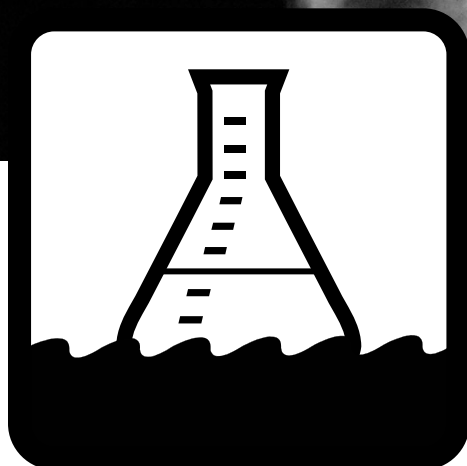
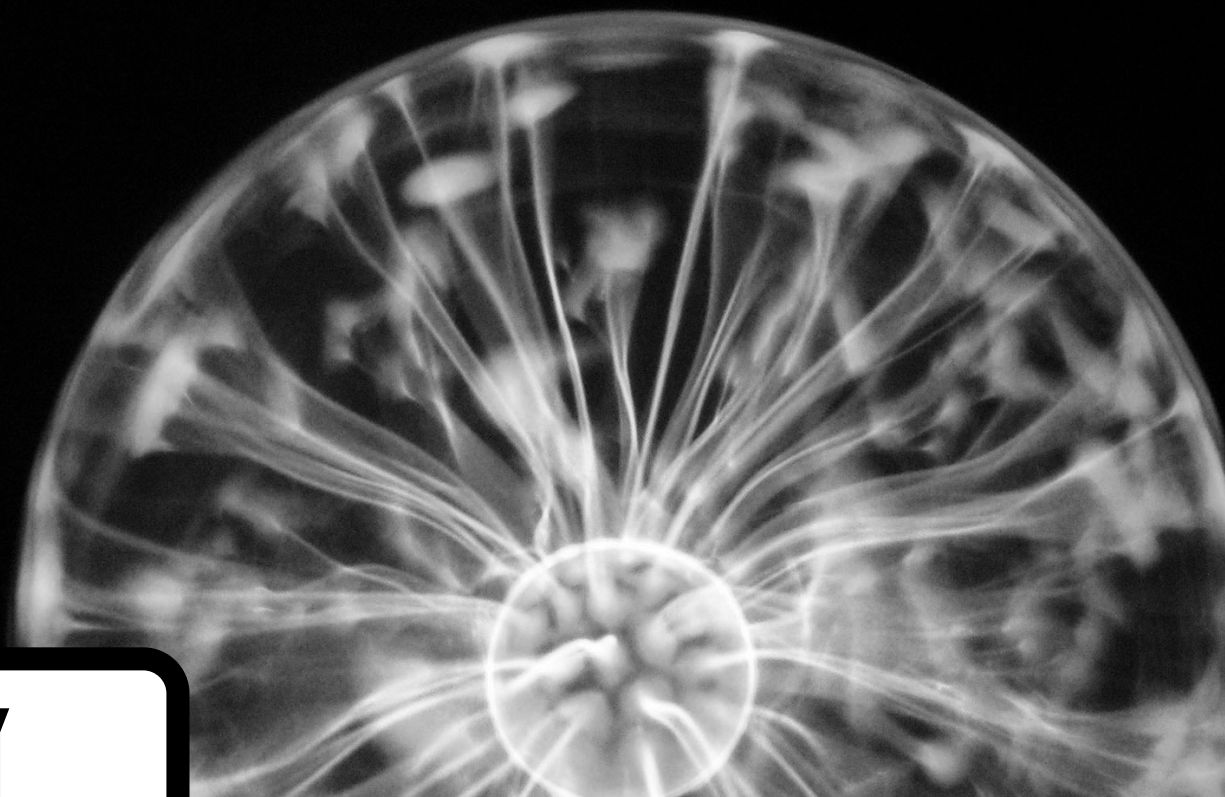


2024-2025

Elementary Science of Energy

Hands-on experiments and background information that allow students to explore the different forms of energy and how they are transformed. Students master forms of energy and their transformations, and then teach others what they have learned and how it can be visualized in the world around them.



Grade Level:



Elementary

Subject Areas:



Science



Math



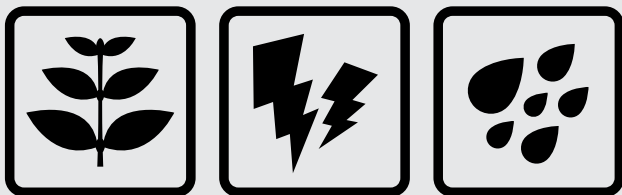
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National Energy Education Development Project



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NEED Mission Statement

The mission of The NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

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Teacher Advisory Board

In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

Energy Data Used in NEED Materials

NEED believes in providing teachers and students with the most recently reported, available, and accurate energy data. Most statistics and data contained within this guide are derived from the U.S. Energy Information Administration. Data is compiled and updated annually where available. Where annual updates are not available, the most current, complete data year available at the time of updates is accessed and printed in NEED materials. To further research energy data, visit the EIA website at www.eia.gov.



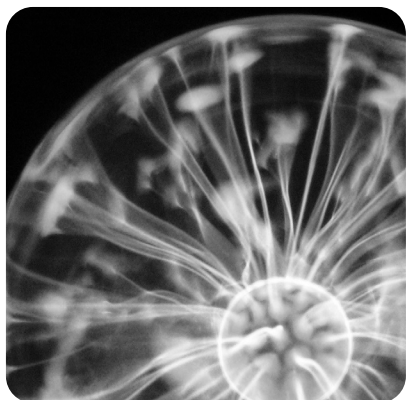
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Elementary Science of Energy

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Elementary Science of Energy Kit

- 1 Set of *Science of Energy* Guides (Elem, Int, Sec)
- 1 9-Volt Battery
- 2 Sets of alligator clips
- 10 Balloons
- 1 Battery holder
- 1 Bi-metal bar
- 1 Empty bottle (for vinegar)
- 1 Candle
- 1 Coated copper wire
- 1 Compass
- 1 Container of baking soda
- 1 Container of calcium chloride
- 2 Containers of sand (one full, one partially full)
- 1 Sealed plastic bag of iron oxide
- 2 Thick copper wires
- 1 Thin copper wire
- 1 D Battery
- 16 Hand warmers
- 8 Glow sticks
- 3 15 mL Measuring cups
- 1 Measuring tape
- 1 DC microammeter
- 3 Motors (one disassembled)
- 1 Hand generated flashlight
- 6 Plastic bags
- 1 Radiometer
- 30 Rubber bands
- 1 Set of happy/sad spheres
- 1 Solar panel kit
- 1 Superball
- 3 Thermometers (metal)
- 4 Student thermometers (plastic)
- 1 Tin wire
- 2 Tongs
- 1 Toy car
- 2 Live wires (nitinol)
- 1 Yo-yo
- 2 Large nails
- 2 Small nails





Standards Correlation Information

www.need.org/educators/curriculum-correlations/

Next Generation Science Standards

- This guide effectively supports many Next Generation Science Standards. This material can satisfy performance expectations, science and engineering practices, disciplinary core ideas, and cross cutting concepts within your required curriculum. For more details on these correlations, please visit NEED's curriculum correlations website.

Common Core State Standards

- This guide has been correlated to the Common Core State Standards in both language arts and mathematics. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED curriculum correlations website.

Individual State Science Standards

- This guide has been correlated to each state's individual science standards. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED website.



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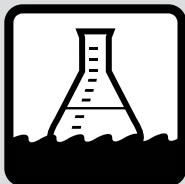
NEED Curriculum Correlations



NEED materials are correlated to the Disciplinary Core Ideas of the Next Generation Science Standards, the Common Core State Standards for English/Language Arts and Mathematics, and also correlated to each state's individual science standards.

Most files are in Excel format. NEED recommends downloading the file to your computer for use. Save resources, don't print!

- [NEED alignment to the Next Generation Science Standards](#)
- [Navigating the NGSS? We Have What You NEED!](#)
- [NGSS and NEED: Fourth Grade Energy](#)
- [NGSS and NEED Guide](#)
- [Common Core State Standards for English and Language Arts](#)
- [Common Core Standards for Mathematics](#)

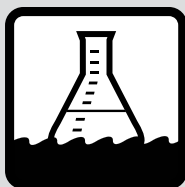


Materials

Station	Materials in Kit	Additional Materials Needed
<i>Teacher Demonstrations</i>	<ul style="list-style-type: none"> ▪ 2 Containers of sand ▪ Thermometers (metal) ▪ Hand generated flashlight 	<ul style="list-style-type: none"> ▪ Safety glasses ▪ Sealable plastic bags
<i>Station One</i>	<ul style="list-style-type: none"> ▪ Set of happy/sad spheres (black spheres) ▪ Yo-yo ▪ Toy car ▪ Balloons ▪ Tongs ▪ Measuring tape 	<ul style="list-style-type: none"> ▪ Cups of hot water ▪ Meter stick (optional) ▪ Scrap paper ▪ Safety glasses ▪ Timer or clock with second hand ▪ Calculator
<i>Station Two</i>	<ul style="list-style-type: none"> ▪ Container of baking soda ▪ Empty plastic bags ▪ Thermometers (metal) ▪ 15 mL Measuring cups ▪ Hand warmers ▪ Sealed plastic bag of iron oxide ▪ Container of calcium chloride ▪ Empty bottle for vinegar 	<ul style="list-style-type: none"> ▪ Scissors ▪ Vinegar ▪ Water ▪ Safety glasses ▪ Timer or clock with second hand
<i>Station Three</i>	<ul style="list-style-type: none"> ▪ Radiometer ▪ Thermometers (plastic) ▪ Solar panel with motor, fan, and disks 	<ul style="list-style-type: none"> ▪ Tape ▪ Light source (bright sunlight, clamp light with halogen or incandescent bulb) ▪ C Battery (optional) ▪ Ruler ▪ Safety glasses ▪ Black and white paper
<i>Station Four</i>	<ul style="list-style-type: none"> ▪ Live wire ▪ Bi-metal bar ▪ Candle ▪ Rubber bands ▪ Tongs 	<ul style="list-style-type: none"> ▪ Clear beaker or cup of hot water ▪ Clear beaker or cup of ice water ▪ Matches ▪ Large, smooth paper clips ▪ Safety glasses
<i>Station Five</i>	<ul style="list-style-type: none"> ▪ Glow sticks ▪ Small nail ▪ Large nail ▪ Thin copper wires ▪ Thick copper wires ▪ Tin wire ▪ DC microammeter ▪ Alligator clips 	<ul style="list-style-type: none"> ▪ Cup of hot water ▪ Cup of ice water ▪ Apple (or other fruit/vegetable) ▪ Ruler ▪ Permanent marker ▪ Safety glasses ▪ Colored pencils (optional)
<i>Station Six</i>	<ul style="list-style-type: none"> ▪ Hand generated flashlight (use from Teacher Demo) ▪ Coated wire (heavy gauge) ▪ Motors (1 disassembled) ▪ 9-volt Battery ▪ D Battery ▪ Compass ▪ Alligator clips ▪ Battery holder ▪ Large nail 	<ul style="list-style-type: none"> ▪ Masking tape ▪ Safety glasses

Science of Energy kits and additional consumable materials are available for purchase by calling 1-800-875-5029 or visit NEED.org/shop for more information.

NOTE: A few items are included in the kit that may not be used at this level. You may remove those items from the boxes.



Teacher Guide

Grade Level

- Elementary, grades 3-5

Important Safety Notes

- All students should wear safety glasses while at any *Elementary Science of Energy* station.
- This kit contains latex balloons and rubber bands. Check to see if any of your students have latex allergies. If they do, the balloons and/or rubber bands should be removed from this station.
- Station One, Four, and Five require hot water. Review with students safe procedures for handling hot water.
- The live wire in Station Four may spring out of the cup. Students should not peer directly over the demonstration, and should handle the live wire with tongs. Giving the students a clear glass or beaker to use in this demonstration may keep them from wanting to look directly over the cup.
- Thermometers in this kit do not contain mercury. These thermometers are made with alcohol spirits and are safe for classroom use. Should they break during the course of this unit, you can dispose of the thermometer and parts as you would anything else in your classroom.
- Hand out the *Lab Safety Rules* and review with students prior to any investigation.

Background

The *Elementary Science of Energy* unit includes a teacher demonstration and six lab stations. Students are divided into six (or more) groups, with each group responsible for learning and teaching the other groups about the experiments in their assigned station. Instructions, guides, masters, and explanatory articles are provided for the teacher and students. Throughout this unit, students are encouraged to record their thinking in science notebooks.

Time

Elementary Science of Energy is designed to take as few as six class sessions of 45-60 minutes each. Teachers may choose to expand the time if their schedules allow.

Possible 6 Day Schedule

DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
Introduction to Energy and Teacher Demonstration	Station Investigations and Plan Presentations	Present and Rotate	Present and Rotate	Energy Flows	Forms and Sources of Energy

Possible Extended Schedule

DAY 1	DAYS 2-3	DAYS 4-6	DAY 7	DAY 8	DAY 9+
Introduction to Energy and Teacher Demonstration	Station Investigations and Plan Presentations	Present and Rotate	Energy Flows	Forms and Sources of Energy	Extensions

Objectives

Upon completion of the *Elementary Science of Energy* unit, students will be able to:

- explain what energy enables us to do;
- differentiate between potential and kinetic energy;
- list the forms of energy and give examples of each;
- explain energy transformations;
- trace the energy flow of a system;
- differentiate between forms and sources of energy; and
- describe how energy is stored or used in the major energy sources.

Unit Preparation

- Familiarize yourself with the equipment in the kit and procure the materials listed in the Additional Materials Needed section of the chart on page 5. Remove materials not needed for elementary explorations, as the kit boxes may contain items used in the other *Science of Energy* units.
- Read the content background information, if necessary, so you are familiar with the concepts presented. The content background section goes into greater detail and is presented at a greater depth of knowledge than the material designed to distribute to your students.
- Make copies of the *Forms of Energy Cards* master on page 45 for each student. It may be helpful to copy two or more copies for each student so they may have duplicates of each form. Students can cut them apart, or you can do this ahead of time. You may also wish to copy the potential forms on one color paper and the kinetic forms on another color paper to help students differentiate between potential and kinetic forms of energy. Have students place cards in plastic bags or envelopes for safe keeping.

Science Notebooks and Student Worksheets

Science notebooks are a great place for students to record their questions, hypotheses, data, observations, and conclusions as they work through this unit. Instructions throughout the unit will suggest students utilize this tool. However, each station includes student worksheets for students to record thoughts as well. You may choose to use either format depending on the level of your students. If choosing to use the pre-made student pages, make enough copies of each page so that students have enough room to record observations at each of the six stations. If choosing to use science notebooks only, provide the station guides at each station so that students can draw their own versions of tables and charts. Science notebook template pages have been provided on page 37-38 that can be given to students. Some teachers may also find it beneficial to have students fasten the pre-made student worksheets into their existing notebooks.

Vocabulary

Listed below are terms in the *Elementary Science of Energy* unit that students will learn while going through each station. A glossary for these terms can be found on pages 120-121. It may be helpful to copy this list or the glossary for your students.

absorb	convert	energy level	gravitational	molecular	renewable
alternating current	current	energy	potential energy	molecule	repel
atom	direct current	transformation	heat*	motion energy	retention
attract	elastic energy	ester	hypothesis	nickel	shaft
Celsius	electrical energy	exothermic	iron oxide	nonrenewable	silicon
chemical energy	electricity	expand	kilowatt-hour	nuclear energy	temperature
chemical reaction	electrode	Fahrenheit	kinetic energy	photovoltaic cell	thermal energy*
collision	electrolyte	fission	Law of	potential energy	titanium
compress	electromagnet	friction	Conservation of	prediction	transform
conduct	endothermic	fusion	Energy	radiant energy	transformation
contract	energy	generator	magnetic field	reaction	turbine
conversion	energy flow		mass	rebound	vacuum

**PLEASE NOTE: In this unit, the terms thermal energy and heat are used to mean the same thing, as in the National Science Education Standards. However, technically, they are not the same thing. Thermal energy is the sum of the energy of the molecules making up a substance - kinetic and potential. When this thermal energy is transferred from one place or object to another, it is called heat.*

NOTE: For more information about energy, see the *Elementary Energy Infobook* available for download from NEED.org/shop.

Content Background Information for Teachers and Aides

Station One: Potential and Kinetic Energy

Potential energy is stored energy, and kinetic energy is energy in motion. All forms of energy fall into one of those two categories, and can be transformed back and forth endlessly. However, no energy transformation is 100% efficient; some of the energy is always dissipated, usually as thermal energy or sound.

Happy and Sad Spheres

Kinetic energy can take many forms; so can potential energy. When an object is moving, it has kinetic energy. When an object is elevated, it has gravitational potential energy (GPE). If a rock is placed at the top of a steep hill, it has GPE. When a force is applied to the rock, it will begin to roll downhill. As it moves, the GPE is transformed into kinetic energy. When the rock reaches the bottom of the hill, it will slow down and eventually come to a stop. All of the energy that was stored as GPE will have been transformed to kinetic energy, then dissipated as thermal or sound energy, or in deforming the rock or ground it travels or stops on.

Dropping an object from a position elevated above the floor works similarly to a rock rolling downhill. However, when the object, in this case a sphere, reaches the floor, it bounces. This is because some of the kinetic energy can be stored as elastic energy. The bouncing action is caused by the elastic energy being transformed back into kinetic energy, but this time in the opposite direction. Some materials are very efficient at transforming elastic energy into kinetic energy. The elasticity of an object depends upon the structure of the compounds making the object. Some materials, like a block of ice, will not bounce well. Very elastic compounds, like rubber, will bounce well. The amount of bounce is related to the material's chemical makeup.

A dropped object will not bounce to the same height as that from which it was dropped. Why is this? It is because some of the energy stored when the object was elevated is dissipated to the object's surroundings as thermal energy or sound, or deformation of the material. No energy transformation is 100% efficient to do work. Some of the energy transfers into the surroundings and cannot be recovered to do work. If you were to bounce a superball repeatedly, over the course of an extended period of time, the temperature of the superball would increase.

The black spheres, called "happy" and "sad" spheres, look very similar. However, they do not behave the same when dropped from the same height. One bounces much higher than the other, which is why it is nicknamed "happy." The material in the happy sphere is neoprene rubber. The other sphere does not bounce much, if at all; isn't that sad? The material in the sad sphere is polynorborene. Even though the size of the spheres is the same, and the densities are almost the same, there is a distinct difference in the elasticity of the two materials. Polynorborene is softer, and is able to absorb and dissipate energy better than neoprene. Therefore, it does not bounce as high as the neoprene sphere. Both spheres stored almost the same amount of GPE; however, what they did with that energy when they hit the surface of the table or floor was different.

Toy Car

The toy car contains a spring, and when the car is depressed and pulled backwards, the spring is compressed, storing elastic energy. Releasing the car allows the spring to transform the elastic energy into kinetic energy, and the car moves. The kinetic energy of a moving object is always being dissipated as thermal energy and sound because of the resistance it encounters. Without additional potential energy being transformed into kinetic energy, eventually all of the kinetic energy is transformed into thermal and sound energy, and the car comes to a stop.

Yo-yo

A yo-yo behaves similarly to a dropped object, and takes the GPE stored by holding it at an elevated position and converts it into kinetic energy. However, the behavior of the yo-yo at the bottom of the string is different than an object bouncing back. As a yo-yo falls and unwinds the string, the yo-yo rotates. The movement of the yo-yo causes it to build momentum, and when it reaches the end of the string, its momentum causes it to continue rotating in its original direction. The result is that the yo-yo rewinds itself up the string, but in the opposite direction. For example, if the string was originally wound clockwise, the rebound would wind the string counter-clockwise on the yo-yo.

As was the case with the spheres, the yo-yo will not rebound all the way to the height from which it was dropped. At the bottom of the string, the rotating yo-yo encounters some friction as it spins within the loop of the string. Some of the kinetic energy is dissipated to the yo-yo's surroundings as thermal energy and a small amount of sound energy; therefore the yo-yo will not climb the string all the way up to your hand if it is simply released. If you want the yo-yo to return to your hand, you must snap your wrist when you initially release it, and add additional energy beyond the GPE imparted by the yo-yo's position.

Balloon

Inflating a balloon pushes compressed air inside, stretching the rubber. When the rubber is stretched, it stores elastic energy, and the balloon pushes back against the air inside the balloon. As long as the balloon stem is held shut, the air inside pushes back with equal pressure against the walls of the balloon. However, when the balloon is released, the elastic energy of the balloon pushes the air out. Because of Newton's Third Law of Motion, when the air moves out of the balloon, the balloon moves forward in the air. In this way, the balloon transforms elastic energy into kinetic energy.

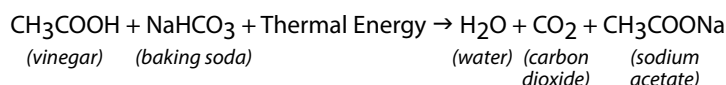
Station Two: Endothermic and Exothermic Processes

Baking Soda and Vinegar

Chemical reactions occur when bonds between atoms are being broken and new bonds are being formed. The result is a new substance or group of substances that were not present before the reaction took place. All chemical reactions involve the transfer of energy. Often the energy transferred is thermal energy, but other forms of energy, like radiant and electrical energy, can be transferred. Some reactions absorb energy and some release it. Station Two contains both kinds of reactions.

