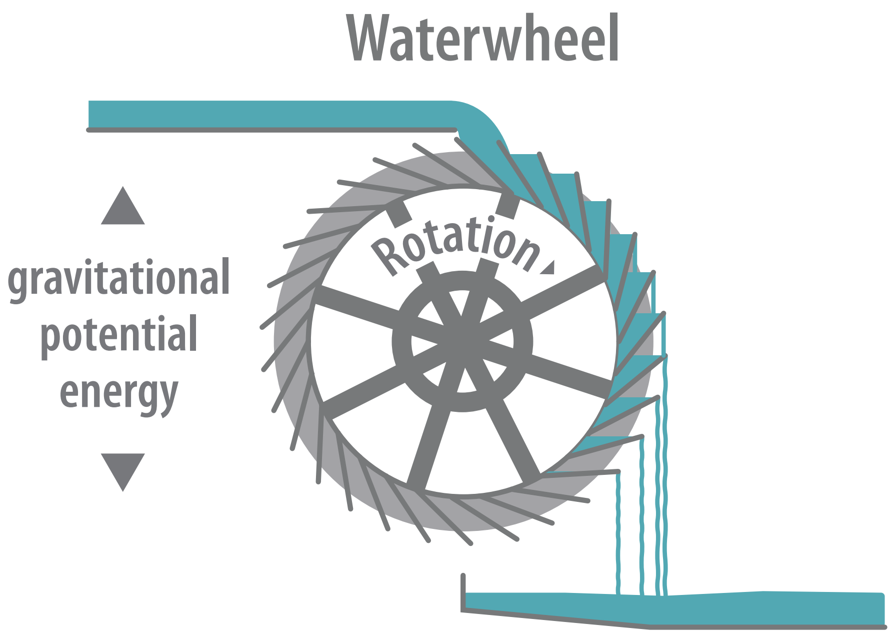
Food	Prediction: Will it heat/melt?	Observations
Cheese (e.g. on nachos)		
Water		
Hot chocolate		

HARNESS THE POWER OF WATER

I wonder…
Can I use the energy from falling water to lift an object?

Waterwheels have been used for more than 2,000 years to harness the power of moving water. They are the predecessors of hydroelectric dams, which produce much of the world's electricity today. Much like modern-day hydroelectric dams, the power a waterwheel can generate depends on the **gravitational potential energy** of the water (the height that the water is falling from relative to the waterwheel).

In this activity, you'll make a simple waterwheel to lift a small object. You'll change the potential energy of the water to see whether it affects the power output of the waterwheel. There are several different types of waterwheels; you can learn more about them and how they work at https://kids.kiddle.co/Water_wheel.



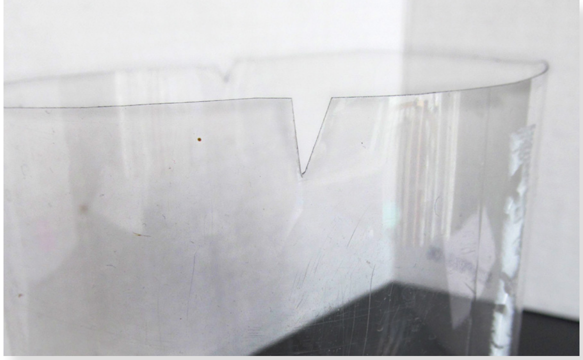
This image shows water from above the waterwheel turning the waterwheel as it falls. The higher the water source, the more gravitational potential energy it has.

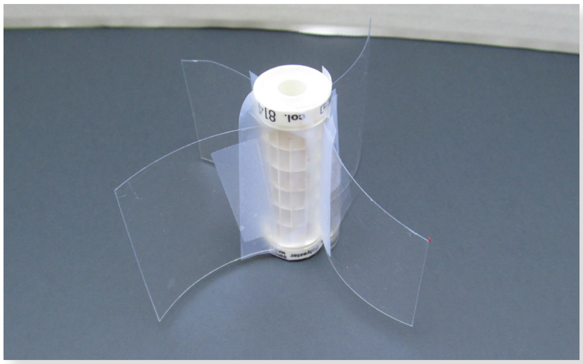
MATERIALS

- 2-liter soda bottle (clean and empty)
- Empty thread spool, any size
- Dental floss (12 inches) with washer tied to end
- Wooden skewer
- Scissors
- Tape
- Ruler
- Water pitcher
- Stopwatch (phone app or regular)
- Table or stool
- Foil baking pan with sides shorter than the cut soda bottle (to catch water spillage)
- Small rocks to add as counterweight, if needed

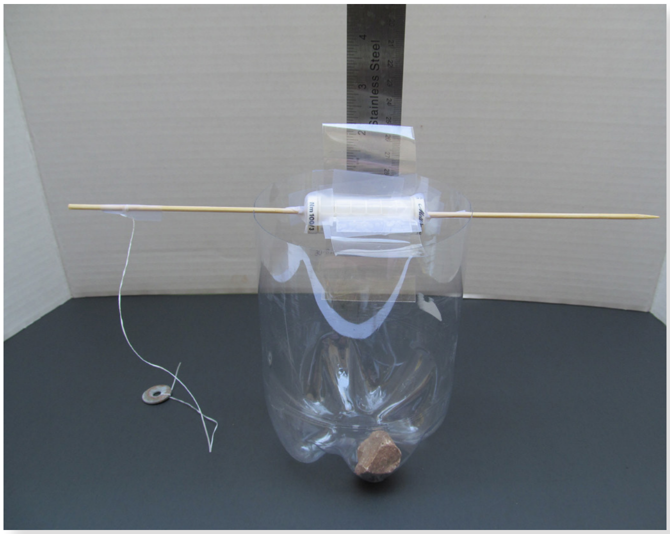
Make the waterwheel:

1. Cut the top off the soda bottle where it starts widening. Save this top part to use as a funnel.
2. Cut a ring off the soda bottle, about 1 inch or so down (this width should be slightly smaller than the length of your thread spool). Then cut this ring into 4 to 6 rectangular pieces about 2" x 1" each. These will be the paddles of the waterwheel.
3. On the rim of the remaining part of the water bottle, cut two notches directly across from each other. The notches are where the skewer will rest (and spin) on the bottle.
4. Tape the paddles onto the spool so all the pieces curve in the same direction.





5. Insert the skewer through the center of the thread spool and tape it in place on the spool.
6. Rest your waterwheel skewer in the notches of the soda bottle. Spin your waterwheel to make sure the spool and skewer turn easily. Trim down the paddles if they touch the sides of the soda bottle.
7. Tie the dental floss to one end of the skewer and let the washer hang down. Tape the dental floss in place to prevent it from slipping.



8. Tape the ruler to the outside of the soda bottle. If the bottle tips, use a rock as a counterweight.
9. Place the entire waterwheel soda bottle in the baking pan on the table. Let the washer at the end of the dental floss hang over the edge of the table.

Make your predictions

Think about what the waterwheel will do when you pour water over the paddles. Record your predictions in your Safety Smart® Science Investigator's Journal.

Now think about what will happen to the washer that is tied to the end of the dental floss when you pour water over your waterwheel. Record your predictions.

Will the results change if you pour the water from a greater height? How will they change? Record your predictions.

Observe

Trial #1: Pour water from lower position

Using the top part of the soda bottle as a funnel held over the paddles of the waterwheel, pour water steadily from the pitcher into the funnel from a measured distance (approximately 1 inch) above the waterwheel.

Using a stopwatch, record how long it takes for the washer to reach the skewer.

Record your results and observations in your journal.

Trial #2: Pour water from higher position

Pour water from the pitcher into the funnel from a much higher distance (approximately 10-12 inches).
Hint: Keep the funnel close to the waterwheel to avoid splashing.

Using a stop watch, record how long it takes for the washer to reach the skewer.

Record your results and observations in your journal.

What is going on here?

Water is an invaluable resource. We depend on it for drinking, growing food, transportation, washing, and power!

Waterwheels use the force of water to move paddles, which in turn rotate the axle (the skewer) that drives machinery. People have been using the power of water for more than 2,000 years! Historically, waterwheels were used to mill flour, grind wood for paper, and irrigate land.

The invention of the waterwheel led to the development of the turbine in the 19th century. Turbines are used in modern-day hydroelectric dams to generate electricity. Using water as a power source is a form of **sustainable energy** as it doesn't run out and doesn't add pollutants to the environment.

photo credit: DXR

The waterwheel in this activity also harnesses the power of the water! The water being poured from the pitcher has both **potential energy** (the energy in an object due to its position) and **kinetic energy** (the energy in an object due to its movement). Your waterwheel is converting the potential and kinetic energy of the falling water into **rotational energy** (energy of a rotating object—in this case, the rotating skewer). When the skewer rotates, it lifts the washer.

When you pour the water from the greater height, you are increasing the water's potential energy. This energy is transferred to the waterwheel, and it rotates faster. As the skewer rotates faster, it lifts the washer faster than when the water was poured from the lower height.

For older kids:

Using equations, we can determine how much power the waterwheel generated.
Can you calculate the power that your waterwheel generates with the equations below?

To determine the power the waterwheel generated:

Power(W) = work(J)/time(s)

But first, you'll need to figure out the work (J) required to lift the washer the length of the dental floss:

Work(J) = mass(m) x gravity(g) x height(h)

Hint: The value of (m) is based on the weight of the washer, and the value of (h) is based on the length of the dental floss. Gravitational acceleration (g) is 9.8 m/s^2.

LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Physical Sciences
- Disciplinary core ideas:
  - PS3B Conservation of Energy and Energy Transfer
  - PS3C Relationship Between Energy and Forces
  - Biogeology
- Cross-cutting concepts: Systems and system models, energy and matter

Safety Smart Science Investigator's Journal: Harness the Power of Water

Sketch your waterwheel and label the axle. Draw arrows to show what direction you think the paddles will move and what will happen to the washer.

What do you think will change when you pour the water from a higher position?

Record your observations

	height of water source in inches (h)	**time to move washer in seconds (s)**	Observations
Trial #1			
Trial #2			

Calculations for older kids

mass of washer (m)	gravity m/s² (g)	change in washer height (h)	**work (J) = m x g x h**
			joules

	time (s) *(from first table)*	work (J) *(from second table)*	**power (W) = J/s**
Trial #1			**watts**
Trial #2			**watts**

ELECTRONS AND ELECTRICITY

I wonder…
Can I harness the power of electrons?

Electricity can seem like a strange and mysterious force. It allows us to read in bed at night, to see the cookies baking in the oven, and to watch our favorite television shows. As helpful as electricity is, it can also be dangerous, particularly if we ignore good safety rules.

There are three different experiments in this adventure. In Experiment #1, you will make your own battery. In Experiment #2, you will build a simple circuit to test the conductivity of various materials. In Experiment #3, you will investigate the importance of insulators in electrical safety.

MATERIALS

- Copper pennies (at least 9)
- Heavy duty aluminum foil
- Plain uncoated cardboard
- White vinegar
- Salt
- Small cups or dishes
- Clear tape or electrical tape
- Multimeter or voltmeter
- LED light bulb, such as used in a flashlight
- Scissors

EXPERIMENT #1: MAKE YOUR OWN BATTERY

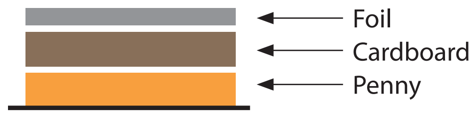
Set up the experiment:

Prepare two small cups of vinegar plus a generous shake of salt in each cup. Clean your pennies by soaking them in one of the cups for about 5 minutes.

Trace a penny on the cardboard. Cut out eight circles. Soak the cardboard circles in the other cup of vinegar and salt.

Trace a penny on the aluminum foil. Cut out eight circles.

Make and test your battery:



1. Place a clean penny on your plate.
2. Stack a wet cardboard circle on the penny.
3. Stack a foil circle on the cardboard.

This is considered one cell of the battery.

4. Use the multimeter to test the voltage by touching the red probe (positive) to the penny and the black probe (negative) to the foil. It may be helpful to hold the cell between your thumb and finger while you test the voltage. Record the voltage on your Safety Smart® Science Investigator's Journal.
5. Add another cell to your stack (penny + cardboard + foil). Measure the voltage. Did it change?
6. Continue to stack penny + cardboard + foil until you have used eight pennies. Top off the stack with the ninth penny.

Use the multimeter to test the voltage. Record the voltage on the worksheet. Did the voltage change? Why do you think that is?

Carefully pick up your battery, pressing on the top and bottom penny to keep the stack together. Hold the wires of the LED bulb on the top and bottom penny. Watch the bulb light up with "penny power"!

Try this:

Does the order of the materials affect the power of your battery? What if you stacked foil + penny + cardboard?

Use tape to hold your battery together, being careful to tape the sides, but leave the top and bottom pennies exposed.

What if you made a tube out of cardboard and stacked your penny battery inside the tube? Does that remind you of a regular store-bought battery?

What is happening here?

A battery converts the ***chemical energy*** of two metal ***electrodes*** (in this case, copper and aluminum) interacting with the acid of the ***electrolyte*** (vinegar in the cardboard) into ***electrical energy***.

An ***electric current*** (movement of electrons from one metal to the other) is created when the wire connects both metal surfaces. Each cell is defined as a stack of copper penny, cardboard, and aluminum foil. Each cell can provide about 0.6 volts; to power an LED light needing 1.7 volts, only three cells need to be used. An eight-cell penny battery can last several hours providing minimal voltage. As the cardboard dries out (and the electrolyte evaporates), the voltage decreases until the battery "dies."

EXPERIMENT #2: BUILD AND TEST A SIMPLE CIRCUIT

MATERIALS

- 2 D batteries
- Masking tape
- Working flashlight that you can unscrew and take apart (select a very basic, incandescent, two-battery flashlight)
- A variety of conductors and insulators:
    - Strip of heavy-duty aluminum foil about 12 inches (30 cm) long
    - Wire about 12 inches (30 cm) long
    - Strip of paper about 12 inches (30 cm) long
    - Shoelace
    - Pipe cleaner or chenille stem
    - Rubber band

Set up the experiment:

- Unscrew the flashlight and carefully remove the light bulb
- Tape the two batteries together, putting positive and negative ends together

Construct a simple electrical circuit to light the bulb:

- Start with the strip of aluminum foil. Wrap one end around the metal screw threads on the light bulb. Secure with a little tape. Do not cover the tip of the light bulb.
- Tape the other end of the foil to the flat (negative) end of the stacked batteries.
- Touch the metal tip of the light bulb to the post (positive) end of the battery stack. What do you think will happen? Answer: The light bulb should glow.

BE SAFETY SMART®: You can touch this electrical current without danger because the amount of electricity flowing is so small. But *never, ever* touch the electrical socket of a real lamp.

What is happening here?

The batteries are producing a little bit of electricity called a ***current***. The aluminum foil strip provides a pathway for the current. The foil is called a ***conductor*** of electricity. The light bulb will glow only if there is an electrical current flowing through it in a complete and uninterrupted path. Your conductor connects the electricity from the batteries to the light bulb so the current can flow through and light the bulb.

Take a closer look:

Look closely at the battery. It is labeled "1.5V," or 1.5 volts. Basically, this is a measure of the power of the battery. Other common batteries, like AA and AAA, are also 1.5V batteries. If a D battery is so much bigger than an AAA battery, why do they provide the same number of volts? Could you use a D battery to power something that normally uses AA batteries? This would be a great science fair project!

A volt is a measure of electromotive force. Here's a simple way to think about electricity: Voltage can be compared to the pressure that pushes water through a hose, where the water is the current of electricity and the hose is the conductor. Earlier in history, people thought electricity really was a fluid, like water, but we now know electricity is not a fluid.

Think about this:

Do you think the light bulb would glow if you reversed the conductor and taped the free end to the positive end of the battery stack and touched the light bulb to the negative end? Would the light bulb glow if you used only one battery? What if the batteries were stacked flat end to flat end (negative to negative)? Try it and see. Record your observations in your Safety Smart Science Investigator's Journal.

Next, use your circuit to test the conductivity of other materials:

Repeat the experiment with the other materials: shoelace, paper strip, wire, pipe cleaner. First, predict which ones will be good conductors (that is, which ones will allow the electricity to flow). Try it out. Record your observations in your journal. What type of material makes the best conductor?

Materials that do not conduct electricity are referred to as "insulators." Often, an insulator is used to cover a conductor in order to protect the environment (and you!) from the electricity flowing through the conductor. In the next experiment, you'll test a circuit with and without an insulator.

EXPERIMENT #3: FEEL THE HEAT OF ELECTRICITY

Now that you have experienced the benefit of electricity, try this experiment to get a sense of the possible danger of electricity.

MATERIALS

- 9V battery (standard alkaline or zinc-carbon battery, not rechargeable)
- Penny
- Thick rubber band

Look carefully at the battery. Notice the markings that indicate the negative (-) post and the positive (+) post. How do they compare to the negative and positive ends of the D battery?

What do you think will happen if you lay the penny across the battery's posts? Try it and find out. Hold the penny on the battery for about 15 seconds. You are creating a simple closed circuit by connecting the two posts with a conductor. The penny is made mostly of copper; copper is a very good conductor of electricity. In fact, most household wiring is made of copper. Feel the heat? That is the result of the electrical current flowing through the battery and the penny. Remove the penny.

Now wrap the rubber band around the battery, covering the terminals. Hold the penny on the battery again. Do you feel any heat this time?

What is happening here?

Electricity is a form of energy. When you put the penny directly onto the battery terminals, you are creating a "short" circuit that allows the current produced by the battery to flow. You feel the current as heat. The heat produced from the flow of electricity can be dangerous.

Rubber is an ***insulator***, a poor conductor of electricity. Therefore, when you put the rubber band between the battery and the penny, the circuit is broken, and you don't feel any heat. In order to protect the surroundings from the heat of electricity and to keep the electricity contained, we wrap electrical cords in a material that won't conduct electricity—an insulator. Notice that every electrical cord is covered in rubber or plastic; you don't see the copper wiring at all.

NOTE: The 9V battery will drain of power very quickly with the penny experiment. Don't leave the penny on for more than a few seconds—just long enough to feel the heat.

What more should I know?

If an electrical cord or appliance is damaged, the electricity can shock you, burn you, or even cause a fire. If you touch electricity, you become part of the circuit—which can be very dangerous. We don't need an insulator on our conductor in our flashlight experiment because the amount of electricity is very small. However, real home appliances use a lot of electricity, so you should never touch a damaged electrical cord. Any damaged cord should be discarded.

SAFETY SMART® TIPS

- Water is a good conductor of electricity, so keep electrical appliances away from water.
- Inspect electrical cords, extension cords, power strips, and appliances for damage.
- Make sure you aren't overloading your extension cords; add up the watts to ensure you are being safe.
- Don't hide electrical cords under carpets or behind drapes.

LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Physical Sciences
- Disciplinary core ideas:
  - PS3 Energy
  - PS2 Motion and Stability: Forces and Interactions
- Cross-cutting concepts: Energy and matter

Safety Smart Science Investigator's Journal: Electrons and Electricity

Experiment #1: Make Your Own Battery

Draw your battery:

Record the voltage reading for one, two, and three cells:

1 Cell	2 Cells	3 Cells

Does the order of the materials in your battery affect the voltage? Test these combinations with the voltmeter.

Order	1	2	3	4	5	6
Top	PENNY	FOIL	CARDBOARD	PENNY	CARDBOARD	FOIL
Middle	CARDBOARD	PENNY	FOIL	FOIL	PENNY	CARDBOARD
Bottom	FOIL	CARDBOARD	PENNY	CARDBOARD	FOIL	PENNY
Voltage						

What can you conclude from this chart? Does the order matter?

Experiment #2: Build and Test a Simple Circuit

What happened when:

...you reversed the conductor? ______________________________

...you taped the batteries flat end to flat end? ______________________________

...you used only one D battery? ______________________________

Test the light bulb circuit with a variety of materials. For each material in the list below, predict if it will be a better conductor ("C") or better insulator ("I"). Compare that with your actual observations.

Material	Prediction	Observation
Aluminum strip		
Shoelace		
Paper strip		
Wire		
Pipe cleaner		
Rubber band		

Experiment #3: Feel the Heat of Electricity

Did you feel heat with the penny on the 9V battery? ______________________________

Did you feel heat with the rubber band on the 9V battery? ______________________________

Why didn't you feel heat with the D batteries? ______________________________

SAFETY SMART® TIPS

- Water is a good conductor of electricity, so keep electrical appliances away from water.
- Inspect electrical cords, extension cords, power strips, and appliances for damage.
- Make sure you aren't overloading your extension cords.
- Don't hide electrical cords under carpets or behind drapes.
- Discard any damaged electrical cords; don't try to repair them.

EXPLORING STATIC ELECTRICITY

I wonder...
What is there to know about static electricity?

We all are familiar with current electricity—that's the kind that powers our appliances and turns on our lights. But there's another kind of electricity that causes us to get a shock on a winter's day or makes our clean socks stick together in the dryer. This form of electricity is called ***static electricity*** because it doesn't flow through conductors (wires). Static means nonmoving. While this form of electricity might be defined as nonmoving, there's a lot of invisible movement going on that generates static electricity. In this adventure, you'll experience how electrons move from one object to another and see the effect of static electricity firsthand.

NOTE: Adventures with static electricity work best when the humidity is low because charged electrons are drawn to the moisture in the air, and away from the materials in your experiment. Be aware of latex allergies in participants.

EXPERIMENT #1: STATIC ELECTRICITY "MAGIC TRICKS"

MATERIALS

- Latex balloons
- Wool hat
- Plastic bag
- Salt
- Pepper
- Paper plate
- Plastic spoon
- Tissue paper

Can a lightweight plastic loop levitate over a balloon?

Cut a loop from a lightweight plastic bag. Rub it with a wool hat. Rub the balloon on your hair. Hold the loop over the balloon and see what happens. Rubbing wool against the balloon and the plastic band transfers a negative charge to both objects. The band floats above the balloon because the like charges repel one another.

Can a mixture of salt and pepper be separated?

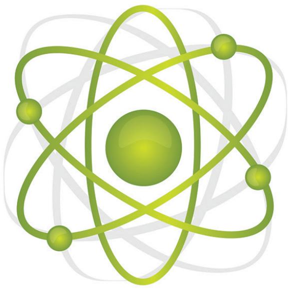
Rub the back of the plastic spoon on a wool hat to create a negative charge on the spoon. Hold the charged spoon over a mixture of salt and ground pepper. The light flecks of pepper are attracted to the spoon (both salt and pepper are attracted, but the flecks are light enough to jump to the spoon) because they received an induced charge from the charged spoon.

Can tissue paper stand on end?

Cut several half-inch squares of tissue paper. Scatter them on the table. Charge a balloon by rubbing it in your hair or on a wool hat. Hold the charged balloon over the tissues. Can you get them to stand up?

The negative charge of the balloon repels electrons in the tissue, leaving a slight positive charge in the tissue. Since opposite charges attract, the tissue is attracted to the balloon.

What is happening here?



Static electricity is produced when you rub certain objects together. All physical objects are made up of atoms. Atoms are made up of particles called protons, neutrons, and electrons. ***Protons*** have a positive electrical charge, ***neutrons*** have no charge, and ***electrons*** have a negative charge. Normally, these charges balance one another out, and the object itself is neutral (no charge). However, if you rub two items together, electrons may jump from one item to the other.

When electrons move, the total number of atomic particles in each object becomes unbalanced. The object that gave up its electrons now has excess protons, so it has a positive charge; the object that picked up the wandering electrons now has extra electrons, so it has a negative charge. This charge caused by the imbalance results in what we know as static electricity.

When you rub the plastic loop against the wool and the balloon on your hair, electrons move to the surface of the loop and the balloon, leaving them with a negative charge where you rubbed. When you move the two negatively charged items closer to each other, they repel and push away from each other.

Think about this:

What happens if you hold a charged plastic loop near an uncharged balloon? Will it be attracted to the balloon? What if you hold an uncharged spoon over the salt and pepper mixture? What happens if you move a charged balloon extremely close to the uncharged tissue paper? Do they stand up, jump, or repel? Record your predictions in your Safety Smart® Science Investigator's Journal.

EXPERIMENT #2: BUILD AND TEST AN ELECTROSCOPE

"Electroscope" is a fancy name for a simple instrument used to detect electric charge. Scientists and teachers have been experimenting with different styles of electroscopes for more than 400 years. In this experiment, you will build your own electroscope and then use it to test and compare the static electricity charge of several household objects.

MATERIALS TO BUILD THE ELECTROSCOPE

- Aluminum foil
- Clear 2-liter soda bottle, clean and dry, label removed
- Large paper clip
- Note card
- Sticky Tack or modeling clay
- Tape
- Scissors
- Pen

MATERIALS TO TEST WITH THE ELECTROSCOPE

(NOTE: You need materials from both lists)

List #1

- 100% wool scarf or sweater
- Silk scarf
- Nylons (pantyhose)
- Plastic wrap
- Cotton handkerchief
- Your hair

List #2

- Latex balloon
- Polystyrene (Styrofoam) plate
- PVC pipe about 12 inches long
- Vinyl record album
- Wooden spoon

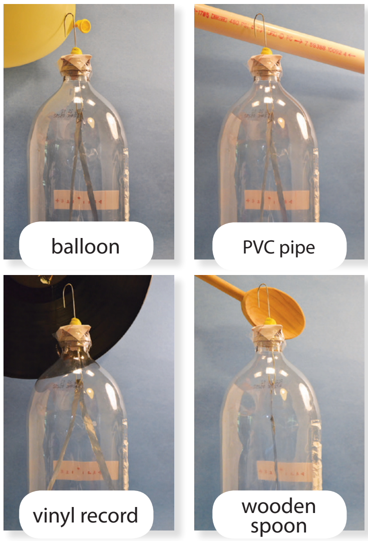
Build the electroscope:

- Cut two strips of aluminum foil about 1/2 inch/12.7 mm wide by 5 inches/127 mm long. The strips must fit inside the mouth of the soda bottle.
- Carefully punch a hole in the end of each strip.
- Smooth each strip to be as flat as possible.
- Bend open the paper clip so there is a hook at each end.
- Cut a strip off the note card, and another piece about 1.5 inches/38.1 mm square.
- Punch a hole in the center of the square scrap.
- Mark the paper strip like this: **4 3 2 1 0 1 2 3 4** This will be your power scale.
- Slide the end of the paper clip through the hole in the square scrap.
- Gently hang the two strips of aluminum foil on the hook. The foil should be as smooth and straight as possible.

- Lower the strips into the bottle, bend the card around the mouth of the bottle, and tape in place.
- Use a small wad of Sticky Tack to hold the paper clip in place so about half of the paper clip is sticking up above the top of the bottle.
- Tape the power scale to the outside of the bottle, facing in so you can see the numbers as you look through the bottle. Position the power scale so the foil strips are resting at "0."

Use the electroscope for testing:

- Select two materials from those available, one from list #1, one from list #2.
- Record the two materials in your Safety Smart Science Investigator's Journal.
- Vigorously rub the soft material on the rigid material.
- Keep your eyes on the aluminum strips as you slowly move the rigid object toward the paper clip on the top of your electroscope.
- Repeat the test with the same materials, this time watching to see how far apart the strips move according to your power scale. Record the score (0-1-2-3-4) in your journal for that pair of materials.



Think about this:

Do all the materials produce the same amount of movement in the foil? Why do you think that is so?

What is happening here?

By rubbing two objects together, you are charging one with electrons from the other, making the charged object negative. When you move the charged object toward the paper clip at the top of the electroscope, the excess electrons jump to the metal and down to the aluminum strips. Both aluminum strips become charged with electrons (negative); the free-hanging aluminum strips spread apart. The amount they move depends on how much charge is transferred from the object to the aluminum. Some objects accept electrons easily (for example, a latex balloon), other objects not as much. Can you relate this demonstration to what happens to your hair when you take off a wool hat?

What more should I know?

You can actually hear static electricity, too. Try this demonstration at home in a quiet room. Bend a metal paper clip open so one end sticks out. Tape the paper clip to the edge of a table, with the straight end pointing up. Charge a latex balloon by rubbing it with a wool scarf several times. Put your ear close to the paper clip and bring the charged balloon very close to the paper clip, but don't touch it. Did you hear anything? As the excess electrons on the balloon rush to the paper clip, they make a tiny crackling sound. This is a miniscule version of lightning!

SAFETY SMART® TIPS

- Lightning is a form of static electricity, but on a much larger scale! The discharging electrons in lightning are strong enough to start a forest fire or injure a person. Lightning will always travel the shortest distance possible from storm cloud to ground. Therefore, never, ever stand under a tall tree during a thunderstorm. If lightning strikes, it is likely to hit the tree, which could severely injure anyone nearby. Take cover in a building or under an approved shelter during thunderstorms.
- Directly plug an appliance's 3-prong electrical plug into a 3-prong wall outlet. The third prong is the "ground," which discharges any excess electrical charge that might build up in the appliance. Bypassing the third prong by using an adapter could put your appliance at risk of damage (and also injure you!).

LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Physical Sciences
- Disciplinary core ideas:
  - PS2 Motion and Stability: Forces and Interactions
  - PS3 Energy
- Cross-cutting concepts: Energy and matter

Safety Smart Science Investigator's Journal: Exploring Static Electricity

Experiment #1: Static Electricity "Magic Tricks"

Make a plastic loop levitate

Prediction: What happens if you hold the charged loop near an uncharged balloon? Will it levitate or be attracted to the balloon?