Endo- means in and *thermal* means heat. Endothermic reactions absorb energy into the chemical bonds and their surroundings become cooler. *Exo-* means out, and *thermal* means heat. The materials that react in an exothermic reaction release energy and their surroundings become warmer. An exothermic reaction releases or emits thermal energy.

The reaction between baking soda and vinegar is endothermic – it absorbs energy and makes the surroundings feel cold. Vinegar contains acetic acid, and baking soda is the common name for sodium bicarbonate. Combining acetic acid and sodium bicarbonate make different chemicals: water, carbon dioxide, and sodium acetate. The chemical reaction is:



In all chemical reactions, energy is required to break bonds, and energy is released when bonds are formed. If the energy required to break bonds is greater than the energy released when new bonds are formed, the reaction will be endothermic. The additional energy needed will be absorbed from the surroundings, causing them to become cooler. The opposite is true of exothermic reactions.

Calcium Chloride and Water

When calcium chloride comes into contact with ice or water, it dissolves, and the calcium chloride dissociates into calcium ions and chloride ions. Even though dissolving calcium chloride is not a chemical reaction, it still requires energy. The attraction forces between those ions and water molecules releases a greater amount of energy than what was required to dissociate them, leading to an overall exothermic process.

Adding electrons to an atom increases its energy. Removing electrons from an atom requires energy. Thus, when ions form, energy can be released or absorbed. Some ionic compounds form a rigid crystal structure, and energy is needed to maintain that structure. Sometimes a crystal structure is very strong, and breaking it requires energy. However, some crystal structures actually release energy when dissolved. This is the case in calcium chloride. Dissolving calcium chloride causes energy to be released into the water and other parts of the surroundings because its structure is breaking down. Since exothermic processes release thermal energy, the temperature of the solution increased.

A common use for calcium chloride is to melt ice on driveways and sidewalks. You can buy ice melt at your local hardware store to melt the ice on your driveway during the winter.

Hand Warmers

Hand warmers contain powdered iron. They are sealed in plastic to prevent oxygen and water in the air from reaching the iron. The old packet is made of iron filings that had been open for several weeks – it is now iron oxide. When the iron was left in an open plastic bag, oxygen in the air was able to come in contact with the surface area of the iron. The oxygen reacted with the iron to form a new chemical, iron oxide, or rust. The reaction that forms rust is an example of a chemical reaction known as oxidation.

As was the case with baking soda and vinegar, energy was transferred in the reaction of iron with oxygen. However in this case, energy was released. The energy needed to break the bond in oxygen was less than the energy released when rust was formed. Therefore, the reaction was exothermic, and the temperature of the surroundings increased.

The hand warmer contains tiny pieces of iron. If it was one solid piece of iron, such as on a car, it would rust much more slowly, and the thermal energy wouldn't be as noticeable because less surface area is exposed to oxygen. The total amount of energy released is the same for a large piece of iron and an equal mass of powdered iron, yet it is released much faster with the powdered iron because there is more surface area exposed to oxygen.

Station Three: Radiant Energy Transformations

Sunlight and Shade: Radiant Energy into Thermal Energy

You may have heard the expression, "It was 100 times cooler in the shade." Why do people say that? Even when the air temperature is the same, it feels hotter when you are in the sun than when you are in the shade. When you are in the sun, the sun's radiant energy is absorbed by your body and turned into thermal energy, making you feel hotter. In the shade, you only feel the thermal energy from the air molecules striking your body. The thermometer facing the light has a higher temperature because the sun's radiant energy is adding to the energy from the air around it.

When the thermometers are covered with paper, the one covered with black paper records a higher temperature than the one covered with white paper. Why is this? The sun produces light in all wavelengths – all colors of the rainbow. Objects that appear white to our eyes are actually reflecting all wavelengths of light, and are not absorbing much, if any, of the light striking them. Black objects, on the other hand, are absorbing nearly all of the light reaching them. Objects that appear black to our eyes are reflecting very little light. Because black objects are absorbing more energy, they get hotter than white objects left in the sun. This causes them to transfer more energy to their surroundings. If your car has a light-colored interior, it will feel cooler to sit on the seats on a sunny day than if your car has a very dark-colored interior.

Radiant Energy and Color: Radiant Energy into Motion Energy in the Radiometer

The radiometer is a glass bulb that is sealed with the parts inside. The space inside the bulb has very little air and is almost a vacuum. The vanes inside the radiometer are balanced on a needle point. There are no moving parts or motors that make them spin. Only the absorbed and reflected light entering the radiometer cause it to spin.

But how can light make an object move if energy has no mass? After careful observation, you will see that the vanes of the radiometer are black on one side and white on the other. As you observed with the thermometers, the white sides of the radiometer vanes reflected more energy than the black sides. In fact, the black sides absorbed enough energy to heat the air molecules near them more than the air molecules near the white sides were heated.

When air molecules are heated, their movement increases. Air molecules may be too tiny to see without magnification, but you can see the effect their movement has. When the molecules next to the black vanes got hotter, and moved faster, they bumped into the black sides more than they bumped into the white sides. Also, the reflected energy from the white sides increased the energy available to the air next to the black sides. The bumping of the air molecules was an unbalanced force and pushed the black vanes. You should have observed that the black sides of the vanes were moving away from the light source.

Changing the distance of the radiometer from the light source will affect its behavior. As you move farther from a light source, the intensity of the light is reduced. Moving farther from the light source should have dramatically reduced the speed of the vanes inside the radiometer because the intensity of the light, and therefore the amount of radiant energy that could be transformed to thermal energy, also decreased dramatically.

Solar Panel: Radiant Energy into Electricity

Electricity is simply moving electrons; if light can make the vanes of a radiometer move, it surely can make something as small as an electron move. In fact, this is called the photoelectric effect, and describing this effect is what earned Albert Einstein his Nobel Prize. Light of specific wavelengths can energize electrons in certain substances. Using the photoelectric effect, plants are able to manufacture sugar from a combination of sunlight, water, and carbon dioxide. This is called photosynthesis.

When we use the photoelectric effect, we are causing electrons in one substance to become energized, move through a circuit, and do work. This is done in a photovoltaic cell, and many photovoltaic cells are connected together into a solar panel. This is how radiant energy can be turned into electrical energy.

Tilting the solar panel away from the light source will yield similar results as moving the radiometer farther away from the light. When the panel is tilted, the motor attached to it will slow down. It will also slow down if the solar panel is moved farther away.

When we use solar energy to generate electric power, the distance from the sun is not an important factor. The Earth is 92 million miles from the sun at ground-level. A solar panel is only ten feet up off the ground. This is such a small percentage change in distance from the sun that it does not make any measureable difference in the amount of electricity being produced. That is why installing solar panels at ground level produce about as much electricity as panels installed on the tops of buildings.

However, our location on the Earth, a round surface, makes a dramatic difference in the power generated. The Earth is tilted about 23° on its axis. This tilt is what causes the difference in seasons. The sun is at different angles in the sky during the day during winter and summer. The farther away from the Equator you travel, the greater the difference in the angles.

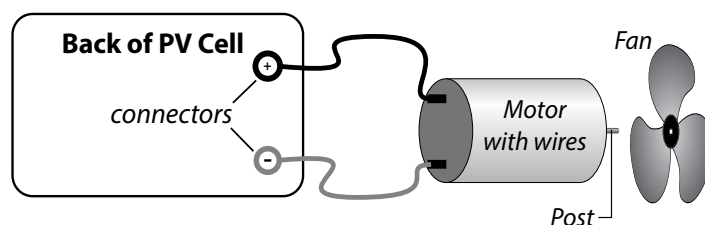
If you tilt the solar panel farther and farther from the light source, you will see a dramatic decrease in the speed of the motor, indicating a decrease in the power produced. The same is true for solar panels installed outdoors to produce power from sunlight. That is why solar panels are mounted at an angle rather than lying flat; they are installed to face directly toward the sun as often as possible. Some can even be motorized to adjust their angles with the change of the position of the sun in the sky throughout the day, or as the sun changes throughout the seasons.

Solar energy is a clean, renewable natural resource, but PV cells are not very efficient. They convert about 20 percent of the radiant energy that strikes them into electricity. The rest is changed into thermal energy or reflected off of the surface. Scientists are continually working on ways to make PV cells more efficient.

Solar Panel Assembly and Connection Instructions

1. Attach the wires from the motor to the connectors on the back of the PV cell by removing the nuts from the connectors, sliding the motor wires onto the posts and replacing and tightening the nuts as shown in the diagram.
2. Attach the fan or disk to the post on the opposite end of the motor.
3. If nothing happens, remove the motor leads from the solar panel and touch them to the ends of a C battery to "jumpstart" the motor, then try again.*

***NOTE:** You may need to hold the panel very close to the lamp if working with a halogen incandescent bulb. Use caution and check to be sure the plastic is not melting.



Station Four: Thermal Energy and Motion Energy

Hands and Paper Clips

Just like when you rub your hands together and they get hot, bending a piece of metal back and forth causes the atoms in the metal to rub against each other. The friction involved in this motion releases thermal energy. If you keep bending the paper clip back and forth, eventually it will get hot enough to weaken the metal and the paper clip will break.

The Rubber Band

This activity demonstrated an energy transformation that both released and absorbed energy.

When the rubber band is quickly stretched and placed against your forehead, or when allowed to contract, a distinct change in temperature can be noticed. The rubber band feels warm when stretched and cool when contracted. When you stretch the rubber band, the rubber molecules move and release thermal energy, and it feels warmer. Allowing the rubber band to contract causes the rubber molecules to move back into place and they absorb energy, and it feels cooler.

The Live Wire

The live wire is made of two metals mixed together, called an alloy. Alloys have specific proportions of metals in them. The alloy in the live wire is called nitinol, and it is a mixture of 50% nickel and 50% titanium. Nitinol is special because the wire is set in a certain shape by shaping it, heating it to a specific temperature, and then immediately plunging it in ice water. The arrangements of the metal atoms in the alloy allow it to “remember” its shape, and when it is heated back to the tempering temperature, the wire goes back into its original shape. You could bend the wire into curlicues, circles, wavy shapes, etc., and as long as it could move freely, the wire would straighten itself out when you put it in warm water. As you can imagine, nitinol wire has many uses, including braces on teeth and keeping greenhouses cool. If a greenhouse gets too hot, the nitinol springs a window or vent open, which allows hot air to rise up and out of the greenhouse, decreasing the temperature.

The Bi-Metal Bar

When substances and objects are heated, they expand. You may have noticed the spaces between sections of sidewalk. They are designed that way so that the concrete can expand on hot, sunny days without cracking. Bridges are built with expansion joints that allow the metal and the concrete in the bridge to expand and contract according to temperature, without breaking.

All objects expand when they are heated, but they do not expand at the same rate. Gases and liquids expand very quickly when they are heated. Their molecules can move about freely. A thermometer works because the liquid inside expands and contracts according to temperature.

Solids do not expand as much as gases and liquids because their molecules cannot move freely. It is sometimes hard to see them expand. The bi-metal bar is a good example of how metals expand when heated. The bi-metal bar is not an alloy or mixture of metals, but rather a sandwich of two pieces of metal – one side is nickel, the other side is stainless steel. These metals expand at different rates.

When the bar is placed in the flame, it bends, and always in the same direction. The stainless steel in the bar expands more quickly than the nickel, so when it is heated, the bar bends. The stainless steel side is the outside of the curve. If the bar is removed from the flame, it straightens itself back out.

When placed in the cup of ice water the bar bent back the other way to its original shape. If you kept the bar in the ice water long enough the bar would bend in the other direction. The stainless steel side also contracts faster when the temperature is lowered, so it is now on the inside of the curve.

Bi-metal strips like this are very useful. They are used in thermostats on furnaces and air conditioners to control the temperature. When the temperature in a room reaches a certain temperature, the bi-metal strip will bend enough to close a circuit and turn on the furnace or air conditioner. Bi-metal strips are also used in holiday lights that twinkle. When the metal gets hot it causes the strip to bend and stops the flow of electricity (breaks the circuit), which turns the light off. As the strip cools it bends back, allowing electricity to flow again, completing the circuit and turning the light on.

Station Five: Chemical Energy

Glow Sticks

Glow sticks contain an outer, flexible tube filled with a chemical compound, called an ester, and a dye. Inside the outer tube is a fragile, sealed glass tube with hydrogen peroxide. When the glass is broken, the peroxide and ester react and release energy. The different dye compounds absorb that energy, and then re-release it as different colors of light. This principle works the same way as neon lights – the gases inside the tubes of a neon light absorb electricity and release it as light. When an electron absorbs energy, it then releases that energy in one specific wavelength. The reason for the different colors in neon lights, fireworks, and glow sticks is related to the arrangement of electrons in the different elements. Neon lights actually contain many different gases, giving them the different, vibrant colors. Glow sticks produce different colors because the different dyes inside have varying arrangements of electrons that release energy differently.

The glow stick is producing light—radiant energy. When you broke the glass, the hydrogen peroxide and ester reacted to form different chemical compounds. The new compounds do not need as much energy to hold their molecules together, so they release the extra energy. The fluorescent dye in the glow stick then becomes energized. When the dye gives up the extra energy and returns to its normal state, it releases the energy it absorbed as the light we see. The reaction between the hydrogen peroxide and the ester is the same regardless of the color of the light stick.

Temperature will affect the rate at which a chemical reaction occurs. Placing the glow stick in ice water draws thermal energy away from the contents in the glow stick and the ester and peroxide molecules slow down. When they slow down, they cannot react as easily, and the chemical reaction slows down. The glow stick becomes more dim. Putting the glow stick in warm water transfers thermal energy inside to the ester and peroxide. Those molecules move faster, and the reaction proceeds at a faster rate, resulting in a brighter glow stick.

One common misconception students have about glow sticks is that freezing them will reverse the reaction and “recharge” them. This is not true. Freezing the glow stick merely slows the reaction rate dramatically, such that students can enjoy the glow stick the next day. Typically, a glow stick will last about 2 hours at room temperature, but only about 30 minutes in warm water. Freezing them can extend the life a few hours, but they will not last much longer than a few hours after being removed from the freezer.

The Apple Battery

Your students will call this the “apple battery”. However, it is more accurately referred to as an electrolytic cell, which contains two pieces of two different metals and a non-metallic conductor, called an electrolyte. A battery is actually a series of electrolytic cells in combination, and the apple is just one cell. The electrolyte ions migrate within the battery to balance out the imbalance in charge. This unbalanced charge is created as the circuit is closed and electrons move. In this section we will refer to the apple as an electrolytic cell; you can decide if your students are at the level to understand the distinction, or if calling it a battery will be simpler for them. The concepts are the same.

The apple electrolytic cell investigation uses the chemical energy in the apple to make electricity. Everything we encounter in our daily lives, such as water, oxygen, sugar, and plastic, could be called a chemical. An apple contains a chemical called malic acid. The malic acid in the apple made an electrolytic cell when combined with two different metals. When the zinc nail and copper wire were pushed into the apple and attached to the microammeter, the needle on the meter moved. This meter measures small amounts of electric current and showed that there is an electric current moving through the apple and wire in a circular pattern called a circuit.

As you observed the meter, the needle moved to the right to indicate an electric current. When the zinc and copper were inserted into the apple, they both reacted with the acid, but they did not react the same way.

What is happening in the apple is a chemical reaction. The same factors that affect the rate of any chemical reaction – temperature, concentration, surface area, and catalysts – will affect the rate of reaction in the apple, too. Using larger pieces of metal increases the concentration of the metal available. Inserting the pieces of metal farther into the apple increases the surface area available for the reaction.

The reactions occurring in the apple created an imbalance in electrical charge. When the zinc and copper were connected to the meter, the electrons flowed from the zinc nail through the meter to the copper wire in the apple. This flow of electrons registered on the meter. Chemical energy is converted to electrical energy. Because the meter moved to the right, it showed that the charge was flowing. This is the way all electric circuits with batteries work. You may substitute other foods for an apple to complete this activity. Other great examples include potatoes, citrus fruits, pickles, and kiwis.

Station Six: Electrical Energy

Battery and Compass

Station Six introduces students to the relationship between electricity and magnetism.

Electrons don’t just move around the nucleus of an atom; they also spin. Electrons have an electrical charge. Their movement creates tiny magnetic fields. In most materials, electrons exist in pairs where the spinning of each electron in the pair is in opposite directions. The magnetic field generated by one electron is canceled by the magnetic field generated by the other electron in the pair. However, in magnetic materials like nickel, cobalt, and iron, there are unpaired electrons with magnetic fields that are not canceled. Where the magnetic fields line up, tiny magnets are created within the metal.

When the wire was connected to both ends of the battery, a shorter pathway, or short circuit, formed, and electricity flowed quickly and easily through the wire. These moving electrons brought with them magnetic fields. A magnetic field developed around the wire according to the “right hand rule.” If you outstretch your right hand, and your thumb points in the direction of the electric current, the fingers of your right hand will curl around in the direction of the magnetic field.

The relationship between electricity and magnets allows us to transform electrical energy into kinetic energy and make things move. The chemicals in the battery interact to generate an electric current, and, like the apple electrolytic cell in Station 5, transform chemical energy into electrical energy.

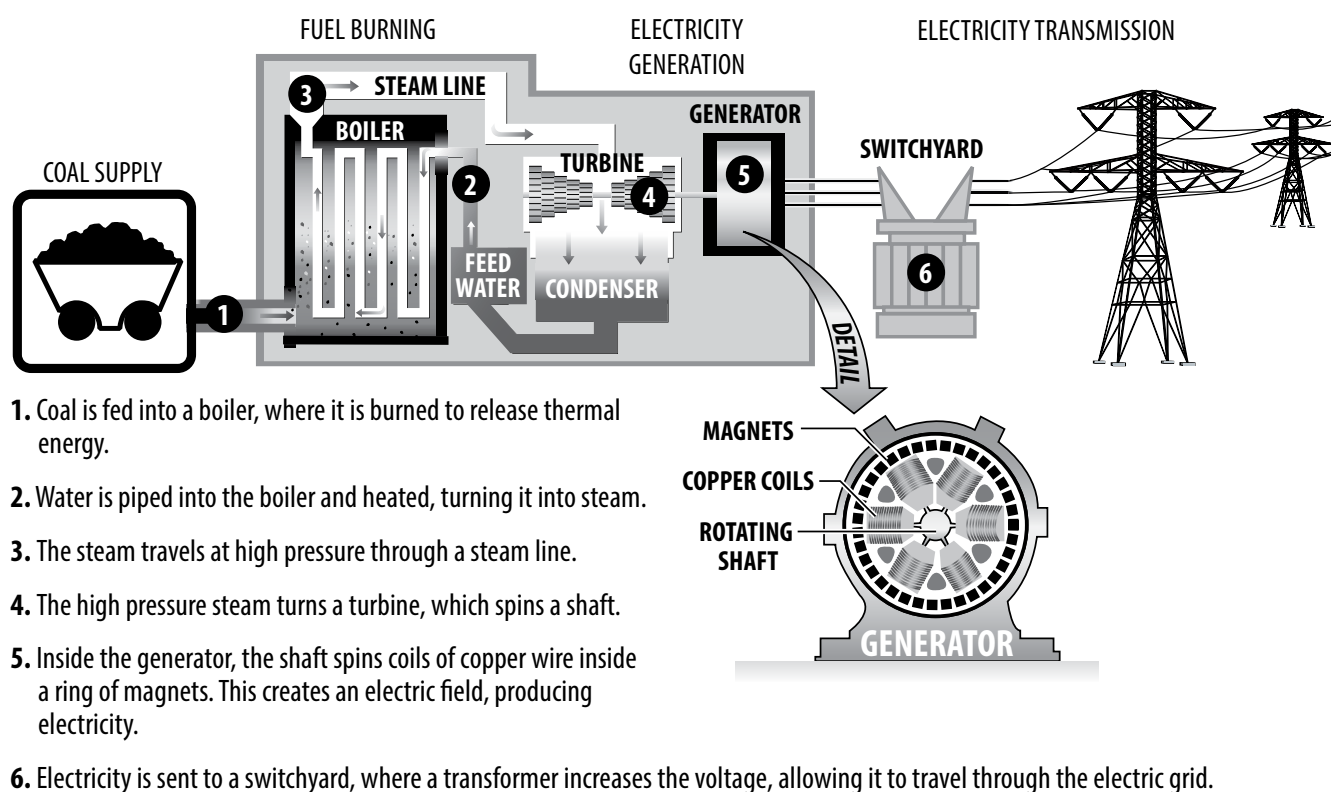
Motors and Batteries

In this station we had two tiny electric motors. Lots of little toys have motors like these. They make the toys move; they convert electrical energy into motion energy. Inside the disassembled motor, you can see a coil of wire on the shaft with magnets around the coil on the casing of the motor.

In the compass demonstration, electricity flowed through a coil of wire, producing a magnetic field around the wire. When electricity passes through the coils of wire in the motor, magnetic fields are created in each of the three coils. The magnetic fields in the coils interact with the magnetic fields of the permanent magnets on the casing of the motor. The magnetic fields interacting create a pushing and pulling motion that spins the motor. Electrical energy is converted to magnetism and then to motion. Toy motors get their electrical energy from batteries and the chemical energy stored in them, and then the toys move. The tape was attached so you could see the shaft turning.

The hand generated flashlight uses a person's kinetic energy to produce electricity to light the bulb. Inside there is a coil of wire and a magnet. When you used your energy to shake the flashlight, the magnet passed through the coil of wire. Moving the magnet through the coil of wire generated electricity by making the electrons in the wire move. This electricity was stored in the rechargeable battery. When you turned the flashlight on, electricity flowed from the battery to the bulb.

Power plants use the same concept to produce electricity. Many energy sources are used to spin turbines. These turbines rotate coils of copper wire inside magnets to generate electricity. The picture below shows a diagram of a coal power plant. Coal is burned to superheat water to a very high temperature, and high pressure steam spins the turbine. Natural gas power plants work the same way as coal power plants, and nuclear power plants use the thermal energy from the splitting of uranium atoms to generate steam. Wind turbines use the force of the wind and hydropower plants use the force of falling water to turn turbine blades. The turbine in a power plant is connected to the generator shaft with the copper wire coil inside the magnets. Electric current is generated as electrons move through the wires. Electricity is a secondary source of energy; it does not exist in a form that we can readily tap into to do useful work. Electricity generation begins with some other form of energy.



Activity One: Teacher Demonstration

Objective

- Students will be able to explain why shaking containers of sand causes the temperature of the sand to increase.

Materials

- 2 Containers of sand (one full, one approximately one-third full)
- 2 Thermometers
- *Teacher Demonstration: What Was Happening?*, page 34
- *Thermometer* master, page 39
- *Fahrenheit/Celsius Conversion* master, page 40
- *Forms of Energy* templates, pages 41-44
- *Forms of Energy Cards*, page 45

Preparation

- Make copies of the masters, or prepare digital copies for projection.
- Make sure the containers of sand are kept together, so the temperature of the sand is identical in both containers for the demonstration.
- Make copies of the blank *Forms of Energy* templates and the *Forms of Energy Cards* sheet for each student. It may be helpful to copy potential and kinetic sheets and cards on different colors of paper.

Procedure

1. Use the *Thermometer* master to explain how to read a thermometer. Explain how to convert Fahrenheit to Celsius and Celsius to Fahrenheit using the *Fahrenheit/Celsius Conversion* master, if appropriate for your students.
2. Place one thermometer in each container. Compare the temperature reading of two thermometers and record the results. Students should record the results in their science notebooks. Students should keep track of which thermometer was used in which container.

Notes:

- It is perfectly acceptable if the thermometers do not read exactly the same temperature at the beginning of this activity. Differences in temperature readings are attributable to differences in the way they are read, the thermometers themselves, etc.
 - The most dramatic difference will be seen by the students if the temperatures are measured in degrees Fahrenheit instead of Celsius, due to the differences in increment sizing on the two scales.
3. Ask students, "If we shake both of these containers in the same way, what will happen to the temperature of the sand in each container? Will they be the same or different? If they will be different, which one will increase more?" Have students write one of three choices (same, full container higher, partially full container higher) in their science notebooks.
 4. Place the lids on each container tightly.
 5. Introduce the activity to the students. Explain and model the shaking of the sand containers. Each student should shake both containers ten times at the same time, one in their right hand one in their left hand, then pass the containers to the next student, or you may discuss as a class an alternative procedure to minimize variables.
 6. While students are shaking the containers, ask them what they already think they know about energy. You may want to record their responses on the board. Ask students to name some moving objects and what sources of energy move them. If needed, prompt your students by asking, what moves a car? What moves a ball through the air? Explain that there are five main things energy helps us do: make things move, make things warm up, make light, make technology work (run electrical devices), and make things grow. Have students record these in their science notebooks and come up with examples of each.
 7. When all the students have shaken the containers, open the containers and place the same thermometer in each container as before. Have the same two students read the same thermometers and record the results on the board. Everyone should record the results in their science notebooks. Discuss the difference and why students think the temperatures changed the way they did.

Vocabulary

- Celsius
- convert
- energy
- Fahrenheit
- friction
- motion energy
- thermal energy

CONTINUED ON NEXT PAGE

8. Review the results of the sand investigation. Ask the class if anyone made a correct prediction. Ask, "Based on your observations and data recorded, was your hypothesis correct? Record your answer in your notebook in a complete sentence, and use your observations to support your answer." Use the *Teacher Demonstration: What Was Happening?* article to explain to students what was happening in the containers.
9. Have students cut out their *Forms of Energy Cards*. Go over each form of energy, using the *Forms of Energy* masters.
10. Have students identify the forms of energy and put them in order to show the energy transformations they observed in the demonstration using their *Forms of Energy Cards*. See page 34 for a thorough explanation of the forms of energy in this demonstration of transformation. If necessary, do another demonstration using an item in your classroom. Have students use their cards again.

Activity Two: Station Investigations

Objective

- Objectives vary by station; students will be able to identify the forms of energy present at various stages of a transformation, and explain what is happening within each set of materials at a grade-appropriate level.

Materials

- Station materials
- *Lab Safety Rules*, page 35
- *Station Presentation Planning Guide*, page 36 (optional)
- Safety glasses for each student
- Copies of *Station Guides* and *What Was Happening?* articles for each station (see chart below)

	STATION 1	STATION 2	STATION 3	STATION 4	STATION 5	STATION 6
Station Guide	49-58	61-69	72-77	80-88	91-96	99-105
What Was Happening?	59-60	70-71	78-79	89-90	97-98	106-107

Preparation

- Review the suggested station rotation schemes for your students to follow. Decide which works best for your time constraints and group of students, or modify one of the schemes to best suit your needs.
- Split students into six groups.
- Organize your classroom into six stations. Make ice and hot water accessible for those stations needing it. Station Three needs to be located near an electrical outlet.
- Copy the *Station Guides* for each student assigned to that station if you will not be using science notebooks.
- Make copies of each *What Was Happening?* article for each station. Do not pass these out until students are done with their initial investigation.
- Read through each station and its notes. You may want to go deeper into some of the content of the station depending upon your classroom content standards. Answer keys for the station investigations are provided on pages 26-31. These answer keys are simply provided as a reference. Students may reflect upon observations that are not suggested within the answers, but accurate based on their use of the materials. It is suggested that teachers have a good familiarity with the stations for this purpose.

Important Information About Select Stations:

- **Station Two:** We suggest that you keep the contents of a hand warmer from this station exposed to the air for a week, and have the students periodically make observations about its appearance after they have done the activities.
- **Station Three:** A C-battery may be needed to possibly give a "jump start" to the motor, overcoming its rotational inertia, before the solar cell is connected.

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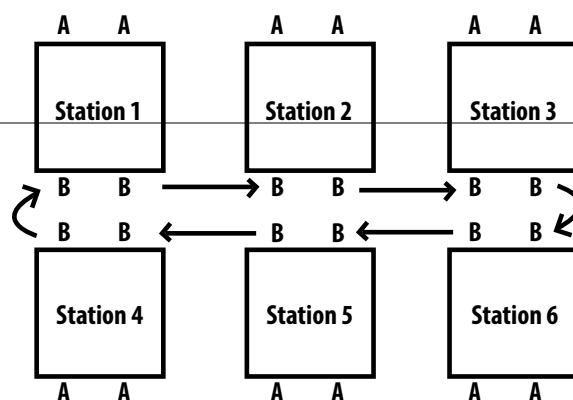
▪When conducting radiant energy transformation activities, it is suggested that teachers attempt to use sunlight or incandescent bulbs as available. Energy efficient bulbs, like LEDs, will not produce enough thermal energy in a short time to produce the desired experimental results. Traditional incandescent, heat lamps, or halogen incandescent bulbs are your best bet. However, a halogen incandescent bulb may not work as well with the PV cell in this station. The light from the halogen bulbs is of a slightly different wavelength. Wavelength of light may still operate the PV cell, but the cell itself may need to be held very closely to the bulb. Use caution in this case, so as to not melt the plastic. Some LEDs may power the solar cell, but it is suggested you test in advance to be sure. Sunlight and traditional incandescent bulbs will provide the best results for these activities.

Notes About Differentiating Instruction:

If more stations are needed to use with larger classes, several stations can be broken into parts. This can help those with pacing difficulties. Also, some stations, such as Station Four, are less challenging in content. Familiarize yourself with stations and assign stations to meet your students' needs.

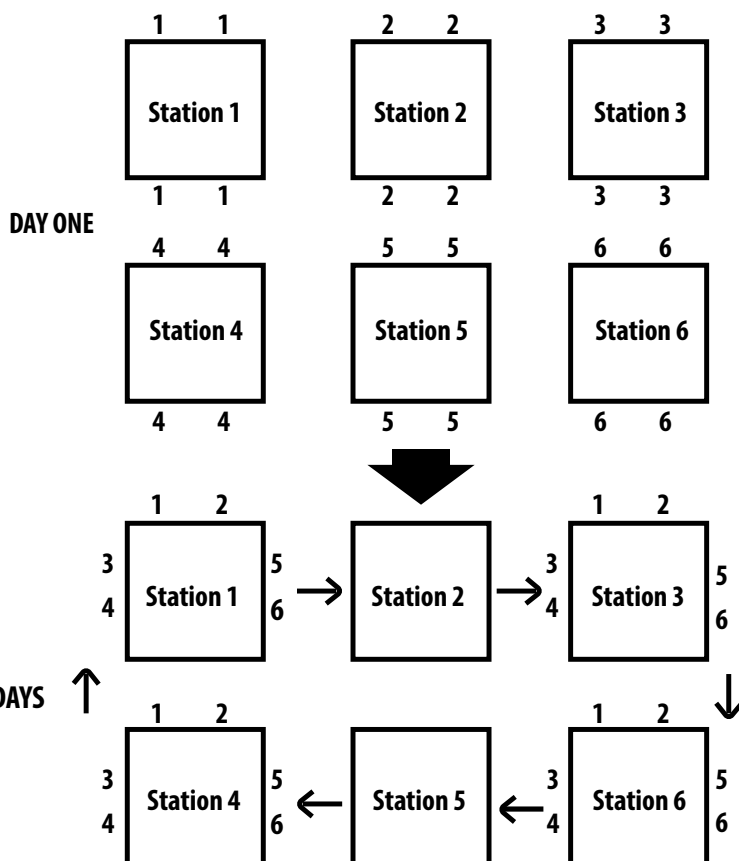
Rotation Scheme A/B (more time, students presenting in working pairs)

Students are assigned in groups of four; two of these students are "A" students, and two are "B" students. All four learn their stations well enough to guide the rest of the class. On the first set of rotations, the A students remain with their stations while the B students rotate. On the second set, the B students remain with their stations while the A students rotate.



Rotation Scheme Jigsaw (less time, students presenting individually)

Students are assigned to each of the six stations, distributing them as equally as possible, to learn their stations well enough to guide the rest of the class. On rotation days, new groups are formed, one from each station (groups of six students), which then rotate through the stations.



✓ Procedure

1. Explain to students that over the next few days they will be investigating energy transforming in different materials. Each group will be assigned a station. Everyone in the group is responsible for learning how to conduct and explain the energy transformations taking place at their station. The first day everyone will focus on learning their station and completing their station guide. Once all groups have learned their stations they will split up. In the A/B rotation scheme, half of the group will stay at the station to present the energy transformations, while the others rotate through the stations. The next day everyone will switch roles. In the jigsaw scheme, one person from each station is in a group (six students per group) and the groups rotate from station to station.
2. Review the *Lab Safety Rules* with the class.
3. Assign students to their groups. Give them the appropriate station guides. Students should read through the guides and write a hypothesis. Once everyone has written a hypothesis, give the groups their materials and let them start investigating. Remind students that they should be recording observations and data in their science notebooks.
4. Students will work in groups to learn their assigned stations in the allotted time. Students should be identifying the energy transformations, and explaining how and why the energy transformations occurred to the best of their abilities. You should intervene if misconceptions develop.
5. When students have finished their investigations, give them the *What Was Happening?* article that goes with their station. Students should read the article and compare what they read to what they thought was going on. Students should make sure they understand the transformation and can model it correctly using their *Forms of Energy Cards*.

Activity Three: Presentation Planning

Objective

- Students will have a plan developed to present their assigned energy transformations.

Materials

- Station materials
- Station Guides* and *What Was Happening?* articles, see page 16 for page references
- Station Presentation Planning Guide*, page 36

Procedure

1. Students review their work and discuss what they learned in their station investigations. All students will need to understand what was happening at their station and be able to explain it to their peers during station rotations.
2. Using their notes, the *What Was Happening?* article, and *Station Presentation Planning Guide*, students decide how they will demonstrate and explain their station to their peers.
3. Students should practice presenting their station. Let students know how much time they will have to present their stations so they can practice in that time frame.

Activity Four: Station Rotations

Objective

- Students will be able to teach their peers about their assigned energy transformations.

Materials

- Station materials
- Safety glasses for each student
- Station Guides*
- Forms of Energy Cards*, page 45

Preparation

- Set out a fresh apple at Station Five.
- Make sure each station has an adequate amount of consumable supplies.
- Have a supply of ice and hot water ready.

Procedure

1. Put students into new groups based on the rotational scheme you've selected. Follow the scheme instructions on page 17.
2. Students will rotate through stations for as many days as needed, usually two, for all groups to observe each of the investigations. Everyone will have a chance to present, and everyone will rotate through the other stations.
3. At each station, the students who learned the energy transformations will coach or guide their peers through the activities, answering questions as needed. As students complete the activities, the group members who learned the station during *Activity Three* above will be responsible for ensuring their group members understand the forms of energy throughout the initial, intermediate, and final stages of the transformation. Students should all be recording data and observations and should be able to show the transformations occurring using their *Forms of Energy Cards*.

Activity Five: Energy Flows

Objective

- Students will be able to construct an energy flow showing transformations in common processes, such as riding a bike or operating a computer.

Materials

- Hand-generated flashlight
- Teacher Demonstration: What Was Happening?*, page 34
- Forms of Energy Cards*, page 45
- Energy Transformations* master, page 46
- Energy Flow Cards*, pages 108-109

Preparation

- Make copies or prepare projections (transparencies, digital download, etc.) of the *Energy Transformations* master. If desired, deconstruct the energy flow by cutting it apart and gluing each piece onto an index card.
- Copy and cut apart the *Energy Flow Cards*. Fold the cards on the dotted lines and assemble the groupings of cards, so that each group of students has a set. The cards are numbered so if the sets get mixed up, they may be easily re-grouped.

Procedure

1. Hold up the hand generated flashlight from the teacher demo box.
2. Demonstrate how the flashlight works, describing all the parts inside. Refer to the *Teacher Demonstration: What Was Happening?* article for an explanation.
3. Ask students the form of energy being transformed in the flashlight.
4. Have students identify the form(s) of energy that are the product(s) of the transformation.
5. Show students the *Energy Transformations* master. Identify the form of energy at each stage of the flow. Students may lay out their *Forms of Energy Cards* or the index cards of the deconstructed flow as you demonstrate.
6. Explain to students that with each transformation step, amounts of energy are transferred to other forms of energy that aren't desired or useful, like heat.
7. Have the students choose another process, such as riding a bike or operating a computer. Instruct them to work backward through the energy transformations, ultimately arriving at some source of nuclear energy as the very first energy form in the energy flow. Students who choose a process involving electricity may get stuck. Try to encourage them to pick a simpler activity for now.
8. If desired, have students arrange their *Forms of Energy Cards* containing the deconstructed energy flow into the proper order for their chosen process.
9. Have students use the first set of *Energy Flow Cards* and arrange them in order to show the flow of energy through a system.
10. Ask students to use their *Forms of Energy Cards* at the same time to identify the form of energy in each of the *Energy Flow Cards*.
11. Distribute the second set of *Energy Flow Cards* and ask students to repeat steps 9-10 above.

Extension

- Have students create their own energy flow cards to demonstrate a portion of their station or a transformation of their choice.

A Note About Your Hand Generated Flashlight

This flashlight stores energy using a NiMH (Nickel Metal Hydride) rechargeable battery. This battery will hold a charge for approximately two hours. For demonstration purposes, teachers may wish to “drain” the charge on the battery by turning on the flashlight and allowing it to remain lit for some time, in order to show the flashlight starting from zero to generate light. If the light is mostly drained and faint, students will immediately be able to see the light brightening as they shake and add energy. From this point, however, it may take extended amounts of shaking to fully recharge the battery and to emit a bright light. Refer to the charging instructions on the box for more information regarding recharging the battery.

Activity Six: Forms and Sources of Energy

Objective

- Students will be able to identify the forms of energy stored or used in each of the major sources of energy.

Materials

- Energy Source Matching*, page 47
- Forms and Sources of Energy*, page 48

Preparation

- Prepare copies of *Energy Source Matching* and *Forms and Sources of Energy* to project or hand out.

Procedure

1. Review the forms of energy with students. Review energy transformations with the hand generated flashlight or another item of your choice.
2. Ask students where the energy for our electrical appliances, heating, lighting, and transportation needs comes from. Give a brief introduction and description of the ten major sources of energy listed on the *Energy Source Matching*. Discuss the difference between renewable and nonrenewable.
3. Have students complete the *Energy Source Matching* activity.
4. Have students complete the *Forms and Sources of Energy* activity. Instruct students to calculate the percentage of total energy acquired from each form of energy listed and from renewable and nonrenewable sources, using the statistics listed in the diagram. Answers can be found on page 32.

Unit Extensions

- Invite other classes of all ages to rotate through the stations and have your class teach others about energy transformations.
- There are three extensions included in this unit: *Science of Energy Bingo* (pages 23-24, 110), *Forms of Energy in the Round* (pages 25, 111-113) and *Electricity Production Simulation* (pages 114-115). Each is designed to get kids up and moving around, interacting with each other, and learning about the forms of energy and how they are transformed.
- Reinforce vocabulary and concepts with the *Forms of Energy Fun* activities found on pages 116-118.
- Use page 119 to have students brainstorm new investigations using the materials in the kit. Students should think of each station and ask, "What if..." For example, a "what if" question for Station Five might be, "What if I used a lemon instead of an apple? Would current flow through the lemon?" Let students plan their own investigations and test their ideas.

Unit Assessment and Evaluation

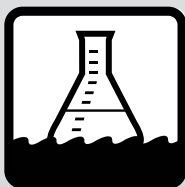
Several methods for assessment and evaluation during this unit are listed below. You know your students best, and which types of assessment best meet the needs of your classroom. Choose any of the following assessments, or develop your own, to gauge students' mastery of the objectives listed with this unit.

- Evaluate students on their group work including: their ability to work as a team to learn the material and prepare their experiment; their ability to teach students from other teams about their experiment; and their ability to handle equipment properly and safely. Devise a rubric and share it with the class.
- Assemble a series of drawings and photographs that represent different parts of various energy flows. For example, photographs of the sun, plants, animals, people, cars, gasoline cans, etc., could be used, and supplemented with drawings that represent coal, nuclear energy, oil, etc. Ask each student to arrange some of the pictures in order of an energy flow, and to place his *Forms of Energy Cards* in the appropriate areas along the energy flow.
- Assess students' science notebooks for developing science process skills and their understanding of the concepts covered at each station. A rubric is provided on page 22.

Science Notebook and Student Worksheet Rubric

This is a sample rubric that can be used with science notebooks or to evaluate student station worksheets. You may choose to only assess one area at a time, or look at an investigation as a whole. It is suggested you share this rubric with students and discuss the different components ahead of time.

	SCIENTIFIC CONCEPTS	SCIENTIFIC INQUIRY	DATA/OBSERVATIONS	CONCLUSIONS
4	Written explanations illustrate accurate and thorough understanding of scientific concepts.	The student independently conducts investigations and designs and carries out his or her own investigations.	Comprehensive data is collected and thorough observations are made. Diagrams, charts, tables, and graphs are used appropriately. Data and observations are presented clearly and neatly with appropriate labels.	The student clearly communicates what was learned and uses strong evidence to support reasoning. The conclusion includes application to real life situations.
3	Written explanations illustrate an accurate understanding of most scientific concepts.	The student follows procedures accurately to conduct given investigations, begins to design his or her own investigations.	Necessary data is collected. Observations are recorded. Diagrams, charts, tables, and graphs are used appropriately most of the time. Data is presented clearly.	The student communicates what was learned and uses some evidence to support reasoning.
2	Written explanations illustrate a limited understanding of scientific concepts.	The student may not conduct an investigation completely, parts of the inquiry process are missing.	Some data is collected. The student may lean more heavily on observations. Diagrams, charts, tables, and graphs may be used inappropriately or have some missing information.	The student communicates what was learned but is missing evidence to support reasoning.
1	Written explanations illustrate an inaccurate understanding of scientific concepts.	The student needs significant support to conduct an investigation.	Data and/or observations are missing or inaccurate.	The conclusion is missing or inaccurate.



Science of Energy BINGO Instructions

Get Ready

Duplicate as many *Science of Energy Bingo* sheets (found on page 110) as needed for each person in your group. In addition, decide now if you want to give the winner of your game a prize and what the prize will be.

Get Set

Pass out one *Science of Energy Bingo* sheet to each member of the group.