Hint: Rubbing the balloon or the plastic loop with wool or hair transfers a negative charge to the object. Like charges attract, opposite charges repel. If one object has a positive charge and the other has a negative charge, the objects will attract. If both objects are negatively charged, they will repel; this is what makes the loop seem to levitate over the balloon.

Separate salt and pepper

Prediction: What happens if you hold an uncharged spoon over the salt and pepper mixture?

What if you use a charged spoon and a mixture that has larger flecks of pepper or whole peppercorns, or salt that is more finely ground?

Make tissue paper stand on end

Prediction: What happens if you move the charged balloon away from the tissue paper pieces? Do they stay standing?

What happens if you move the charged balloon very close to the tissue paper? Do they stand, jump, or repel?

Experiment #2: Build and Test an Electroscope

		Score 0-1-2-3-4	
Material #1	Material #2	Predicted	Observed

SAFETY SMART® TIPS

- Lightning is a form of static electricity, but on a much larger scale! Lightning will always travel the shortest distance possible from storm cloud to ground. Therefore, never, ever stand under a tall tree during a thunderstorm.
- Insert an appliance's 3-prong electrical plug directly into a 3-prong wall outlet. The third prong is the "ground," which discharges any potentially harmful excess electrical charge that might build up in the appliance. Don't use an adapter to bypass the third prong.

TRANSACTION SECURITY: CODEMAKING AND ENCRYPTION

I wonder…
How can I send information securely?

In this adventure, you'll learn about codemaking, fingerprints, and encryption. You'll write a word in Morse code, design your own personal code, and see how unique your own fingerprints are.

MATERIALS

- Ink pad
- Paper
- Morse code charts (see worksheet)
- Flashlight
- Whistle
- Baby wipes to clean off ink

* Reference diagram of four major types of fingerprints (see below)

SETUP

Gently press each thumb onto the ink pad and then press them onto your worksheet in the space provided, right and left as indicated.

Now stamp your thumbs on a sheet where everyone else has also stamped theirs. No names on this sheet. This sheet will be used during the activity.

DESIGN

Using the Morse code decoder chart, and standard "•" and "—" as symbols, write your name in Morse code on your worksheet.

Write another word in Morse code. You will communicate this word by humming, whistling, and flashing a light.

Design your own code for the alphabet on your worksheet. Write a short sentence in your code (for example, "I love you" or "This is fun").

TEST

Can your parent match your thumbprints (from your worksheet) with your thumbprint on a sheet of unlabeled prints?

Can your parent decode the word you wrote in Morse code (your name)?

Can your parent decode a word you sound out/flash out in Morse code?

Can your parent decode the sentence you wrote in your own personal code?

WHAT IS HAPPENING HERE?

Your fingerprints are unique to you. No one in the world has the same prints as you. Fingerprints can be used to identify you, and only you. Some cell phones use a feature to lock and unlock the phone based on your personal fingerprint. In this case, your fingerprint acts like a key to keep the phone secure.

There are four major types of fingerprints: arches, loops, whorls, and composites (which have characteristics of more than one of the other types). Can you identify your type?

Morse code is a simple communication system developed by Samuel Morse in the 1840s. Morse code assigns a series of dots and dashes to represent each letter in the English language. It was used in conjunction with the telegraph machine to communicate over long distances before there were telephones, fax machines, or the internet. The most familiar message in Morse code is "S-O-S" which is the international sign for distress. It is represented in Morse code as:

• • • — — — • • •

SOS was used because it was an easy sequence to remember even in times of stress, not because it meant anything (such as "save our ship").

Cryptography is the science of codemaking. Codes have been used for centuries to send sensitive messages and protect secrets.

TRY THIS AT HOME

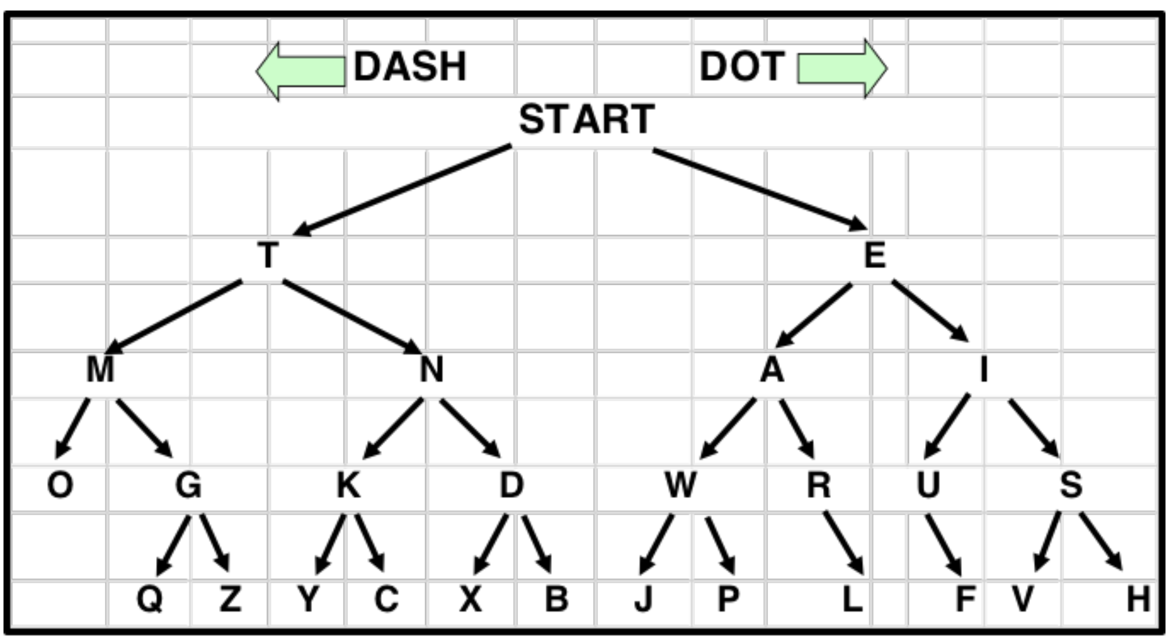
Compare your thumbprints with those of your relatives. Are there any similarities?

Try communicating with your friends across your yard using Morse code.

MORSE CODE

A	· −	J	· − − −	S	· · ·
B	− · · ·	K	− · −	T	−
C	− · − ·	L	· − · ·	U	· · −
D	− · ·	M	− −	V	· · · −
E	·	N	− ·	W	· − −
F	· · − ·	O	− − −	X	− · · −
G	− − ·	P	· − − ·	Y	− · − −
H	· · · ·	Q	− − · −	Z	− − · ·
I	· ·	R	· − ·		

MORSE CODE Decoding Chart



LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Physical Sciences
- Disciplinary core ideas:
  - PS4 Waves and Their Applications in Technologies for Information Transfer
  - LS3 Heredity: Inheritance and Variation of Traits
- Cross-cutting concepts: Patterns

Safety Smart Science Investigator's Journal: Transaction Security: Codemaking and Encryption

Left Thumbprint	Right Thumbprint

Your first name in Morse code

A word in Morse code

Design your own code:

A	B	C	D	E	F	G	H	I	J	K	L	M
N	O	P	Q	R	S	T	U	V	W	X	Y	Z

CREATE A GEYSER WITH SODA AND MINTS

I wonder...
Can I make a soda pop geyser without shaking up the bottle?

In this experiment, you will unleash the power of the bubbles in soda pop through a safe reaction. Soda is ***carbonated***, which means the liquid has carbon dioxide gas included in it.

NOTE: This experiment can be done on a small, personal scale with little mess and little risk. It can also be done on a large "WOW!" scale, perhaps at the end of Family Science Night and outside. The materials and setup for both approaches are included here.

MATERIALS FOR PERSONAL SETUP

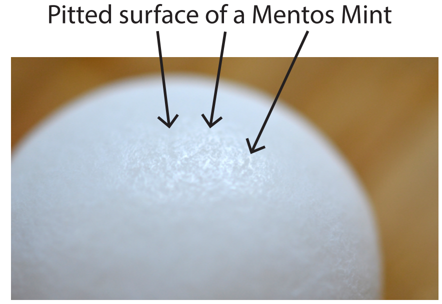
- Magnifying glass
- 2 Mentos mint candies for each participant (use only the mint variety)
- 3 small-size (8 oz.) clear plastic bottles
- Rough rock small enough to drop into the bottle
- Smooth marble
- ½ liter of sugar-free soda for each participant
- Plastic wash bin
- Safety goggles

NOTE: The soda must be fully carbonated (not flat) and room temperature. Sugared soda can be used, but it makes a stickier mess to clean up. Leave the original cap on until ready to do the experiment.

Run the personal experiment:

- Using a magnifying glass, take a close look at the surface of the Mentos, the rock, and the marble. How do they compare? Record your observations.
- What do you think will happen when you drop each item into a bottle of soda? Record your predictions in the Journal.
- Slowly pour soda into the first two bottles until each one is about half full. Fill the third bottle completely.
- Set all three small bottles in the plastic bin.
  - Drop the marble into bottle #1. What happens? Look closely at the marble in the liquid. What do you see?
  - Drop the rock into bottle #2. What happens? What do you see?
  - Drop two Mentos into bottle #3. What happens?
  - Record your observations in your journal.

Pitted surface of a Mentos Mint



What is happening here?

Even though it looks smooth, the Mentos mint candy actually has a very rough surface, covered with thousands of tiny pits. Did you notice that when you looked at them with the magnifying glass? These pits attract the carbon dioxide (CO_2) gas molecules in the soda pop, pulling them out of the liquid. As the carbon dioxide molecules rush to the Mentos that have dropped to the bottom of the cup, bubbles form and grow around the pits. When the bubbles grow big enough, they rise to the surface and the carbon dioxide gas "explodes" out of the top of the bottle to escape the liquid (and in the process, it pushes some of the liquid up and out at the same time). The reaction only lasts a few seconds, but it is amazing!

The rock is also pitted, but the smooth glass marble isn't. Scientists call these pits ***nucleation sites***. Nucleation sites break up the network of molecules in the liquid, which lets the gas molecules band together, eventually forming a bubble.

The soda that remains in the bottle is safe to drink, but it may taste "flat" since so much carbon dioxide has escaped from the liquid into the air.

TO MAKE A WOW! GEYSER

The geyser eruption is exciting, but quick. For best effect, line up several bottles and activate them in sequence.

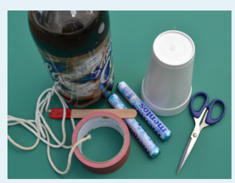
MATERIALS FOR THE WOW! SETUP

- 2-liter bottle sugar-free soda pop, unopened
- 6 Mentos mint candies
- Mentos delivery tube (see instructions below)
- Plastic baby pool to contain overflow if done indoors
- Safety goggles
- 2 bricks

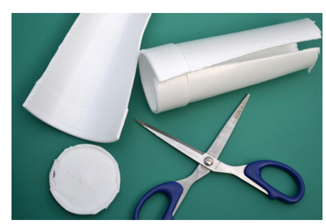
NOTE: The soda must be fully carbonated (not flat) and room temperature. Sugared soda can be used, but it makes a stickier mess to clean up. Leave the original cap on until ready to do the experiment.

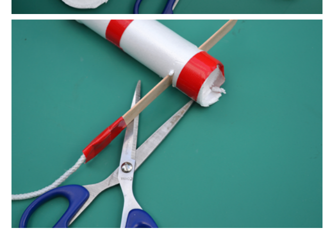
MATERIALS FOR THE MENTOS DELIVERY TUBE

- Large Styrofoam cup
- Jumbo craft stick
- Duct tape
- 4 feet to 6 feet of lightweight rope
- Scissors



Set up the delivery tube:

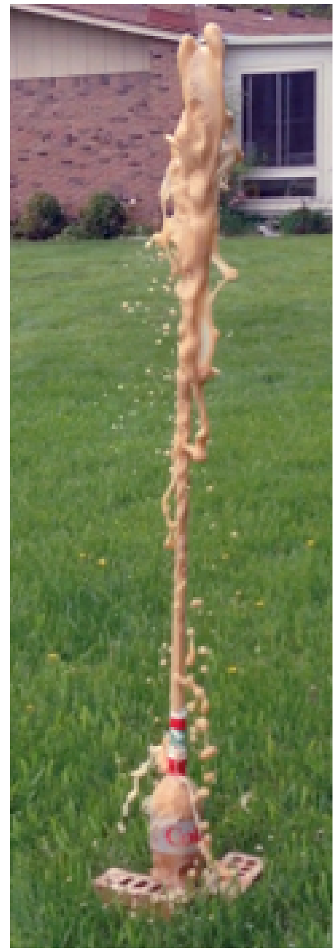




- Tape the end of the rope to the end of the craft stick. Set aside.
- Cut the Styrofoam cup down the side, cut out the bottom, and cut off about one-third of the remaining sheet, too.
- Wrap the larger Styrofoam sleeve snuggly around the top of the unopened bottle to form a tight cylinder; secure the tube with duct tape. Do not tape the tube to the bottle yet.
- **An adult does this step:** Just above the mouth of the bottle, carefully snip a slot on each side of the tube just large enough for the craft stick to slide in and out easily.
- **Test the tube:** Slide the craft stick into place. Drop in as many Mentos as will fit; you should be able to insert five or six. Pull on the string to remove the craft stick from the tube. The candies should fall out the bottom of the tube. Make any adjustments necessary.

Run the WOW! geyser experiment:

- Head outside or set the bottle in the center of the baby pool. Use two bricks to hold the bottle upright.
- Unscrew the cap of the soda pop bottle.
- Slide the Mentos delivery tube onto the neck of the soda pop bottle. Secure it tightly to the bottle with duct tape, wrapping tape around the neck of the bottle.
- Insert the craft stick, making sure the rope extends away from the bottle.
- Put on safety goggles.
- Carefully fill the tube with Mentos, one at a time, taking care to stack the candies one on top of the other.
- Step away from the bottle, to the end of the rope (about 4 feet to 6 feet away).
- Gently tug on the rope until the craft stick comes out of the tube and the Mentos fall in. Wow!



What more should I know?

Carbon dioxide (CO_2) is a gas that occurs naturally in the earth's atmosphere. (In fact, we breathe in oxygen and we breathe out carbon dioxide!) It is used in soft drinks to make them bubbly and fizzy. It also helps preserve the soda and keep it from spoiling.

The very first soft drink was carbonated water, which first appeared in the 1700s. And in 1886, a pharmacist in Atlanta, Ga., named John Pemberton created Coca-Cola!

SAFETY SMART® TIPS

We all know that staying healthy and fit means we should eat a variety of foods, including fruits, vegetables, and whole grains. Being healthy and fit also means keeping our teeth healthy. So let's all do our part and be Safety Smart by flossing and brushing our teeth after every meal to remove germs and prevent cavities. And remember to brush as soon as possible after eating sugary foods.

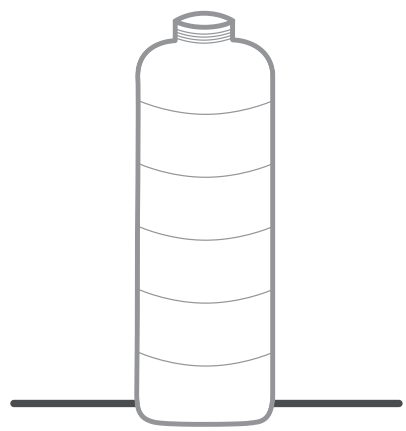
LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Engineering, Physical Sciences
- Disciplinary core ideas:
  - PS1 Matter and Its Interactions
  - PS1B Chemical Reactions
- Cross-cutting concepts: Cause and effect

Safety Smart Science Investigator's Journal:
Create a Geyser With Soda and Mints

			What happens when you drop the item into the soda pop?	
Item		Describe the surface of the item	**Prediction**	**Observation**
1	**Marble**			
2	**Rock**			
3	**Mentos Mint**			



Draw your own soda pop and Mentos geyser

SAFETY SMART® TIPS

- Eating a variety of foods, including fruits, vegetables, and whole grains, is important for staying healthy and fit, but so is keeping our teeth healthy.
- Floss and brush your teeth after every meal to remove germs and prevent cavities.
- Brush as soon as possible after eating sugary foods.

LEVERS AND OTHER SIMPLE MACHINES

I wonder...
How can I safely move and lift a heavy load?

Your challenge is to move and lift a box filled with a whole lot of weight! You'll do it once without any tools, then again with the help of three "simple machines": a lever, a wheel, and an inclined plane. See whether it's easier to do the job when you use the tools.

MATERIALS

- A large plastic storage box (13-15 gallons)
- Several bricks or heavy text books, enough to weigh 25-35 pounds/11-16 kilograms
- 2 pieces of 2x4 boards, each about 4 feet/1.5 meters long
- 1 piece of PVC pipe, 1 inch diameter, about 2 feet/.75 meters long
- Masking tape
- Assorted levers: broom handle and brick, shovel, scrap of wood 2x4, hockey stick, old golf club (any rigid bar)
- Tape measure
- Stop watch (many cell phones have a stop watch application)
- Scale (optional)

Set up the experiment:

- Arrange this experiment near a step.

  Optional: Use a riser or inverted milk crate against a wall instead of a step.
- Put the bricks/books inside the storage box and snap on the lid.

  Optional: Weigh the box.
- Mark a starting line on the floor with masking tape, about 15 feet/4.5 meters away from the step. Put the loaded box at the starting line. The finish line is at the step.

Have the child push the box to the finish line and lift up onto the step. Try to do this on your own.

(Adults, help keep little fingers and toes from getting hurt!)

Think about this:

How hard is it to push the box to the finish line and up onto the step?
Give it a rating:

1: Couldn't do it without an adult's help;

2: Hard but I managed on my own;

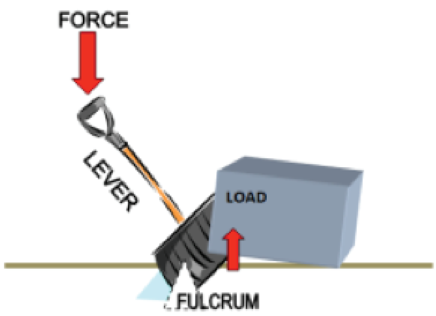
3: Easy, didn't struggle at all.

Record your rating and your time in your Safety Smart® Science Investigator's Journal.

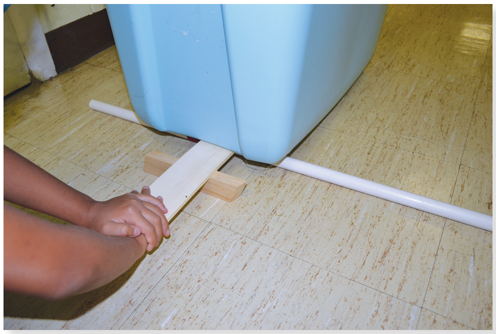
Now try using three simple machines:

Simple machines make work easier by transferring the effort from *us* to the *machine*.

1. LEVER—Slide one of the levers (broom handle, for example) under the box. Press down on the lever to lift the box. The point at which the lever presses against the ground is called the "fulcrum."



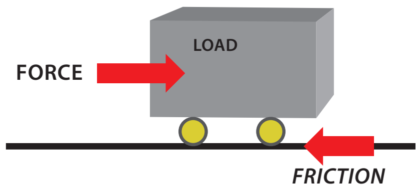
2. WHEEL—While holding up the box with your lever, slide the piece of PVC pipe under the box. Roll the box on its new "wheel" (the PVC pipe) toward the finish line, reinstalling the pipe as necessary. Stop about 2 feet/.75 meters from the step.



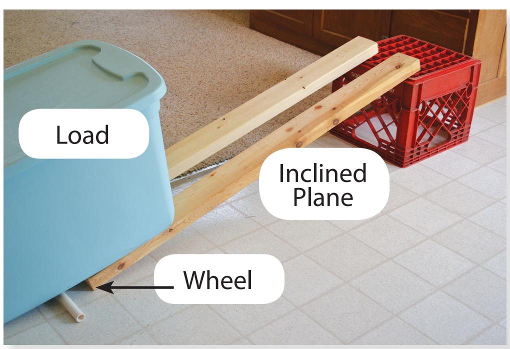
Think about this:

Was it easier to move the box with the wheel? Was it faster than just pushing it? Record your rating in your journal.

The box moves quickly with the wheel because the wheel reduces friction. Less friction, easier to slide!



3. INCLINED PLANE—Use the two boards to build a ramp (inclined plane) from the floor to the step. Slide the box up the ramp and onto the step. You might need to use your favorite lever to lift the end of the box onto the ramp. Be careful the lever doesn't slip.



Think about this:

Was it easier to push the box up the inclined plane, or lift it straight up?

What more should I know?

Which type of lever worked best? Did it matter whether your lever was long or short? What if you moved the fulcrum closer to the box? Record your observations in your journal. Was it harder or easier to lift the box?

What could you do to make the wheel more useful? Would it help to add an axle so the wheel stays attached to the box as it rolls? Would it help if the wheel was bigger?

What if the boards for your inclined plane were very long? Do you think it would be easier or harder to push the box up the ramp? Do very short boards make a steep inclined plane, or a flat one?

SAFETY SMART® TIPS

- Be safe when lifting heavy loads: Ask for help. Know where you're going before you lift the load. Get a firm grip. Lift with your legs, not with your back. Don't lift higher than your waist.
- Pick up your toys, books, and other clutter from the floor every night. Keep hallways, stairs, and pathways clear so no one trips!

LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Physical Sciences
- Disciplinary core ideas:
  - PS3C Relationship Between Energy and Forces
  - PS2 Motion and Stability: Forces and Interactions
- Cross-cutting concepts: Cause and effect

Safety Smart Science Investigator's Journal: Levers and Other Simple Machines

- How long did it take for you to push the box and lift it up ***without*** any tools? __________ seconds.

  Rate the effort:

  1: Couldn't do it without an adult's help

  2: Hard but I managed on my own

  3: Easy, didn't struggle at all

- What happened when you moved the fulcrum farther from the load? Was it harder or easier to lift?

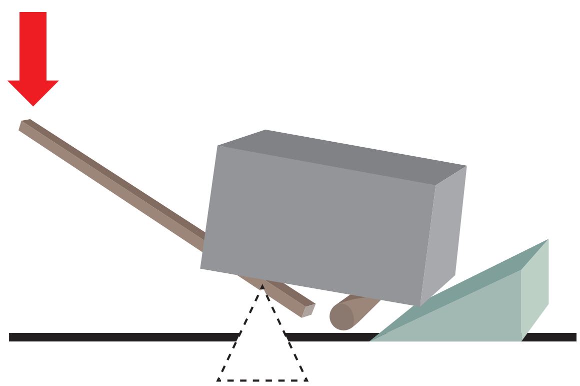
  ____

  ____

  ____

- How hard was it to move and lift the load with the use of the wheels, the lever, and the inclined plane (ramp)?

  Rate the effort: Wheels **1 – 2 – 3** Lever **1 – 2 – 3** Inclined plane **1 – 2 – 3**



Draw a line from the components to its picture in this diagram.

- Force
- Lever
- Fulcrum
- Load
- Wheel
- Inclined plane

Simple machines in everyday life: Match the...

OBJECT	*to the*	TOOL
Nutcracker		Lever
Bottle opener		Inclined plane
Wheelchair ramp		Wheel
Wagon		Lever
Automotive jack		Lever
Playground slide		Inclined plane

SAFETY SMART® TIPS

- Be safe when lifting heavy loads: Ask for help. Know where you're going before you lift the load. Get a firm grip. Lift with your legs, not with your back. Don't lift higher than your waist.
- Pick up your toys, books, and other clutter from the floor every night. Keep hallways, stairs, and pathways clear so no one trips!

FLOAT OR NOT?

I wonder...
Which of these objects will float?

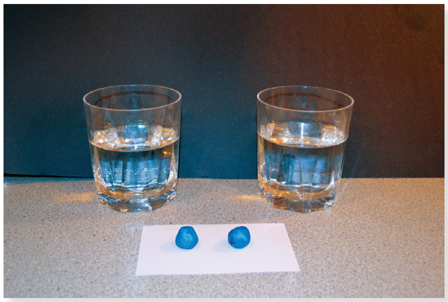
Try these experiments to learn why some things float and some things don't.

MATERIALS

- 2 clear cups
- Piece of modeling clay about the size of a walnut
- Can of regular soda (unopened)
- Can of diet soda (unopened)
- 6 more assorted everyday objects (pencil, eraser, key, ruler, foam cup, action figure, golf ball, table tennis ball, etc.)
- Bucket of water (Optional: For best results, use a clean fish tank filled with water)

EXPERIMENT #1: WHICH OBJECTS WILL FLOAT?

For all age groups

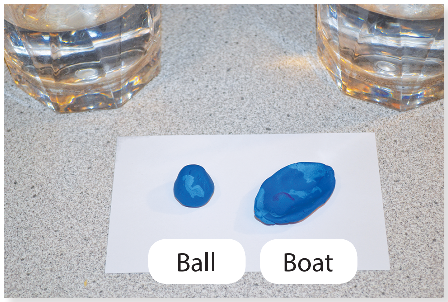


Set up the experiment:

Divide the clay into two equal pieces. Roll one piece into a ball. Form the other piece into a boat with a bowl shape. Arrange your other objects nearby.

Predict the results:

Which of these objects will float? Think about the object's size, shape, weight, density. Use the chart in your Safety Smart® Science Investigator's Journal to record your prediction for each object.



Run the test and record your observations:

Carefully set each object into the cup of water. Gently push each object under the water and let go. Does the object pop up or stay submerged?

Think about this:

After you test each object, record in your journal whether the object floated or sank. Does the result make you want to change any of your predictions for the other objects?

What more should I know?

If you carefully lay your clay boat on the water surface, it should float. But push your boat under the water, and it sinks to the bottom. What is going on? Why didn't the boat rise up like the table tennis ball or diet soda? The air that fills the bowl of your boat helps keep it afloat. When you push the boat under water, the air in the bowl is replaced by water. The air inside the table tennis ball can't get out, even if you push the ball under the water. Try flattening your boat into a pancake. Does it float now?

The diet soda floats because there is no sugar in the soda, whereas there is lots of sugar in the regular soda. Both cans contain the same amount of liquid (12 ounces/.35 litres) and air, but the diet soda is less dense than the sugared soda. In fact, the diet soda is less ***dense*** than the water, which is why the diet soda can floats. ***Density*** is another factor that affects an object's ability to float.

Bonus fun air and water experiments

best for older children

MATERIALS

- 2 plastic cups, preferably clear (empty tennis ball cans work great)
- Bucket or tank of water
- Tissue paper

EXPERIMENT #2: CAN YOU SUBMERGE A PIECE OF PAPER AND STILL KEEP IT DRY?

Set up the experiment:

- Crumple the tissue paper into a loose wad.
- Put the wad into the bottom of a dry cup.
- Turn the cup over. If the paper falls out, loosen the wad so it's bigger and put it back into the cup. You want the paper to stay in the bottom of the cup when you turn it over.
- Predict: If I put this cup under the water, will the paper get wet? Explain your prediction in your journal.

Try it!

Turn the cup upside-down. Slowly push the cup straight down into the water. Continue pushing until the cup is completely underwater. What is happening to the level of the water? What do you feel?

Think about this:

Pull the cup straight out of the water. Check the paper. Is it wet or dry?

The tissue paper stays dry even though the cup is submerged because the air in the cup pushes the water away from the tissue. As long as you keep the air trapped, the tissue will stay dry.

EXPERIMENT #3: CAN YOU POUR AIR FROM ONE CUP TO ANOTHER?

For this experiment, you need a bucket or tank of water large enough for both your hands. Be sure to set the tank on a sturdy table—it will be very heavy.

- Fill the bucket or tank.
- Put the first cup under water and let it fill up with water. It will sink to the bottom.
- Push the second cup straight down into the water, open end first. What do you feel? Is the water pushing back?
- Reach into the water and hold the mouths of both cups close to each other. Carefully tip the cup filled with air toward the cup filled with water.

Did you catch some air in the other cup? The air comes out of the cup because the air is lighter than water. Some of the air might escape as bubbles, but you should be able to catch some in the other cup. You just proved you can pour air!

What more should I know?

The science behind floating was first described by an ancient Greek scientist named Archimedes (ar-kuh-MEE-deez). Archimedes said that the water pushes against the object while the object pushes down on the water at the same time. The object actually pushes away ("displaces") some of the water. Think about how the level of the water in the tub rises when you climb in. Your body is "displacing" some of the water. If the displaced water weighs more than the object, the object will float; otherwise, the object sinks.

SAFETY SMART® TIP

Be safe in the water with a personal flotation device, also known as a life jacket. Playing in a pool or lake can be great fun, but safety comes first! If you don't know how to swim or if you're on a boat, wear a personal floatation device. The material in the life jacket floats so well that it can hold your body up out of the water.

LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Physical Sciences
- Disciplinary core ideas:
  - PS1 Matter and Its Interactions
- Cross-cutting concepts: Structure and function

Safety Smart Science Investigator's Journal: Float or Not?