Go

PART ONE: FILLING IN THE BINGO SHEETS

Give the group the following instructions to create bingo cards:

- This bingo activity is very similar to regular bingo. However, there are a few things you'll need to know to play this game. First, please take a minute to look at your bingo sheet and read the 16 statements at the top of the page. Shortly, you'll be going around the room trying to find 16 people about whom the statements are true so you can write their names in one of the 16 boxes.
- When I give you the signal, you'll get up and ask a person if a statement at the top of your bingo sheet is true for them. If the person gives what you believe is a correct response, write the person's name in the corresponding box on the lower part of the page. For example, if you ask a person question "D" and they give you what you think is a correct response, then go ahead and write the person's name in box D. A correct response is important because later on, if you get bingo, that person will be asked to answer the question correctly in front of the group. If they can't answer the question correctly, then you lose bingo. So, if someone gives you an incorrect answer, ask someone else! Don't use your name for one of the boxes or use the same person's name twice.
- Try to fill all 16 boxes in the next 20 minutes. This will increase your chances of winning. After the 20 minutes are up, please sit down and I will begin asking players to stand up and give their names. Are there any questions? You'll now have 20 minutes. Go!
- During the next 20 minutes, move around the room to assist the players. Every five minutes or so tell the players how many minutes are remaining in the game. Give the players a warning when just a minute or two remains. When the 20 minutes are up, stop the players and ask them to be seated.

PART TWO: PLAYING BINGO

Give the class the following instructions to play the game:

- When I point to you, please stand up and in a LOUD and CLEAR voice give us your name. Now, if anyone has the name of the person I call on, put a big "X" in the box with that person's name. When you get four names in a row—across, down, or diagonally—shout "Bingo!" Then I'll ask you to come up front to verify your results.
- Let's start off with you (point to a player in the group). Please stand and give us your name. (Player gives name. Let's say the player's name was "Joe.") Okay, players, if any of you have Joe's name in one of your boxes, go ahead and put an "X" through that box.
- When the first player shouts "Bingo," ask them to come to the front of the room and give their name. Then ask them to tell the group how their bingo run was made, e.g., down from A to M, across from E to H, and so on.

Science of Energy Bingo is a great icebreaker for a NEED workshop or conference. As a classroom activity, it also makes a great introduction to an energy unit.

Preparation

▪ 5 minutes

Time

▪ 45 minutes

Bingos are available on several different topics. Check out these resources for more bingo options! All are available for free download at NEED.org/shop.

- Biomass Bingo—*Energy Stories and More*
- Change a Light Bingo—*Energy Conservation Contract*
- Coal Bingo—*Coal guides*
- Energy Bingo—*Energy Games and Icebreakers*
- Energy Efficiency Bingo—*School Energy Experts and School Energy Managers*
- Hydropower Bingo—*Hydropower guides*
- Hydrogen Bingo—*H₂ Educate*
- Nuclear Energy Bingo—*Nuclear guides*
- Oil and Natural Gas Bingo—*Oil and Natural Gas guides*
- Solar Bingo—*Solar guides*
- Transportation Bingo—*Transportation guides*
- Wind Energy Bingo—*Wind guides*

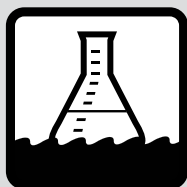
Now you need to verify the bingo winner's results. Ask the bingo winner to call out the first person's name on their bingo run. That player then stands and the bingo winner asks them the question which they previously answered during the 20-minute session. For example, if the statement was "can name two renewable sources of energy," the player must now name two sources. If they can answer the question correctly, the bingo winner calls out the next person's name on their bingo run. However, if they do not answer the question correctly, the bingo winner does not have bingo after all and must sit down with the rest of the players. You should continue to point to players until another person yells "Bingo."

SCIENCE OF ENERGY BINGO

ANSWERS

- | | | | |
|---|--|--|---|
| A. Knows what type of reaction releases thermal energy | B. Knows the form of energy that comes from the sun | C. Knows one way to store energy | D. Knows the form in which our bodies store energy |
| E. Knows the force responsible for the attraction between the Earth and nearby masses | F. Knows why rubbing your hands together makes them warm | G. Can name a form of kinetic energy | H. Has visited a thermal power plant |
| I. Knows where most energy on Earth originates | J. Knows what type of reaction absorbs thermal energy | K. Has used a radiant clothes dryer | L. Knows what form of energy is stored in most energy sources |
| M. Knows how an electric generator works | N. Knows what device turns energy from the sun directly into electricity | O. Can name a form of potential energy | P. Knows what energy can be transformed into |

A exothermic	B radiant	C battery, chemical, in a spring, etc.	D chemical
E gravity	F motion energy is transformed into thermal energy through friction	G radiant, thermal, motion (kinetic), sound, electrical	H Anyone who has visited a nuclear, coal, natural gas, or waste-to-energy power plant has visited a thermal power plant.
I the sun	J endothermic	K Anyone who has hung wet clothes on a line outside has used a radiant clothes dryer	L chemical
M Coils of wire surround a magnet. The magnet(s) rotate inside the wire, inducing electric current in the wire. The coils can also rotate inside magnets.	N photovoltaic cell, PV cell	O chemical, nuclear, elastic, gravitational	P any other form of energy



Forms of Energy in the Round Instructions

Get Ready

- Copy one set of the *Forms of Energy in the Round Cards* on pages 111-113 on card stock and cut into individual cards.
- Have a class set of the *Elementary Energy Infobooks* available for quick reference.

Get Set

- Distribute one card to each student. If you have cards left over, give some students two cards so that all of the cards are distributed.
- Have the students look at their bolded words at the top of the cards. Give them five minutes to review the information about their words using the *Elementary Energy Infobooks*.

Go

- Choose a student to begin and give the following instructions:
 - Read the question on your card. The student with the correct answer will stand up and read the bolded answer, "I have ____."
 - That student will then read the question on their card, and the round will continue until the first student stands up and answers a question, signaling the end of the round.
- If there is a disagreement about the correct answer, have the students listen to the question carefully looking for key words (forms versus sources, for example) and discuss until a consensus is reached about the correct answer.

NOTE: There may be terms on the list that are new to your students. Go over the words ahead of time with younger students, or substitute cards on your own.

ANSWER KEY

STARTING WITH CHEMICAL ENERGY'S CLUE:

NUCLEAR FUSION

POTENTIAL ENERGY

CONDUCTOR

RADIANT ENERGY

LAW OF CONSERVATION OF ENERGY

MOTION

PHOTOSYNTHESIS

EXOTHERMIC PROCESS

ELECTRICAL ENERGY

CHEMICAL CHANGE

THERMAL ENERGY

ENERGY

PHOTOVOLTAIC CELL

KINETIC ENERGY

INERTIA

ELASTIC ENERGY

GRAVITY

NUCLEAR FISSION

NUCLEAR ENERGY

INSULATOR

CONVECTION

GENERATOR

SOUND

REFLECTION

FRICTION

PHYSICAL CHANGE

ENDOTHERMIC PROCESS

VISIBLE LIGHT

CONDUCTION

CHEMICAL ENERGY

Forms of Energy in the Round is a quick, entertaining game to reinforce information about energy sources, forms of energy, and general energy information from the *Elementary Energy Infobook*.

Preparation

- 10 minutes

Time

- 20-30 minutes

Alternative Instructions

- Give each student or pair a set of cards.
- Students will put the cards in order, taping or arranging each card so that the answer is directly under the question.
- Have students connect the cards to fit in a circle or have them arrange them in a column.

"In the Rounds" are available on several different topics. Check out these resources for more, fun "In the Round" examples! All are available for free download at NEED.org/shop.

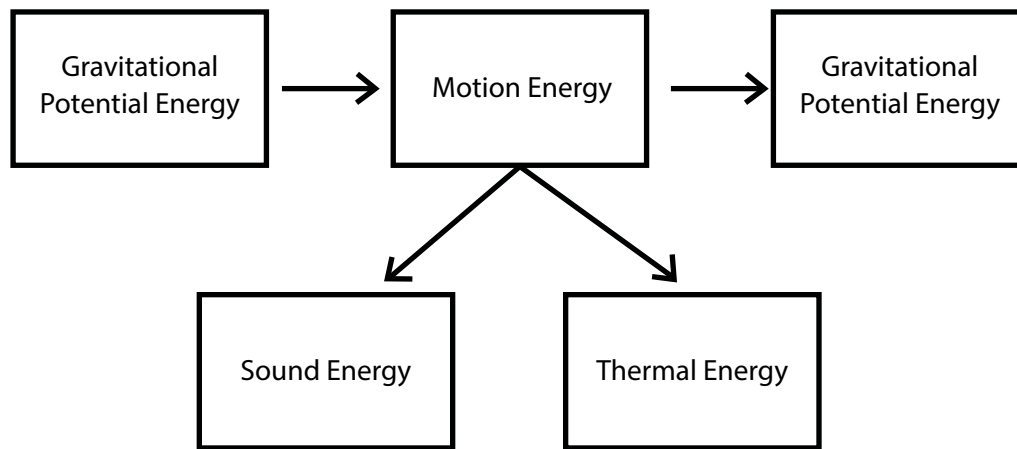
- Coal in the Round—*Exploring Coal*
- Conservation in the Round—*School Energy Experts* and *School Energy Managers*
- Hydrogen in the Round—*H₂ Educate*
- Oil and Natural Gas Industry in the Round—*Fossil Fuels to Products, Exploring Oil and Natural Gas*
- Uranium in the Round—Nuclear guides
- Solar Energy in the Round—*Energy From the Sun*
- Transportation Fuels in the Round—Transportation guides



Station Investigation Answer Keys

Station One – Part One

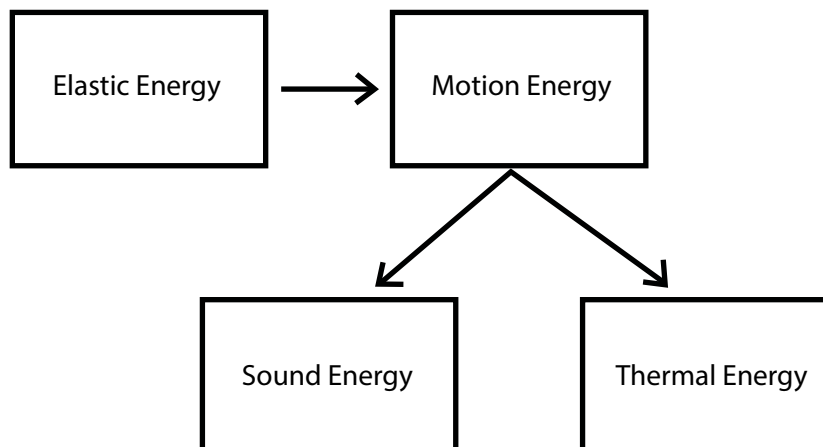
- 1 – Potential Energy; 2 – Potential and Kinetic Energy; 3 – Kinetic Energy; 4 – Potential Energy
- Students' answers may vary depending on which sphere was their first or second tested. The "happy" sphere, however, should be only slightly affected by the addition of thermal energy from the hot water, while the "sad" sphere will be significantly affected in that it will bounce noticeably higher.
- Students' answers will vary as in #2. Students should identify the sphere that bounces higher as the happy sphere.
- Students should identify the sphere that does not bounce much at all as the sad sphere.
- Energy Transformations:



Real World Application: Sad sphere rubber will do a better job of absorbing the energy of a fall, and will provide a better cushion to a child falling on it.

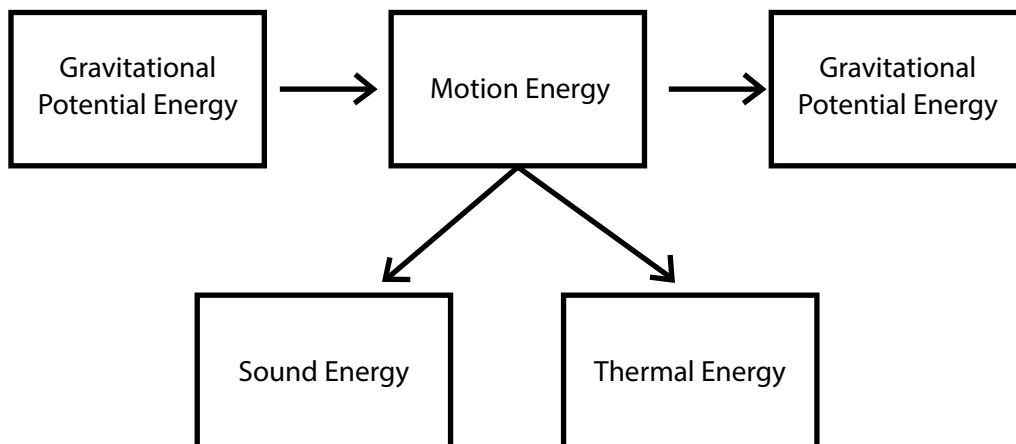
Station One – Part Two (Toy Car)

1.



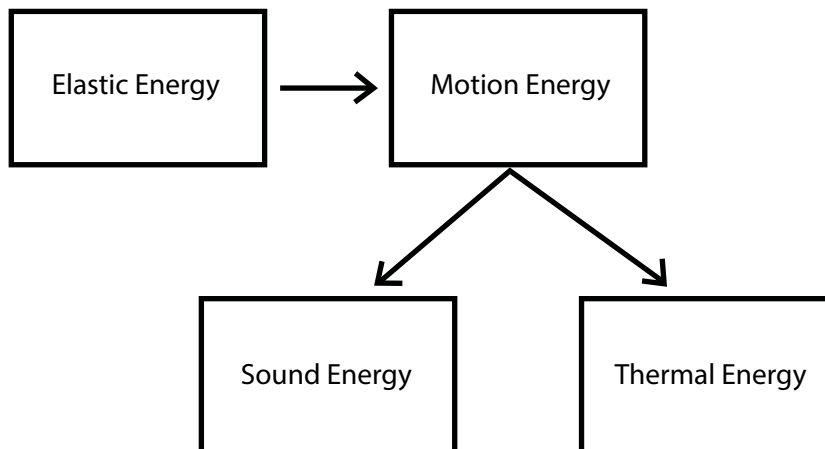
Station One – Part Two (Yo-yo)

1.



Station One – Part Two (Balloon)

1.

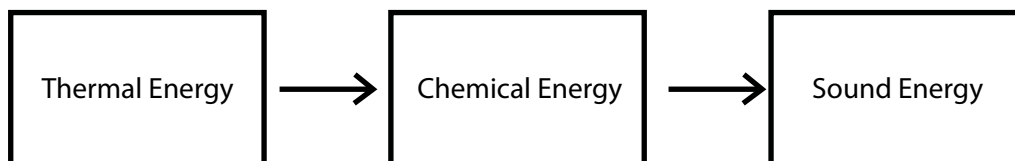


Station One – Final Conclusion

Students' answers will vary, but should demonstrate an understanding of the form of potential energy used in each toy. Answers should also include a description of how to increase the amount of potential energy given to the toy at the beginning of the investigation.

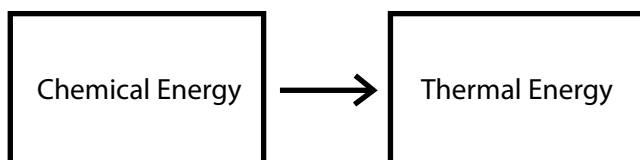
Station Two – Part One

1. Mixing baking soda and vinegar is an endothermic process.
2. Students' answers should describe that the bag felt colder and/or the temperature decreased, and that this shows that thermal energy is going into the system of reactants or the bag. "Thermal energy in" is therefore an endothermic process.
- 3.



Station Two – Part Two

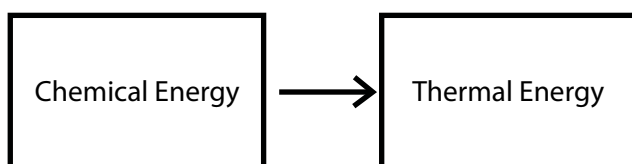
1. Dissolving the calcium chloride and water is an exothermic process.
2. Students' answers should describe that the bag felt warmer and/or the temperature increased, and that this shows thermal energy is being released from the system or bag. "Thermal energy out" is therefore an exothermic process.
- 3.



Real World Application: The thermal energy released when calcium chloride dissolves in water can be used to melt ice on the roads in winter months or colder areas.

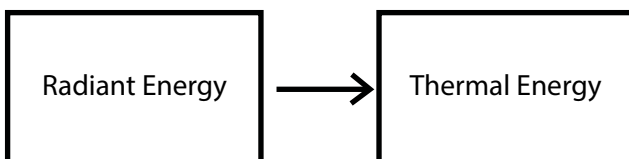
Station Two – Part Three

1. Students should be able to explain that when iron is exposed to or around oxygen, it rusts. Thermal energy is released when iron rusts.
2. The hand warmer shows an exothermic process because the temperature increased, showing that thermal energy is being released.
3. Students' answers should demonstrate that a chemical change is observed because a new substance – rust – is appearing that is different from what was present at the start – iron and oxygen. Students may also say that the temperature change is evidence of a chemical change.
4. Students' answers may vary, but should include a suggestion that smaller pieces of iron will react faster with oxygen than one large piece. A lot of small pieces have more surfaces that can be exposed to oxygen. This results in more thermal energy being released.
- 5.



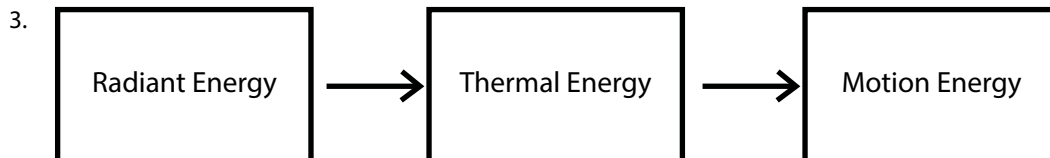
Station Three – Part One

1. Students' answers may vary, however, a correct answer that uses data from this activity will suggest that sitting in the shade on a hot day will keep a person from feeling hotter. When the sunlight reaches a person's body, the radiant energy from the sun is transformed to thermal energy and the person gets hotter. If the person is in the shade they will not be getting as much radiant energy and feel cooler.
2. Students' answers will vary and may suggest a drawer or cabinet. A bag of chocolate should be stored in a cooler, darker place where the sunlight cannot shine on it and it is not exposed to other heat sources.
- 3.



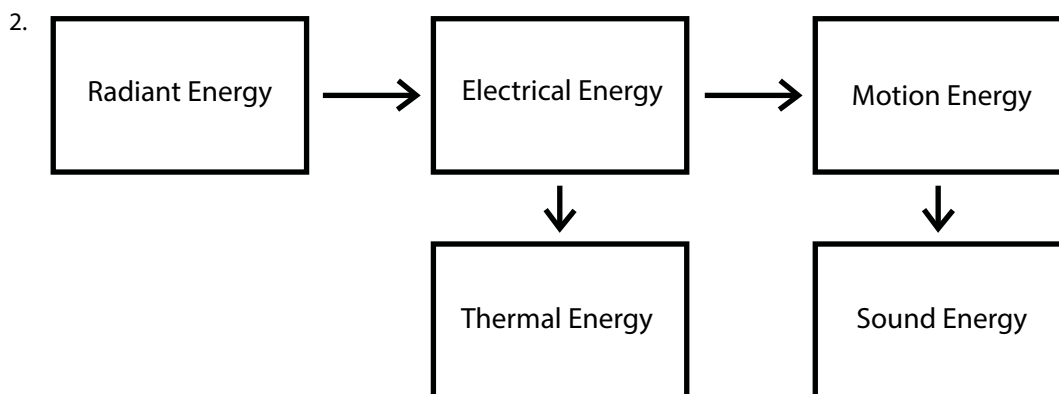
Station Three – Part Two

1. A white shirt would be cooler in the summer because black objects absorb more radiant energy, and get hotter.
2. Students' answers should suggest that the radiometer would not work if all the vanes were the same color. If the vanes were all the same color, there would be no difference in the temperature of the air molecules on one side or the other. The difference in temperature near each vane is what makes the radiometer spin.



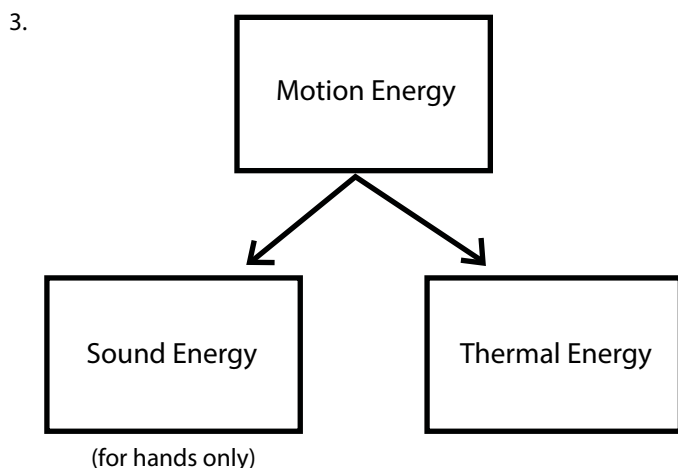
Station Three – Part Three

1. Solar powered calculators have a battery that provides power when there is not enough light to generate the electricity needed to operate the calculator.

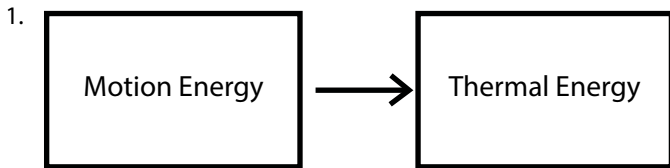


Station Four – Part One

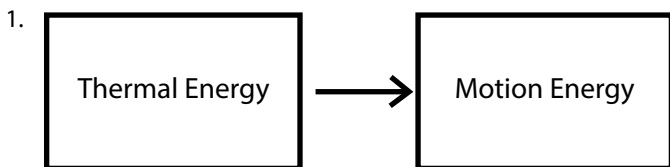
1. When you rub your hands together, the motion of your hands is transformed into sound and thermal energy because of the friction between your hands.
2. Students' answers may vary significantly depending on how they envision the game. The winning team would notice the friction more, because they are keeping their grip on the rope and pulling it forward. The losing team would also feel the results of the friction, however, as the rope slides through their hands.



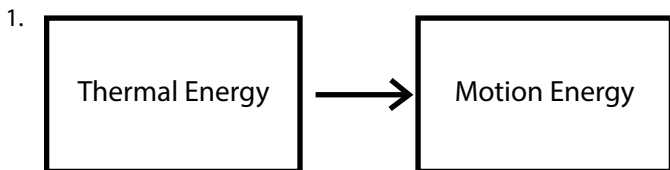
Station Four – Part Two



Station Four – Part Three

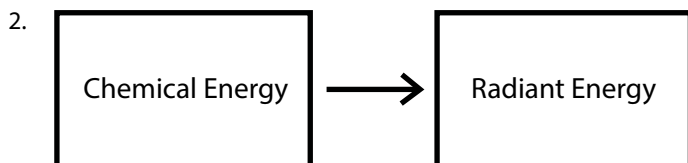


Station Four – Part Four



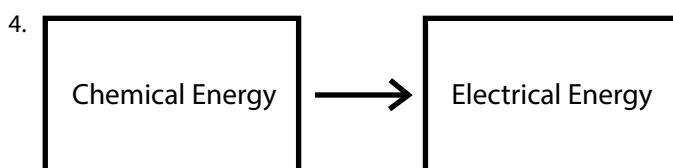
Station Five – Part One

1. Students' answers should describe that when thermal energy was transferred to the glow sticks from the warm water, the glow stick glowed brighter. When thermal energy was transferred away from the glow sticks into the ice water, the glow stick got dimmer. The more thermal energy available to the glow stick, the faster the chemical reaction inside, and the brighter the glow stick will be.



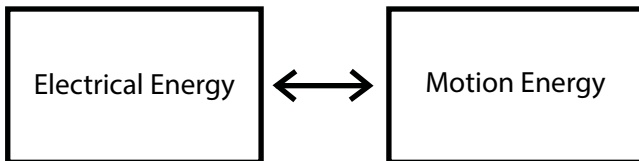
Station Five – Part Two

1. Students' answers should be able to describe that the needle on the meter will move to the right when the electric current is moving through the meter from left to right. If the current is moving in the opposite direction, the needle moves to the left.
2. Students' answers should relate that copper and zinc (nail) produced the most electricity. The large zinc nail with the thick copper wire should have proved to be the best combination. When two zinc nails or two copper wires were used, no electricity was produced because there was no chemical reaction occurring, and no electrons moving.
3. Students' answers will vary, but should demonstrate an understanding of the need for some kind of liquid or juice inside the food for the battery to work. Some students might also be able to describe the juice or liquid as an acid within a battery. Other examples are lemons, grapefruit, oranges, pickles, peaches, glasses of juice or soda, and potatoes.



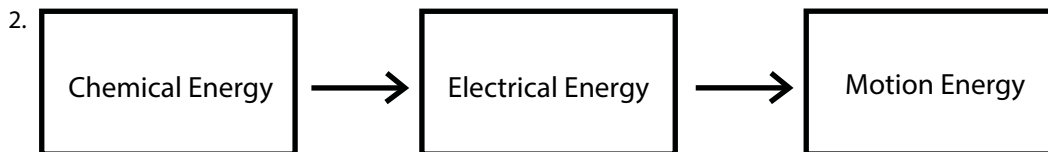
Station Six – Part One

1. A magnet or magnetic field will make a compass move. The wire caused the compass needle to move. When electric current flowed through the wire, a magnetic field was created around the wire.
2. Students' answers should be able to describe that the wire didn't cause the compass needle to move until it was connected to both ends of the battery and electricity was flowing through it. Electric current affects a compass because it creates a magnetic field around the wire it is flowing through.
3. Student answers may vary, but a strong understanding of this station's concepts will be evident if students can claim that electricity cannot exist without magnetism. Magnets can be moved around a coil of wires to make electricity flow, and electricity can be pushed through a coil of wire to make a magnet. They are both related to each other, and if there is electricity, there is also a magnetic field.
- 4.



Station Six – Part Two

1. Batteries provide the electrical energy that allows the motor to spin.





Answer Keys

Energy Source Matching, page 47



Energy Source Matching

Write the number of the energy source on the line next to its definition.

- | | | |
|--------------------|-----------|--|
| 1. Petroleum (oil) | <u>9</u> | Black rock burned to make electricity. |
| 2. Wind | <u>7</u> | Energy from heat inside the Earth. |
| 3. Biomass | <u>8</u> | Energy from flowing water. |
| 4. Uranium | <u>3</u> | Energy from wood, waste, and garbage. |
| 5. Propane | <u>2</u> | Energy from moving air. |
| 6. Solar | <u>4</u> | Energy from splitting atoms. |
| 7. Geothermal | <u>5</u> | Portable fossil fuel gas often used in grills. |
| 8. Hydropower | <u>1</u> | Fossil fuel for cars, trucks, and jets. |
| 9. Coal | <u>10</u> | Fossil fuel gas moved by pipeline. |
| 10. Natural Gas | <u>6</u> | Energy in rays from the sun. |

Forms and Sources of Energy, page 48

NONRENEWABLE

Petroleum - chemical
Coal - chemical
Natural Gas - chemical
Uranium - nuclear
Propane - chemical

RENEWABLE

Biomass - chemical
Hydropower - motion
Wind - motion
Solar - radiant
Geothermal - thermal

▪Chemical - 87%, Nuclear - 8%, Motion - 3%, Radiant - 1%, Thermal - less than 1%*

▪Nonrenewables - 90%, Renewables - 9%*

*Total may not equal 100% due to independent rounding.

Energy Crossword, page 116

ACROSS

1. kinetic
4. endothermic
6. chemical
9. react
11. photovoltaic
12. light
13. nuclear
14. solar

DOWN

2. potential
3. energy
5. elastic
7. thermal
8. exothermic
10. electrical

Energy Scramble, page 117

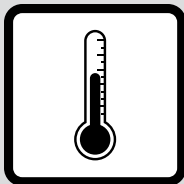
ELECTRICITY, HEAT, MOTION, LIGHT, GROW, ENERGY

Energy Transformations, page 117

- | | |
|---------------------------------------|---|
| 1. radiant to electrical | 8. radiant to thermal and motion |
| 2. chemical to electrical | 9. chemical to thermal and radiant |
| 3. chemical to motion | 10. nuclear to radiant and thermal |
| 4. motion to electrical | 11. chemical to motion and radiant |
| 5. chemical to thermal | 12. chemical to motion and thermal |
| 6. chemical to radiant | 13. chemical to motion and thermal and sound |
| 7. chemical to electrical and radiant | 14. chemical to radiant and thermal and sound |

Energy Flow, page 118

- | | |
|-----------------------------|----------------------------------|
| ▪Radiant (Light) Energy - 8 | ▪Motion Energy - 5 |
| ▪Chemical Energy (Corn) - 3 | ▪Nuclear Energy - 1 |
| ▪Radiant Energy - 2 | ▪Electrical Energy - 7 |
| ▪Chemical Energy (Girl) - 4 | ▪Electrical Energy (Battery) - 6 |



Teacher Demonstration: What Was Happening?

Containers of Sand, page 15

The energy we use is stored in different forms. Energy does not disappear, it just changes forms. This is the Law of Conservation of Energy. This law states that energy is neither created nor destroyed.

There are two containers of sand, one filled about one-third of the way and the other filled to the top. Since they have been in the same environment, they should be the same temperature.

After each student has shaken the containers, the temperature was recorded. You should have seen a two to five degree Celsius increase with the third-full one, less with the full one. The difference will be more apparent on the Fahrenheit scale since the increments are smaller on the Fahrenheit scale. A five-degree difference in Celsius equals a nine-degree difference in Fahrenheit.

Shaking the containers, we moved the grains of sand, causing them to collide with each other. They rubbed against each other, causing friction between the particles and producing thermal energy (heat). We transformed motion energy into thermal energy (heat).

The increase in temperature was greater for the container that was only one-third full, because the partially full container has more space in it for the sand to move around. The grains of sand collide with each other with greater velocity. More velocity means more kinetic energy (motion). In the container filled with sand, the grains of sand have little space to move.

Hand Generated Flashlight, page 20

A hand generated flashlight works by converting motion into electrical energy. Electricity is powering the light and charging the capacitor or battery to use when not shaking.

Inside of the flashlight is a stationary coil of wire. There is also one magnet that passes through the coil of wire when the flashlight is gently shaken. This magnet is called the "charging" magnet. At each end of the inner housing is sometimes an additional magnet. These magnets are oriented to repel the charging magnet so it moves smoothly through the coil of wire. This is called a magnetic repulsion recoil system. There may also be rubber bumpers, rather than magnets, that cause the central magnet to recoil.

As the flashlight is shaken, electricity is generated as the charging magnet passes back and forth through the coil of wire. The electricity is stored in a capacitor or battery. When the flashlight is turned on, the capacitor or battery delivers electricity to a light emitting diode (LED). The light will stay on as long as the capacitor or battery is charged.

Energy Flows, page 20

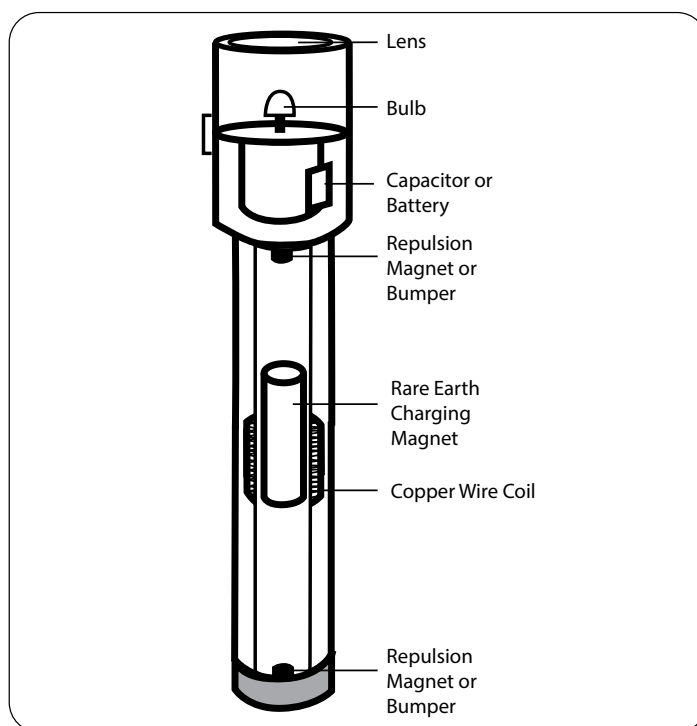
The energy flow from shaking the containers of sand originated from our sun, and so did the energy in the flashlight.

Let's start with the thermal energy, or heat, we produced as a result of the motion our bodies provided. Our bodies got the energy to

shake the container from the food we ate. The energy was stored in the food as chemical energy in the bonds of the molecules. Chemical energy is stored in food through photosynthesis. Sunlight, or radiant energy, changes water and carbon dioxide into the glucose and oxygen in plants. Glucose is a sugar with lots of energy—chemical energy.

Nuclear energy produced the radiant energy from the sun. Inside the sun's core, atoms of hydrogen are fused together to form atoms of helium. The fusion occurs because of the tremendous heat and gravitational forces inside the sun's core. The resulting atom of helium has less mass than the original atoms of hydrogen. This missing mass is changed into energy—radiant energy.

The increase in the temperature of the containers of sand is the result of nuclear energy. In fact, all energy transformations can be traced back to nuclear energy: fission, fusion, or radioactive decay. The energy stored in fossil fuels (coal, petroleum, natural gas, propane) is a result of sunlight from millions of years ago. Wind, hydropower, and biomass energy are also a result of the sun's radiant energy. Geothermal energy is a result of the radioactive decay of elements in the Earth's core. The electricity produced in a nuclear power plant is the result of the splitting, or fission, of heavy uranium atoms into lighter atoms. When fission occurs, mass is changed into energy. All energy transformations can be traced back to nuclear energy.



In a hand generated flashlight, motion energy is transformed into electrical energy and radiant energy.



Lab Safety Rules

Eye Safety

- Always wear safety glasses when performing experiments.

Fire Safety

- Do not heat any substance or piece of equipment unless specifically instructed to do so.
- Be careful of loose clothing. Do not reach across or over a flame.
- Keep long hair pulled back and secured.
- Do not heat any substance in a closed container.
- Always use tongs or protective gloves when handling hot objects. Do not touch hot objects with your hands.
- Keep all lab equipment, chemicals, papers, and personal effects away from the flame.
- Extinguish any flame as soon as you are finished with the experiment and move it away from the immediate work area.

Heat Safety

- Always use tongs or protective gloves when handling hot objects and substances.
- Keep hot objects away from the edge of the lab table, in a place where no one will accidentally come into contact with them.
- Remember that many objects will remain hot for a long time after the heat source is removed or turned off.

Glass Safety

- Never use a piece of glass equipment that appears cracked or broken.
- Handle glass equipment carefully. If a piece of glassware breaks, do not attempt to clean it up yourself. Inform your teacher.
- Glass equipment can become very hot. Use tongs if glassware has been heated.
- Clean glass equipment carefully before packing it away.

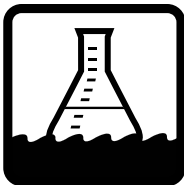
Chemical Safety

- Do not smell, touch, or taste chemicals unless instructed to do so.
- Keep chemical containers closed except when using them.
- Do not mix chemicals without specific instructions.
- Do not shake or heat chemicals without specific instructions.
- Dispose of used chemicals as instructed. Do not pour chemicals back into containers without specific instructions to do so from your teacher.
- If a chemical accidentally touches your skin, immediately wash the affected area with water and inform your teacher.

MSDS Safety Sheets are included for all chemicals in the kits as well as the products of all chemical reactions.

Glow Stick Safety: The solutions in the glow sticks are non-toxic and non-flammable. Eye contact may cause temporary discomfort, similar to that produced by soap or shampoo. Do not drink or ingest contents. Do not puncture glow sticks. Should a glow stick rupture, rinse the affected area thoroughly with water and repeat. Solutions may stain surfaces or fabrics. If you have concerns about possible reactions or sensitivities, please call the number listed on the back of the packaging.

Thermometer Safety: Thermometers included in the *Elementary Science of Energy* kit contain alcohol spirits and are safe for classroom use. They do not contain mercury.



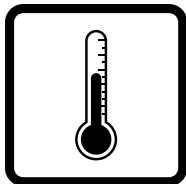
Station # _____ Presentation Planning Guide

PRESENTATION ELEMENTS	WHO IS RESPONSIBLE?
Present the question.	
Demonstration: What will you do?	
Ask the group to identify the energy transformations.	
Explain what was happening at your station.	

This image shows a full page of blank graph paper. The background is a very light gray, and it is covered by a precise grid of thin, darker gray lines. The grid consists of small, equal-sized squares that extend across the entire visible area of the page, providing a template for drawing or writing.

[illegible]

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.



Thermometer

A thermometer measures temperature. The temperature of a substance is a measure of the average amount of kinetic energy in the substance.

This thermometer is a long, glass tube filled with colored alcohol. Alcohol is used in many thermometers because it expands in direct proportion to the increase in kinetic energy or temperature.

Temperature can be measured using many different scales.

The scales we use most are:

■ Celsius

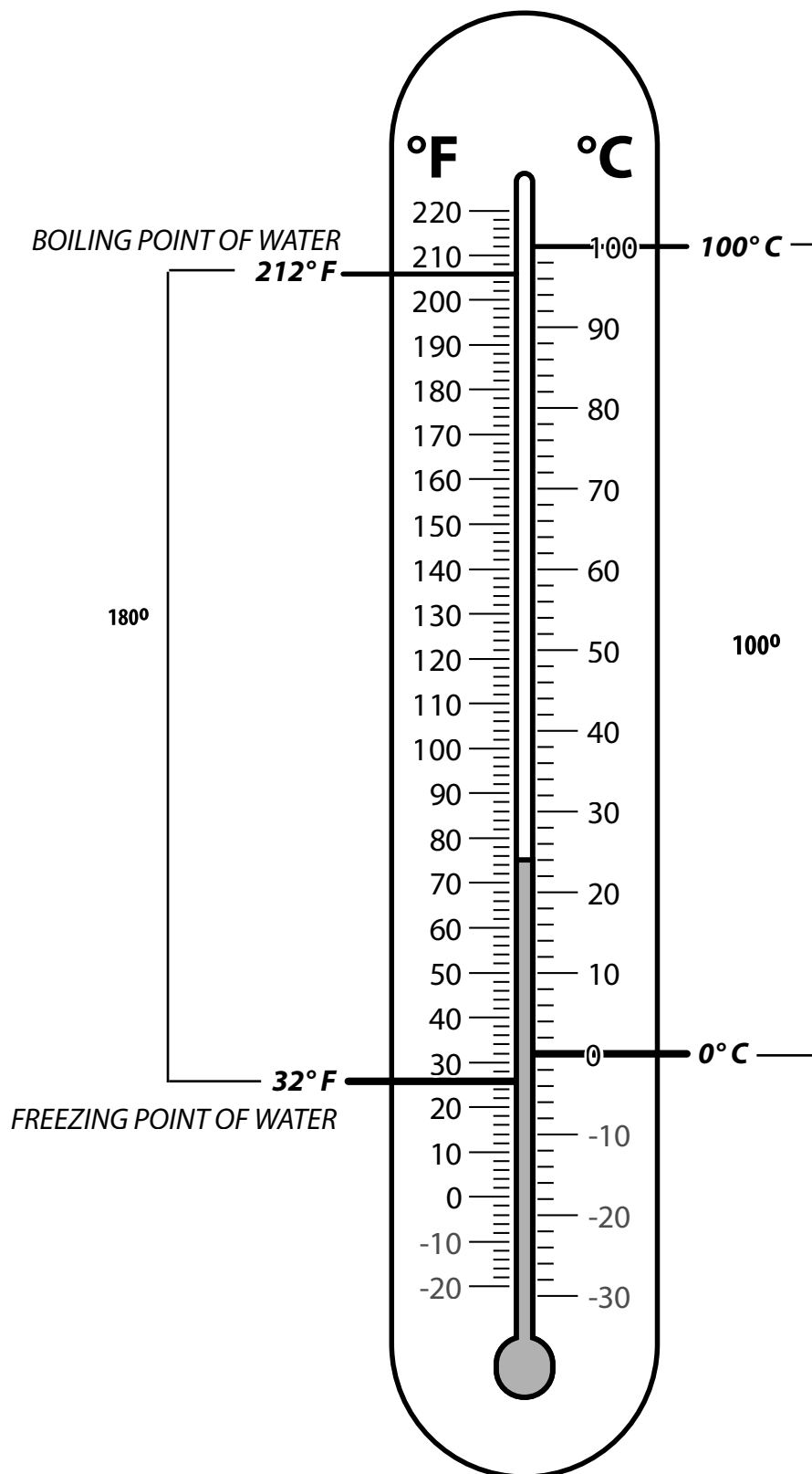
The **Celsius (C)** scale uses the freezing point of water as 0°C and the boiling point of water as 100°C .

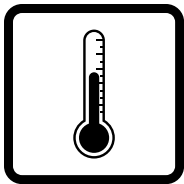
■ Fahrenheit

The **Fahrenheit (F)** scale uses the freezing point of water as 32°F and the boiling point of water as 212°F .

In the United States, we usually use the Fahrenheit scale in our daily lives, and the Celsius scale for scientific work. People in most countries use the Celsius scale in their daily lives as well as for scientific work.

Notice the numerical difference between the freezing and boiling points of water are different on the two scales. The difference on the Celsius scale is 100, while the difference on the Fahrenheit scale is 180. There are more increments on the Fahrenheit scale because it shows less of an energy change with each degree.





Fahrenheit/Celsius Conversion

On the Fahrenheit scale, the freezing point of water is 32° and the boiling point of water is 212°.

On the Celsius scale, the freezing point of water is 0° and the boiling point of water is 100°.

To convert from Celsius to Fahrenheit, multiply the C number by $\frac{180}{100}$ or $\frac{9}{5}$, then add 32, as shown in the formula below.

$$F = (C \times \frac{9}{5}) + 32$$

If C = 5

$$F = (5 \times \frac{9}{5}) + 32$$

$$F = 9 + 32$$

$$F = 41$$

To convert from Fahrenheit to Celsius, subtract 32 from the F number, then multiply by $\frac{100}{180}$ or $\frac{5}{9}$ as shown in the formula below.