Object	PREDICT: floats or sinks	OBSERVE: floats or sinks	I got it right!
Ball of clay			
Boat of clay			
Can of regular soda			
Can of diet soda			

Flat Boat prediction: Sink or float? Explain ______________________________

____

Observation: Sink or float? ______________________________

Wad of Paper prediction: Dry or wet? Explain ______________________________

____

Observation: Dry or wet? ______________________________

Can you pour air? ______________________________

SAFETY SMART® TIP

A personal flotation device, also called a life jacket, is designed to keep you safe in water, while boating, or during water sports. Be sure to wear the right size and one that is U.S. Coast Guard-approved and UL Listed.

HOW GERMS SPREAD

I wonder...
How can I reduce the spread of germs?

You can't see them, but germs are everywhere you are! Germs, or more properly ***microbes***, are microscopic organisms that exist everywhere. Some germs are helpful (like the yeast used to make bread rise), but other germs can make us sick (like the virus that causes the common cold). One of the very best ways to get rid of germs is to wash your hands thoroughly several times a day.

In this adventure, we'll use pretend germs to see how easily they can spread to others. Then we'll practice good handwashing technique to demonstrate how effective washing is at removing the germs.

This adventure is great for all ages, and especially practical for young children.

NOTE 1: This adventure should be set up near a sink with running water, such as right outside a restroom or near the cafeteria kitchen. Two Safety Smart® Science Coaches are needed: one to supervise the germ activity, and one to oversee the handwashing. Hang a poster at each sink with the Germ-Free Handwashing Song*.

NOTE 2: This adventure can also be done with special products that glow under blacklight. These products are designed specifically to demonstrate proper handwashing technique. (For example, www.germjuice.com and www.globright.com)

MATERIALS

- Hand lotion
- Tube of micro glitter, available at craft stores
- Paper towels
- Hand wipes (e.g., baby wipes)
- A variety of household objects such as a cup, placemat, hairbrush, computer mouse, and telephone (wipe them off in between students to remove any glitter "germs")
- Access to a sink with running water, hand soap, and paper towels or air dryer

Get your hands "germy":

Rub a tiny amount of lotion on your hands to moisten them. Dip just the tip of your index finger into the glitter—just the tip, you don't need much!

Now touch or handle the various household objects.

Think about this:

Do you see any glitter left behind? Can you transfer the glitter from one hand to the other (look for the color)? Can you rub the glitter off any of the objects using just your fingers (no towel)? Look around on the table and floor. Do you see any glitter? Imagine if each speck of glitter contained millions of germs. Yuck!

Clean your hands:

First, use a dry paper towel to try to wipe off the glitter from your hands. Did it come off?

Next, use a hand wipe. Did more glitter come off?

Finally, wash your hands under warm running water, with soap, for at least 20 seconds while singing the Germ-Free Handwashing Song. Dry with a clean paper towel.

Think about this:

Which hand-cleaning method was the most effective? Do you still see glitter on your hands? How about on your clothes or other body parts? Ask someone to look at your face. Do they see any glitter? It's amazing—and a little startling—how easily the glitter spreads all over your environment.

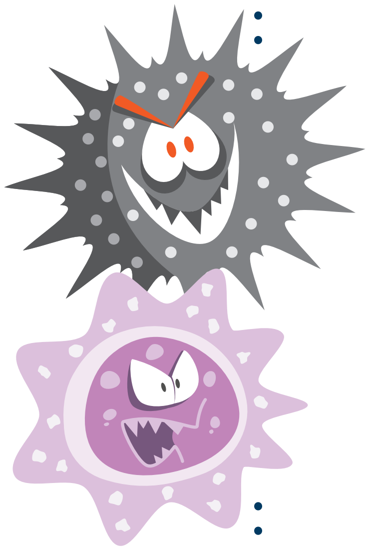
Proper and frequent handwashing is the best defense against the spread of germs. Record in your Safety Smart® Science Investigator's Journal when you typically wash your hands.

What more should I know?

People haven't always understood the importance of proper handwashing. Back in the old days, doctors didn't wash before surgery, cooks didn't wash before they made dinner, kids didn't wash after using the bathroom. Diseases spread throughout communities because sick people spread the germs to their neighbors. Patients died because the doctors spread germs from sick patients to healthy ones. But in 1847, a doctor named Ignaz Semmelweis ("*ig-NATS SEM-mel-vice*") observed that newborn babies were healthier when the nurses and doctors washed their hands before touching the babies. He encouraged everyone to wash up, and the babies in their clinic stopped getting sick. So next time you wash your hands, thank Dr. Semmelweis for proving that it keeps us healthier!

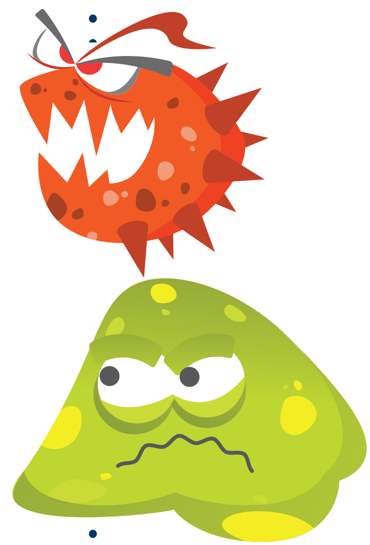
SAFETY SMART® TIPS

- If you feel a sneeze coming on, grab a tissue to cover your mouth and nose, or sneeze into your elbow if a tissue isn't available. Keep those germs off your hands and away from others!
- Be sure to wash your hands thoroughly before eating, after using the bathroom, after playing with animals, and if you've been around someone who is sick.
- Use a piece of paper towel instead of your clean hand to open the door as you leave a public restroom.



Germ-Free Handwashing Song

Germ-free, clean as can be.
Twenty seconds in the water, that's how you'll be!
Germ-free, definitely.
Twenty seconds in the water, that's how you'll be!
Germ-free, philosophy.
Twenty seconds in the water, that's how you'll be!



LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Physical Sciences
- Disciplinary core ideas:
  - PS1 Matter and Its Interactions
- Cross-cutting concepts: Energy and matter

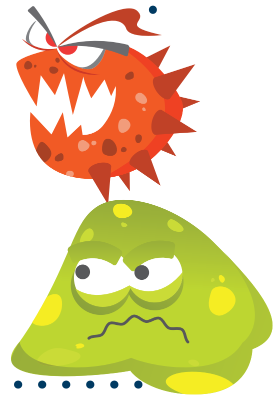
Safety Smart Science Investigator's Journal: How Germs Spread

The United States Centers for Disease Control and Prevention (CDC) has declared that proper handwashing is the single most effective method of reducing the spread of germs. So...

Wash your hands thoroughly—fronts, backs, in between your fingers, and under your fingernails—with warm water and soap. Scrub for ***at least 20 seconds***, or the time it takes to chant:

Germ-Free Handwashing Song

Germ-free, clean as can be.
Twenty seconds in the water, that's how you'll be!
Germ-free, definitely.
Twenty seconds in the water, that's how you'll be!
Germ-free, philosophy.
Twenty seconds in the water, that's how you'll be!



Dry your hands with a clean towel or disposable paper towel.

List at least 3 times in the day when you wash your hands:

____

____

____

What more should I know?

People haven't always understood the importance of proper handwashing. Back in the old days, doctors didn't wash before surgery, cooks didn't wash before they made dinner, kids didn't wash after using the bathroom. Diseases spread throughout communities because sick people spread the germs to their neighbors. Patients died because the doctors spread germs from sick patients to healthy ones. But in 1847, a doctor named **Ignatz Semmelweis** ("SEM-mel-vice") observed that newborn babies were healthier when the nurses and doctors washed their hands before touching the babies. He encouraged everyone to wash up, and the babies in their clinic stopped getting sick. So next time you wash your hands, thank Dr. Semmelweis for proving that it keeps us healthier!

SAFETY SMART® TIPS

If you feel a sneeze coming on, grab a tissue to cover your mouth and nose, or sneeze into your elbow if a tissue isn't available. Thoroughly wash your hands after using the bathroom, playing with animals, or visiting a sick friend.

FROM DIRTY WATER TO DRINKING WATER

I wonder...
How does dirty water get clean and safe to drink?

Clean water is essential for healthy, safe living. Our bodies are about 60 percent water, and our brains are even higher at 70 percent water. We drink water, bathe in water, cook with water, wash with water. We turn on the faucet at home or at school and expect a flow of clean water. But water doesn't necessarily start out pure and clean. The water from our faucet goes through many steps to ***filter out*** impurities so it is safe for us to drink. In this adventure, we'll test different filters to see which ones work the best at cleaning our dirty water.

NOTE: Even though we will be filtering the dirty water, it is still not safe to drink. Some organisms are so small, they may flow through these experimental filters in this adventure. Never drink water unless you're certain it is safe.

MATERIALS

- Towels to protect the table; this adventure can get messy!
- Bucket or tank of muddy water, including small rocks, sand, pieces of leaves, etc.
- Ladle
- Several small bowls or clear plastic cups, one for each type of filter (clear deli containers work great)
- Variety of filter materials:
  - Slotted spoon
  - Pasta strainer
  - Mesh sieve
  - Cheesecloth
  - Coffee filters
  - Old T-shirt (cut into 6-inch squares)

Predict how well each filter will work:

Look over the different filters provided. Which one do you think will work the best to remove the debris from the water? Which one will do the poorest job? Line them up in the order of their effectiveness, as you predict. Record your prediction in your Safety Smart® Science Investigator's Journal.

What information are you using to make your decision? Are you considering the size of the holes or the type of material or your own personal experience? How confident do you feel that you have lined up the filters in the right order?

Run the experiment:

Line up one cup for each filter. Put the filter over the cup (have someone hold the filter in place). Use the ladle to pour a cup of dirty water through the filter. Be sure to stir up the water so you get pebbles and other debris in your ladle. Repeat for all the filters.

Think about this:

Notice how much debris is left in each filter and how clear or dirty the water in the cup looks. Which filters captured the most debris? Did any of the filters make the water completely clear? How long does it take for the water to flow through each filter?

What more should I know?

Real water filtration plants send the dirty water through a series of filters, not just one type. As the water moves through the system, the sequence of filters removes smaller and smaller impurities, until the water is safe to drink. You can simulate a water filtration plant using the same group of filters.

Line up the filters in order, worst to best, based on your observations. Pour a ladle of dirty water into the worst filter (probably the slotted spoon). Now pour the filtered water from that cup through the next filter in line. Continue pouring the filtered water from one cup through the next filter, all the way down the line. Is the water getting cleaner as it moves through the row of filters?

Clean water is healthy water:

In our place and time, we take clean water for granted. We know it's not healthy to drink dirty, polluted water. Water can carry bacteria and microbiological organisms that can make us sick, so we only drink clean water. But there was a time not too long ago when people didn't understand that dirty water could be deadly. In 1854, the people of London, England, were getting very, very sick. Many were dying from a disease called cholera. **Dr. John Snow** figured out that most of the sick people were getting their water from the same community pump. To test his idea, Dr. Snow took the handle off the pump, which made it stop working. Very soon, he noticed that fewer people in that neighborhood were getting cholera. Dr. Snow's test got other scientists interested in studying the benefits of clean water and led to improved water filtration systems.

SAFETY SMART® TIPS

- We know that we should get at least one hour a day of physical activity to keep us healthy. Our bodies use lots of water when we are active, so it's important to stay hydrated when we play. Keep a cup or bottle of water nearby and drink up!
- Remember to wash your fruits and vegetables with clean water before you eat them, even ones you peel like a banana or orange.
- Water is a precious natural resource that we want to conserve. You can help by turning off the faucet while you brush your teeth and taking shorter showers. If you open a bottle of water, drink it all.

LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Physical Sciences
- Disciplinary core ideas:
  - PS1 Matter and Its Interactions
- Cross-cutting concepts: Energy and matter; systems and system models

Safety Smart Science Investigator's Journal: From Dirty Water to Drinking Water

Rank the filters in terms of their effectiveness:

Ability to filter	Type of Filter	Prediction	Actual
Worst—allowed the most debris through			
Best—water was the clearest			

SAFETY SMART® TIPS

- We know that we should get at least one hour a day of physical activity to keep us healthy. Our bodies use lots of water when we are active, so it's important to stay hydrated when we play. Keep a cup or bottle of water nearby and drink up!
- Remember to wash your fruits and vegetables with clean water before you eat them, even ones you peel like a banana or orange.
- Water is a precious natural resource that we want to conserve. You can help by turning off the faucet while you brush your teeth and taking shorter showers. If you open a bottle of water, drink it all.

Family Science Night

SOUND AND HEARING

I wonder…
Can I pay attention to the sounds around me when I'm listening to music?

It's very easy to miss important audio safety clues when you're riding your bike or even walking on the sidewalk while wearing headphones or earbuds. This experiment uses over-the-ear headphones and in-ear headphones, commonly called earbuds. These are the two most popular kinds of personal listening devices for young people. You will experience how these devices make it hard to hear outside noises such as a siren, train whistle, car horn, or other sounds you might hear when walking, biking, or skating—especially if the music is turned up loudly.

MATERIALS

- 1 pair of over-the-ear headphones
- 1 pair of in-ear phones (earbuds)
- MP3 player such as an iPod
- Whistle
- Noise-making toy
- Bike horn, bell, or smoke alarm
- Tape measure

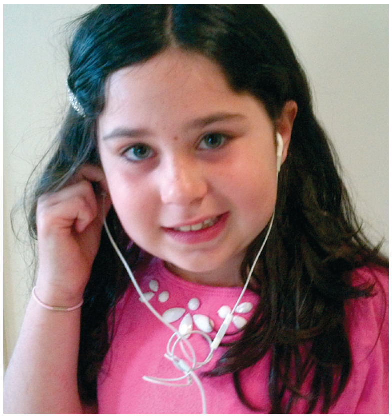
OPTIONAL MATERIALS

- Smartphone such as an iPhone or Android, or an MP3 player that can load apps, such as an iPod Touch.
- Decibel-measuring app, such as Decibel 10th, TooLoud?, or dB Volume Meter.
- Phonometer—handheld sound meter (check with your science teacher)

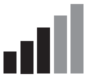
Pre-Event Planning

Select an age-appropriate song on the MP3 player that starts out with about 60 seconds of consistent volume music. You will use this song for all the trials. Possible choices include "Summer Rain," by the Jonas Brothers, or "What We Came Here For," by Camp Rock 2.

EXPERIMENT #1



1. Predict whether you'll be able to hear the noise alert* for different volume levels for both earphone styles. Record your predictions on Chart #2 in your journal.
2. Put on the earbuds.
3. Start the music and set it at the lowest level you'd listen to if you were trying to fall asleep ("Bedtime Music" level).
   - On Chart #1 in your journal, draw a picture of the volume level indicator from the MP3.



EXAMPLE

*The noise alert can be a whistle, bike horn, smoke alarm, noise-making toy, or an adult making a "waa-waa" sound.

4. Repeat with two higher volume levels:

   • "Background Music"—a comfortable level for listening to music while doing other activities, such as household chores.

   • "Rockin' Out"—the maximum level you'd set to jam to music. Caution: Be careful to monitor this so it's loud but not unsafe.

5. Reset the volume to the lowest level, using your drawing from Chart #1 as a guide.

6. Have an adult make the noise alert sound from behind you, out of sight.

   • Can you hear the sound?

   • Record your observation on Chart #2 for each volume level.

7. Repeat the prediction and experiment with the over-the-ear headphones.

How well did you predict whether you could hear the background sound?

8. If there's time, repeat the test one more time, with the adult standing across the room. Can you hear the noise alert from a distance when you have the volume at "Rockin' Out" level? From a distance of 20 feet? 10 feet? 5 feet? (Use a tape measure.) Record your observation on Chart #3 in your Journal. How close does the adult need to be for you to hear the warning?

Think about this:

The earphones direct the sound of the music into your ear, while blocking out other sounds by covering the opening of your ear.

Sometimes it's nice to listen only to the music, and block out everything else. But at other times it's important to be able to hear background sounds such as a siren, car horn, train whistle, or call out. Is there a magic "safe" level of volume for your MP3 so you can still hear important background noises? Not really. No one volume level is safe for all situations. The "safe" volume level will vary depending on your location and the kind of activity you are doing. When in doubt, start with your volume set very low and determine whether you can hear important background noises while gradually increasing the volume to a safe maximum. You can also use just one ear-bud instead of two, which leaves one ear completely uncovered and alert.

In Experiment #2, you'll more accurately measure the decibel level at each of the three levels of volume used in Experiment #1.

What more should I know?

A decibel is a unit used to measure the intensity of sound. The louder the sound, the higher the decibel level. Silence is 0 decibels. Normal conversation is about 60 decibels. You can damage your ears with extended listening of sounds over 100 decibels. The decibel was named for **Alexander Graham Bell**, a pioneer in sound research and commonly known as the inventor of the telephone. "Deci" means 1/10, so a "decibel" is 1/10 of a bel, though the unit "bel" is rarely used.

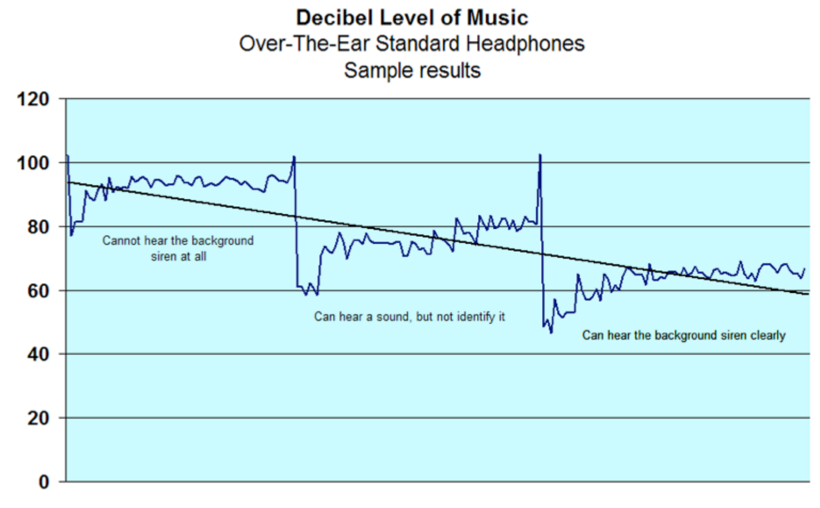
Decibels (approx.)	Sample sounds
0 dB	Threshold of hearing
20 dB	Rustling of leaves
40 dB	Bird calls
60 dB	Normal conversation, dishwasher
80 dB	Alarm clock, heavy traffic
85 dB	Smoke alarm
90 dB	Truck traffic, lawn mower
104 dB	Auto horn

EXPERIMENT #2

Using a smartphone and a decibel-measuring app such as Decibel 10th, TooLoud?, or dB Volume Meter, you can measure the approximate decibels of the music at different levels of volume. You can use the same MP3 player used in Experiment #1.

1. Plug the headphones into the MP3 player. Start the music. Set the volume level on your MP3 at the "Rockin' Out" level, using the drawing of your volume indicator from Experiment #1 as a guide.
2. Position the microphone of the smart-phone inside the cup of the headphone. Start the app on the smartphone.
3. Watch the line graph form on the screen of the smartphone as the app records the decibels. Stop the app. Record the average decibel level (dB) for that trial.
4. Restart the song at the "Background Music" volume level. Start the app. Record the dB level for this trial on Chart #1. Repeat for "Bedtime Music" volume level.

Depending on the app that you used, you may be able to send the results of your tests to a printer via email. See the sample at right.



Think about this:

The decibel app allows you to more accurately calculate the different levels of volume in our experiment. Did your chart confirm the approximate decibel measurement for each level of volume? Did it help you find a "safe" level for wearing headphones?

SAFETY SMART® TIPS

- We all like to wear headphones to listen to music or the radio. But don't forget to be Safety Smart! Adjust the volume to a level that allows you to hear background noises, especially when biking, skating, skateboarding, or walking in busy areas like along the side of the road or near train tracks.
- Distance affects your ability to detect sound. You may not be able to hear the siren of a fire engine in the distance, but the vehicle could be speeding toward you. If your hearing is compromised by headphones or earbuds, you really need to use your eyes to be aware of the potential hazards around—and behind—you.

LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Physical Sciences
- Disciplinary core ideas:
  - PS4 Waves and Their Applications in Technology for Information Transfer
- Cross-cutting concepts: Cause and effect

Safety Smart Science Investigator's Journal: Sound and Hearing

Draw a picture of the volume indicator for each level of sound so you can reset the MP3 player at the right volume for each trial. Fill in the decibels measured on the smartphone app.

Relative Volume Level	Decibels (approx.)	Decibels (measured)*	Draw Here
1. Bedtime Music	60 dB		
2. Background Music	75 dB		
3. Rockin' Out	90 dB		

* As indicated on the smartphone app (ex: Decibel 10th, dB Volume Meter, Too Loud?, etc.)

Record your prediction and actual observation here for each trial.

	Can you hear the warning sound?			
	Over the Ear Head Phones		Earbuds	
Relative Volume Level	Prediction	Observation	Prediction	Observation
1. Bedtime Music				
2. Background Music				
3. Rockin' Out				

Can you hear the noise alert from across the room with "Rockin' Out" music in your ears?

From a distance of...	
20 feet (6 meters)	
10 feet (3 meters)	
5 feet (1 1/2 meters)	

Decibels (approx.)	Sample Sounds
0 dB	Threshold of hearing
20 dB	Rustling of leaves
40 dB	Bird calls
60 dB	Normal conversation, Dishwasher
80 dB	Alarm clock, Heavy traffic
85 dB	Smoke alarm
90 dB	Truck traffic, Lawnmower
104 dB	Auto horn

SAFETY SMART® TIPS

- We all like to wear headphones to listen to music or the radio. But don't forget to be Safety Smart! Adjust the volume to a level that allows you to hear background noises, especially when biking, skating, skateboarding, or walking in busy areas like along the side of the road or near train tracks.
- When wearing headphones or earbuds, be aware of your surroundings and the potential risks in that environment, and then adjust your volume accordingly, no matter the exact decibel reading.

MAKE YOUR OWN BOUNCY BALL

I wonder...
Can I make a ball that bounces from common household ingredients?

In this adventure, you'll use common household materials to make your own bouncy ball. Then you'll predict how well your ball will bounce, and run tests to see the actual results.

MATERIALS

- Borax
- Cornstarch
- Warm water
- Liquid glue, such as Elmer's Glue-All
- Food coloring
- Bowl of ice water
- Small zip-top bags, 1 per participant
- Paper cups, 2 per participant
- Measuring spoons
- Stir sticks
- Marker or pen
- Two yardsticks
- Masking tape

Set up the experiment:

You'll need access to both a hard surface (floor or tabletop) and a cushioned carpet surface (a carpet square could work).

- Secure one yardstick to the wall next to the hard surface.
- Secure the other yardstick to the wall next to the carpet surface.
- Have each participant label one cup "borax" and the other cup "glue."
- *Optional:* Have a slow-motion camera (smartphone) available to capture the bounces.

Predict the results:

How high do you think your ball will bounce? What if you bounce the ball on tile? On carpet? What if your ball is extra cold? Record your predictions in your Safety Smart® Science Investigator's Journal. Circle your highest prediction.

Make your bouncy ball:

Into the "borax" cup, add:

- 2 tablespoons warm water
- 1/2 teaspoon borax

Stir to dissolve the borax.

Into the "glue" cup, add:

- 1 tablespoon glue
- 1 tablespoon cornstarch
- Several drops of food coloring

Stir to mix in the color and break up the corn starch lumps.

Pour about half of the borax solution into the glue cup. Let it sit; do not stir for about 15 seconds. What do you see?

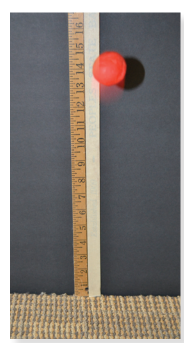
Stir the dough into a clump, then remove it from the cup and knead it with your hands. How does the dough feel? Is it slimy? Sticky? Dry? Does the feeling change as you knead it?

Roll the dough into a ball.

Run the bounce tests and record your observations:

1. Bounce your ball three times on the hard surface in front of the yardstick. Record the bounce heights in your journal.
2. Bounce your ball three times on the carpet. Record the bounce heights in your journal.

Put your ball in a sealed bag. Submerge the bag into a bowl of ice water for one minute.



Repeat the bounce tests with the chilled ball.

3. Hard surface
4. Carpet surface

What is happening here?

Glue, known chemically as a **polymer**, is a little bit like a bunch of cut strings in a pile. The strings don't hold together because they are not connected to one another. Borax comes along and ties all the strings into a tangled net, making the pile strong and resilient. Cornstarch helps dry up the wet goo to make it easier to handle and roll into a ball. And the food coloring just makes it look nice. It's a **chemical reaction**.

+

A chemical reaction occurs when two or more substances come together under just the right conditions for a new substance to be created. Chemistry doesn't just happen in a laboratory. Although some chemical reactions can be dangerous, safe chemical reactions happen around us all the time. For example, when baking bread, yeast combined with sugar and warm water gives off oxygen bubbles that make the dough rise (and accounts for all the little holes in soft bread). Other familiar forms of chemical reaction include:

- **Digestion:** Whenever you eat, your body uses many different and complex chemical reactions to break down the food and convert it into energy and other things that your body needs.
- **Combustion:** Fire is another type of chemical reaction, called combustion. Fire needs oxygen, fuel, and heat to exist, and the reaction creates light, heat, and smoke.
- **Oxidation:** Rust is a chemical reaction that you might see happening on old metal tools, wire fences, or nails. Some types of metal, such as iron, react with the oxygen and moisture (water) in the air to produce rust. Apples can also oxidize. If you leave a cut apple open to the air, the flesh turns brown. That is a safe form of oxidation.

LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Chemical Reactions (Physical Sciences)
- Disciplinary core ideas:
  - PS1B Chemical Reactions
- Cross-cutting concepts: Energy and matter; structure and function

Safety Smart Science Investigator's Journal: Make Your Own Bouncy Ball

Fill in your bounce predictions before you make the ball. Circle your highest prediction. Record the actual bounces here. Run three trials for each bounce test. Did you predict correctly?

BOUNCE TEST		Bounce Height (inches or cm)				
		PREDICT	OBSERVE			
			1	2	3	Average
1	Bounce on hard surface					
2	Bounce on carpet					
Chill the ball						
3	Bounce on hard surface					
4	Bounce on carpet					

When you combined the borax solution and the glue mixture, what did you see?

How did the dough feel when you first took it out of the cup?

How did the dough change as you kneaded it?

What substances are part of these common household chemical reactions? What happens as a result of the reactions?				
1. Kitchen	2. Dining Room	3. Bathroom	4. Garage	5. Inside YOU!
Baking bread	*Candle flame*	*Sudsy shower*	*Rusty tools*	*Digestion*

1. Yeast, sugar, water, heat –> risen bread; 2. Wick, oxygen, heat -> light, heat, smoke; 3. Soap, water, dirt -> clean skin; 4. Iron, oxygen, water - > rust; 5. Food, stomach acid-> energy

For longest play time, keep the ball in a sealed plastic bag. The ingredients used are generally safe, but the dough should never be eaten. Keep away from pets and small children.

MAKE ELEPHANT TOOTHPASTE

I wonder...
What happens when molecules break apart?

In this adventure, you'll create a safe chemical reaction that some call elephant toothpaste.

MATERIALS

- Hydrogen peroxide liquid (available at a drugstore or beauty supply store)
- Liquid dish soap
- Dry active yeast
- Warm water (keep it in a thermos)
- Food coloring
- Clean, empty plastic water bottle(s)
- Small cup
- Measuring cup
- Measuring spoons
- Funnel
- Safety goggles
- Plastic wash tub

SETUP

Put on the safety goggles.

Set the bottle in a plastic wash tub to contain the mess.

Adults only: Pour ½ cup hydrogen peroxide into the bottle using the funnel.

Add a few drops of food coloring to the bottle.

Add a generous squirt of dish soap to the bottle.

In the small cup, combine 1 tablespoon dry yeast (one packet) with 3 tablespoons warm water.

Mix gently to dissolve the yeast into the water—this creates a yeast "slurry."

OBSERVATION AND PREDICTION

What does the mixture in the bottle look like? Is anything happening? Sketch what you see in the "before" section of your worksheet.

What does the yeast slurry look like? Is anything happening yet?

What do you think will happen when you pour the yeast slurry into the bottle?

TEST

Quickly pour the yeast slurry into the bottle and watch what happens!

Sketch the "after" picture on your worksheet.

How does the bottle feel?

If possible, capture the reaction with the slo-mo function of a smartphone camera app.

WHAT IS HAPPENING HERE?

The yeast causes the molecules in the hydrogen peroxide (H_2O_2) to break down into water and oxygen gas. The soapy water captures the oxygen gas in bubbles. The food coloring just makes it pretty.

More Chemistry for older students:

Each molecule of hydrogen peroxide has two hydrogen atoms and two oxygen atoms. The yeast acts as a ***catalyst*** that ***decomposes*** the hydrogen peroxide, ***liberating*** the water and the extra oxygen atom. This is an ***exothermic*** reaction, which means it releases heat also. The foam is made up of oxygen gas which gets trapped in the soapy water. It is perfectly safe to handle.

$$2H_2O_2 + \text{catalyst (yeast)} \rightarrow H_2O \text{ (water)} + O_2\text{(oxygen)}$$

Key words

- **Catalyst:** kick-starter for the reaction
- **Decomposes:** breaks down
- **Liberating:** freeing
- **Exothermic:** a reaction that releases heat

TRY THIS AT HOME

What if the water were cold? What if you used more yeast? What if you used less hydrogen peroxide? What if you omitted the dish soap? What if you did this in a bowl instead of a bottle?