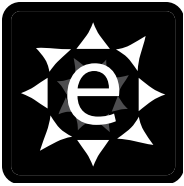
$$C = (F - 32) \times \frac{5}{9}$$

If F = 50

$$C = (50 - 32) \times \frac{5}{9}$$

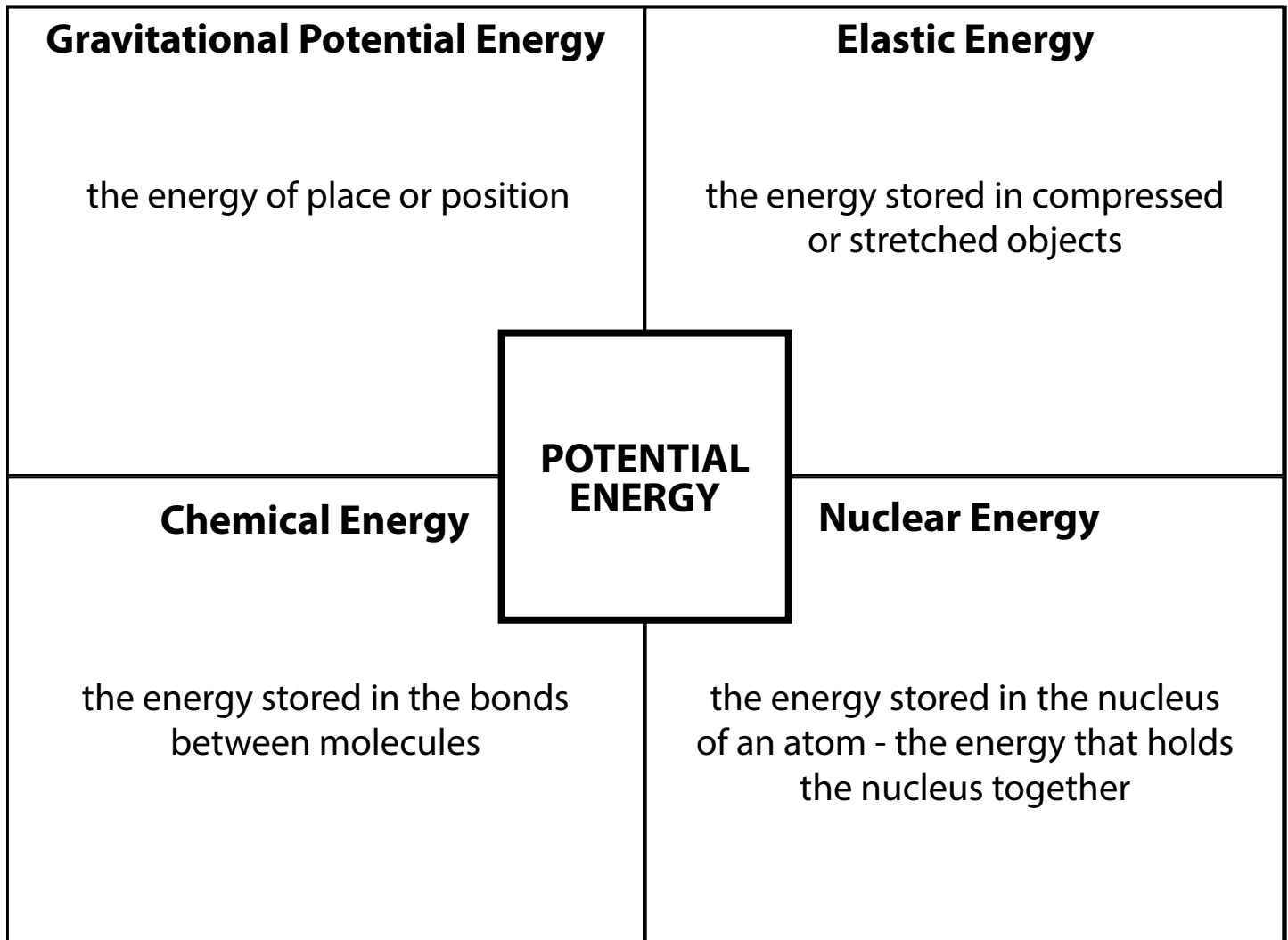
$$C = 18 \times \frac{5}{9}$$

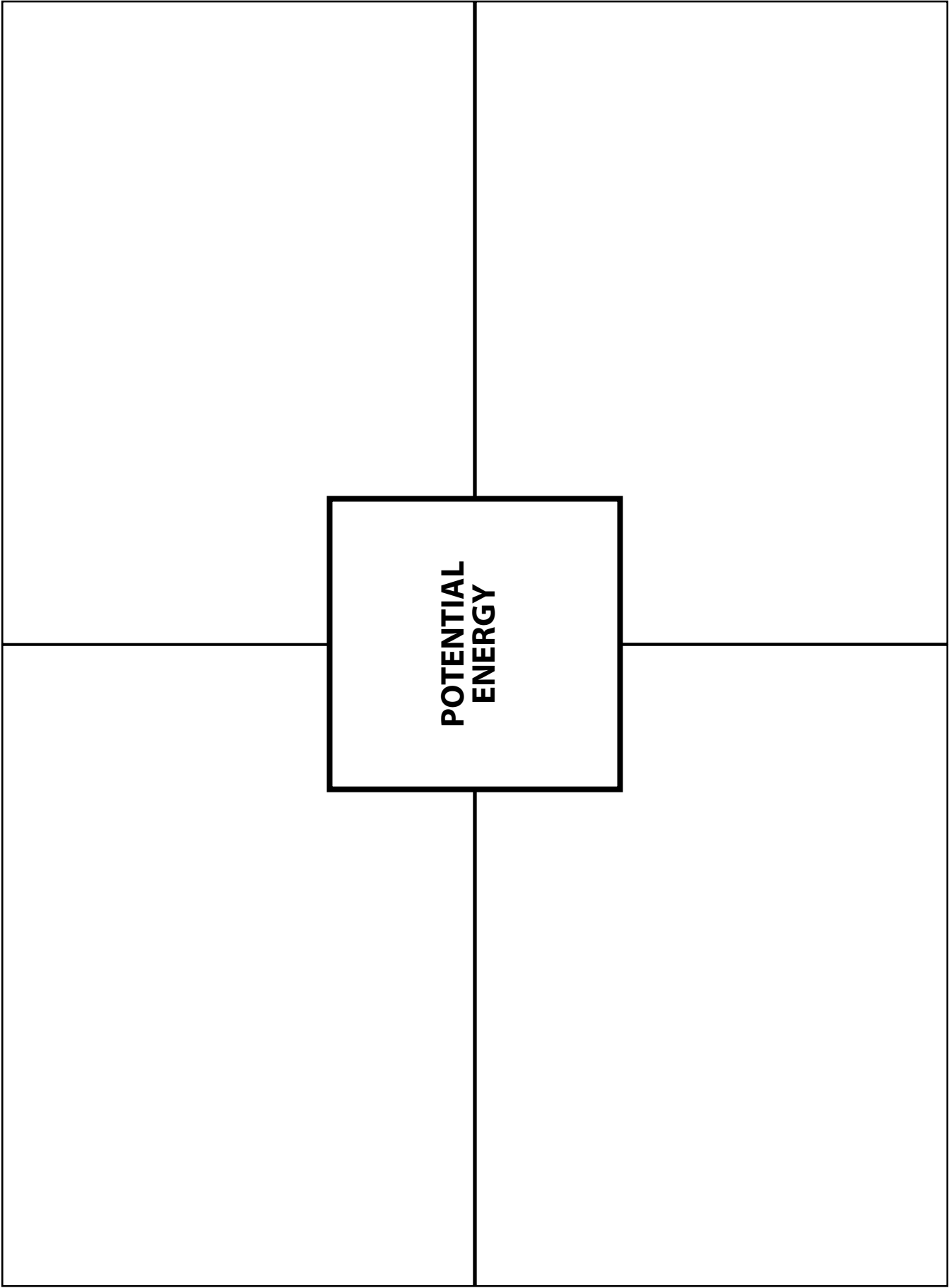
$$C = 10$$

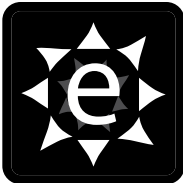


Forms of Energy

Energy can be stored. Stored energy is called potential energy.

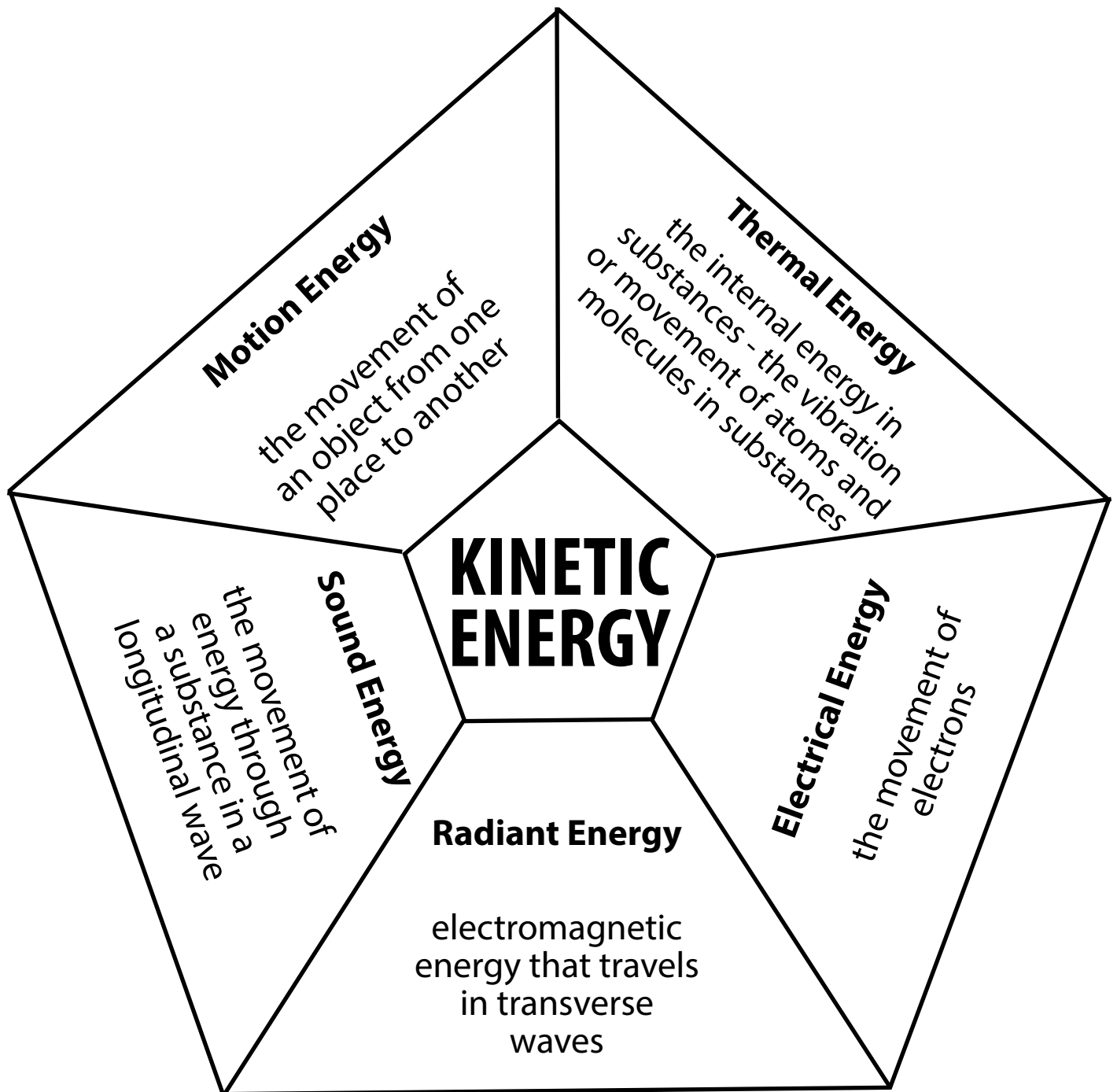


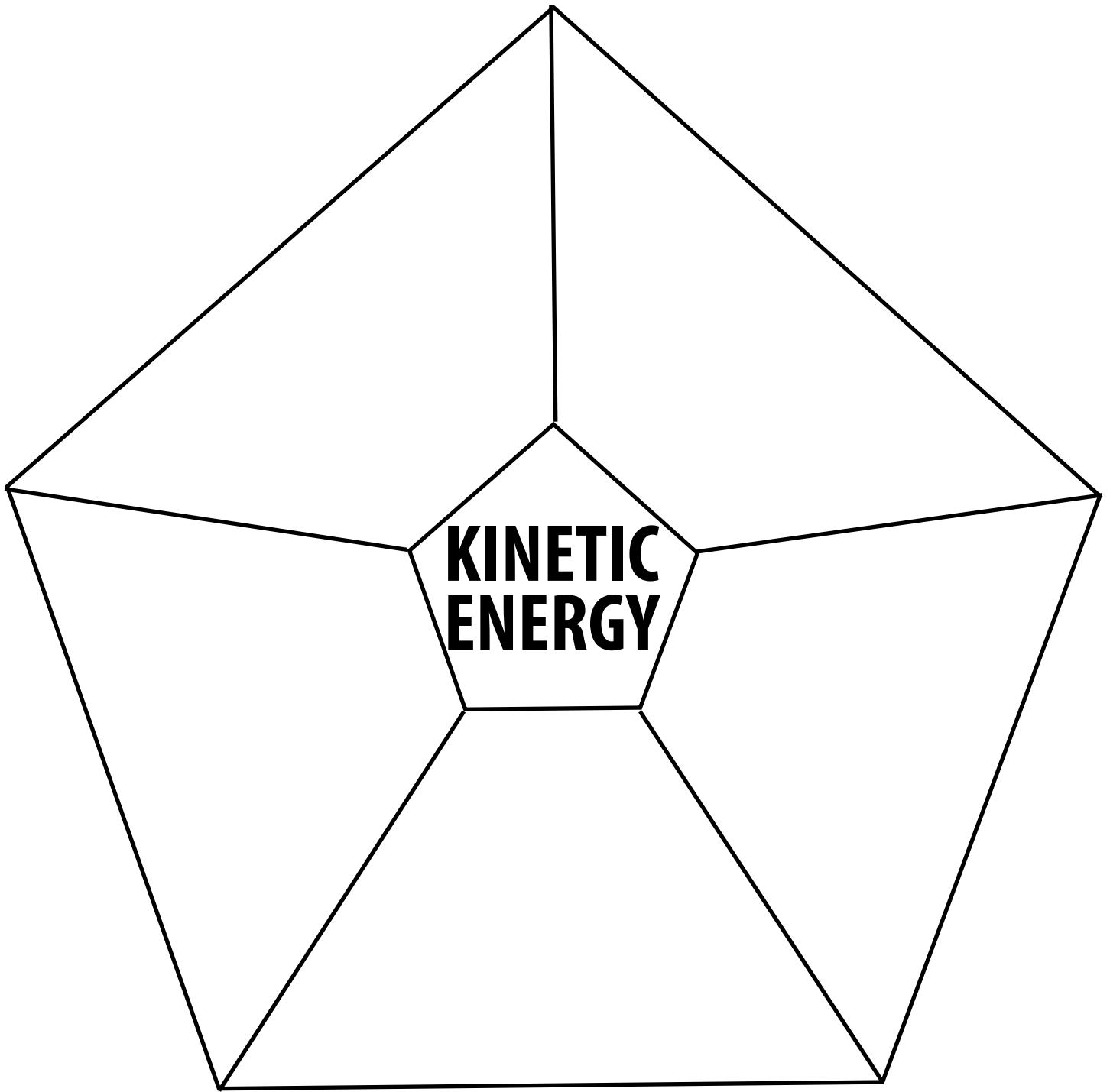


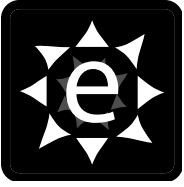


Forms of Energy

Energy can be in motion. Motion energy is called kinetic energy.

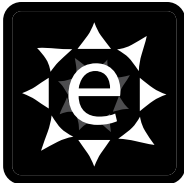






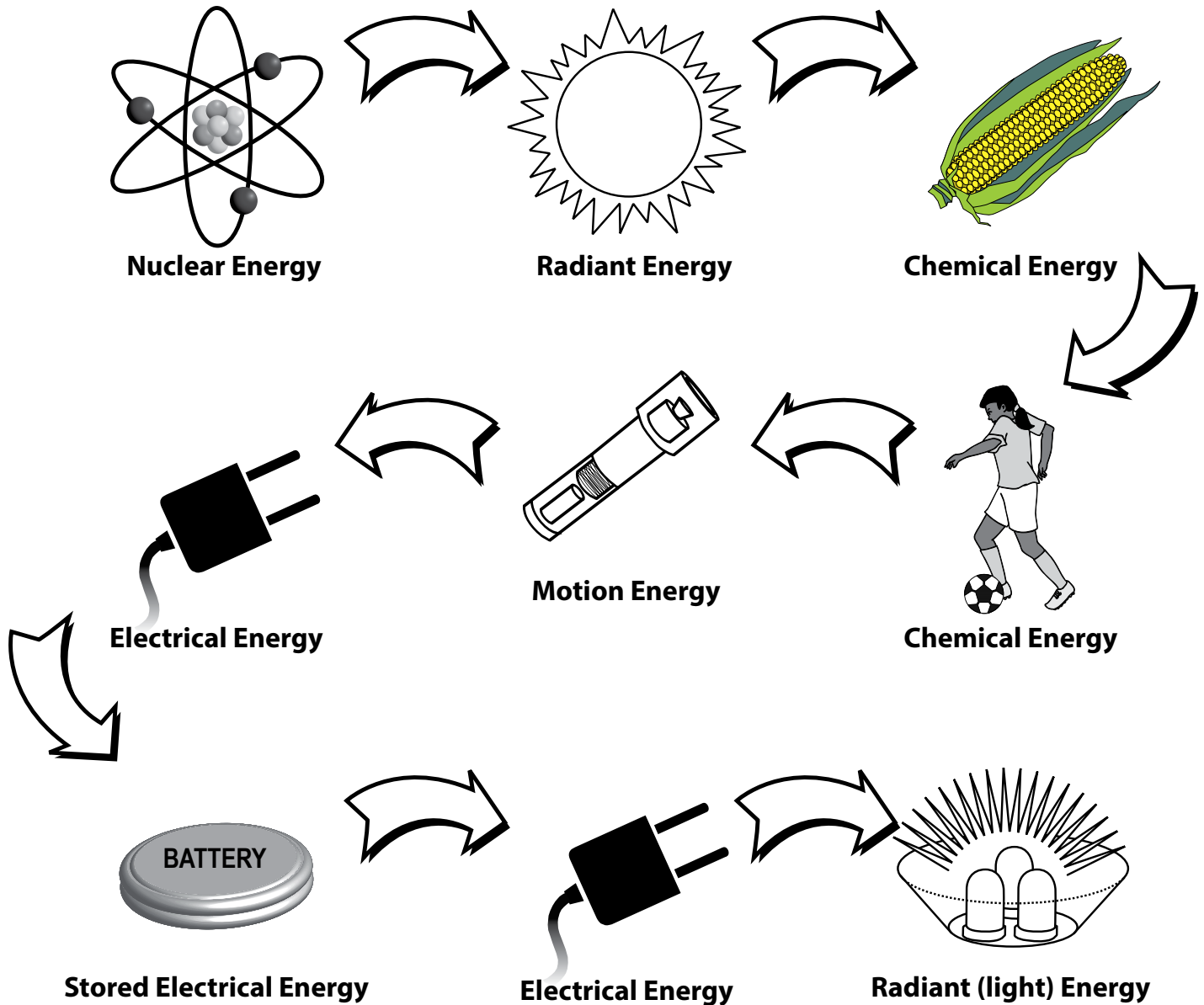
Forms of Energy Cards

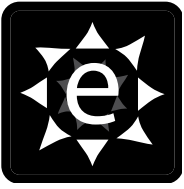
POTENTIAL ENERGY	KINETIC ENERGY
GRAVITATIONAL POTENTIAL ENERGY	THERMAL ENERGY
ELASTIC ENERGY	ELECTRICAL ENERGY
CHEMICAL ENERGY	RADIANT ENERGY
NUCLEAR ENERGY	SOUND ENERGY
	MOTION ENERGY



Energy Transformations

Hand Generated Flashlight

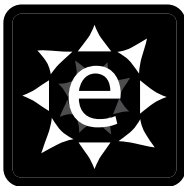




Energy Source Matching

Write the number of the energy source on the line next to its definition.

- | | | |
|---------------------------|-------|--|
| 1. Petroleum (oil) | _____ | Black rock burned to make electricity. |
| 2. Wind | _____ | Energy from heat inside the Earth. |
| 3. Biomass | _____ | Energy from flowing water. |
| 4. Uranium | _____ | Energy from wood, waste, and garbage. |
| 5. Propane | _____ | Energy from moving air. |
| 6. Solar | _____ | Energy from splitting atoms. |
| 7. Geothermal | _____ | Portable fossil fuel gas often used in grills. |
| 8. Hydropower | _____ | Fossil fuel for cars, trucks, and jets. |
| 9. Coal | _____ | Fossil fuel gas moved by pipeline. |
| 10. Natural Gas | _____ | Energy in rays from the sun. |



Forms and Sources of Energy

In the United States we use a variety of resources to meet our energy needs. Use the information below to analyze how each energy source is stored and delivered.

- 1 Using the information from the *Forms of Energy* charts, and the graphic below, determine how energy is stored or delivered in each of the sources of energy. Remember, if the source of energy must be burned, the energy is stored as chemical energy.

NONRENEWABLE

Petroleum _____

Coal _____

Natural Gas _____

Uranium _____

Propane _____

RENEWABLE

Biomass _____

Wind _____

Hydropower _____

Solar _____

Geothermal _____

- 2 Look at the U.S. Energy Consumption by Source graphic below and calculate the percentage of the nation's energy use that each form of energy provides.

What percentage of the nation's energy is provided by each form of energy?

Chemical _____

Nuclear _____

Motion _____

Radiant _____

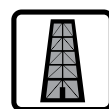
Thermal _____

What percentage of the nation's energy is provided by nonrenewables? _____

by renewables? _____

U.S. Energy Consumption by Source, 2022

NONRENEWABLE



PETROLEUM 37% *
Uses: transportation, manufacturing - includes propane



NATURAL GAS 35% *
Uses: heating, manufacturing, electricity - includes propane



COAL 10%
Uses: electricity, manufacturing



URANIUM 8%
Uses: electricity



PROPANE *Propane consumption is included in petroleum and natural gas totals.
Uses: heating, manufacturing

RENEWABLE



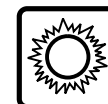
BIOMASS 5%
Uses: heating, electricity, transportation



WIND 2%
Uses: electricity



HYDROPOWER 1%
Uses: electricity

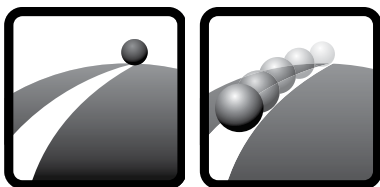


SOLAR 1%
Uses: heating, electricity



GEOOTHERMAL < 1%
Uses: heating, electricity

**Total does not add up to 100% due to independent rounding.
Data: Energy Information Administration



Station One Guide

POTENTIAL AND KINETIC ENERGY

Part One: Happy and Sad Spheres

Question

What will happen when you drop the spheres?

Materials

- Measuring tape or meter stick
- 1 Set of happy/sad spheres
- Hard surface (to drop spheres on)
- Tongs
- 2 Cups of hot water
- Safety glasses
- 2 Pieces of scrap paper
- Timer
- Calculator

Vocabulary

- absorb
- collision
- kinetic energy
- Law of Conservation of Energy
- potential energy
- rebound
- thermal energy

Procedure

Section A

- Drop one black sphere onto a hard surface from a height of one meter.
- Record how high the ball rebounds in your chart.
- Do two more trials, repeating steps 1 and 2. Record your data in your data table. Calculate the average.
- On a piece of scrap paper, write "Sphere 1." Place the sphere you just used on the sheet of scrap paper labeled "Sphere 1."
- Keep track of this sphere as "Sphere 1."

Section B

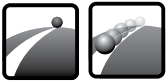
- Drop the second black sphere onto the hard surface from a height of one meter.
- Record how high the ball rebounds in your chart.
- Do two more trials, repeating steps 1 and 2, and record your data. Calculate the average.
- On a piece of scrap paper, write "Sphere 2." Place the sphere you just used on the sheet of scrap paper labeled "Sphere 2."
- Keep track of this sphere as "Sphere 2."

	TRIAL 1 (cm)	TRIAL 2 (cm)	TRIAL 3 (cm)	AVERAGE
SPHERE 1				
SPHERE 2				

Section C

- Place one cup of hot water on or near each piece of scrap paper.
- Place Sphere 1 into its cup of hot water. Start the timer for two minutes.
- What effect do you think the hot water will have on the spheres?

Hypothesis: I think the hot water will _____



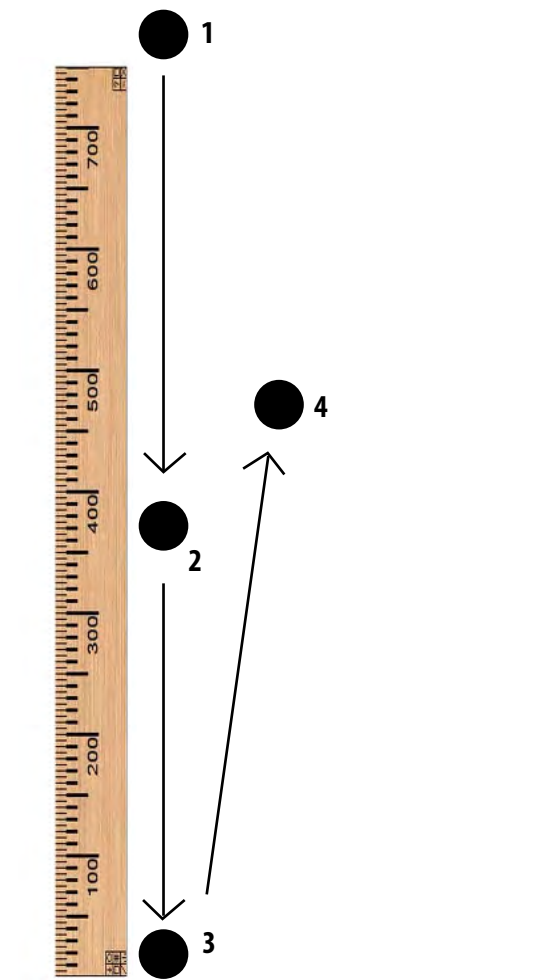
Station One Guide | *POTENTIAL AND KINETIC ENERGY*

- After two minutes, use tongs to remove Sphere 1 from the hot water. Place Sphere 2 into its cup of hot water. Restart the timer for two minutes.
- Drop Sphere 1 onto a hard surface from a height of one meter and record your data.
- Repeat two more times and record the data each time.
- After two minutes, use tongs to remove Sphere 2 from the hot water.
- Drop Sphere 2 onto a hard surface from a height of one meter and record your data.
- Repeat two more times with Sphere 2 and record the data each time.
- Calculate the averages for each sphere and record the data.

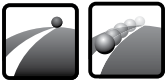
HOT WATER	TRIAL 1	TRIAL 2	TRIAL 3	AVERAGE
SPHERE 1				
SPHERE 2				

** Part One Conclusion

- Using your observations from the lab, add the terms kinetic and potential energy to the diagram below. Some spaces may have both terms.



- _____
- _____
- _____
- _____



Station One Guide | *POTENTIAL AND KINETIC ENERGY*

2. Explain how the hot water affected the kinetic energy of both spheres, using words or pictures.

Sphere 1:

Sphere 2:

3. The two spheres are made from two different types of rubber. The happy sphere is made of a type of rubber that transforms energy differently than the sad sphere. When it bounces, it does not squish as much as the sad sphere, and it bounces higher. Complete the following statement using information you recorded above.

I think that sphere number _____ is the happy sphere because _____

_____.

4. The sad sphere does not bounce as high because it is squishier than the happy sphere and cannot bounce as easily. Complete the following statement using information you recorded above.

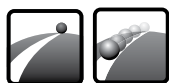
I think that sphere number _____ is the sad sphere because _____

_____.

5. Using your *Forms of Energy Cards*, show the energy transformations (in order) demonstrated in this lab. Write out the transformations below.

❖ Real World Application

If you were going to fall onto the gym floor, would you prefer the padding to be made of the happy sphere or sad sphere rubber? Use the information from the activity to explain your answer.



Station One Guide | *POTENTIAL AND KINETIC ENERGY*

Part Two: Toys

Caution

This activity uses a balloon made out of latex. If you have a latex allergy you should not handle the balloon.

Question

How does each toy demonstrate energy transformations?

Materials

- Toy car
- Balloon (see Caution above)
- Yo-yo
- Safety glasses

Vocabulary

- compress
- contract
- conversion
- elastic energy
- friction
- kinetic energy
- Law of Conservation of Energy
- motion energy
- potential energy

Section A: Toy Car

Hypothesis

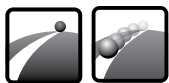
I think pushing down on the toy car and pulling it backwards will demonstrate the transformation of energy from _____ to _____.

Procedure

1. Push down on the top of the car, pull it backwards, and hold. Describe and record how it feels.
2. Release the car and observe what happens. Draw a picture of the car, showing its potential and kinetic energy.

POTENTIAL ENERGY	KINETIC ENERGY

3. Make certain each person in your group has a chance to participate and try both steps.



Station One Guide | *POTENTIAL AND KINETIC ENERGY*

** Conclusion

Using your *Forms of Energy Cards*, show the energy transformations (in order) demonstrated in this activity. Write out the transformations below.



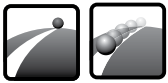
Hypothesis

✓ Procedure

2. Draw a picture of the yo-yo, showing when it has potential and kinetic energy.

POTENTIAL ENERGY	KINETIC ENERGY

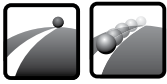
3. Make certain each person in your group has a chance to participate.



Station One Guide | *POTENTIAL AND KINETIC ENERGY*

**** Conclusion**

1. Using your *Forms of Energy Cards*, show the energy transformations (in order) demonstrated in this activity. Write out the transformations below.



Station One Guide | *POTENTIAL AND KINETIC ENERGY*

Section C: Balloon

Caution

Only one person per group should blow up the balloon to avoid spreading germs.

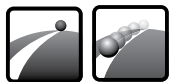
Hypothesis

I think releasing the inflated balloon will demonstrate the transformation of energy from _____
to _____.

Procedure

1. Give the balloon to one person in your group. Inflate the balloon and HOLD – don't let the air escape but DO NOT tie the balloon.
2. Holding the balloon, let each person in your group feel the inflated balloon. Describe and record how it feels.
3. Release the balloon and observe what happens. Draw a picture of the balloon, showing its potential and kinetic energy.

POTENTIAL ENERGY	KINETIC ENERGY



Station One Guide | *POTENTIAL AND KINETIC ENERGY*

** Conclusion

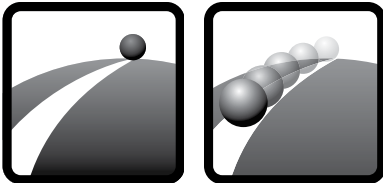
1. Using your *Forms of Energy Cards*, show the energy transformations (in order) demonstrated in this activity. Write out the transformations below.

** Part Two Conclusion

1. Think of ways you could change the amount of kinetic energy for each toy. Write out an example for each toy and test it out.

Station One: Read

Read the *Station One: What Was Happening?* article.



Station One: What Was Happening?

Part One: Spheres

What is potential energy? What is kinetic energy?

When an object is moving, it has kinetic energy. Energy that is stored and not being used is potential energy. When an object like a ball is held up high, and is not falling, it has gravitational potential energy. A rock at the top of a hill has gravitational potential energy. As it rolls down the hill, the gravitational potential energy transforms, or changes, into kinetic energy – the energy of motion.

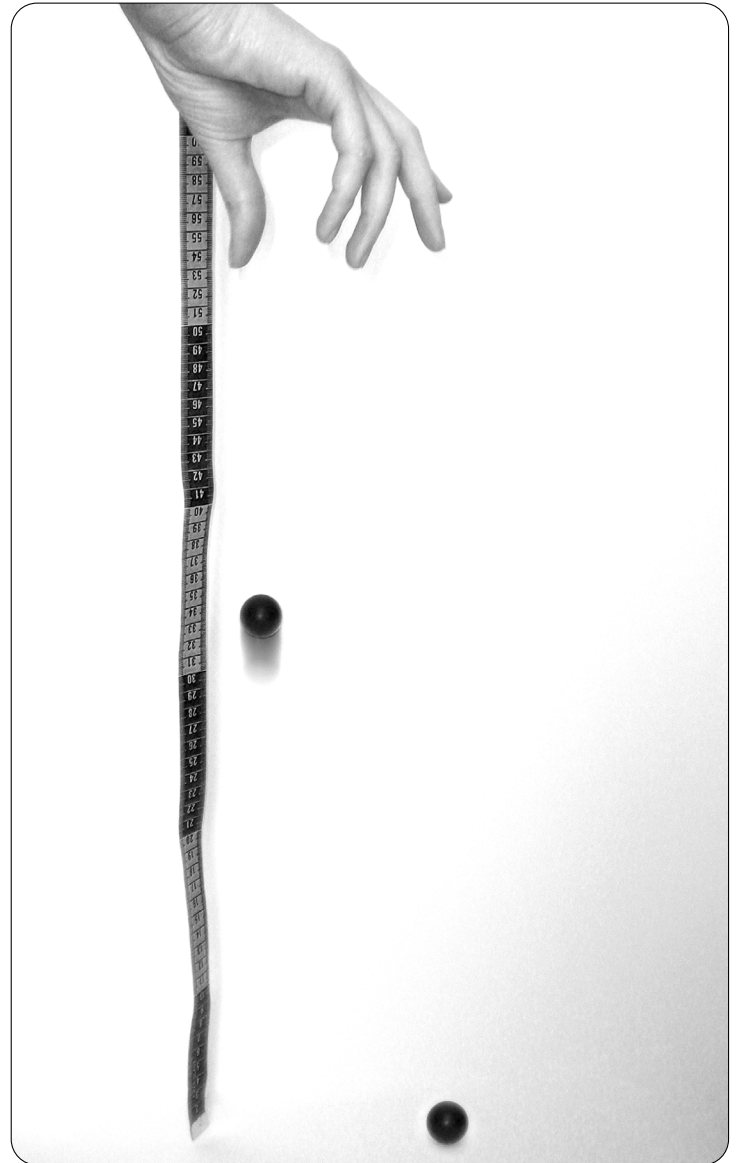
What is a transformation? What happens to the energy in the spheres?

When you drop or push a sphere, its potential energy changes to kinetic energy as it falls. The faster it moves, the more kinetic energy it has. When the sphere runs into something, there is a collision. A collision occurs when a moving object hits another object. If it stops completely, it has no more kinetic energy. All of the kinetic energy changes into other forms of energy. The Law of Conservation of Energy says that energy is neither created nor destroyed. The energy the sphere had when it was moving cannot just disappear. Where does it go?

The kinetic energy is converted into other forms of energy, like sound and heat. Usually, when there is a collision, an object doesn't stop completely. It rebounds, or bounces. This means it has not lost all of its kinetic energy. The sphere will continue bouncing after it is dropped until it changes all of its kinetic energy into other forms of energy. It will then sit still on the floor.

Why did the two spheres bounce differently?

The two spheres look the same, but they didn't bounce or behave the same. That tells you there is something different between them. The spheres are made of two different kinds of rubber. The happy sphere bounces because it is made from a harder rubber that doesn't squish easily. It does not let go of much energy or absorb much energy when the sphere collides with the floor. This is what allows it to bounce back. The sad sphere is made of a rubber that is able to squish easily. It lets go of a lot of its energy when it collides with the floor. The sad sphere doesn't have as much energy to rebound or bounce, unlike the happy sphere.



The happy sphere (left) keeps more of its energy, allowing it to rebound higher than the sad sphere (right). More of the energy in the sad sphere is transferred into heat and sound.

How did the hot water impact the rebound?

Heating the spheres causes thermal energy to be transferred into the spheres from the hot water. This changes how each sphere behaves when it is dropped. The sad sphere was able to absorb more energy from the water. This absorbed energy allowed it to rebound or bounce higher.

What energy transformations occurred?

These demonstrations showed us how potential energy is transformed into motion and how motion is transformed into sound and heat.

Part Two: Toys

These demonstrations explored potential and kinetic energy and how energy transforms from one form to another.

Toy Car

How did the toy car store energy?

The toy car has a spring in it. When you pushed down on the car and pulled it backwards, you transferred your kinetic energy by compressing the spring. When the car is released, the car starts to move. The elastic energy in the spring changed to motion.

Why did the car stop moving?

The car stopped because of friction and the transfer of energy in the spring. Friction changes some of the motion to heat and sound. The spring will return to its original shape and have no potential energy until it is stretched or compressed again.



Yo-Yo

How does the yo-yo store potential energy?

The yo-yo stores gravitational potential energy when it is held in your hand until it drops. When it drops, the yo-yo transforms the potential energy into motion.

Why doesn't the yo-yo return to your hand?

As the yo-yo travels towards the bottom it is rotating. That causes the yo-yo to want to move back upwards or rebound when it reaches the bottom. It does not come the whole way back to your hand. The yo-yo loses some of its energy to friction in the string, heat from the friction, and a tiny bit of sound. Can you hear it?



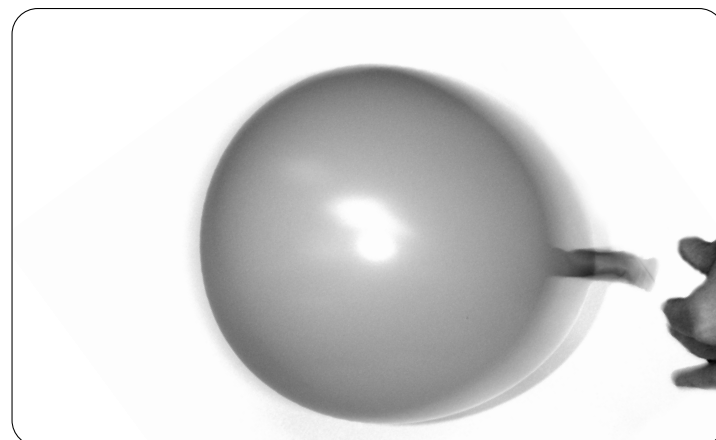
Balloon

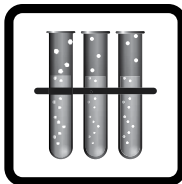
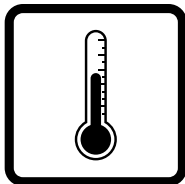
How does a balloon store energy?

When you blow up a balloon, you are using your kinetic energy to stretch the rubber, just like you used your energy to compress the spring in the toy car. Energy is stored in stretched rubber and compressed air instead of a compressed spring.

Where did the energy go when you let go of the balloon?

The potential energy was converted to motion, heat, and sound.





Station Two Guide

ENDOTHERMIC AND EXOTHERMIC PROCESSES

Part One: Baking Soda and Vinegar

Question

What happens to the temperature of vinegar when you add baking soda?

Hypothesis

I think the temperature will _____

Materials

- Baking soda
- Safety glasses
- Measuring cups
- Plastic bags
- Thermometer
- Vinegar
- Timer

Vocabulary

- chemical energy
- chemical reaction
- endothermic
- exothermic
- expand
- kinetic energy
- physical change
- potential energy
- temperature
- thermal energy

Procedure

1. Pour 10 mL of vinegar into an empty plastic bag.
2. Feel the bag. Observe and record how warm or cool the vinegar feels.
3. Place the thermometer in the bag. Make sure the bulb of the thermometer is in the solution.
4. Record the temperature of the vinegar. Leave the thermometer in the bag.
5. Carefully pour 10 cm³ of baking soda into the bag and gently mix. Be careful – the chemical reaction will cause foam to fill the bag.

NOTE: Milliliter (mL) is a liquid measurement and cubic centimeters (cm³) is a dry measurement. 1 mL = 1 cm³

6. Wait 30 seconds and record the temperature again.
7. Remove the thermometer from the bag and carefully seal the bag.
8. Feel the bag again and note how the temperature change feels. Record your observations.
9. Record and illustrate your observations in the data box on the next page.



Station Two Guide | *ENDOTHERMIC AND EXOTHERMIC PROCESSES*

Data

VINEGAR ONLY		VINEGAR + BAKING SODA (AFTER 30 SECONDS)
TEMPERATURE		
OBSERVATIONS AND ILLUSTRATIONS:		

** Part One Conclusion

1. An endothermic process uses heat. *Endo-* means in and *thermal* means heat. Endothermic – the heat goes in. An exothermic process gives off heat. *Exo-* means out and *thermal* means heat. Exothermic – the heat goes out. Which of these two types of chemical processes did you observe in the baking soda and vinegar?
2. Explain how you know the process is endothermic or exothermic using your data.



Station Two Guide | *ENDOTHERMIC AND EXOTHERMIC PROCESSES*

3. Using your *Forms of Energy Cards*, show the energy transformations (in order) demonstrated in this activity. Write out the transformations below.



Station Two Guide | *ENDOTHERMIC AND EXOTHERMIC PROCESSES*

Part Two: Calcium Chloride and Water

Question

What happens to the temperature of water when you add calcium chloride?

Hypothesis

I think the temperature will _____.

Materials

- Calcium chloride
- Measuring cup
- Safety glasses
- Plastic bags
- Thermometer
- Water
- Timer or clock

Vocabulary

- chemical energy
- chemical reaction
- dissolve
- endothermic
- exothermic
- potential energy
- temperature
- thermal energy

Procedure

1. Pour 10 mL of water into an empty plastic bag.
 2. Feel the bag and record your observations.
 3. Place the thermometer in the bag. Make sure the bulb of the thermometer is in the water.
 4. Record the temperature of the water. Leave the thermometer in the bag.
 5. Carefully pour 4 cm³ of calcium chloride into the water and gently mix.
- NOTE:** Milliliter (mL) is a liquid measurement and cubic centimeters (cm³) is a dry measurement. 1 mL = 1 cm³
6. Wait 30 seconds and record the temperature again.
 7. Remove the thermometer from the bag and carefully seal the bag.
 8. Feel the bag again and note any changes in the temperature.
 9. Record and illustrate your observations in the data box on the next page.