LEARNING MESSAGES

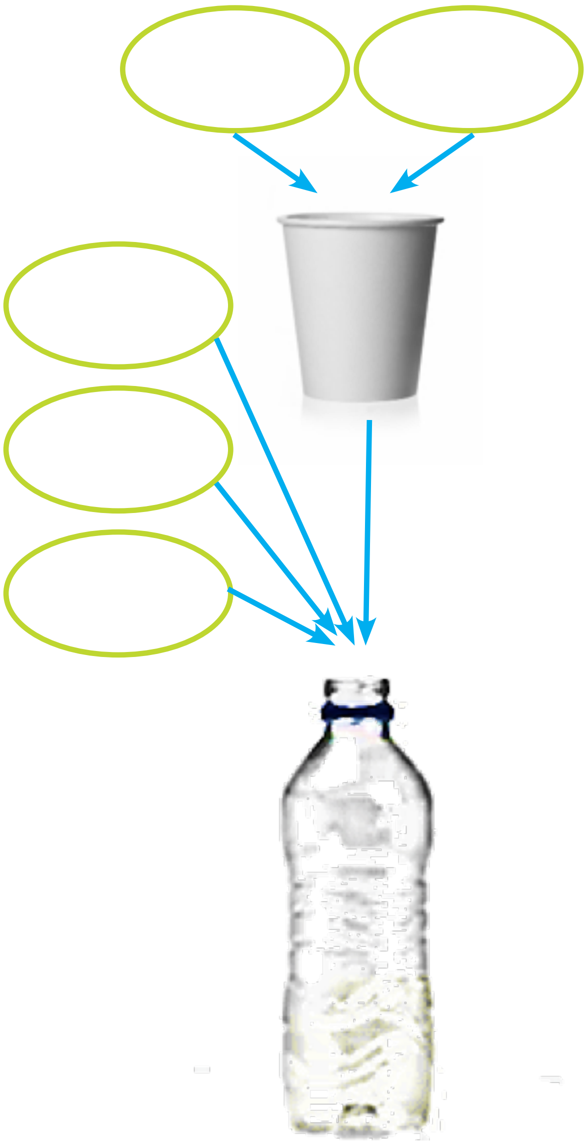
Complementary Next Generation Science Standards

- Topic focus: Physical Sciences, Chemistry
- Disciplinary core ideas:
  - PS1 Matter and Its Interactions
  - PS1B Chemical Reactions
- Cross-cutting concepts: Cause and effect

Safety Smart Science Investigator's Journal: Make Elephant Toothpaste

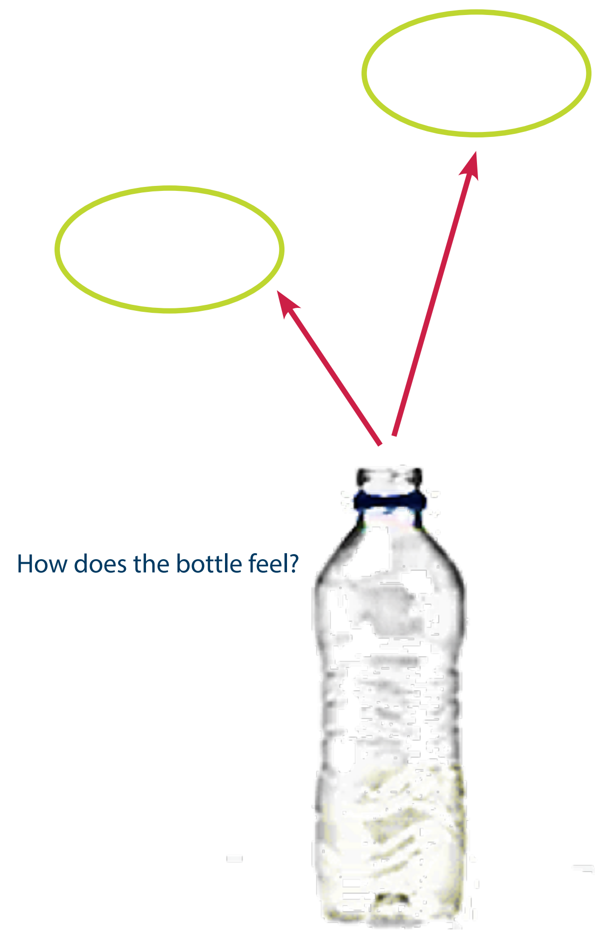
Fill in the ingredients

BEFORE



Sketch what happens

AFTER



LITHIUM BATTERY SAFETY

I wonder...
How much energy is really in a battery?

In this adventure, you'll explore the power and safety challenges of lithium button cell batteries, the kind used to power all sorts of new technologies, including hoverboards and singing birthday cards.

MATERIALS

- Lithium button-cell battery* (keep the packaging)
- Hot dog at room temperature, cut in half crosswise
- 1.7V LED light bulb*
- Small disposable plate
- Pen or marker
- Table knife
- Timekeeping device
- Ruler with millimeters
- Disposable plastic gloves
- Instant-read digital thermometer with probe
- Magnifying glass

*Lithium button-cell batteries (3V) and LED light bulbs can be purchased in bulk online. You can also deconstruct an inexpensive solar light to remove the LED bulb, being careful to leave the leads (wires) attached to the bulb.

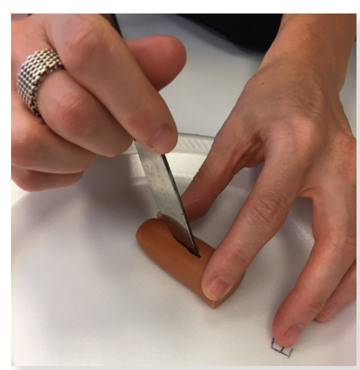
NOTE: Each participant will use half a hot dog, one battery, one paper plate, and one glove

Set up the experiment:

Prepare a poster with the word "conductive" and its definition: "Having the ability to transmit heat or electricity"; hang near the adventure station.

Remove the safety sticker from the battery and keep it with the packaging. What do you think it is for?

Write the participant's name on the edge of the plate. Cut a small slit in the hot dog with the table knife. Set the hot dog on the plate.



Make your predictions

What will happen if you put the battery in the slit in the hot dog? After 2 minutes? After 5 minutes? After 15 minutes?

Will there be a change in temperature of the hot dog? After 2 minutes? After 5 minutes? After 15 minutes?

Record your predictions in your Safety Smart® Science Investigator's Journal.

Observe

Record your observations and data in your Safety Smart Science Investigator's Journal.

Draw the battery and its markings on your worksheet. Use the magnifying glass to see up close. Draw a picture of the hot dog before the experiment.

Hold the battery between the two wires of the LED, matching positive and negative wires to positive and negative sides. The light should illuminate. If not, turn the battery over and try again. The illumination proves the battery is working. Set the light bulb aside.

Measure the temperature of the hot dog inside the slit before the experiment and record it on your worksheet, then set aside the thermometer. (Do not leave it in the hot dog.) Slip the battery fully into the slit in the hot dog. Start the timer.

After 2 minutes, carefully inspect the hot dog. Use your eyes and your ears. Use the magnifying glass to get a close look. Take the temperature of the hot dog inside the slit, next to the battery. Record your observations and the interior hot dog temperature.

After 5 minutes, inspect the hot dog and measure the temperature inside the slit again. Record your observations and the new interior hot dog temperature.

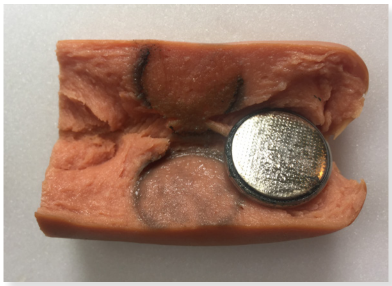
While you wait, read the battery packaging, paying close attention to the warnings printed there. Inspect an unopened battery package. Would it be easy for a small child to open the packaging?

After 15 minutes, record your observations and the hot dog temperature.

Using a gloved hand, remove the battery from the hot dog. Carefully tear open the hot dog to see the area where the battery had been. Record your observations.

Properly dispose of the hot dog and the battery after the trial is complete. Do not eat the hot dog. Treat exhausted batteries as hazardous household waste and dispose of them properly.

What is happening here?



The water in the hot dog is closing the circuit between the positive and negative poles (sides) of the battery, allowing an electrical current to flow. The current is causing the meat to burn. The longer the battery stays in the hot dog, the more the hot dog will be damaged.

Lithium batteries pack a lot of power into a small, lightweight package. They are useful for products where their small size and low cost is convenient, such as in watches, key fobs, cell phones, and "singing" greeting cards. Using many together can generate enough energy to power larger products, such as a hoverboard or electric car.

But as our adventure shows, lithium batteries pose a danger if they are misused or mishandled. For example, **if swallowed, the lithium battery will burn the lining of the throat.** Other parts of our body are vulnerable too, like the inside of the mouth, nose, or ear canal. Like any foreign object, a battery can also cause choking if swallowed. Never leave a lithium battery within the reach of a child or pet. Go immediately to the nearest emergency room if you suspect someone has swallowed a lithium battery. As we observed in this experiment, the battery starts a chemical reaction very quickly.

Engineers design solutions to minimize the danger of lithium batteries so we can safely use their power. Designing a solution can be as simple as making the package hard for a child to open. Another safeguard is to affix a small sticker on the "conductive" side of the battery which prevents the battery from conducting current in case it does get swallowed. (Look at the sticker you removed from the battery at the beginning of this activity!)

Can you think of a simple solution to reduce the risk of a child swallowing a lithium battery? Hint: consider packaging, taste, size, texture, shape, and where the batteries are stored at home.

Record your ideas in your Safety Smart Science Investigator's Journal. Draw a diagram to illustrate your favorite idea.

What more should I know?

What if you used a hard-boiled egg or a chunk of cheese instead of a hot dog? Would you observe the same outcome?

How do you think batteries are going to be used in the future? What will they look like?

LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Energy
- Disciplinary core ideas:
  - 4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.
- Cross-cutting concepts: Energy and matter; connections to engineering, technology, and applications of science

Safety Smart Science Investigator's Journal: Lithium Battery Safety

Measure the diameter of your battery in millimeters: ______________

In the circles below, draw the markings on each side of your battery:

How many volts is your battery? _____________________

Carefully read the battery packaging and the battery sticker warnings.

Record your predictions and observations:

	Before	**After 2 Minutes**	**After 5 Minutes**	**After 15 Minutes**
PREDICTION: Draw what you think you'll see				
OBSERVATION: What did you see? Hear?				
TEMPERATURE: Inside hot dog (ºF)				

Did the temperature of the hot dog change while the battery was in place? Why do you think that happened?

How do you think batteries are going to be used in the future? What will they look like?

What could be done to reduce the risk of a pet or child swallowing a lithium battery? (Hint: Consider the battery's size, shape, texture, packaging, location in the powered object, where extra batteries are stored at home, etc.) Draw your best idea and explain its benefits. **(Ask your parents to help you post your ideas to UL XplorLabs on Facebook and Twitter! @ULXplorlabs)**

Family Science Night

ENERGY STICKS: MAKING POTENTIAL AND KINETIC ENERGY

I wonder...
What is the difference between potential and kinetic energy?

In this experiment, you will use craft sticks to harness energy (potential energy)—then release it (kinetic energy)—by weaving craft sticks into powerful chains.

MATERIALS

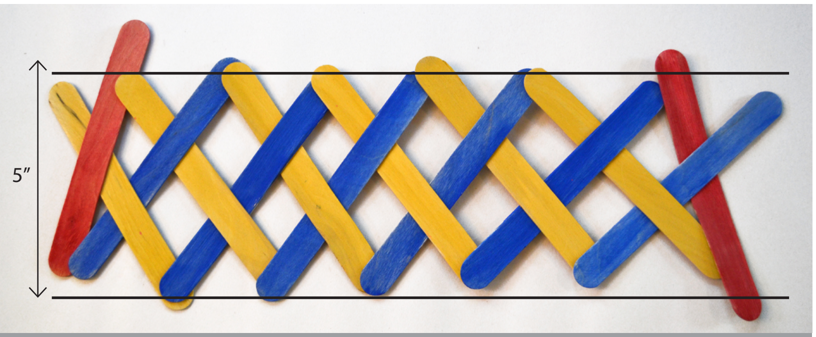
- Jumbo craft sticks (painted as described below)
- Books or bricks to act as weights during building of a chain
- Yardstick
- Lots of floor space

In this activity, you will make two different styles of energy stick assemblies. The basic style is an **energy shape**, made from just a few sticks. These designs are good for practicing how to "weave" craft sticks. The more challenging—and more exciting—style is an **energy chain**. The energy chain demonstrates the release of potential energy and can be made as long as you want, even all the way around the room. Many children can participate in building an energy chain.

Energy Shapes

Set up the experiment:

- Before Family Science Night, color the craft sticks with thinned watercolor paint. Use at least two different colors. This will aid in teaching the students how to build the shapes/chain. Do not use thick paint as it may cause the sticks to bond together when the shapes are assembled.
- With tape or chalk on the floor, draw two parallel lines, about 3 feet (1 m) long and 5 inches (12.5 cm) apart.



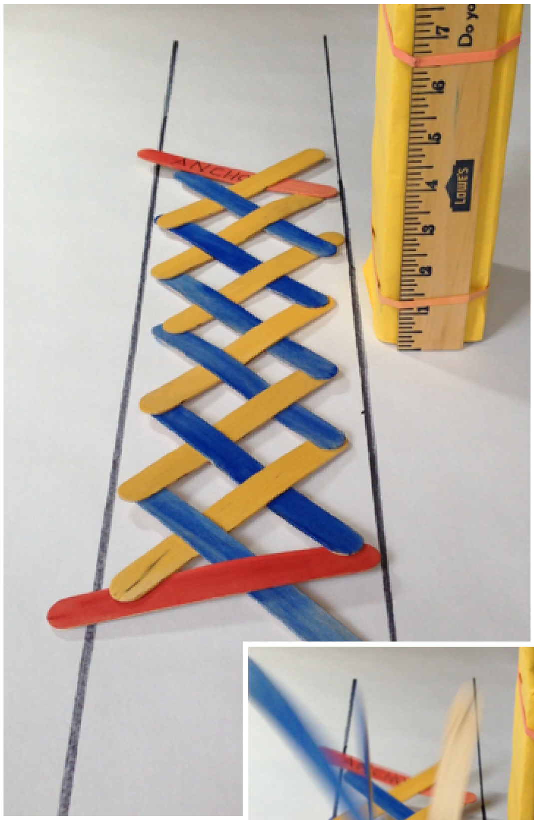
Energy Chain

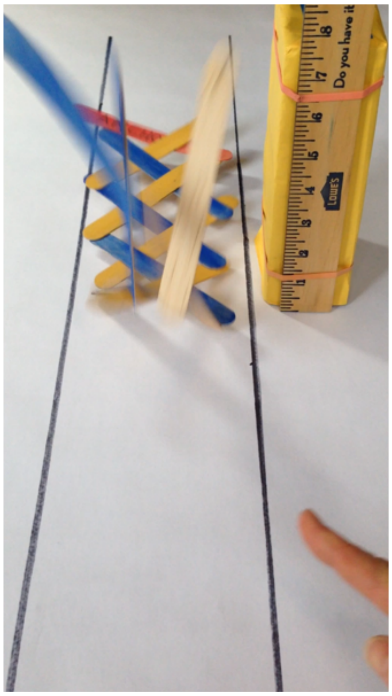
EXPERIMENTS

NOTE: See the Journal page for additional pictures and setup instructions.

Energy Stick Shapes (4-stick and 6-stick)

Practice weaving the craft sticks together to make energy shapes as shown in the picture above. The tension in the sticks as they are flexed (bent) holds the shape together without glue or tape. The tension is a form of potential energy. You are releasing the potential energy if your shape "pops" apart as you are trying to weave the sticks. If you drop the completed shape and the sticks scatter apart, that releases the potential energy, too.



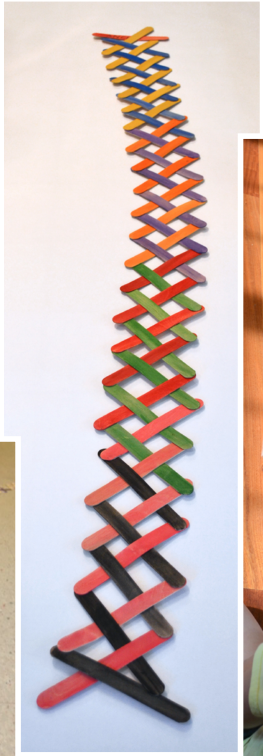


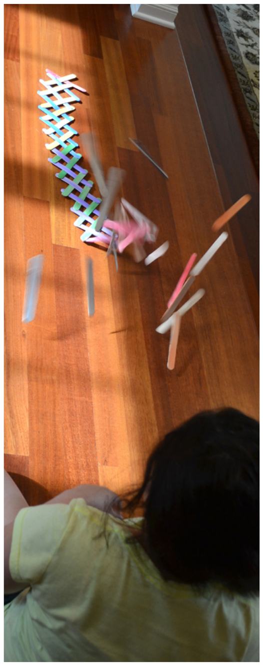
Energy Stick Chain

- Record your predictions:
  - o What is the highest a stick will jump?
  - o How many sticks will jump completely outside the boundary lines?
- Build the chain using 12 woven sticks and one anchor stick at the beginning. 12 sticks make a chain about 16 inches (40cm) long.
- Use your hand to hold the active end of the chain (the end with no anchor) flat while you are building.
- Position the yardstick upright next to the midpoint of your chain, with the 1-inch (2.5-cm) mark on the floor.
- Release the active end of the chain.
- As the chain "explodes," watch carefully to measure the height of the highest-jumping stick against the yardstick.
- Count the number of sticks that jump completely outside the boundary lines.
- Record your observations.
- Repeat for a total of three trials. Do you get the same results every time?
- Is there anything you can do to increase the height? To scatter more sticks outside the lines? (Hint: Does the length of the chain make a difference?)

What is happening here?

Wonder why the sticks in the chain jumped off the ground all on their own when you release the end of the chain? The wooden sticks are slightly flexible. When you assemble an energy stick chain, you are harnessing that flex as ***potential energy***. That means the sticks store the potential energy—and, if conditions are just right, when you let go of the active end of the chain, the sticks flex back to their original shape, and the potential energy is released as "kinetic"—or moving—energy. The ***kinetic energy*** is what you see when the sticks jump up off the ground.





A cool variation for older kids:

Build a massive energy stick chain around the room. Try different designs to see whether the design changes the amount of energy released. Weave some turns in your chain, add plastic cup towers, domino chains, and more! Go for a world record! (The current world record is held by a Japanese corporation, which built a chain using 9,911 sticks.) One box of 500 jumbo craft sticks will make a chain about 55 feet (17m) long.

SAFETY SMART® TIPS

Energy does work for us. Energy can never be created or destroyed; it can only be converted from one form to another—it's the Law of the Conservation of Energy. When we talk about the environment, there are many sources of energy, and it's important to use renewable energy sources when we can because they are constantly being replaced. Using renewable sources like solar and wind is not only energy smart, it's Safety Smart!

LEARNING MESSAGES

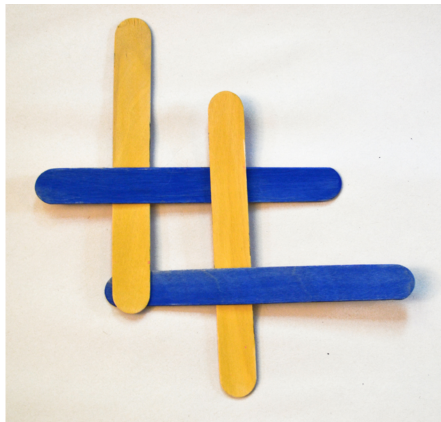
Complementary Next Generation Science Standards

- Topic focus: Engineering, Physical Sciences, Energy
- Disciplinary core ideas:
  - PS3B Conservation of Energy and Energy Transfer
  - PS3C Relationship Between Energy and Forces
- Cross-cutting concepts: Energy and matter; patterns

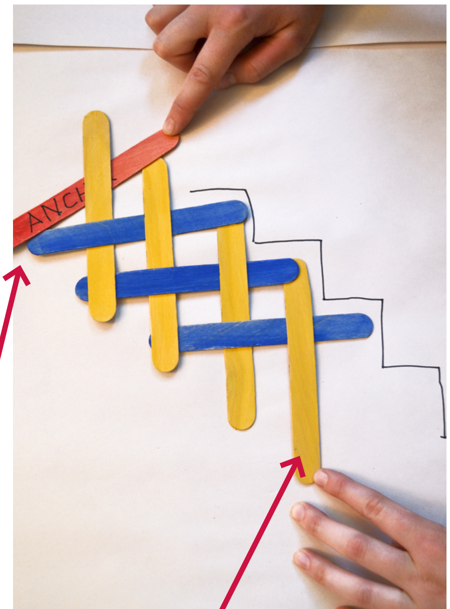
Safety Smart Science Investigator's Journal:
Energy Sticks: Making Potential and Kinetic Energy

Energy Shapes—can you make all four? Can you design your own?

Step 1: Weave together 4 sticks, keeping same colors parallel.



Step 2: Weave in more sticks, making a stair-step, and keeping like colors parallel.



Step 3: Add a stick to anchor the chain once it is about six sticks long. This locks the beginning of the chain.

Step 4: Hold down the last stick as you continue to weave. This is the active end.

How many sticks did you use to make your chain?

	Prediction	Observations		
		Trial 1	Trial 2	Trial 3
How many sticks will jump outside the boundary lines?				
What is the highest a stick will jump?				

SAFETY SMART® TIPS

- Energy can't be created or destroyed, only converted from one form to another.
- It's important to use renewable energy sources when we can because they won't get used up the way other sources of energy can.

WIND ENERGY

I wonder…
How can we use the power of the wind?

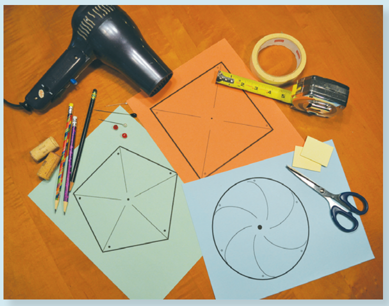
When we see trees swaying, a flag waving, or a sailboat coasting across the water, we are watching the power of the wind. It can be soft and gentle or fierce and destructive. For hundreds and hundreds of years, people have been capturing the power of the wind. Windmills have been used to pump water, grind grain, and even produce electricity. Today, sleek new windmills, more properly called ***wind turbines***, are being built all over the United States. Maybe you have seen one yourself. In this adventure, make different styles of paper pinwheels and learn some of the science behind wind power.

For a fun way to demonstrate the science of wind turbines, set up a web-connected computer to watch the short video "Winderiffic" at www.ulsafetysmart.com.

EXPERIMENT #1: BUILD AND TEST A PINWHEEL

MATERIALS

- Paper preprinted with the three pinwheel templates (square, pentagon, circle)
- Large-head straight pins
- Assorted beads
- Pencils with erasers or bottle corks
- Scissors



NOTE: The square pinwheel is best for the youngest children. They can complete the entire adventure using just this simple pinwheel. Older children will enjoy making and testing all three designs.

Set up the experiment:

- Cut out each shape along the bold outlines.
- Cut into the shapes along the lighter lines, stopping in the center as shown on the diagram.
- Holding the straight pin in one hand, bring every other point to the center, pushing the point of the pin through the paper, then poke the pin through the center of the pinwheel as indicated.

- Slide a bead onto the pin and stick the pin through the eraser of the pencil (or the end of a cork)
- Test your pinwheel by gently blowing on it

What is happening here?

The pinwheel has pockets that catch the wind as you blow. The ***kinetic energy*** (moving energy) in the wind causes the pinwheel to spin. It is fun to watch the pinwheel spin, but there's lots more to learn about wind energy from your pinwheel.

Put your pinwheels to the test:

In this phase, you'll test the different pinwheels by spinning them with the airflow from a hair dryer.

- How far away can you stand and still spin the pinwheel?
- Do different styles react differently?
- What happens if you cut off a blade of the pinwheel? Does it still spin?
- Record your findings in your Safety Smart® Science Investigator's Journal.

MATERIALS

- At least one pinwheel, any style (4, 5, or 6 points)
- Hair dryer with a "low" setting
- Extension cord
- Tape measure (at least 10 feet/3.5 meters)
- Masking tape
- Small sticky notes
- Pencils or pens

Set up the experiment:

- Stretch the tape measure on the floor, close enough to an electrical outlet that the hair dryer can reach the area.
- Have a parent stand at the end of the tape measure, holding the pinwheel about waist-high.
- The child should stand next to the tape measure, about 16 inches (40 cm) from the pinwheel.
- Point the hairdryer at the pinwheel.

Run the experiment:

- Turn on the hair dryer to low. Point the airflow so the pinwheel spins.
- Slowly back up along the tape measure until the pinwheel stops spinning. Mark that distance on the floor with a sticky note and record it in your journal.

- Now cut off one blade from the pinwheel and repeat the test. Do you need to stand closer to the pinwheel to get it to spin again? Mark the distance on the floor with a sticky note.
- Repeat the test with all three styles of pinwheel, marking and recording the distance between the pinwheel and the hair dryer.
- Which design do you think worked best? Did it matter whether blades were missing? Record your findings in your journal.

What more should I know?

Wind is a renewable energy. That means it is energy that comes from natural resources. Sunlight is another form of renewable energy. Using renewable energy like wind is good for our planet. What are other ways you can help take care of our planet? List them in your Safety Smart Science Investigator's Journal.

Sir Isaac Newton

There's even more to learn!

Way back in 1687, a scientist named **Sir Isaac Newton** developed his famous "three laws of motion." Newton's laws help explain some of the most important characteristics of energy.

The laws are:

1. The law of inertia (*i-NER-shuh*)
2. Force = *mass x acceleration*, or simply "F=ma"
3. For every action, there is an equal and opposite reaction

1. Inertia is the law that says an object will not move unless a force is applied to it. So let's try it. Just hold your pinwheel. It is not spinning; inertia says it will not spin unless you apply a force. Your breath can be the force. Blow on your pinwheel and it starts to move. Stop the spinning by applying a different force: your finger. You've just experienced Newton's first law of motion. Amazingly, that simple—almost obvious—demonstration of inertia is the basis for some really complex science.

2. Newton's second law of motion describes the relationship between force, mass, and acceleration. Blow on your pinwheel very gently and watch it spin. What can you do to make it spin faster? The force of your breath determines how fast the pinwheel spins. The mass (which is a little like the weight) of the pinwheel doesn't change since you are always using the same pinwheel. But the acceleration (which is a little like the speed) does change as the force changes. What if you added some mass (weight) to the pinwheel? How would you have to adjust your breath (force) to get it to spin?

3. "For every action, there is an equal and opposite reaction." This is Newton's third law of motion. When you apply an action (your breath) to the pinwheel, the pinwheel reacts by spinning. You can also visualize Newton's third law with another simple experiment involving a balloon (see below).

EXPERIMENT #2: EQUAL AND OPPOSITE BALLOON

MATERIALS

- Balloon (not Mylar)
- Drinking straw (optional)
- Fishing line (at least 10 feet/3.5 meters) (optional)

Think about this:

Try to blow up the balloon with only a gentle stream of air. How big did the balloon get?

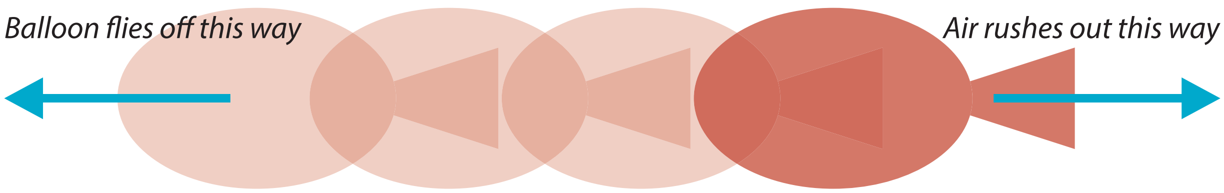
Now blow it up fully, but don't tie off the end. How hard did you have to blow to inflate the balloon? Was it harder to blow as the balloon got bigger? Hold the end of the balloon tightly closed, but not tied off.

Press on the outside of the balloon. Is it firm and bouncy? Does it feel a little like the air in the balloon is pushing back? Well, it is. The air outside the balloon is pushing against the air captured inside the balloon.

Now hold up the balloon and let go! Watch the balloon fly across the room as the air is pushed out of the balloon.

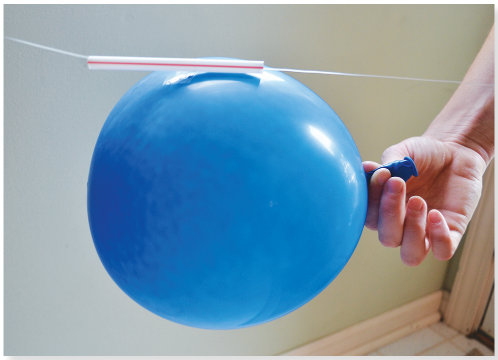
What is happening here?

Newton's third law of motion says that for every action, there is an equal and opposite reaction. You just experienced Newton's third law firsthand. The air inside the balloon was pushing against the air outside the balloon. As long as the air was captured, the balloon stayed inflated. But when you let the balloon go, the air inside pushed out of the opening of the balloon—and the balloon took off flying in the opposite direction.



A cool variation for older kids:

- With the balloon blown up, tape a drinking straw to the side, in line with the neck of the balloon.
- Slide a long piece of fishing line through the straw.
- Have one person at each end hold the fishing line taut, with the balloon at one end.
- Let go of the balloon and watch it zip down the fishing line. How far can you get it to travel? How fast? Wanna race?



SAFETY SMART® TIPS

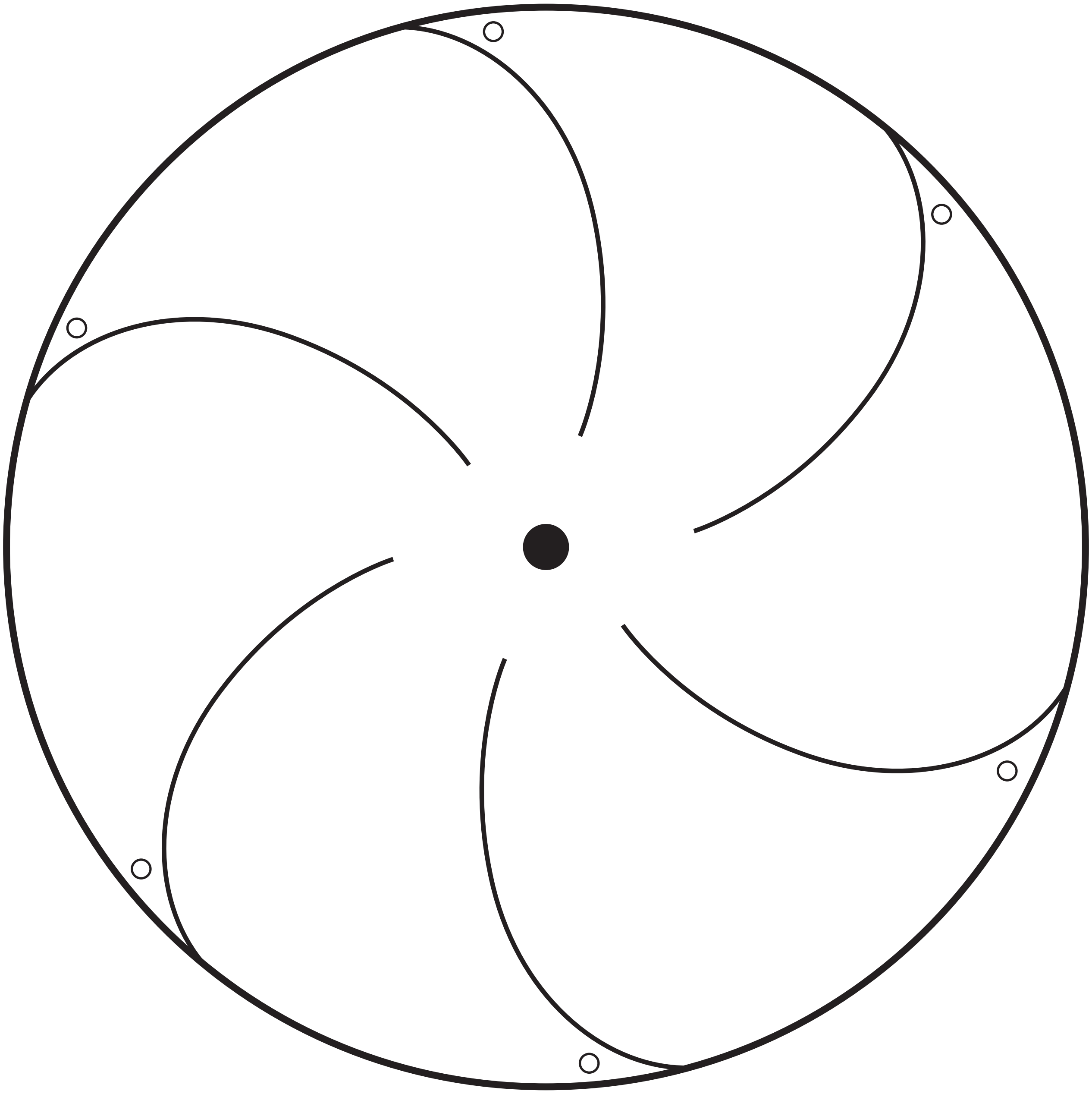
Using renewable energy like the wind and the sun is Safety Smart and good for our planet. You can help keep Earth clean by practicing the 3 R's:

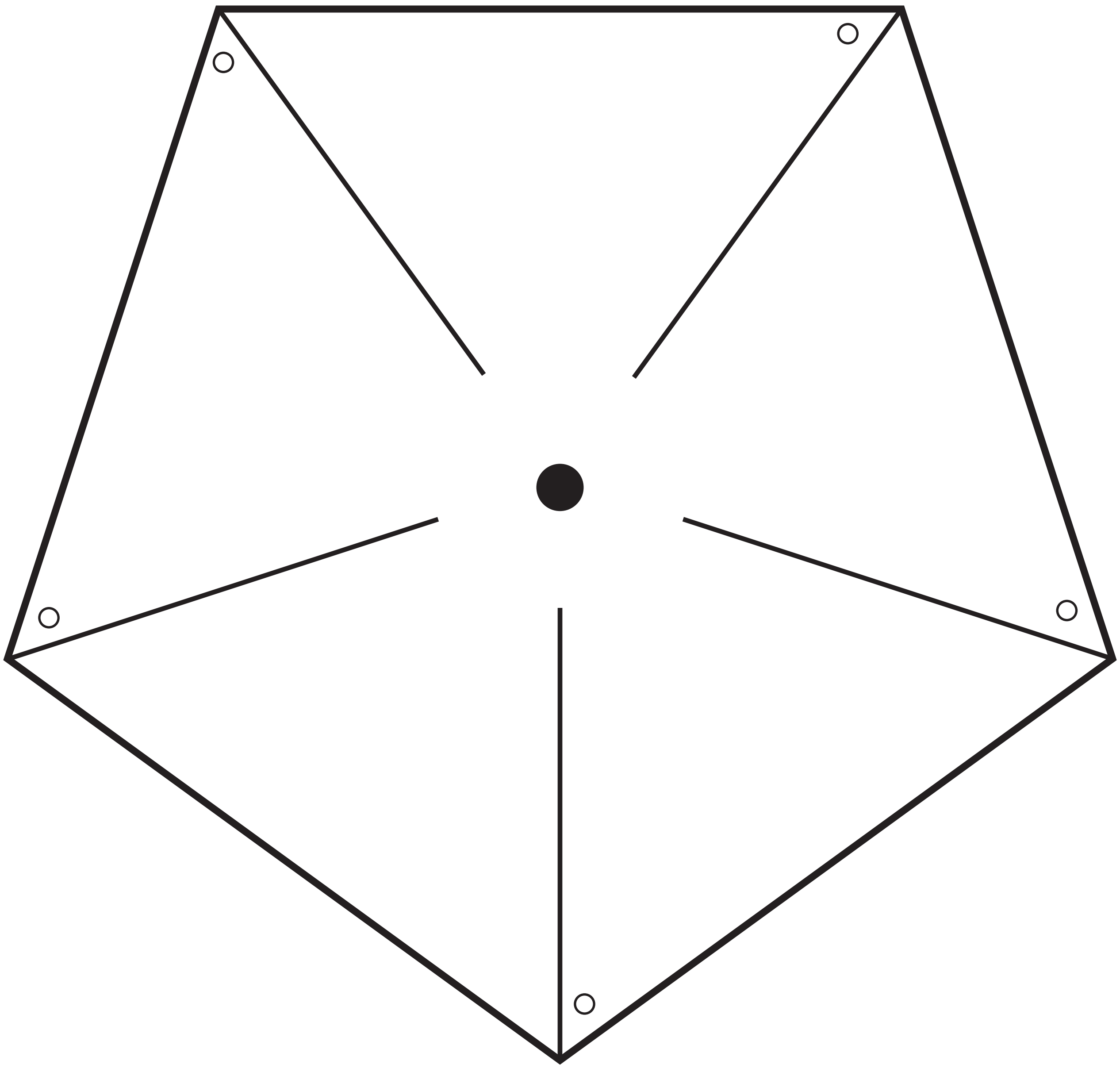
- Reduce...your use of water by turning off the faucet while you brush your teeth
- Reuse...by donating gently used toys and clothes to charity
- Recycle...by returning plastic, glass, paper, and other recyclable materials

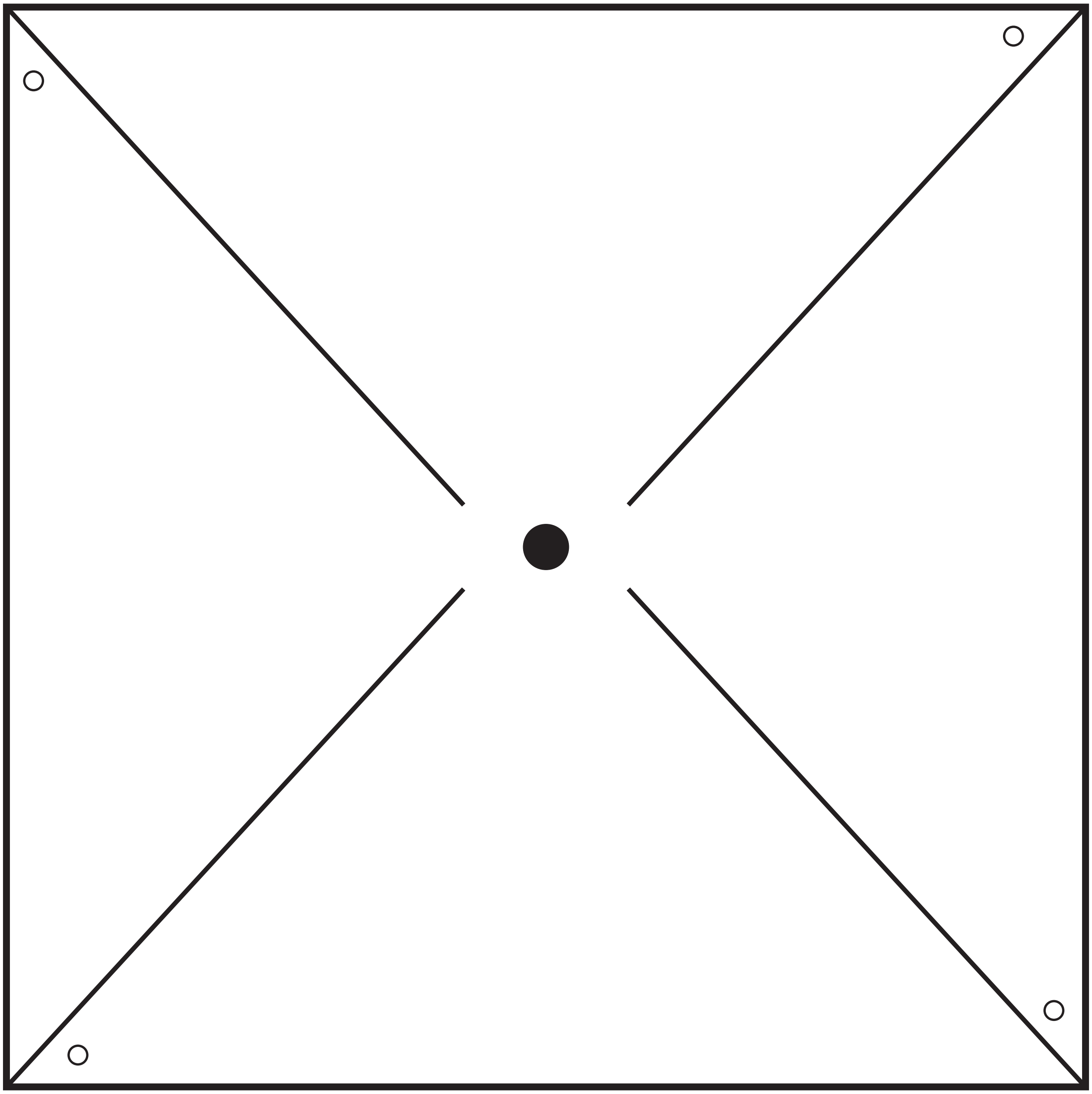
LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Earth Sciences, Physical Sciences
- Disciplinary core ideas:
  - ESS3 Earth and Human Activity
  - PS3B Conservation of Energy and Energy Transfer
- Cross-cutting concepts: Systems and system models

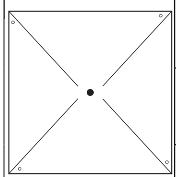
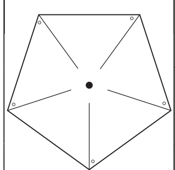
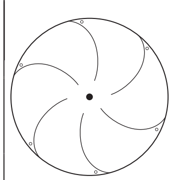






Safety Smart Science Investigator's Journal: Wind Energy

Record your predictions and observations here. How far away could you stand with the hair dryer and still get the pinwheel to spin? How does that change when you cut blades off the pinwheels? Which style worked the best?

Style of Pinwheel	Number of Blades	PREDICT: Distance	OBSERVE: Distance
Square 	All 4		
	3		
	2		
	1		
Hexagon 	All 5		
	4		
	3		
	2		
	1		
Circle 	All 6		
	5		
	4		
	3		
	2		
	1		

How can you help take care of our planet?

____

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BE SAFETY SMART®

Practice the 3 R's:
Reduce, Reuse, Recycle.

SOLAR ENERGY

I wonder…
Can I can see the power of solar energy in action?

For a fun way to learn about the science of solar power, watch the short video "Solartastic" at www.ULsafetysmart.com.

The sun is a vital part of our earth's environment. The sun provides warmth, daylight, and sun rays that help humans, animals, and plants thrive. We can capture some of the energy in the sun, called solar energy, and turn it into electricity to heat our homes and to power machines. In this experiment, you'll see how you can influence the amount of energy you capture from the light, using different-colored surfaces. You'll also observe the different waves that make up white ("visible") light. And finally, you'll experience how light energy can be converted into electricity.

There are three different parts to this adventure:

A. Observe how solar energy produces heat;

B. Break light down into its different-colored waves; and

C. Investigate how solar energy is converted into electricity.

PART A—OBSERVE HOW SOLAR ENERGY PRODUCES HEAT

NOTE: This experiment assumes you are holding your Family Science Night indoors, so we'll use a heat lamp instead of the sun.

MATERIALS

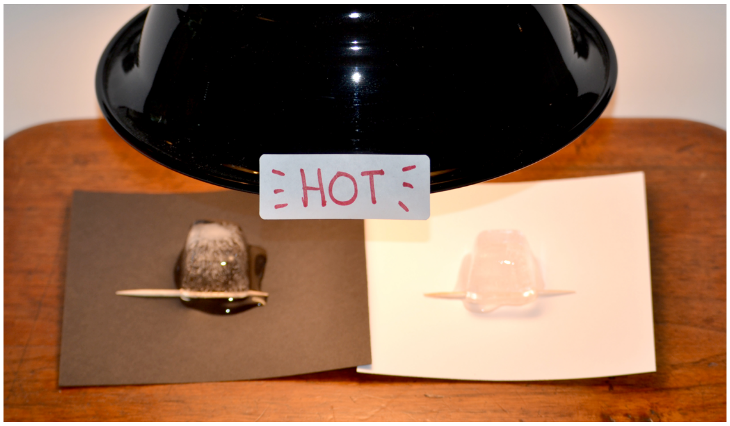
- Clamp-on shop lamp (or similar)
- 100-watt incandescent lightbulb
  If you can't find an incandescent 100-watt lightbulb, look for a heat lamp bulb at a pet shop
- 2 four-inch-by-four-inch cards (one black, one white)
- Ice cubes of equal size (optional: add food coloring to make the results more obvious)
- Toothpicks
- Ruler

Think about this:

If you put an ice cube on each card and heat them under the lamp, will they both melt at the same rate? Which color will melt faster? Record your predictions and observations on the chart in your Journal.

Run the experiment:

1. Position the lamp so it is 6 inches (15 cm) from the table surface. Put the two cards under the lamp, evenly positioned as shown.
2. Select two ice cubes of the same size.
3. Lay each ice cube on a toothpick, one on each card. The toothpick should raise the edge of the ice cube off the card just slightly. This makes it easier to detect the melting water.
4. Turn on the lamp. You'll need to wait about 5 minutes to see a reaction.



While you wait for the ice to react, complete part B of this adventure:

PART B—BREAK DOWN LIGHT INTO ITS DIFFERENT-COLORED WAVES

MATERIALS

- Flashlight with strong beam
- Prism (can be purchased at a teacher supply store or online for about $10; search for "optical prism")
- Large box such as a paper case box, inside painted black
- Piece of white paper, set inside the box

Think about this:

Usually, our eyes can't see different colors in white light. It just looks bright. But white light is actually made up of all the colors in the visible light spectrum. If we send the light through a specially shaped glass called a prism, what happens? How will the white light look now? Will there be colors? How many colors can you see? Record your predictions in the chart in your Journal.

Position the flashlight so the beam shines through the prism onto the white paper inside the box. The box will help keep extra light out of the experiment. You may need to adjust the prism or flashlight to see a spectrum. What do you see? Record your observations on the chart in your Journal.

What more should I know?

The light we see, though it seems invisible or simply bright to us, is actually made up of many different colors of light. The human eye sees "white light"—that's when all the colors that make up the visible spectrum are combined. But in fact, each color has a different wavelength.

The different wavelengths of light travel at different speeds, but that isn't noticeable when light moves through air. When light travels through the angle of the glass prism, however, the waves are slowed down, causing the white single beam to split into different colors. This range of colors is called the "spectrum of visible light." Traditionally, the spectrum contains seven colors: red, orange, yellow, green, blue, indigo, and violet. (You can remember these colors by remembering "Roy G. Biv.") A rainbow is produced when sunlight travels through raindrops, which act like millions of tiny prisms.

Now that you've investigated the wavelength of light and the spectrum of colors, go back to check on your ice cubes in part A.

5. After about 5 minutes, examine the ice cubes and the water underneath each one.

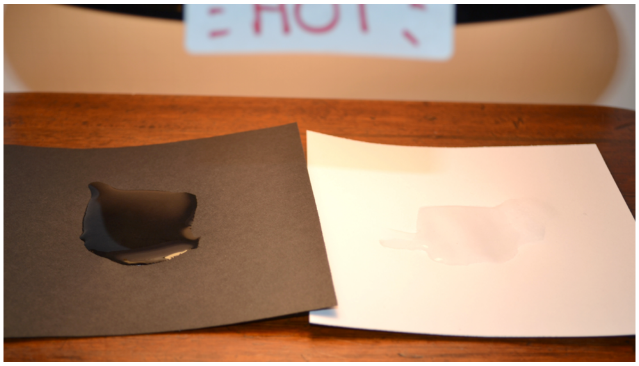
Observe: Which ice cube has melted more? Record your observations in your Journal.

Think about this:

If both ice cubes were the same size, and both the same distance from the lamp, why did one melt faster than the other?

Light is a form of energy. We can turn light into heat energy by absorbing the light.

The black card absorbs all wavelengths (all the colors) in the light. In fact, that's why the card appears black to our eyes. On the other hand, the white card reflects all wavelengths in the light. The more wavelengths the paper absorbs, the more heat it produces. The black card heated up more than the white card, making the ice cube melt faster.



PART C—INVESTIGATE HOW SOLAR ENERGY IS TURNED INTO ELECTRICITY

For hundreds of years, scientists and inventors have developed different ways to harness the power of the sun's energy. Today, the sun's light can be captured in solar cells that convert the energy into electricity. Since the sun is free to use and is renewable, it's a safe and efficient source of energy for our planet.

In this part of the adventure, you'll investigate how energy from the sun can power an electric light even when the sun has gone down.

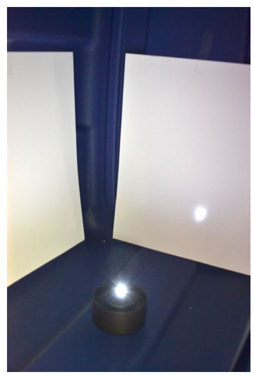
MATERIALS

- 2 solar-powered garden lights (available at garden stores or dollar stores for $1-5 each)
- Large box with lid such as a paper case box, the inside lined with white paper or painted white

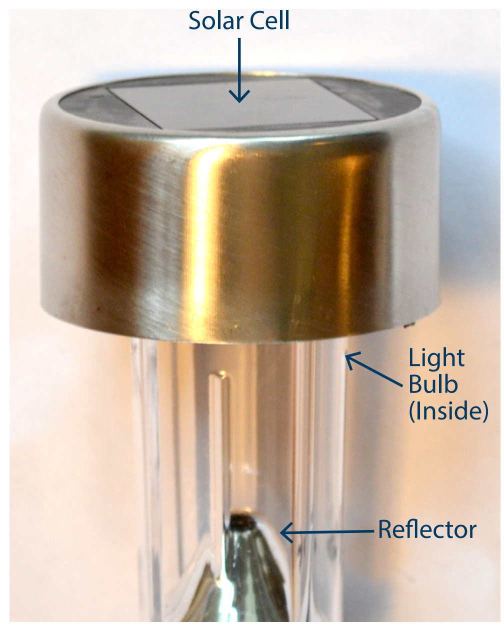
Preparation: Be sure to fully charge one solar light outside before bringing it in for Family Science Night.

Carefully take the second light apart to see the internal components.

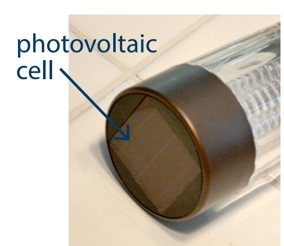
Run the experiment:



1. Hold the working light by its base and observe:
   - Is the light on?
   - What can I do to get the light to turn on?
   - Put the light inside the box with the lid partially closed. Is the light on now?
   - If the clear light casing comes apart, notice the intensity of the light with the bulb fully exposed. The light is like a pin-dot.
   - Now put the outside glass/plastic light diffuser back on. What does the light look like now? Does it seem as bright? Why would the manufacturer add the diffuser?
2. Look at the internal components of the second light and think about this:
   - Where does the light get its electricity from?
   - If this is a "solar" light, why is there a battery inside?
   - Why doesn't the lightbulb stay lit all the time when the sun is shining?



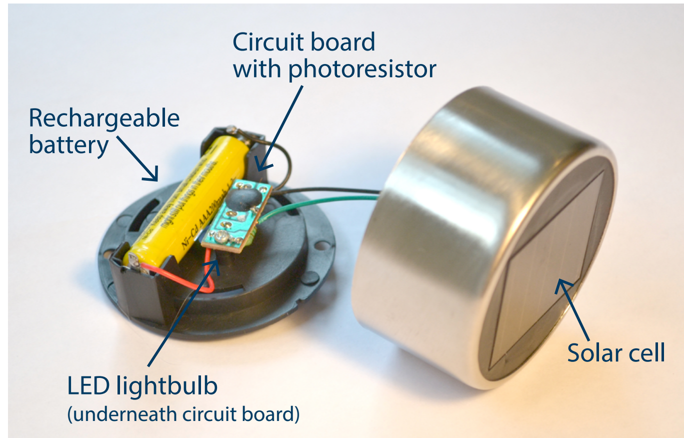
Let's learn more...

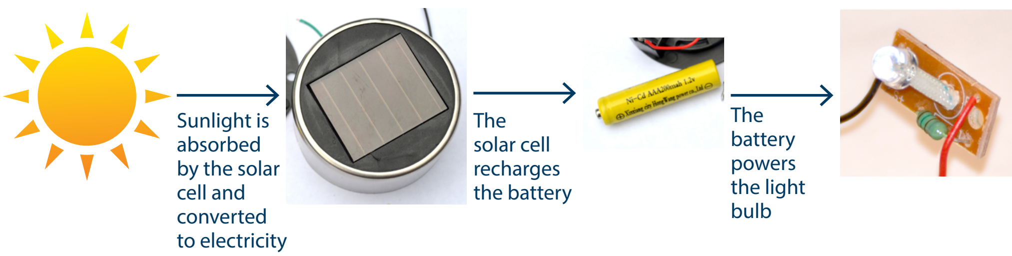


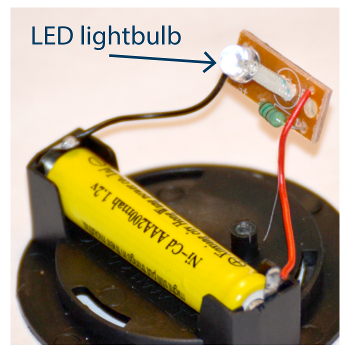
Look at the top of the outside of the light unit. See the smooth dark glass square? That is the "photovoltaic cell," also called the solar cell. This plate of special materials absorbs the energy from the sun and captures it in the rechargeable battery. The more solar cells, the more energy collected. This one is 1.5-inch-by-1.5-inch (approximately 4 cm x 4 cm).

This solar-powered light DOES have a battery. But unlike regular batteries that wear out over time, the battery in this unit is rechargeable. Every day, the sunlight, captured by the solar cell, recharges the battery. And every night, the lightbulb glows until the electricity in the battery is drained. This is a great demonstration of renewable energy.

Inside the unit is a miniature electrical circuit board (green). The circuit board connects the solar cell, the rechargeable battery, and the tiny LED (light-emitting diode) lightbulb. The circuit board is smart enough to "step up" the voltage provided by the battery to a level needed to illuminate the LED. It also includes a sensor called a "photoresistor" that controls when the lightbulb actually turns on. If you cover the sensor with your hand, or put the whole unit inside a dark box, the photoresistor thinks it's nighttime and the electrical circuit is completed. This allows electricity from the battery to illuminate the lightbulb. When it is daylight, the photoresistor disconnects the electrical circuit, so the lightbulb turns off. During the day, the solar cell collects energy from the sun, and recharges the battery…over and over, day in and day out.







A typical garden light will collect about 1.8 volts of electricity each day, which is more than enough to fully charge the 1.2-volt AAA NiCad battery in the unit. The light will glow for as many as 15 hours on a fully charged battery.

How can you make sure your solar light will work as well as possible and as long as possible? Answer: Put it out where it will get full sunlight, and keep the solar cell clean and uncovered. Also, make sure the parts are connected securely so water doesn't get into the battery compartment, which could cause it to corrode. Free electricity from the sun, every day—that's renewable energy!

SAFETY SMART® TIPS

- Using renewable energy is good for our planet because it is safe, clean, and readily accessible. Solar lighting is one easy way to use renewable energy in our homes right now.
- Dispose of unwanted rechargeable batteries in a properly designated collection bin. (Many stores have them.) Rechargeable batteries contain chemicals that shouldn't be put into your household trash.

LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Physical Sciences, Energy
- Disciplinary core ideas:
  - PS3 Energy
  - PS1 Matter and Its Interactions
- Cross-cutting concepts: Energy and matter; cause and effect

Safety Smart Science Investigator's Journal: Solar Energy

Part A: Observe How Solar Energy Produces Heat

	Which ice cube will melt faster?		
	Black card	White card	No difference
Predict			
Observe			

Think about this: If both ice cubes were about the same size, and both the same distance from the lamp, why did one melt faster than the other?____

Part B: Break Down Light Into Its Different-Colored Waves

	What colors can you see from the prism?						
	Red	Orange	Yellow	Green	Blue	Purple	Black
Predict							
Observe							

Part C: Investigate How Solar Energy Is Turned Into Electricity

How can you get the solar-powered light to turn on and off? ____________________________

Where does the light get its power from? (Hint: there are 2 answers) ______________ and ______________

Label the parts of the solar-powered light:

- Photovoltaic Solar Cell
- Photoresistor
- Battery
- Lightbulb
- Circuit Board
- Diffuser

SAFETY SMART® TIPS

Solar energy is a renewable energy, which means it is energy that comes from natural sources such as wind, falling water, the heat of the earth, the waves of the ocean, and yes, the sun. Humans have been using solar energy for thousands of years. You can use it, too, to power your garden light, your calculator, or even your whole home!

IMPACT CRATERS AND THE MOON

I wonder...
How do impact craters change the moon's surface?

Some craters on the moon were formed by asteroids and meteoroids impacting the moon's surface. Learning about impact craters on the moon can help scientists learn about the history of earth and even of the universe! In this adventure, you'll recreate the moon's surface, examine what happens when meteoroids hit the moon and form an impact crater, and measure one of the major changes to the moon's surface that's caused by the impact.

MATERIALS

- Foil baking pan, at least 8 inches by 12 inches (any size will work, though the bigger the size, the more flour and cocoa you will need)
- 4 cups flour, or enough to be approximately 1.25 inches deep in the foil pan (may need to be replenished after 10 or so trials)
- 2 tablespoons cocoa powder (should be reapplied after 10 or so trials)
- Ruler
- 3 marbles, all same size and weight
- 3 marbles of different sizes/weights
- Scale (to weigh marbles)
- 3 wooden dowels or sticks, 3/8 inch diameter up to 1 inch diameter and cut to 6-inch, 12-inch, and 18-inch lengths
- Modeling clay (small amount; enough to hold dowels upright)
- *Optional:* tripod and video camera

Set up the experiment:

Pour flour into the aluminum tray until it's about 1.25 inches deep and evenly distributed.

Lightly sprinkle enough cocoa powder to cover all the flour.

Use modeling clay to secure the dowels to the table. These will be used as markers to identify the different heights from which to drop the marbles.

Optional: Set up a tripod and video camera to record the marbles forming the craters. Afterward, these can be viewed in slow motion or frame by frame. Ask your parents to share on social media with **#sciencenightfun!**

(Sample of photos saved from a video of a crater formation)

Make your predictions

How will the height of the marble affect the size of the crater? What about if the marble is bigger or smaller? Record your predictions in your Safety Smart® Science Investigator's Journal.

Observe: Height Variable

Drop your marble from three different heights. Note the height first, then draw and measure the ejecta that has been created. (***Ejecta*** is rock material thrown out of the crater during impact!)

How far does the splattered cocoa and flour extend? Measure the ejecta from the center of your crater to the furthest point of the splatter. Record your observations and data in your Safety Smart Science Investigator's Journal.

(distance from center of crater to furthest ejecta)

Observe: Size Variable

Drop your marbles of different sizes for three more trials. Choose the a height to use for all three trials, Note the marble weight first in each case, then drop your large, medium, and small marbles from the same height each time. Draw and measure the ejecta that has been created.

How far does the splattered cocoa and flour extend? Measure the ejecta from the center of your crater to the furthest point of the splatter. Record your observations and data in your Safety Smart Science Investigator's Journal.

(distance from center of crater to furthest ejecta)

NOTE: Each set of trials should have only one variable at a time (either varying heights or varying size).

What is going on here?

Craters on the moon don't erode the way they do on Earth. Since there's no water and no moving tectonic plates on the moon to erode the surface, craters on the moon look the same now as they did when they were formed billions of years ago. Scientists can learn a lot about craters on Earth by studying the ones on the moon. These studies provide insight into Earth's early history and how the creation of craters have affected the environment here.

Impact craters on the moon can sometimes be seen by the naked eye. These craters were formed by ***asteroids*** (large rocks orbiting the sun) and ***meteoroids*** (smaller rocks or particles orbiting the sun) hitting the moon's surface while traveling very fast. The objects have so much energy when they hit the moon's surface that some of the crust below it gets compacted while other parts of the crust get pushed out (the part that gets pushed out is the ***ejecta***, represented by the splattered cocoa and flour in your experiment).

The size of the crater depends on both the size of the asteroid or meteoroid and the ***velocity*** (speed) that it's traveling at when it hits. Dropping the marbles from different heights simulates the different velocities at which asteroids and meteoroids might hit the moon. The higher the velocity, the larger the crater. This is because asteroids and meteoroids traveling at higher velocities have more kinetic energy, and therefore they displace more of the moon's crust when they hit. Similarly, larger (heavier) objects have more kinetic energy than smaller ones, so they create larger craters.

Think about this:

In 2013, an 880-pound meteoroid traveling at 40,000 miles per hour hit the moon and created a crater 131 feet in diameter. If you were looking up, you would have seen the lunar crash as a flash of light on Earth!

Did you know craters can be found on Earth, too? The Barringer Meteor Crater (pictured below) found in Arizona was formed about 50,000 years ago. It's about 1 mile wide and 570 feet deep.

Mario Roberto Durán Ortiz/CC BY-SA 4.0

LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Earth and Space Sciences
- Disciplinary core ideas:
  - ESS1B Earth and the Solar System
  - PS21 Motion and Stability: Forces and Interactions
- Cross-cutting concepts: Cause and effect

Safety Smart® Science Investigator's Journal: Impact Craters and the Moon

Variable: Height

Hypothesis: Compared with the other marbles, I predict that the ejecta formed by the highest marble dropped will **(check one)**

- ☐ create the furthest distance from the center of the crater to the ejecta edge
- ☐ create the least distance from the center of the crater to the ejecta edge
- ☐ have the same distance from the center of the crater to the ejecta edge

Sketch your craters:

1st crater	2nd crater	3rd crater
Height of marble when dropped: ________	Height of marble when dropped: ________	Height of marble when dropped: ________
Distance from center of crater to furthest ejecta: _______	Distance from center of crater to furthest ejecta: _______	Distance from center of crater to furthest ejecta: _______

Conclusion: Was your hypothesis correct? If not, which height most closely matched your predicted outcome? Can you explain why?

____

____

____

Safety Smart® Science Investigator's Journal: Impact Craters and the Moon

Variable: Size (Weight)

Hypothesis: Compared with the other marbles, I predict that the ejecta formed by the heaviest marble dropped will **(check one)**

- ☐ create the furthest distance from the center of the crater to the ejecta edge
- ☐ create the least distance from the center of the crater to the ejecta edge
- ☐ have the same distance from the center of the crater to the ejecta edge

Sketch your craters:

1st crater	2nd crater	3rd crater
Height of marble when dropped: _______	Height of marble when dropped: _______	Height of marble when dropped: _______
Distance from center of crater to furthest ejecta: ______	Distance from center of crater to furthest ejecta: ______	Distance from center of crater to furthest ejecta: ______

Conclusion: Was your hypothesis correct? If not, which size marble most closely matched your predicted outcome? Can you explain why?

RECYCLE OLD PAPER INTO NEW PAPER

I wonder…
Can I help preserve trees by making my own paper?

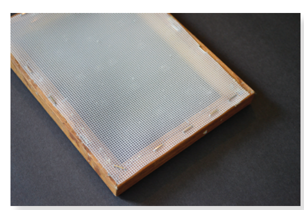
In this adventure, you'll recycle waste paper into new paper and predict which type of pulp will produce the best paper. Old paper can be the primary ingredient to make new paper so that trash is kept out of our landfills and existing trees are preserved. Trees provide many benefits to people, animals, and the environment. For example, trees absorb **carbon dioxide**, which helps protect our atmosphere. Fruit trees provide food, and branches provide shelter for tree-dwelling animals.

MATERIALS

- Variety of scrap paper such as newspaper, copier paper, construction paper, etc.
- Water
- Blender
- 3 buckets for water labeled A, B, C
- 3 tubs labeled A, B, C (plastic wash tubs work well)
- Old towels
- Sponges
- Pieces of old bedsheets or T-shirts (7″x9″)
- Wooden frame (5″x7″)
- Screening*
- Staple gun

* Screening can be cut from plastic needlepoint mesh, a fine mesh placemat, aluminum window screening, or even a pair of pantyhose. The screen must allow water to drain through, but not the pulp fibers. Experiment with different screens to get different textures on your finished paper.

Make a paper frame mold:



1. Remove the glass and any hardware from the wooden frame.
2. Cut a piece of screen to fully cover the opening of the frame.
3. Staple the screen to the back of the frame, keeping the screen taut. This is the mold. The screen side is the top surface of the mold.

NOTE: Do-it-yourself papermaking usually calls for the use of a deckle in addition to a mold. The deckle looks just like the mold, but with no screening. It helps make clean edges on the paper. In the interest of simplicity, we are not using a deckle in this activity.

Prepare the pulp:

You will make three different kinds of pulp to compare the outcomes.

A. Only newspaper

B. Only copy paper, any color, mixed or single color

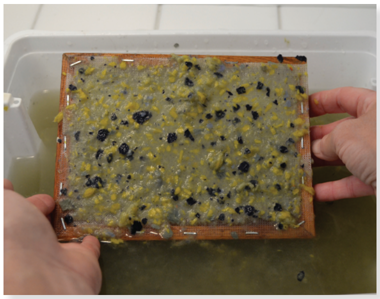
C. Mix of newspaper, construction paper, paper towels, copy paper, and any other scrap paper

1. Rip or tear scraps (don't cut!) into approximately 1-inch pieces.
2. Soak the scraps in three different buckets of water for at least 15 minutes (or overnight for best results).
3. Mash the wet pulp to break up clumps.
4. When you're ready to make paper, fill the blender about three-quarters full with water.
5. Add a couple of scoops of the newspaper-only (A) pulp mixture. Put the lid on blender.
6. Blend on high until the paper/pulp is thoroughly mixed into the water. This is called a **slurry**. The more blended the pulp, the smoother the paper.
7. Pour the slurry into the tub labeled A.

Repeat the steps above for the other two pulp mixtures. Keep the three different pulp/slurry mixtures in separate tubs.

Each tub should be about 90 percent water and 10 percent pulp mixture. This will be a very watery mixture. Add more water if necessary.

Make a small stack of old towels or newspaper, topped with a 7"x9" piece of bed sheeting, T-shirt fabric, or other fine-weave fabric.



Predict the results:

Predict which tub will make the strongest paper and why. Which tub will make the smoothest paper and why? Record your predictions in your journal.

Make a sheet of paper:

Each participant will make three sheets of paper, one from each tub of pulp.

1. Grip the mold with two hands, screen side up.
2. Dip the edge of the mold into the vat of pulp.
3. Slowly scoop the mold through the vat to collect an even layer of pulp on the screen.
4. Lift the mold out of the tub. Allow excess water to drain off for a few seconds.
5. Gently lay the mold, pulp-side down, onto a piece of sheeting on a small stack of towels.

6. Through the screen, use a sponge to soak up excess water. Wring out the sponge as necessary.

   Keep sponging the screen to remove as much water as possible. Press firmly. Sponge for about three to five minutes.

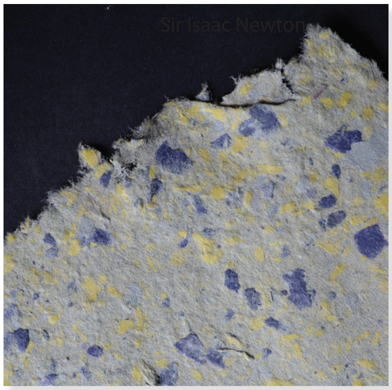
7. Carefully lift the mold away from the wet paper. You may need to coax the paper to release from the screen. The paper should stick to the fabric sheeting.

The paper should be allowed to dry overnight. You can let the paper dry on the sheeting, or stick it to a smooth surface such as a window, plastic tray, or tabletop.

Consider arranging with the art teacher or administrators to store the wet paper sheets until the following school day. Children can identify which recycled paper is theirs if they write their name on a scrap of construction paper and add it to the pulp when it's still on the mesh screen.

What is happening here?

The fiber in plant materials, including wood, is called **cellulose**. Cellulose is what gives plants their structure and sturdiness. It is basically made up of long strands of **glucose**, which is a form of sugar. When cellulose is separated into the individual fibers in the presence of water, some of the glucose dissolves into a sort of watery glue. When the water dries up, the glucose dries up and binds the cellulose fibers back together. If the fibers have been spread out very thin, the resulting material is paper.



Old paper can be used to make new paper so trees are preserved and trash is kept out of landfills. Today, many manufacturers use recycled paper to make writing paper, packaging material, newspapers, greeting cards, and other paper products. If your school doesn't have a paper recycling program, consider starting one!

More paper science

Wood is plentiful and easy to break down into cellulose, therefore it is the primary raw material used for papermaking all over the world. Theoretically, any plant material could be used for paper as long as the cellulose fibers have been isolated by beating, pounding, shredding, chopping, or some other means. The strongest paper comes from long fibers that are beaten from the raw material instead of chopped. You can isolate fibers of cellulose by gently pounding a reed or stem with a rock. The material tends to shred into strands as you pound. If you snip the same reed with scissors you create short pieces of fiber. This is why you tear, instead of cut, old paper to make new recycled paper.

Recycled paper is made from plant material that has already been beaten, chopped, pounded, or shredded into cellulose the first time the paper was produced. Therefore, the fibers in recycled paper are shorter and weaker than in new paper made from virgin wood. Generally, you can't recycle paper indefinitely because the overused cellulose fibers would produce inferior paper. To ensure good quality paper, some commercially produced recycled paper contains new wood fiber. If you see a label on a package that says "80% post-consumer content" that typically means the paper is made from 80 percent recycled paper and 20 percent new fiber.

People tend to like white paper. So the papermaking industry has used different chemicals over the years to brighten and whiten naturally dingy fibers. **Chlorine**, like the bleach used for laundry, is a good whitener of fibers. Over time, chlorine can turn into **hydrochloric acid**. Acid can also be found in areas of severe air pollution and naturally occurs in some plants as **lignin**, which can make its way into paper. Acid in paper tends to yellow and degrade the fibers over time. That is why old paper and old books are often yellow and brittle. Today, some paper is produced to be acid-free. Acid-free paper will last a very long time without breaking down, making it a good choice for photographs, scrapbooks, and important documents.

Since paper is made up of fibers, the longer the fiber, the stronger the paper. Naturally strong fibers also make stronger paper. And fibers that don't need to be bleached will produce more durable paper. Cotton makes good paper because the fibers are strong, durable, and naturally white so they don't need to be bleached. Also, cotton contains less natural acid than wood fiber. **Cotton** rag paper is actually made from old cotton fabric and is especially long-lasting. Other cotton paper is made from the fibers found around the cotton seed. Though short, these fibers (known as **linters**) share cotton's other desirable qualities and produce fine paper. High-quality paper is often marked with a percentage of cotton content, with 100 percent cotton being the highest quality.

Paper is made smooth and thin by the application of **pressure**. In the activity above, you apply pressure when you sponge the water out of wet pulp. When your paper sheet is nearly dry, you can use a household iron (adults only!) to press the paper flat and smooth. Big paper factories, called **mills**, roll their paper pulp through giant presses that squeeze out all the water and squish the paper fibers as thin and as smooth as possible. Although commercially produced paper is much smoother and stronger than what you can make yourself, the basic production process is the same.

LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Earth and Space Sciences
- Disciplinary core ideas:
  - ESS3C Human impacts on earth systems
- Cross-cutting concepts: Cause and effect

Safety Smart Science Investigator's Journal: Recycle Old Paper Into New Paper

Predict which tub will produce the strongest and the smoothest paper. Rank the tubs in order. Why did you rank them this way?

____

____

	STRENGTH		SMOOTHNESS	
Baking bread	**Predict**	**Observe**	**Predict**	**Observe**
A Newspaper only				
B Copier paper only				
C Mix of papers				

- Can you think of ways to make your paper smoother? Stronger?

____

____

____

- Commercial paper factories press their wet paper pulp through massive rollers under great pressure. What do you think that does to the paper?

____

____

____

Did you know you can make paper out of denim blue jeans? Denim fabric is made of cotton, a natural fiber like wood. Cotton fibers make high-quality, durable paper.

Ancient Egyptians made their paper out of papyrus, a reed that grows along river banks. Ancient Celts used thin calfskin called **parchment** as their paper. Today, most of our paper is from wood or recycled from used paper.

WHY HEAT RISES

I wonder…
Why do we install smoke alarms up high?

Try this experiment to see how hot air rises.

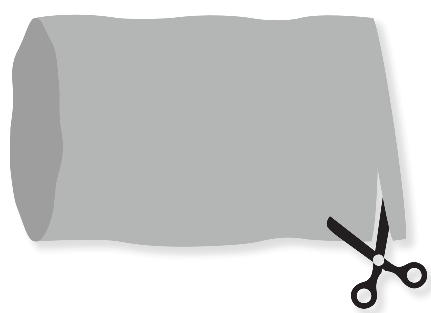
MATERIALS

- Lightweight 30-gallon trash bags*
- Hair dryer—UL Listed
- Cellophane tape
- Thread
- Scissors

*The best bags for this adventure are 30-gallon size, 0.5 mil thickness, which is very thin for a large trash bag. Look for the cheapest large trash bags; they will be the thinnest.

What happens with “regular” air inside the bag?

Wave the bag around to fill it with air. Quickly gather up the open end to close off the bag. Hold the filled bag upright.



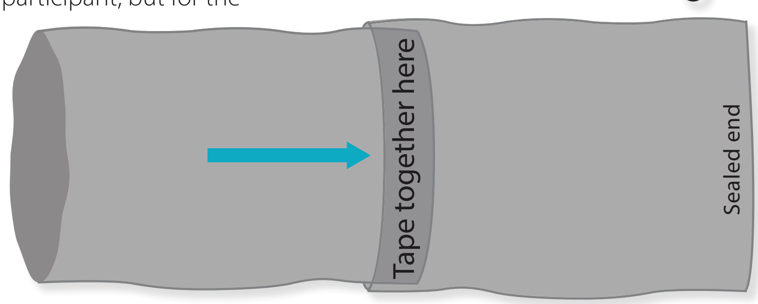
Think about this:

Does the bag stay up or flop over? The air in the bag is the same temperature as the air in the room. The weight of the plastic is not supported by this air. The bag flops over.

What happens if we heat the air inside the bag?

This adventure can be done with just one trash bag per participant, but for the best effect, follow the instructions to make an extra large bag from two individual bags.

- Cut the sealed end off one of the bags, to make a big tube.
- Slide the tube just inside the open end of another bag.
- Tape the edges together, tube to bag, to make one giant bag.



- Tie 4 small knots along the edge of the open end of the bag to make the opening smaller, about 6 inches (15 cm) in diameter.
- Using a piece of thread about 5 feet (1.5 m) long, tie it to one of the knots.
- Tie a small object (key, large binder clip, etc.) to the other end of the thread. This is the weight to keep your hot air balloon from floating out of reach.

You're now ready to test your hot air balloon!

- Point the hair dryer into the opening of the bag, being careful not to allow the plastic to touch the hair dryer.
- Turn the hair dryer on its hottest setting.

Think about this:

Notice that the air inside the bag is warming up and the bag is filled to capacity. Could you get the bag this full with room temperature air? Does the bag want to flop over, or does it seem to hold itself upright?

Gently touch the outside of the bag to feel the warmth. Count slowly to 30 and turn off the hair dryer. Watch as the bag rises up on its own. How long will yours stay afloat? Log your results in your Safety Smart® Science Investigator's Journal.

The cool balloon flopped over. The warm balloon rose up. Why is that?

The heat from the hair dryer causes the air molecules to move around and spread apart, so there are fewer molecules inside the bag. That makes the air inside the bag (the hot air) lighter than the cooler air outside the bag, so the bag rises. When the warm air cools off or escapes from the bag, the bag drops to the ground. A real hot air balloon stays afloat because it has a gas burner under the opening of the balloon that continuously heats the air inside.

What does this have to do with smoke alarms?

If there were a fire in your house, the heated air would rise. Smoke generated by the fire would rise up with the hot air and collect at the ceiling of the room, so that's a good place for the smoke alarm—high up on the wall or on the ceiling. If the smoke alarm senses the smoke in the warm air, it sends out a warning signal that alerts you and your family so you can get out safely.

SAFETY SMART® TIPS

What should you do in a fire?
Because hot air and smoke rise, when you see or smell smoke the safest place is near the floor. So get down and get out! The important thing is to get out as soon as possible and call 9-1-1.

Try this: When you get home, practice crawling along the walls of your room (with your eyes closed as if the room were dark) and see how easily you can find your way to the door.

Test your home's smoke alarms
Most smoke alarms use batteries, which can wear out over time. Have your parents help you test the signal on each smoke alarm in your house.

What sound do you hear? Change the batteries in every smoke alarm every six months. An easy way to remember: Change the batteries on your birthday, and then again on your "half-birthday."

Family fire escape plan
It's a good idea to develop a fire escape plan for your family. Have a family meeting and discuss how to safely exit every room in the house. Remember to identify at least two ways out of each room.

Walk through your house together, looking for safe escape routes. Be sure everyone agrees upon a place to meet outside, like your play set, your mailbox, or a nearby neighbor's house, where everyone would gather if you had to leave the house in an emergency. Remind everyone that the important part of a fire escape plan is to get out as fast as you can, and then to call 9-1-1. Hopefully you'll never need to use this plan, but it's always best to be prepared.

LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Earth Sciences
- Disciplinary core ideas:
  - ESS2 Earth's Systems
- Cross-cutting concepts: Cause and effect

Safety Smart Science Investigator's Journal: Why Heat Rises

How long did your hot air balloon float? ______________

How high did it float? ______________ ft (m)

What could we have done to make it float even better? ____

____

____

____

SAFETY SMART® TIPS

Test your home's smoke alarms

Batteries can wear out over time. Have your parents help you test the signal on each smoke alarm in your house. **What sound do you hear?** Change the batteries in every smoke alarm every six months. An easy way to remember: Change the batteries on your birthday, and then again on your "half-birthday." Write it on the family calendar!

Family fire escape plan

It's a very good idea to develop a fire escape plan for your family. Have a family meeting and discuss how to safely exit every room in your house. Remember to identify at least two ways out of each room. **Walk through your house together, looking for safe escape routes.** Be sure everyone knows how to call 9-1-1. And agree upon a place outside, like your play set, your mailbox, or a nearby neighbor's house, where everyone would gather if you had to leave the house in an emergency. Hopefully you'll never need to use this plan, but it's always best to be prepared.

WITHSTANDING AN EARTHQUAKE

I wonder…
Will certain shapes help a building survive an earthquake and still be safe?

When buildings and other structures are stressed by natural disasters like earthquakes, they can weaken. But what if there were ways to prevent that weakening, resulting in safer buildings that remain strong?

In this adventure, we'll be simulating an earthquake to test different shapes used in buildings. Our goal is for our structures to stay upright, without any significant change in ***structural integrity*** (measured by how much the height changes).

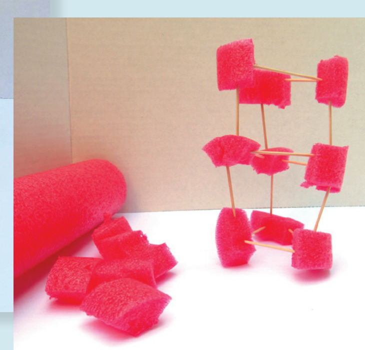
MATERIALS FOR THE SHAKER TABLE (to save time, this can be made in advance of your Family Science Night)

- 3-ring binder
  (a hardcover book or two sheets of strong cardboard, similar in size to the binder, can also be used)
- 4 balls of equal size, such as bouncy balls, golf balls, or tennis balls
- 2 rubber bands, big enough to fit around the binder without breaking
- Ruler (flatter is better)
- Masking tape
- Marker
- Scissors

MATERIALS FOR BUILDING

- Tape measure (for measuring the height before and after)
- Toothpicks—enough for 1 or 2 structures per student
  - 30-40 toothpicks each, grades K-3
  - 40-50 toothpicks each, grades 4-8
- Mini marshmallows—enough for 1 or 2 structures per student
  - 15-20 marshmallows each, grades K-3
  - 20-30 marshmallows each, grades 4-8

  NOTE: Cut-up pool noodles also work
- *Optional:* Eraser, large marshmallow, small action figure, or other object for the top of the structures

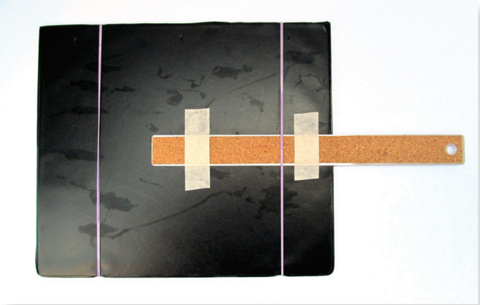


Put together the shaker table:

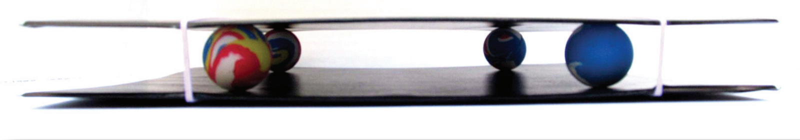
Cut the front and back of a 3-ring binder off the spine.

Tape the ruler to the back of one cover.

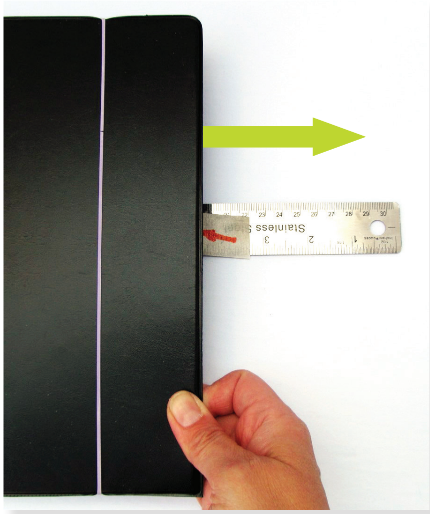
Stack the two covers and place the rubber bands around them, perpendicular to the ruler.

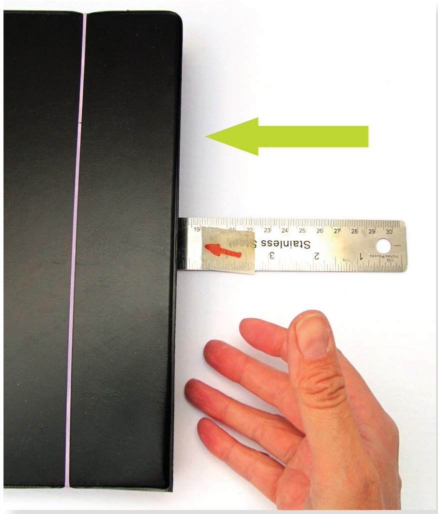


Place the four balls between the binders.



On the front of the ruler, mark the tape to label the ruler about 1 inch from the edge of the cover. This will allow us to measure the displacement of the top cover and make each "earthquake" the same.





Make your predictions

Think about different shapes, such as triangles, circles, and rectangles, and the ways they can be used in buildings.

Design and sketch two to four possible designs in your Safety Smart® Science Investigator's Journal, then record your prediction for which designs will be most and least resilient.

Build your top two design choices out of your materials. Make sure you're keeping in mind any design parameters that have been set.

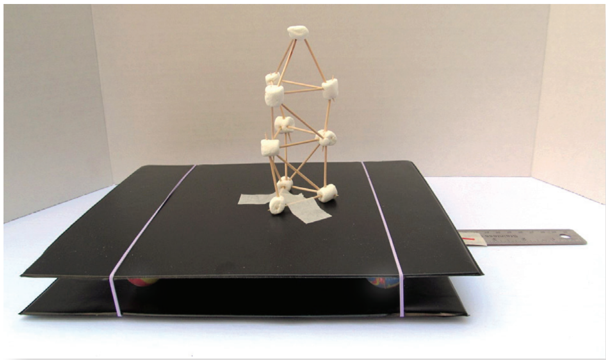
Optional: Tape a small weight (eraser, large marshmallow, action figure, etc.) to the top of structure to give it more mass and make it more realistic This also makes the structure less stable, which may be exciting to watch.

Suggested design parameters:

- Students in grades K-3: Structures should be at least 1 toothpick tall and no more than 2 toothpicks wide.
- Students in grades 4-8: Structures should be at least 3 toothpicks tall and no more than 2 toothpicks wide.

Observe

Tape your completed structures to the top of the shaker table and measure the heights. Record your data in your Safety Smart Science Investigator's Journal.



Create the earthquake by moving the top plate of the shaker table to the spot marked on the ruler, then let it go. Repeat this pull-and-release a specific number of times.

NOTE: Each student should repeat the process the same amount (10 to 20 times) so that the earthquake has the same magnitude for every trial. Add the number to your Safety Smart Science Investigator's Journal

In your Journal, measure and record the height of your structures after the earthquake is over to see whether the structures endured damage (had a change in height) or were resilient (stayed the same height). Was there any difference in the resilience of the two buildings? Why do you think this was the case?

What is going on here?

The rock plates that make up the earth's crust are always slowly moving. Sometimes these plates can't move past each other unless they break. The breaking plates release an incredible amount of energy in the form of an earthquake. The shaker table represents the ground movement during the release of this energy.

Engineers must design buildings to keep people safe during and after earthquakes and other natural disasters. Recently, the frequency (number) and intensity (strength) of natural disasters has increased. Engineers are now adopting an approach of ***resilience engineering*** to ensure that designs are safer. This means they must design buildings and products not only to withstand natural disasters but also to recover quickly and safely from these events.

One way that engineers design resilient buildings is by using triangles in the building structure. Triangles are special because they can bear large weights without losing their shape; the forces from an earthquake get evenly distributed across all three sides of the triangular supports in a building. This makes a triangle the strongest shape, and it's commonly used by engineers when they're designing resilient buildings.

LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Engineering
- Disciplinary core ideas:
  - ESS2B Plate Tectonics and Large-Scale Systems
  - ESS3 Earth and Human Activity
  - ETS1 Engineering Design
  - PS2A Forces and Motion
- Cross-cutting concepts: Structure and function, cause and effect

Safety Smart Science Investigator's Journal: Withstanding an Earthquake

What shapes will make a structure strongest? Think about your design, then sketch up to four different possibilities and rank them on how you think they'll perform, from most resilient (1) to least (4).

Design #1 • Rank _____	Design #2 • Rank _____
Design #3 • Rank _____	Design #4 • Rank _____

Choose two of the designs to build and test on the shaker table, then record the height for each one before and after the earthquake.

Earthquake magnitude (number of times you pull and release): ________

Trial #1: Design #:_______ Height before:________ Height after:________

Trial #2: Design #:_______ Height before:________ Height after:________

Results

Which design worked better? Why do you think it did? What could you change to make it even stronger?

____

____

Where else do you see shapes used in structures? Take photos of everyday objects that use shapes for strength and structural integrity. Are you noticing the use of triangles in more recently designed buildings? Now you know why!

____

____

ENGINEER A MARBLE RUN

I wonder...
Can I design a marble run to meet a specific goal?

In this adventure, you'll design, construct, and test a marble run to meet a specific goal. How close can you come to the target time for your marble to roll to the end of the line?

MATERIALS

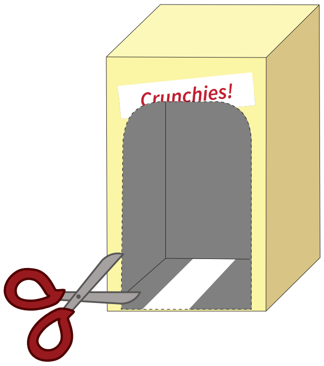
- Marbles, all one size
- Foam pipe insulation tubing, 6-foot length*
- Masking tape
- Several foam or plastic cups (20 oz. work well)
- Empty cereal or tissue box
- Scissors
- Yardstick
- Measuring tape at least 12 feet long
- Ruler
- Digital stopwatch (cell phone stopwatch works well)

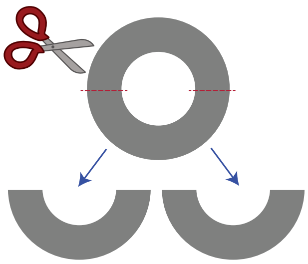
*Available at home centers or hardware stores

Set up the experiment:

1. Hang the "Key Concepts Defined" poster (provided) near the adventure station
2. Cut the cereal box as shown at right to make a catch box for the end of the run.
3. Use scissors to split the foam tubing into two long channels. The tubing may be purchased presplit along one length. Tape the two lengths together to form one channel about 12 feet long.
4. Tape the yardstick to a wall with the 1-inch end at the floor.
5. Tape the measuring tape to the floor, perpendicular to the yardstick.

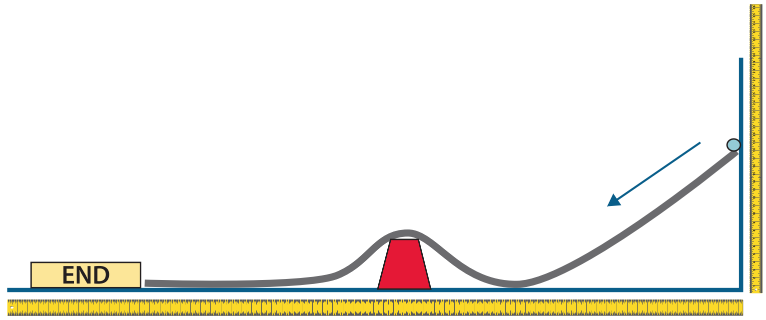
Depending on the size of your group, you may want to set up multiple stations for building marble runs.





Let the adventure begin

Your goal is to design a run that carries a marble through the foam channel from beginning to end in exactly 2.00 seconds. (NOTE TO ADULTS: Adjust the goal time for your specific setup and materials.) You can set the starting point as high or as low as you wish, up to 36 inches.



Tape the end of the foam channel next to the yardstick. Align the foam channel with the measuring tape along the floor. Put the cereal box right at the end of the channel to catch the marble. Add hills using the cups.

You will get **10 trials**. Start the stopwatch as you release the marble. Stop the timer when the marble crosses the end of the channel into the catch box. Be sure to reset your stopwatch after each trial. Adjust your design after each trial, if necessary, to get closer to the goal time. Record your setup and the time for each trial on your Safety Smart® Science Investigator's Journal.

The things you can change in your design are called ***variables***. The things that don't change are called ***constants***. The information and measurements you use in your design are called ***data***.

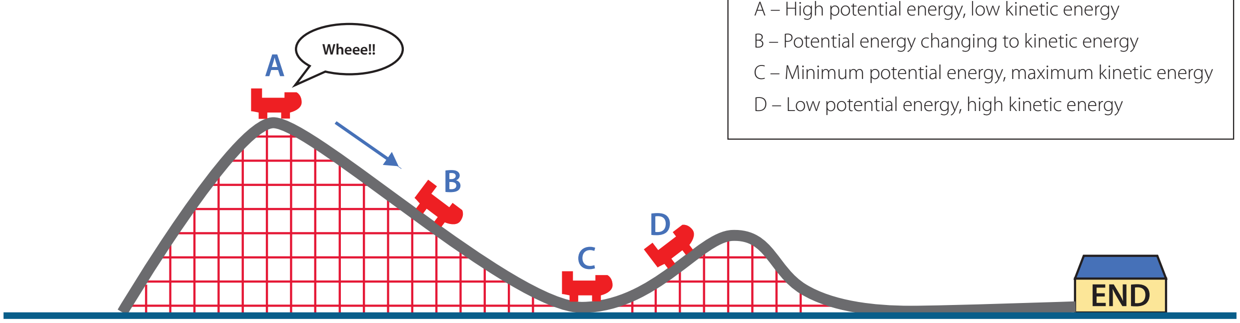
When you adjust your design, try not to change too many variables at once. Engineers work carefully to keep track of the variables so they know which one had the biggest effect on the outcome. Try changing only the number of bumps or only the starting height, for example, but not both at the same time.

What is going on here?

The marble rolls down at the beginning of the run, slows down or speeds up because of the up-and-down motion of the bumps, and finally rolls off the end of the channel into the cereal box. As the engineer, you can affect the speed of the marble by changing the variables in your design.

Sitting still, the marble has stored energy, which scientists call ***potential energy***. When you release the marble at the top of the run, gravity pulls it down, releasing the marble's potential energy as motion. The energy of motion is called ***kinetic energy***. When the marble starts to climb a bump, it slows down until it reaches the crest of the bump. At that point, the marble picks up speed as it rolls down again. Every time the marble climbs a hill, it uses potential energy, every time it rolls down, the energy changes to kinetic energy.

A – High potential energy, low kinetic energy
B – Potential energy changing to kinetic energy
C – Minimum potential energy, maximum kinetic energy
D – Low potential energy, high kinetic energy



What more should I know?

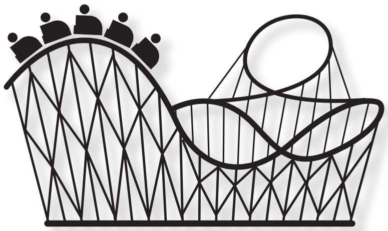
What would happen if you placed a marble in the channel (for example, at spot C in the diagram on the previous page) before releasing a marble at the beginning of the run? Would both marbles make it to the end of the path? At the same time?

You can make a marble run at home with all kinds of recyclable materials such as paper towel tubes, cottage cheese containers, and cracker boxes. The possibilities are endless. Can you design a marble run that travels from your front door to the kitchen? From upstairs to downstairs? One with tunnels, curves, or cliffs? Just be sure to stay safe by keeping the marbles away from babies and pets.

Engineers design systems similar to the marble run in many different applications. Some of the same science that you experimented with applies to large operations like packaging warehouses, airport baggage handling systems, and even roller coasters.

In our adventure, we relied on gravity to move our marble down a ramp, over hills, and to its destination in a precise amount of time. Now imagine that the single marble is actually a case of marbles and your ramp is part of a large package delivery to a warehouse for a big-box retailer. Instead of rolling into a cereal box at the end of the ramp, your case of marbles might travel from the central storage shelf, down a conveyor belt (similar to the foam tube), and into the hands of a truck-loading robot. The box must arrive at exactly the right time so the robot can grab it securely.

Now think about this: When you check a suitcase at the counter before flying on an airplane, your suitcase goes for quite a ride before you even board the plane. Behind the scenes, your suitcase (along with hundreds of others) is sent rolling through a complex system of conveyor belts toward the loading area for the airplanes. As the baggage travels, scanners read the black and white bar codes on the baggage tags and push each bag down the proper path so each ends up on the correct airplane. Imagine that your marble is a suitcase and your foam tube is a conveyor belt moving the suitcase toward the airplane (the cereal box in our adventure). Have a great trip!



In the example of a roller coaster, you are the object rolling down the ramp and then up and over the hills instead of a marble. Have you ever noticed how most roller coasters start with the cart going slowly up a large hill? The design engineers do this—move the cart uphill first—to take advantage of the potential energy gained by rising to the top of a large hill. When the cart crests over the top (like letting go of your marble at the beginning of your foam tube run), gravity takes over and pulls the cart—and you!—down the track and over the hills to the squealing delight of the passengers. If there's enough kinetic energy, the track might even do a loop before safely rolling back into the station.

For a different take on this project, check out how UL got 200 kids involved in building, testing, and refining a marble ramp during a day at company headquarters!

https://www.youtube.com/watch?v=rTyBiK06ZiI

LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Motion and Stability: Forces and Interactions
- Disciplinary core ideas:
    - K-PS2-2 Analyze data to determine if a design solution works as intended to change the speed or direction of an object
- Cross-cutting concepts: Cause and effect; engineering

Engineer a Marble Run

Key Concepts Defined

Variable
a factor or characteristic that can be changed
(e.g., height of the start of the marble run)

Constant
a factor or characteristic that does not change
(e.g., weight of the marble)

Data
information, facts, or values collected during an experiment
(e.g., time to roll to the end of the run)

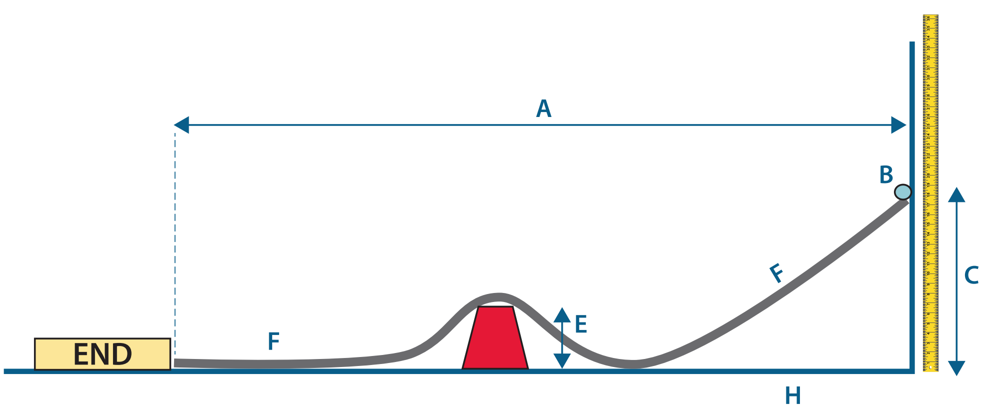
Potential Energy
energy possessed by an object (marble) by virtue of its
position relative to other objects (the run)

Kinetic Energy
energy possessed by an object (marble) by virtue of its being
in motion (rolling down the hill)

Safety Smart Science Investigator's Journal: Engineer a Marble Run

Using the diagram below, identify each design component as a ***variable*** or a ***constant***. Remember, you can adjust variables, but constants stay the same throughout the activity.

Is it a variable or a constant?			
DESIGN CONCEPT		VARIABLE	CONSTANT
A	Travel distance	X	
B	Weight of marble		
C	Height of starting point		
D	Number of bumps		
E	Height of each bump		
F	Length of channel (foam tube)		
G	Channel material		
H	Position of each bump		



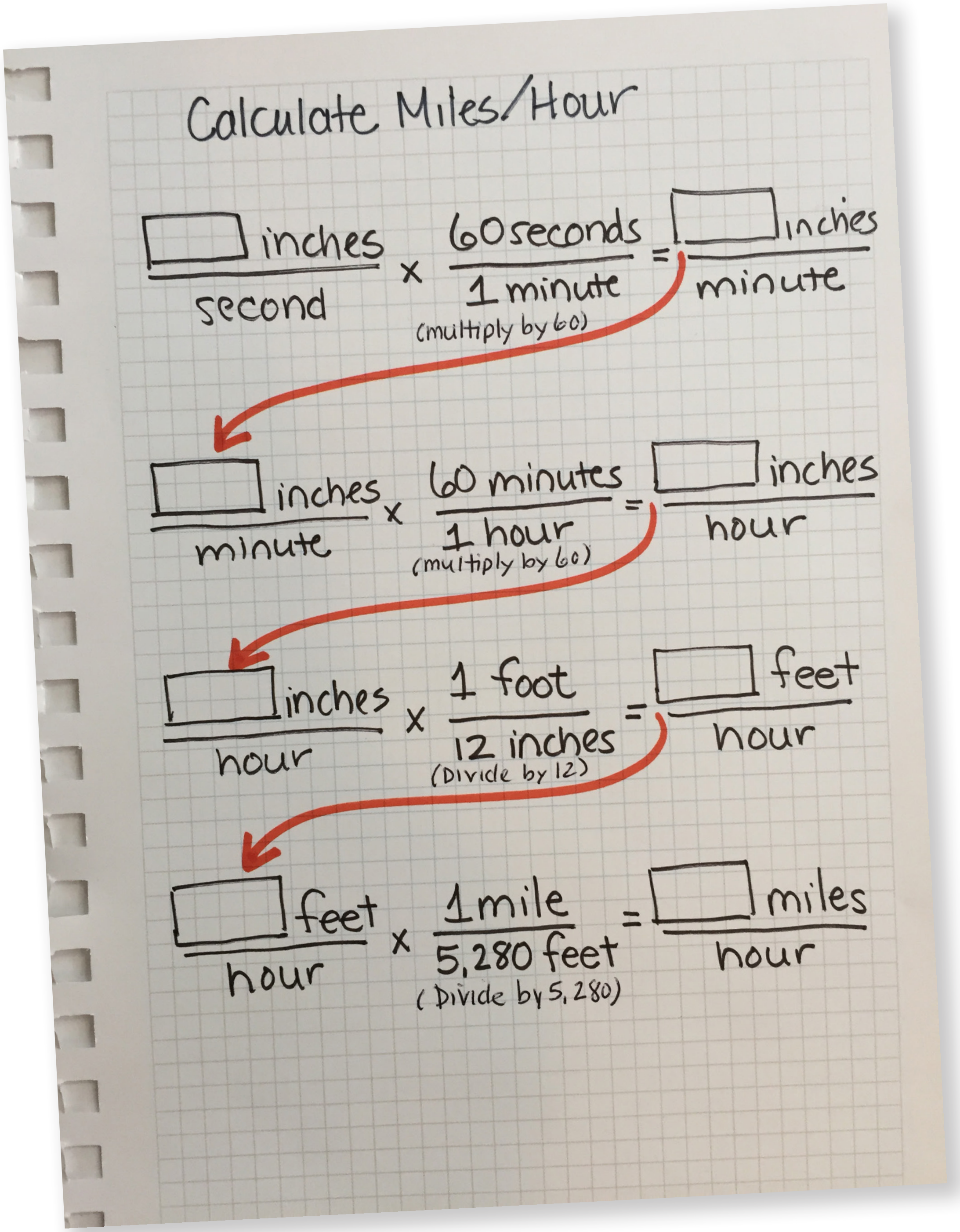
Use the chart below to record the data for each of your trials. Circle any trials that hit your goal exactly. Calculate the average time for your trials. How close is your average time to the goal time?

Trial	C Starting Height (inches)	D Number of Bumps	A Distance Traveled (inches)	Time (seconds)	For older students: Calculate marble speed*
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
Calculate Average Time = Total time for all trials divided by total number of trials					
Goal Time				seconds	
How close is your average time to the Goal Time?					

*__Speed__ (inches per second) = **Distance** (inches)/**Time** (seconds)

For older students:

How fast did your marble roll compared with a car? Use the worksheet below to calculate miles per hour for one of your trials.



ENGINEER YOUR OWN HOVERCRAFT

I wonder...
Can I design an object to float in mid-air?

In this this adventure, you'll build two different styles of hovercraft. Can you engineer yours to travel the farthest? The longest? What factors affect the hovercraft's performance?

MATERIALS

- Balloons of various sizes
- Old CDs or DVDs
- Sippy caps from plastic water bottles (the kind that slide up and down to open/close)
- UL Listed hot glue gun (adult use only)
- Small paper plate

SETUP

Build two versions of the hovercraft.

- **Design 1:** Paper plate with a hole poked in the center (use a pencil)
- **Design 2:** CD plus sippy cap secured over the hole with hot glue

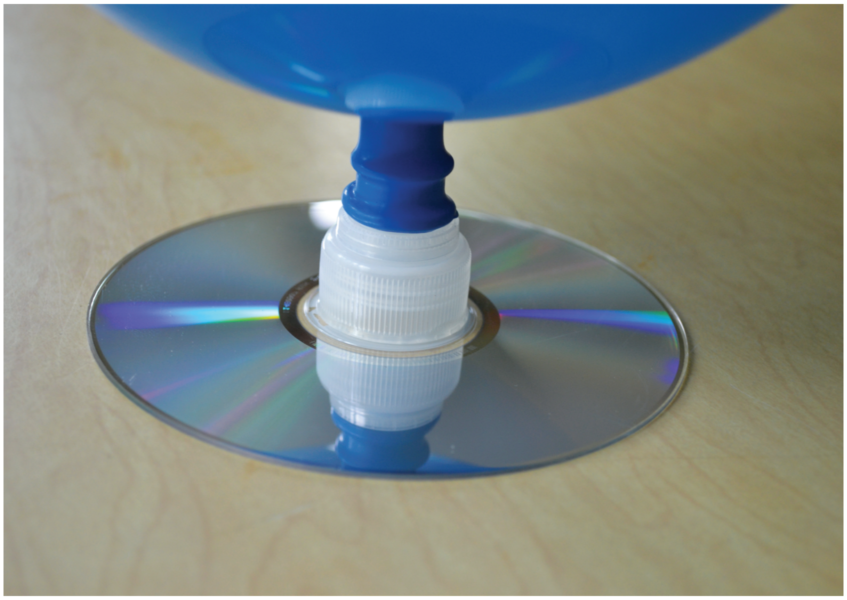
For best results, release the hovercraft on a very smooth surface.

PREDICTION

Which design will move the farthest across the floor? Write your prediction on your worksheet.

TEST YOUR HOVERCRAFTS

- **Design 1:** Blow up the balloon and pinch the neck but don't tie it. Push the end of the balloon through the hole in the plate. Set the hovercraft on the smooth surface. Release the balloon so the air escapes under the plate.
- **Design 2:** Close the sippy top. Blow up a balloon. Carefully pull the lip of the balloon over the opening of the sippy cap. Set the hovercraft on a very smooth surface with the CD flat on the surface. Holding the balloon and cap (not the CD), open the cap to release the air. Take your hands away.



REFINE THE DESIGN

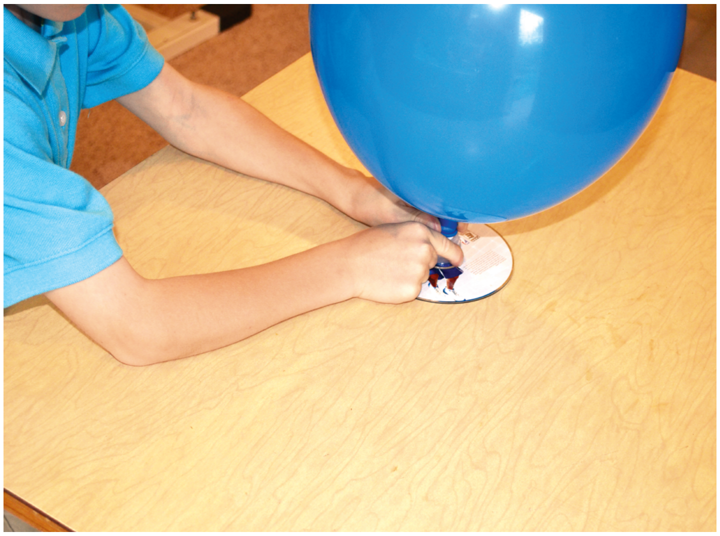
Is there anything you can do to control the speed or direction of the hovercraft? What if you use a different size balloon? Does a larger balloon make a better hovercraft? What could you do to reduce the friction between the hovercraft and the surface—that is, make the surface more slippery?

Label the parts of the hovercraft on your worksheet. Circle your best design and write a sentence explaining why you think it worked better.

WHAT IS HAPPENING HERE?

The air rushes out of the balloon because the pressure on the outside of the balloon is greater than the pressure inside. That rushing airflow is directed under the CD or the paper plate and escapes by pushing against the surface. If the force of the air is great enough, the hovercraft rises off the surface just a bit and moves around. Large balloons hold more air but also weigh more than smaller balloons. The hovercraft must carry the weight of the balloon, so larger balloons may not give the best performance.

Friction also affects how well the hovercraft slides on the surface. The less friction between the hovercraft and the surface, the better the hovercraft will slide on the surface. If your surface or CD is rough or sticky, friction is high and the hovercraft won't move well. Oil, grease, and wax have low friction. **Try this at home:** Lightly oil the base of your hovercraft and the surface of your table with furniture polish. Does your hovercraft move better on the oiled surface?



LEARNING MESSAGES

Complementary Next Generation Science Standards

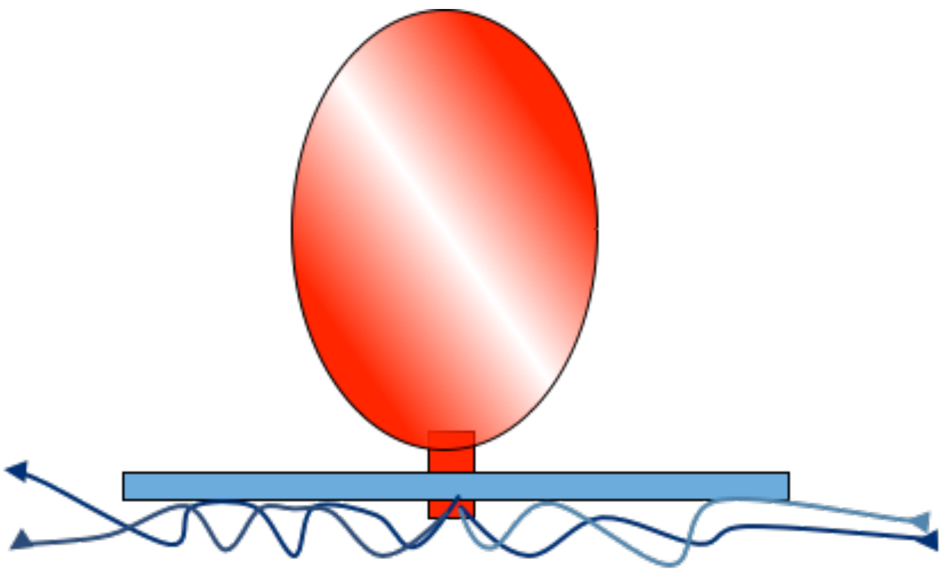
- Topic focus: Engineering, Physical Sciences
- Disciplinary core ideas:
  - ETS1 Engineering Design
  - PS3 Energy
- Cross-cutting concepts: Cause and effect; structure and function

Safety Smart Science Investigator's Journal: Engineer Your Own Hovercraft

How well will the hovercraft perform?

	Design 1: Paper Plate	Design 2: CD
Prediction		
Observation		

Label the parts of the hovercraft:



Were you able to improve the performance of the hovercraft? If so, how?

BUILDING BRIDGES

I wonder...
How strong a bridge can I build from simple materials?

In this experiment, you will use paper index cards to build several different bridges and load them with pennies to test their relative strength.

MATERIALS

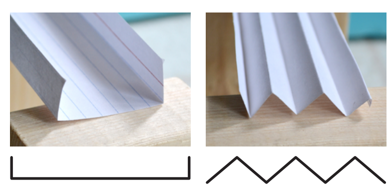
- Index cards
- Pennies (about 50)
- 6 matching blocks, each about 2 inches tall

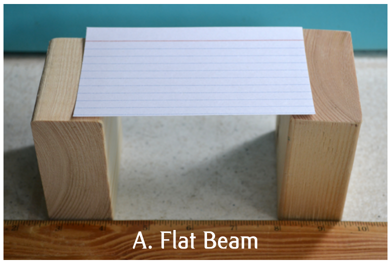
OPTIONAL

- Plastic soda straws (without the flexible bend)
- String
- Ruler
- Duct tape
- 4 large soup cans (unopened)
- Wire coat hanger
- 2 chairs

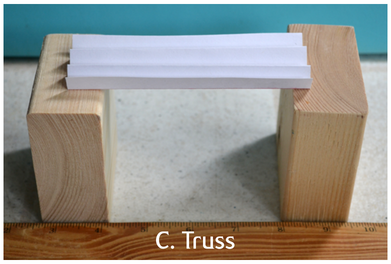
Set up the experiment:

- Position two supports so the gap between them is 4 inches (10 cm)
- Form the three different bridge designs, each from one fresh index card.
  - A. Flat beam: No folds, just lay index card across blocks
  - B. Girder: Fold long sides up to form a channel
  - C. Truss: Fan-fold the card the long-way




A. Flat Beam


B. Girder


C. Truss

Predict the results:

Using the chart in your journal, rank the bridge designs by what you think their relative strength is. The strongest bridge gets a rank of 1, the next strongest a rank of 2, the weakest a rank of 3.

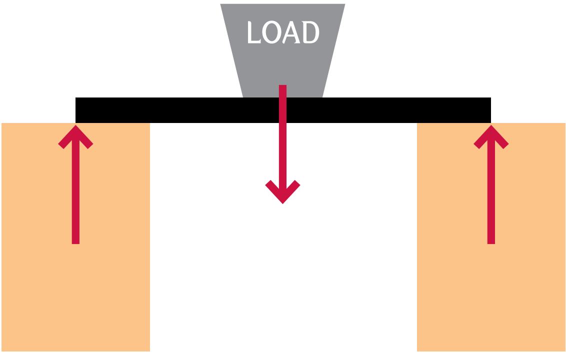
Run the test and record your observations:

- Lay your bridge across the gap.
- Load pennies in a stack, a few at a time, until the bridge collapses.
- Record the number of pennies the bridge supported.
- Repeat for all bridge designs, then rank the bridges again based on which one turned out to be the best-suggested design (the strongest) down to the weakest.

Can you make a bridge that is even stronger than the best-suggested design? (You can draw it on the Journal page accompanying this activity.) What if you added some tape to your design? What if you combined more than one shape or more than one index card? If you add tape and more index cards to your design, you are adding "cost" to your bridge. In real life, the costs for building a certain design and the materials to use for it need to be balanced with the amount of money budgeted for the project.

What is happening here?

The ***load*** on your bridge (the pennies) puts a downward ***force*** on the bridge. The bridge must be able to offset that downward force or it will collapse. Bridge A, the flat beam, offsets the load only at the two ends of the bridge. It is the simplest bridge design and not a very strong bridge. Bridge B, the girder bridge, spreads some of the load over the creases in the index card. Bridge C, the modified truss bridge, supports the load best because of the "V" shapes folded into the card. More complex designs do a better job of handling the load by spreading the force of the load over more parts of the bridge. Civil engineers study bridge design, force, and load so they can design the strongest, most reliable, and most cost-effective bridge for each location.



What more should I know?

Civil engineering deals with designing, building, and maintaining structures, including things like roads, bridges, canals and buildings. Civil engineers are responsible for creating some of the most amazing sites around the world. Benjamin Wright, known as the father of American civil engineering, was chief engineer of the Erie Canal. It spans 363 miles, from Lake Erie in western New York to the Hudson River in the east.

Émile Nouguier codesigned the Eiffel Tower in Paris, an A-shaped structure more than 1,000 feet high. Joseph Strauss was chief engineer of the Golden Gate Bridge in San Francisco.

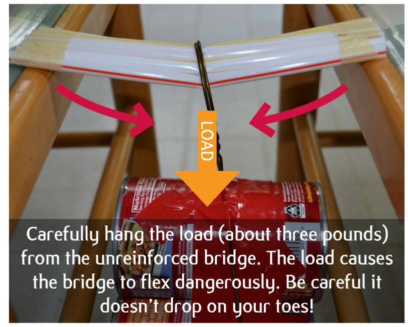
John A. Roebling was famous for his work on wire-rope suspension bridge designs, in particular the Brooklyn Bridge. His daughter-in-law, Emily Warren Roebling, was a self-taught civil engineer who completed work on the bridge after his death.

A cool variation for older kids:

Using the optional materials, build a suspension bridge out of soda straws, string, and tape anchored between two chairs.

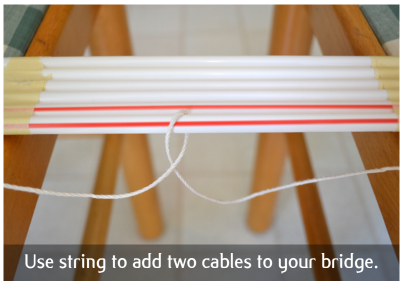
Tape six straws together, side by side.

Create your load out of four large soup cans, a wire coat hanger, and duct tape.

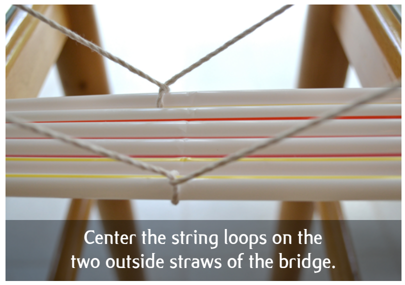


Carefully hang the load (about three pounds) from the unreinforced bridge. The load causes the bridge to flex dangerously. Be careful it doesn't drop on your toes!

Add suspension cables to reinforce your bridge. Use plenty of tape to secure the string to the back of each chair.

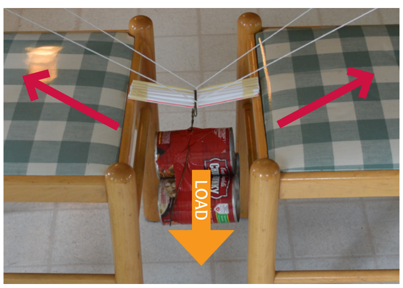


Use string to add two cables to your bridge.



Center the string loops on the two outside straws of the bridge.

Secure the ends of the string to the back of each chair.



Hang the soup can load back on the bridge. The cables relieve some of the load and the bridge stays strong. Notice how taut the strings are. That proves they are holding some of the weight of the load.

SAFETY SMART® TIPS

- Traveling can be exciting, especially when you are crossing a huge suspension bridge or watching a bascule bridge (drawbridge) opening and closing for a ship to pass through. But we need to always remember to be Safety Smart while traveling, too!
- Buckle your seat belt!
- Never distract the driver!
- Wear your helmet when biking, skating, or blading!
- Look both ways and stop talking on the phone when you cross the street!

LEARNING MESSAGES

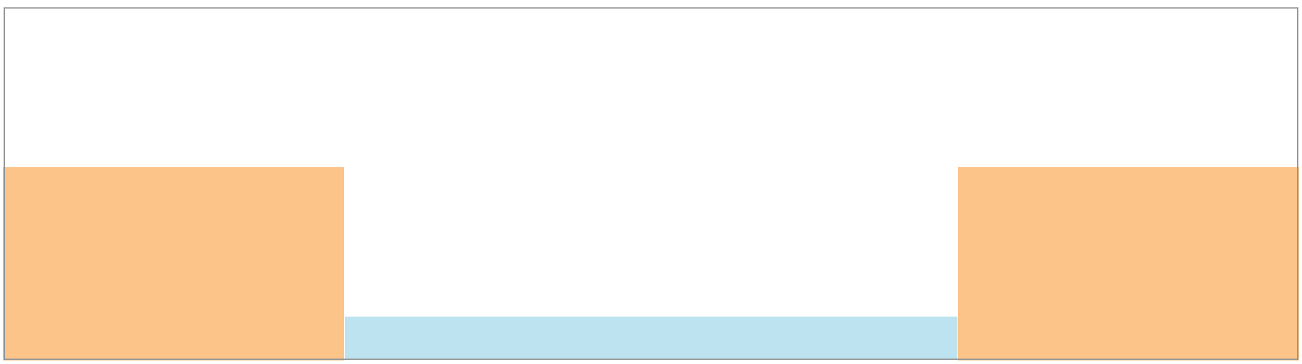
Complementary Next Generation Science Standards

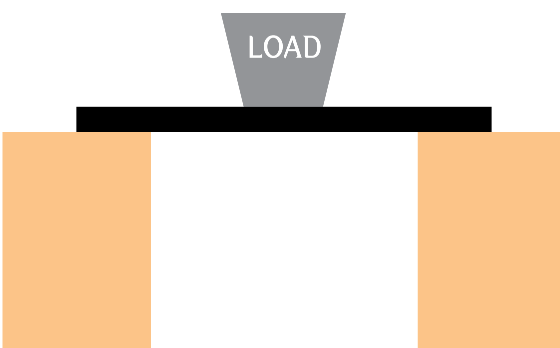
- Topic focus: Engineering
- Disciplinary core ideas:
  - ETS1 Engineering Design
- Cross-cutting concepts: Structure and function

Safety Smart Science Investigator's Journal: Building Bridges

		Prediction		Observation	
	Bridge Design	Rank Strongest to Weakest (1 is strongest)	Number of Pennies the Bridge Will Hold	Number of Pennies Bridge Does Hold	Rank Strongest to Weakest (1 is strongest)
A	Single Beam				
B	Open Box (Girder)				
C	Small Fold (Truss)				
D	Your Own Design (draw on diagram below)				

Draw your bridge design here





Draw three arrows to show the force of the load against the force of the bridge.

SAFETY SMART® TIPS

- Always buckle your seat belt.
- Don't distract the driver.
- Wear a helmet when biking, skating, or blading.
- Before crossing the street, stop talking on the phone and look both ways.

BUILD A CATAPULT AND TEST IT

I wonder...
How can I make a catapult? How can I make it even better?

In this experiment, you'll explore simple physics by making and testing two different kinds of catapults.

MATERIALS

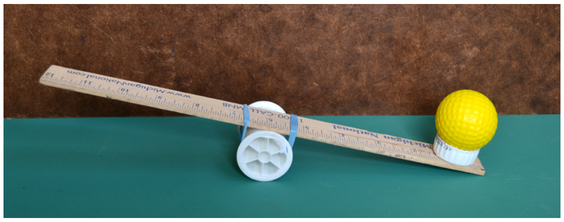
- Plastic or foam golf balls or jumbo marshmallows
- Plastic bottle caps
- Masking tape
- Rubber bands
- Measuring tape
- Ruler
- Empty thread spool or similar
- 14 jumbo craft sticks

OPTIONAL:

- Cups taped together into a cluster, as a target

CATAPULT #1: RULER

- Use a rubber band to secure the spool to the midpoint of the ruler.
- Use masking tape to attached a bottle cap to one end of the ruler.



CATAPULT #2: CRAFT STICKS

- Stack 12 craft sticks. Wrap a rubber band around each end to hold the stack together.
- Stack the remaining two craft sticks. Wrap another rubber band around one end to hold the two sticks together.
- Slide the tall stack between the two sticks so the two sticks form a sideways "V." Secure the tall stack to the "V" with another rubber band.
- Use masking tape to attach a bottle cap to the top of the open end of the "V", about 1 inch in from the end.

Predict the results:

Predict how far your ball will travel for each style of catapult and record your predictions in your Journal.

Run the test and record your observations:

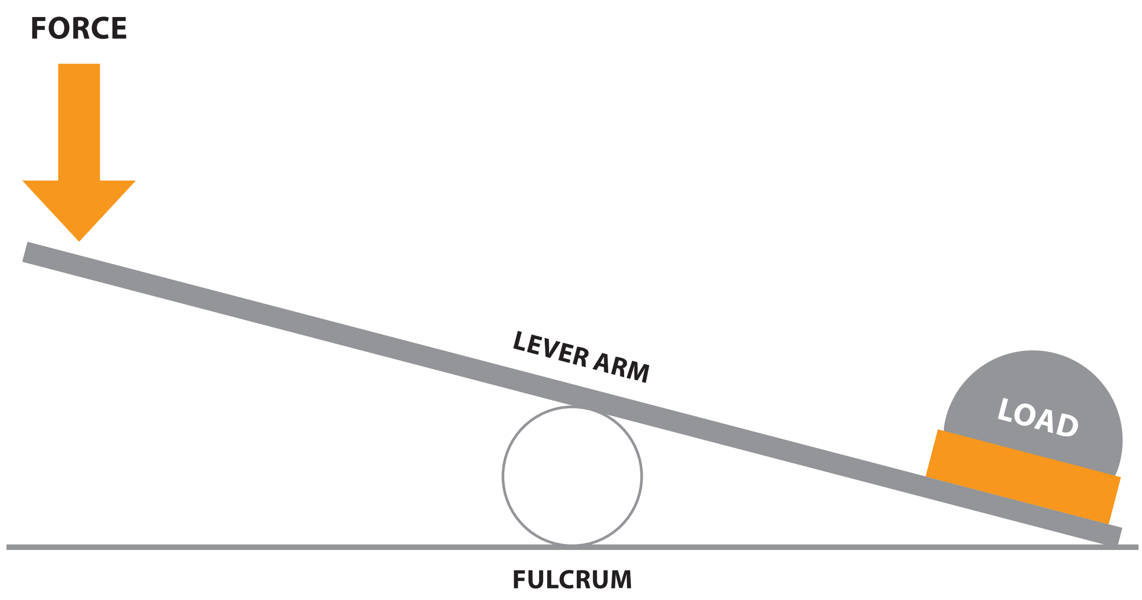
- Shoot the ball three times with each catapult design. For the Ruler Catapult, simply press down on the high end to shoot the ball. For the Craft Stick Catapult, place your middle finger on the bottom stick and your index finger on the top stick; press down with your index finger to flex the top stick down, and then release to shoot the ball.
- Record how far each one travels every time.
- Calculate the average distance for each design.

What is happening here?

Catapult #1: Ruler

This simple catapult is a form of ***lever***. The spool acts as the ***fulcrum*** of the lever, and the ruler is the ***lever arm***. The golf ball is the ***load***, and your hand pressing down on the opposite end of the lever is the ***force***. When you hit the force end of the lever, you produce ***torque***, which causes the other end of the lever to quickly rise up and toss the ball into the air. The ball continues to move even after the lever arm stops because of Newton's First Law of Motion, which says that an object in motion tends to stay in motion.

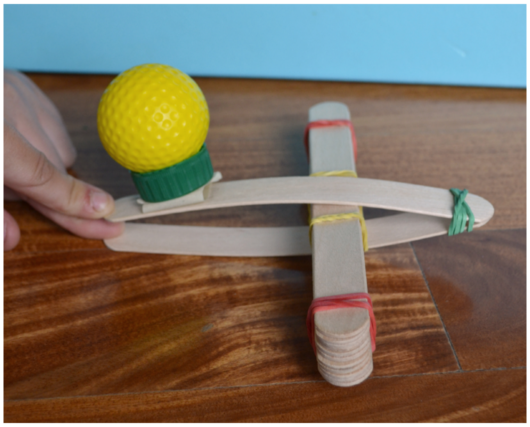
You can change the height and/or distance the ball flies by moving the fulcrum (the spool) along the lever arm (the ruler). Based on your trials and the physics involved, make minor adjustments to the catapult. Predict whether the catapult will shoot farther or not with each adjustment. Try to get your catapult to shoot the farthest, the highest, or into a target. Record the results in your Journal. Which position sends the ball the greatest distance? The greatest height?



Catapult #2: Craft Sticks

This catapult depends on ***tension*** to launch the ball. When you press down the ***load arm***, you ***force*** tension in the flexed craft stick. When you release the flexed stick, the wood releases tension in the form of ***kinetic energy***, and the ball goes flying.

You can change how far the ball flies by adjusting the height of the load arm (the top of the "V"), and/or the location of the fulcrum (the tall stack of craft sticks), and/or the amount of force you press down on the load arm. Based on your trials and the physics involved, make minor adjustments to the catapult. Predict whether the catapult will shoot farther or not with each adjustment. Try to get your catapult to shoot the farthest, the highest, or into a target. Record the results in your Journal.



SAFETY SMART® TIPS

We can use simple machines like catapults to move heavy things for us—simple machines make work easier by transferring the effort from us to the machine! But we do need to take care of ourselves so we stay healthy and fit. Getting an hour of physical activity every day is an easy way to stay healthy and fit. Have fun and be Safety Smart—grab your friends and play!

- Climb on the monkey bars
- Swim
- Jump rope
- Play soccer, football, baseball, softball, or hockey
- Do gymnastics
- Play tag, hopscotch, four square, or spud

LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Engineering
- Disciplinary core ideas:
  - ETS1 Engineering Design
  - PS2A Forces and Motion
- Cross-cutting concepts: Energy and matter; structure and function

Safety Smart Science Investigator's Journal: Build a Catapult and Test It

	How far will my catapult shoot?					
Design	Prediction	Observation			Calculate Average	
		Trial 1	Trial 2	Trial 3	Total = 1+2+3	Total / 3 =
1 - Ruler						
Fulcrum at midpoint						
Fulcrum moved closer to load						
Fulcrum moved closer to force						
2 - Craft Sticks						
As designed						
Height of load arm changed						
Location of fulcrum changed						
Amount of force changed						

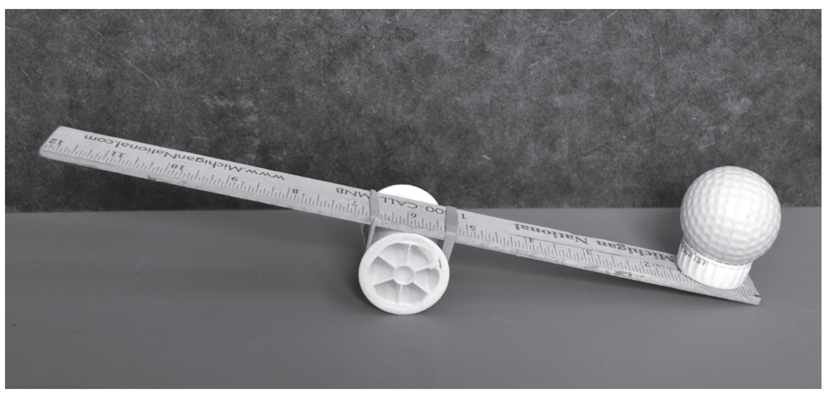
Draw a line from the word below to the corresponding part of the catapult.

LOAD

FULCRUM

LEVER ARM

FORCE



SAFETY SMART® TIPS

- Machines make work easier for us to move things, but it's important to stay in good shape so you won't hurt yourself, even while you're using a machine.
- Try to get an hour of physical activity a day by going to the playground, swimming, playing sports, doing gymnastics, or other games that get you moving.

WATCH EARTHWORMS WORK

I wonder...
How do earthworms move and eat (and help plants grow)?

Earthworms play an essential role in our ecosystem thanks to how they move through the soil and what they eat, breaking down food and other organic matter into nutrients that plants can use. In this activity, you'll make a wormery—a worm habitat—that you can take home to observe firsthand how these simple but amazing creatures work.

MATERIALS

- 2 liter soda bottle (clean and empty)
- 1/2 liter water bottle with cap (empty)
- 1 cup soil
- 1/2 cup sand
- Scissors
- Dark construction paper or card stock
- Tape
- Trowel
- Ruler
- Water
- *Optional:* leaves, grass clippings, or vegetable garden waste
- 2 or 3 earthworms (see "where to find earthworms" on the last page; you may also send students home with instructions to find their own worms)

NOTE: Part of this adventure is completed at home, so each family should take home a copy of these materials, including the Journal pages!

Create the wormery:

Cut the top off the larger bottle where it widens out.

Fill the smaller bottle with water and replace the cap, then center it inside the larger bottle (the water helps the smaller bottle keep its shape).

Using the trowel and your ruler, fill the remaining space in the large bottle with alternating layers of soil and sand—2 inches of soil, 1 inch of sand, repeat—until you get 2 inches from the top of the bottle. End with soil on top. Pack down the soil and sand layers with your fingers.

Optional: You can also add small pieces of dead leaves (leaf litter) or grass clippings between layers. This will help students see decomposition in action.

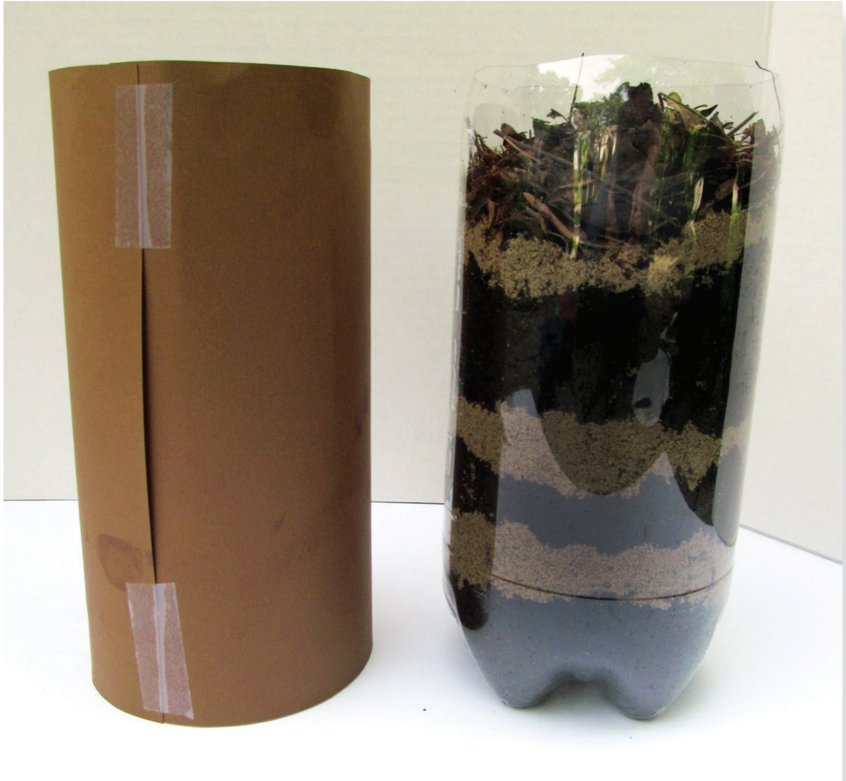
Add a small amount of water, just enough for the contents of the container to be damp but not soaking wet.

Gently lay a few earthworms on top, then place a few leaves, grass clippings, or vegetable garden waste over them.
NOTE: You may also send students home with empty wormeries and instructions to search for their own worms.

Wrap paper around the container and tape it. Make sure the paper can be removed easily to check in on the worms throughout the week.

Take care when transporting your wormery.

- Hold from the bottom.
- Keep from direct blowing heat or cold.
- Do not leave outside; take inside as soon as you get home.



Observe

Leave your covered wormery in a quiet spot out of the sun for a few days to give the worms time to settle in.

Each day, add a little water to keep the wormery moist. Top it off with leaves, grass, or vegetable waste if any soil is exposed. (This provides more food for the worms and also helps keep the wormery moist.)

Remove the paper in the evenings to check on the earthworms (this is when they're most active).

Record your observations and trace the worms' paths in your Safety Smart® Science Investigator's Journal, then replace the paper. Take progress photos (**without flash**) and ask your parents to share your photos and observations on social media with **#sciencenightfun**!

After about a week of observations, return the contents of the wormery (including the earthworms) to your backyard or other damp, shaded dirt area. The worms will thank you!

What is going on here?

Worms may not have arms or legs, but that doesn't mean they aren't great movers! They have short, bristly hairs called ***setae***. To move, a worm stretches itself out and then extends its setae in the front to anchor itself. Then it brings its back end forward and makes itself short.

Earthworms are important to our ***ecosystem*** because as they move through the soil, they bring organic matter (leaves and grass clippings, food bits, etc.), oxygen, and water down to the roots of plants and trees, where it's needed most. They also eat decaying organic matter, bacteria, and fungi and break them down into nutrients that the plants can use. The tunnels that the worms make allow the water and nutrients to get down to the tree roots.

Earthworms do such a great job breaking down organic matter that some people add worms to their compost bins. This is called ***vermicomposting***. Worms help speed up the process of decomposing kitchen waste into organic matter, which makes for excellent garden fertilizer. Your wormery is essentially a mini vermicomposter!

Think about this:

What do you think will happen if you put layers of compost between the sand and soil? Will the worms move it when they make their tunnels?

Try adding different types of lettuce or vegetables on top when needed (brightly colored veggies are best) and see what the earthworms do with it. Do they move the vegetables? Do the vegetables get eaten or ignored?

Lightly tap the wormery near where the worms are; how quickly do they move, and in which direction?

Trying pouring enough water into the wormery close to one side so you can see the water line about 2 to 3 inches from the bottom (make sure there is still a dry place to crawl to). Do the worms move to higher ground or stay near the damp areas?

What more should I know?

Earthworms are pretty simple organisms—they have no bones, arms, legs, eyes, or ears—but they can still sense light and sound! They breathe through their skin, and they have five organs that function like hearts to circulate their blood. All of that blood flowing makes earthworms really good at healing; in fact, if a worm loses its back half, it can regrow its body. These creatures are so valuable to our ecosystem, some people keep them as pets to help make great fertilizer for their gardens.

Where to find earthworms

- Check a local tackle/bait shop or big-box store.
- Buy them online.
- Gently pick up worms that come to the surface when it's raining.
- Moisten an area of your yard and cover it with wood or cardboard; come back the next day and dig carefully to catch the worms.

EXTRA ACTIVITY: MAKE A CUP COMPOSTER

MATERIALS

- 16 ounce clear plastic cup
- Plastic wrap
- Rubber band
- Hole punch
- Potting soil or backyard soil (this is to kickstart the composter with all the good microbes and bacteria that help break down the kitchen waste)
- Garden or kitchen waste, starting with bits of fruit or shredded lettuce

Make your mini composter:

Using the hole punch, place three to five holes around the cup about 1 inch from the top; this allows for some airflow.

Fill the cup just over halfway with soil and kitchen or garden waste (only fruits and veggies; no dairy or meat products). Add water to moisten the contents but not drench them.

Cover the cup with plastic wrap and secure it with the rubber band. Punch holes in the top to allow for some airflow.

Observe

Place the cup composter in a sunny location. Every few days, give the contents a stir. Add more water if it feels or looks dry.

Watch the kitchen waste turn black as it decomposes into nutrient-rich soil! Use it to fertilize some seeds in your garden or in a small flowerpot.

Think about this:

Decomposition happens slowly over a few days or weeks. If you keep a video log of your experience making the mini composter and checking on it, you'll be able to chart the time it takes for the kitchen waste to decompose! Talk about your observations as you make each new video for your log. Share it with your family members and classmates.

LEARNING MESSAGES

Complementary Next Generation Science Standards

- Topic focus: Life Sciences
- Disciplinary core ideas:
  - LS2 Ecosystems: Interactions, Energy, and Dynamics
- Cross-cutting concepts: Systems and system models, cause and effect

Safety Smart Science Investigator's Journal: Watch Earthworms Work

Sketch and label your wormery throughout the week. Try taping tracing paper to the outside of the bottle so you can trace the paths the worms make!

Day 1	Day 3
Day 5	Day 7

What do worms prefer to eat?

Try putting different kinds of vegetable kitchen waste at the top of your wormery and observe what happens. Do the worms move it? Do they like it? Do they avoid it? Does color make a difference?

Date food given	Type of food given	Observations after 1 day	Observations after 3 days	Observations after 5 days

What's happening to the layers of sand and soil? What about the leaf and grass clippings?

What happens when the worms are exposed to light or when you tap on the side of the wormery? Why do you think this happens? Ask your parents to share your observations on social media with **#sciencenightfun**.

BUILD A BEE AND POLLINATE

I wonder...
Why are bees so important to our environment?

In this adventure, you'll build a honeybee and try your hand at pollinating a flower. We recommend using real flowers for this activity, but directions for a make-it-yourself flower are included as an alternative.

MATERIALS

- Clean egg cartons (1/2 carton per participant)
- Wax paper
- Black pipe cleaners (2 full-length per participant)
- Sharpened pencil
- Tape
- Black permanent marker
- Wire snippers
- Scissors
- Several real flowers (lilies, tulips, or other cuplike flowers with exposed pollen work best)

OPTIONAL ADDITIONAL MATERIALS TO CRAFT FLOWERS

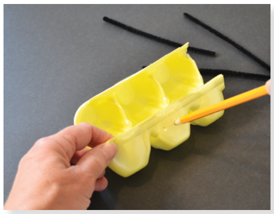
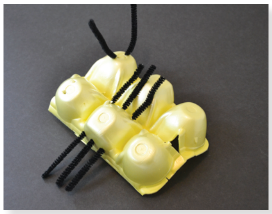
- Powdered orange drink mix
- Small paper cups
- Markers
- Glue

Set up the experiment:

1. Remove and recycle the lid of each egg carton.
2. Cut the "egg" part in half to make two pieces, each 2 cells by 3 cells.
3. Snip pipe cleaners in half. Each participant needs four half-length pieces.

Make your bee:

1. Fold the egg carton in half to make three connected segments.
2. Using the tip of a pencil, poke three holes on each side of the middle segment for the bee's legs.
3. Poke two holes on the head for antennae.
4. Slide a piece of pipe cleaner through each hole in the middle segment and out the other side to make three pairs of legs.
5. Bend the fourth pipe cleaner into a U shape. Slide it through the holes in the head to make the antennae.
6. Tape the body closed.
7. Use a permanent marker to color big eyes on the head and stripes on the back-end segment.
8. Cut wings out of wax paper. Tape to the top of the middle body segment.



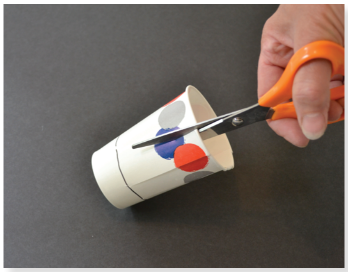
Pollinate your flowers:

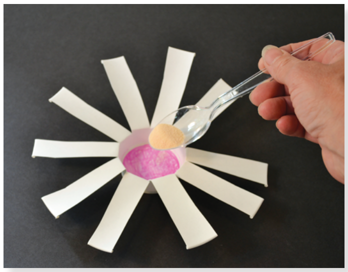
1. "Fly" the bee to a flower.
2. Allow the bee's fuzzy feet to touch the pollen in the flower.
3. Notice the grains that stick to the bee's feet.
4. "Fly" the bee to another flower. Some of the old grains will fall off, others may stick. This is how flowers are pollinated by bees.



Optional: Make a paper flower with pollen:

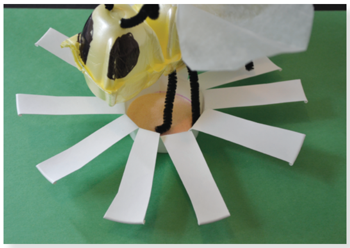
1. Draw a line around the outside of the paper cup about a half-inch from the bottom.
2. Snip the sides of the cup from the lip to the line. Snip all around the cup to make the petals.
3. Fold the petals down. Color the flower if desired.
4. Pour a small amount of powdered orange drink mix into the center of the flower to simulate pollen.





Pollinate your paper flowers:

1. Dip the tips of your bee's legs into glue.
2. "Fly" the bee to your flower.
3. Let the bee's sticky feet dip into the "pollen." Some of the grains will stick to the bee's feet.



What is happening here?

Bees go to flowers in search of nectar, which they use to make honey.

As the bee is drinking the flower's nectar, **static electricity** and hairs on the bee's legs and body pick up grains of pollen from the center of the flower.

When the bee goes to another flower, some of the pollen grains fall into the new flower. The flower is **pollinated**. This causes seeds to form in the flower.

The seeds will turn into fruit, berries, or vegetables, depending on the type of plant. A bee may visit thousands of flowers a day. By pollinating flowers, bees help ensure that people and animals have fruits, berries, and vegetables to eat.

Bees are a type of **insect**. All insects have three body segments and six legs. Here are more facts about the different parts of a honey bee:

- A bee's large **compound eyes** have thousands of lenses. Under a microscope, it is possible to see that a short hair grows from each of these lenses. Bees have hairy eyes!
- Two **antennae** are attached to the bee's head. A bee gathers a lot of information with its antennae, including present chemicals, texture, odor, and even taste.
- The middle section of the bee's body is called the thorax. Instead of lungs, honeybees breathe through holes in their **thorax**. This is where the wings are, too. Honeybees actually have two pairs of wings. **Forewings** are larger and **hindwings** are smaller, and all are transparent.
- The back end of a bee is called the **abdomen**. It is usually striped black and yellow. Older bees have a greater proportion of black bands than

yellow bands. Older bees have a greater proportion of black bands than yellow bands. Younger bees have more yellow on their abdomen, and more hairs, as well. The bee's **stinger** is in the abdomen, too.

Birds, bats, and the wind also help move pollen from one plant to another. Other insects help pollinate flowers, but honeybees pollinate more than any other insect. Can you think of other insects that help pollinate flowers? (Ants, beetles, butterflies, and moths.)

LEARNING MESSAGES

Complementary Next Generation Science Standards

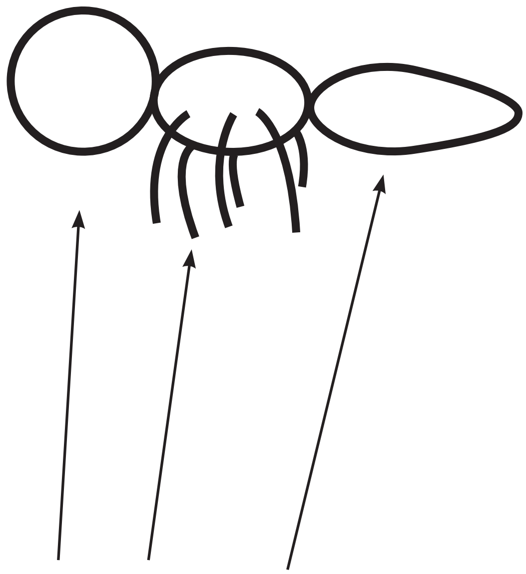
- Topic focus: Life Sciences
- Disciplinary core ideas:
  - LS1A Structure and Function
  - LS1C Organization for matter and energy flow in organisms
  - LS2A Interdependent relationships in ecosystems
- Cross-cutting concepts: Structure and function

Safety Smart Science Investigator’s Journal: Build a Bee and Pollinate

Finish drawing the bee below. Don’t forget to add the hairs to the eyes and legs!

- Add eyes
- Add wings
- Add antennae
- Add stinger
- Add stripes
- Add pollen to its legs

Draw a flower here:



Bees are insects.

- All insects have 6 legs.
- An insect’s body has three segments: head, thorax, and abdomen

This is an ant. Ants are also insects. Ants can pollinate flowers, too. Finish drawing the ant. Is yours a flying ant?