Station Two Guide | *ENDOTHERMIC AND EXOTHERMIC PROCESSES*

Data

WATER		WATER + CALCIUM CHLORIDE (AFTER 30 SECONDS)
TEMPERATURE		
OBSERVATIONS AND ILLUSTRATIONS:		

** Part Two Conclusion

1. An endothermic process uses heat. *Endo-* means in and *thermal* means heat. Endothermic – the heat goes in. An exothermic process gives off heat. *Exo-* means out and *thermal* means heat. Exothermic – the heat goes out. Which of these two types of chemical processes did you observe in the calcium chloride and water?
2. Explain how you know the process is endothermic or exothermic using your data.



Station Two Guide | *ENDOTHERMIC AND EXOTHERMIC PROCESSES*

3. Using your *Forms of Energy Cards*, show the energy transformations (in order) demonstrated in this activity. Write out the transformations below.

**** Real World Application**

Some places that receive snow in the winter use calcium chloride on the roads. Using what you learned in this activity, explain why these places might use this material during cold months.



Station Two Guide | *ENDOTHERMIC AND EXOTHERMIC PROCESSES*

Part Three: Hand Warmers

Question

What happens to the temperature of iron pieces in a hand warmer when you expose it to oxygen in the air?

Hypothesis

I think _____.

Materials

- Safety glasses
- Hand warmers
- Plastic bags
- Scissors
- Thermometer
- Sealed plastic bag of iron oxide (old packet)
- Timer or clock

Vocabulary

- chemical change
- chemical energy
- chemical reaction
- endothermic
- exothermic
- iron oxide
- thermal energy

Procedure

Section A (New Packet)

1. Remove a hand warmer from the plastic wrap.
2. Cut open the cloth hand warmer packet and pour the contents of the hand warmer into an empty plastic bag. This will be called the 'new packet'.
3. Record your observations.
4. Record the temperature on your data table and record your start time.
5. Leave the bag open for three minutes.
6. After three minutes, check and record the temperature and time.
7. Seal the bag with the thermometer inside.
8. After three more minutes, check the temperature again (without opening the bag). Record the temperature and time.

Data

OBSERVATIONS: NEW PACKET



Station Two Guide | *ENDOTHERMIC AND EXOTHERMIC PROCESSES*

NEW PACKET	OPEN BAG	SEALED BAG	
TIME	STARTING: _____	AFTER 3 MINUTES: _____	AFTER 3 MORE MINUTES: _____
TEMPERATURE			

Section B (Old Packet)

1. Observe the 'old packet' of powdered iron and record your observations.
2. Touch the bag and observe how the temperature feels to the touch.
3. Put a thermometer in the bag and record the temperature.

Data

OBSERVATIONS: OLD PACKET

OLD PACKET TEMPERATURE	
------------------------	--

** Part Three Conclusion

1. What happens to iron when it is exposed to oxygen?
2. Does this activity show an endothermic process or an exothermic process? Explain how you know.
3. Does this activity show a chemical change or physical change? Use any data you collected to support your answer.
4. Why do you think the hand warmer is full of powdered iron instead of one large piece of iron?

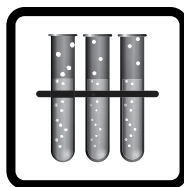
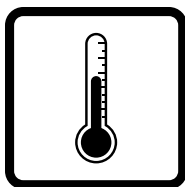


Station Two Guide | *ENDOTHERMIC AND EXOTHERMIC PROCESSES*

5. Using your *Forms of Energy Cards*, show the energy transformations (in order) demonstrated in this activity. Write out the transformations below.

Station Two: Read

Read the *Station Two: What Was Happening?* article.



Station Two: What Was Happening?

ENDOTHERMIC AND EXOTHERMIC PROCESSES

Most items we use on a daily basis are called chemicals. These chemicals can go through a change in what we call a chemical process. Some processes change the substance into something new – a chemical change. Some do not. Chemical reactions are processes that form new substances through a chemical change. Some signs that a chemical reaction has occurred include a temperature change, color change, gas bubbles forming, a solid forming, or the release of energy - like heat or light. All chemical reactions involve the transfer of energy.

Some processes are not chemical reactions. Physical changes are changes to substances that keep the items as the same old substance. When you add heat to a pot of water and make steam, the steam is still made of water. This is a physical change. Some physical changes involve the transfer of energy, too.

Station Two showed you some processes that release or absorb thermal energy – they get hotter or colder.

Part One: Baking Soda and Vinegar

How do you know a chemical reaction occurred in the baking soda and vinegar experiment?

When the baking soda was added to the vinegar, the temperature decreased. Also, bubbles of gas were formed that hadn't been there before. This was the foaming you saw inside the bag. A temperature change and the appearance of a new gas tell us that a chemical reaction was occurring.

What energy transformation occurred?

Mixing baking soda and vinegar absorbed thermal energy. When things feel cold, it is because they are pulling the heat from our fingers. The bag felt colder after the reaction, and the temperature went down. We know the chemical reaction pulled thermal energy in. Because the thermal energy was pulled in, this is called an endothermic reaction. The thermal energy was changed into energy stored in the chemical bonds of the new substances formed, called chemical energy.



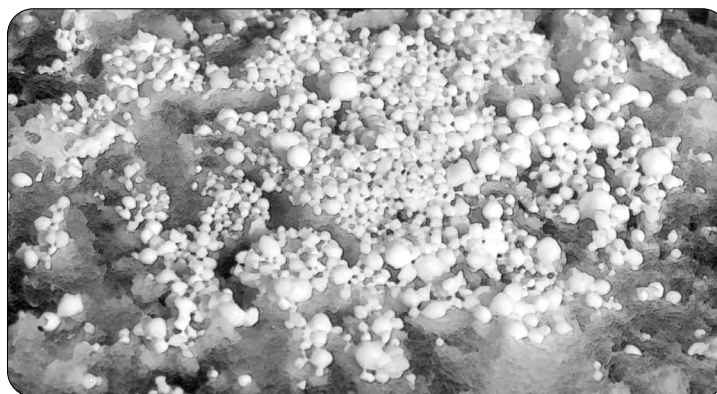
An endothermic reaction occurred when you combined vinegar and baking soda.

Part Two: Calcium Chloride and Water

What happened when calcium chloride and water were combined?

Mixing calcium chloride into water is similar to dissolving sugar in water. The two substances don't react or form new substances, they just mix. This is an example of a physical change. The calcium chloride and water looked different, but they didn't make new substances.

However, when you mixed the calcium chloride and the water, it got much warmer. When calcium chloride is mixed into water, it releases a lot of thermal energy, and feels very hot. We call this process an exothermic process because heat moves out and warms your fingers.



Calcium chloride (the small, round spheres) is commonly used to melt ice on driveways and sidewalks.

What energy transformations occurred?

Even though this isn't a chemical reaction, the process does show how chemical energy can be used to transfer thermal energy.

Part Three: Hand Warmers

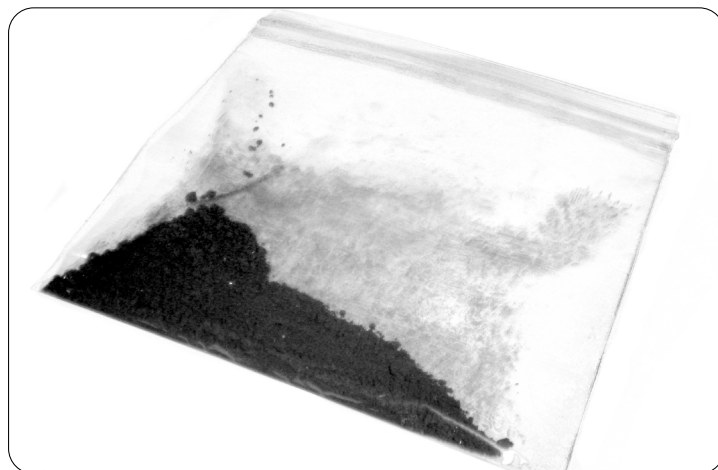
What happened when the hand warmer was exposed to oxygen in the air?

The hand warmer contains tiny pieces of iron. This powdered iron reacts with the oxygen in the air to form rust. Usually, iron rusts very, very slowly. The packet from the hand warmer also contains salt, charcoal, and a few other things, that help it react with oxygen much faster than usual. These items speed up the rusting process and energy is released faster, too. You could feel the temperature change. If the new packet was left open for a week or two, it would eventually look like the contents of the old packet – rusty and crumbly. We know a chemical reaction occurs because the contents change color and behave differently by being crumbly. This tells us that a new substance has formed.

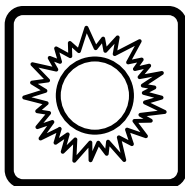
Iron typically rusts slowly because it is also usually in larger pieces. The iron filings in the handwarmer are very tiny. More of the surfaces of the iron are exposed to oxygen with these tiny pieces than with a larger piece. This allows the rusting to happen more quickly.

What energy transformations occurred?

Just like the baking soda and vinegar, we saw a new substance (rust) form where it was not before, and the temperature changed. However, unlike the baking soda and vinegar, the temperature went up instead of down. This tells us that the energy is moving from the chemical reaction to our hands, and the chemical energy in the iron and oxygen is being changed to thermal energy, which heats our fingers. This is an exothermic process.



When exposed to oxygen and water vapor, iron will turn into iron oxide.



Station Three Guide

RADIANT ENERGY TRANSFORMATIONS

Part One: Sunlight and Shade

Question

How does direct sunlight affect the temperature of an object?

Hypothesis

I think a thermometer placed in the light will _____.

I think a thermometer placed in the shade will _____.

Materials

- 2 Thermometers
- Sunlight or light source (using incandescent or halogen bulb)
- Safety glasses

Vocabulary

- absorb
- radiant energy
- thermal energy
- transform

Procedure

1. Place one thermometer in direct light and the other in the shade.
2. Label one "sunny" and the other "shade".
3. Record the starting temperature of both thermometers.
4. Record the temperature on both thermometers in your data table every three minutes.

Data

	STARTING TEMPERATURE	3 MINUTES	6 MINUTES	TOTAL TEMPERATURE CHANGE
THERMOMETER IN DIRECT LIGHT				
THERMOMETER IN SHADE				

Part One Conclusion

1. On a hot day, would you prefer to sit in the sun or in the shade? Why?

2. Other than in the refrigerator, where in the kitchen would be the best place to store a bag of chocolate? Why?



Station Three Guide | *RADIANT ENERGY TRANSFORMATIONS*

3. Using your *Forms of Energy Cards*, show the energy transformations (in order) demonstrated in this activity. Write out the transformations below.



Station Three Guide | *RADIANT ENERGY TRANSFORMATIONS*

Part Two: Radiant Energy and Color

Question

How does color affect a radiant energy transformation?

Hypothesis

I think the thermometer on the white paper will _____

I think the thermometer on the black paper will _____

Materials

- Radiometer
- Light source (bright sunlight, clamp light, flashlight, sun, etc.)
- Safety glasses
- Piece of black paper
- Piece of white paper
- Two thermometers
- Ruler

Vocabulary

- absorb
- expand
- molecule
- motion energy
- radiant energy
- reflect
- thermal energy
- transform

Procedure

1. Place one thermometer on the black paper.
2. Place the other thermometer on the white paper.
3. Record the temperature of each thermometer.
4. Place the two thermometers on their papers about 20-30 cm from a bright light.
5. Wait five minutes and record the temperatures. Calculate the total temperature change.

Data

	STARTING TEMPERATURE	TEMPERATURE AFTER 5 MINUTES	TOTAL TEMPERATURE CHANGE
BLACK PAPER			
WHITE PAPER			

6. Observe the radiometer. What color are the vanes?

7. Place the radiometer in direct light. What do you observe?



1. Would a white or black shirt keep you cooler in the summer? Using your data, explain your answer.

3. Using your *Forms of Energy Cards*, show the energy transformations (in order) demonstrated in this activity. Write out the transformations below.



Station Three Guide | *RADIANT ENERGY TRANSFORMATIONS*

Part Three: Solar Panel

🔍 Questions

How is the solar panel affected by radiant energy? What can a solar panel do with solar energy?

☀️ Hypothesis

I think radiant energy shining on the solar panel will cause the motor to _____.

📄 Materials

- Solar panel with motor, fan, and disks
- Light source (bright sunlight, clamp light, etc.)
- Safety glasses

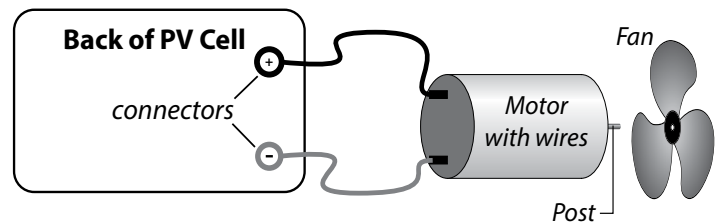
🗉 Vocabulary

- absorb
- electrical energy
- kinetic energy
- photovoltaic
- radiant energy
- solar panel
- transform

✓ Procedure

NOTE: If the solar panel is not already assembled, ask your teacher for help.

1. Place the solar panel in a strong light source. Record your observations in words or pictures.



OBSERVATIONS: SOLAR PANEL

2. Explore ways to change the speed of the fan without touching the fan. Record at least two strategies.

STRATEGIES:

1.

2.



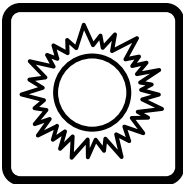
Station Three Guide | *RADIANT ENERGY TRANSFORMATIONS*

*** Part Three Conclusion

1. Why do solar powered calculators also have a battery?
2. Using your *Forms of Energy Cards*, show the energy transformations (in order) demonstrated in this activity. Write out the transformations below.

Station Three: Read

Read the *Station Three: What Was Happening?* article.



Station Three: What Was Happening?

RADIANT ENERGY TRANSFORMATIONS

Part One: Sunlight and Shade

Why do you feel hotter in direct sunlight and cooler in the shade?

On a hot day, you often feel hotter when you are in the sun than when you are in the shade. When you are in the sun, the sun's radiant energy is absorbed by your body and transformed to thermal energy, making you feel hotter. People wear lighter clothing on hot days because lighter clothing helps them to reflect more light and stay cool. Dark clothes absorb light and make them feel hotter.

What happens to a thermometer when it is placed in direct sunlight?

The thermometer facing the light has a higher temperature because the sun's radiant energy is being transformed into thermal energy.

Part Two: Radiant Energy and Color

How does radiant energy make things move?

Did you know that radiant energy can make things move? When you put the radiometer in the light, the vanes began to turn. Black objects get hotter than white objects in the sun. A black object absorbs most of the radiant energy that strikes it and reflects only a little. A white object reflects most of the radiant energy that strikes it and absorbs only a little.

When the black vanes get warmer in the radiometer, so do the air molecules next to them. Molecules in solids just wiggle in place, but molecules in gases, like air, move around all over the place and bump into each other and their containers. If the molecules get warmer, they move around more and bump into things more. When the black vanes get hotter on the radiometer, the air molecules near them also get hotter. These molecules bump into the black vanes and give the black vanes a little push. A lot of air molecules pushing against the vanes make them move, and the radiometer will spin.

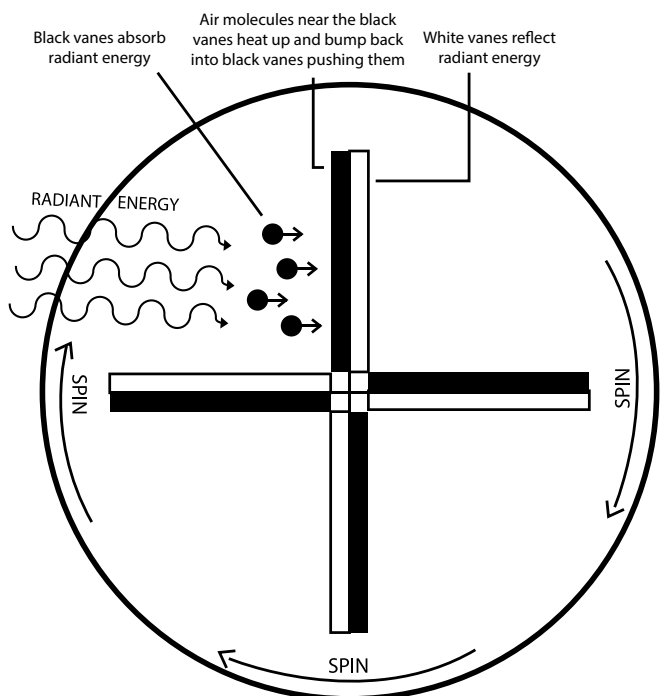
How is radiant energy transformed?

Radiant energy can be transformed very easily into thermal energy and makes us feel hot. In fact, this transformation of radiant energy from the sun into thermal energy is what keeps us, and all other organisms, alive on Earth. Without this transformation, it would be too cold for even penguins and polar bears to survive.



Which person do you think feels cooler?

Top View of Radiometer



When the air molecules hit the white sides of the vanes, they push a little. When the air molecules hit the black sides of the vanes, they push a lot. Since there is more of a push on one side than the other, the vanes begin to turn.

Part Three: Solar Panel

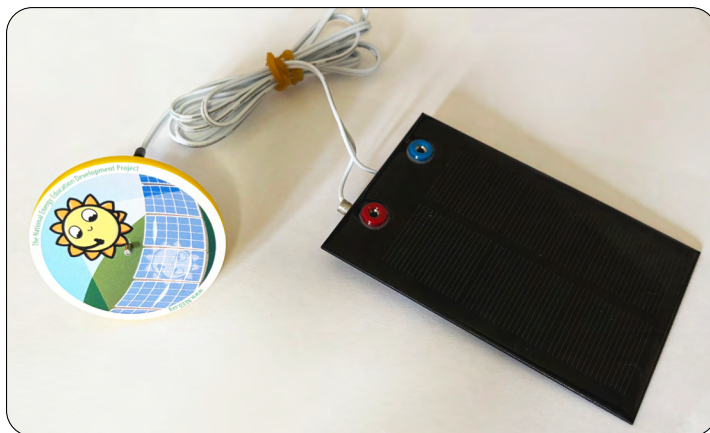
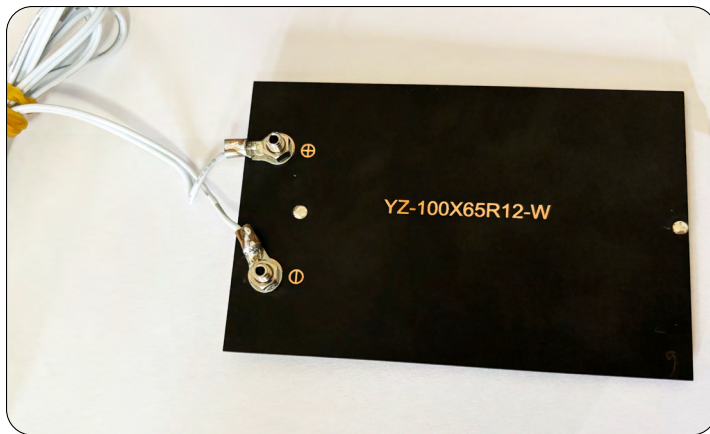
How can a solar panel power everyday items?

You have probably seen solar calculators or solar toys that use light to produce electricity. In this investigation you saw radiant energy converted into electrical energy, then into motion energy.

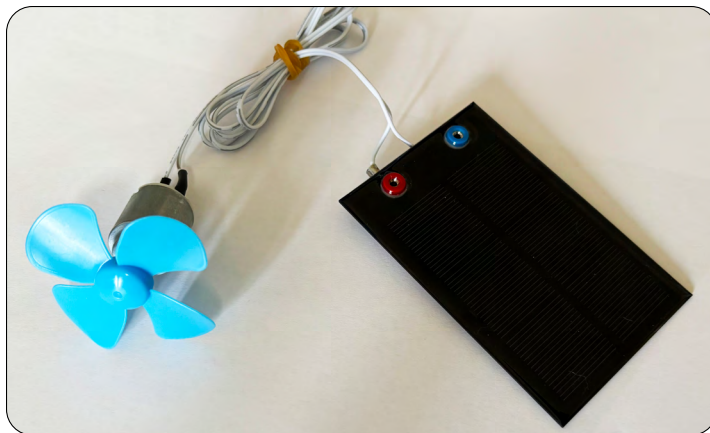
When light strikes the solar panel, an electric current is produced instantly. The motor then transforms the electrical energy into motion energy, which you saw in the movement of the fan.

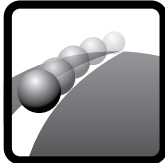
A larger solar panel has the ability to produce more electricity. The amount of radiant energy available will also affect the amount of electricity produced.

Solar panels are used for many things that need electricity. They can be mounted on homes or businesses or used by power companies. Solar panels are excellent for items that are far away from a power source. However, solar powered items often need a backup source of power for when the sun isn't shining.



A solar panel is made of lots of photovoltaic cells, connected together. Photo means light and volt is a measure of electricity.





Station Four Guide

THERMAL ENERGY AND MOTION ENERGY

Part One: Hands and Paper Clips

Questions

What energy transformations take place when you rub your hands together and bend paper clips?

Hypothesis

I think _____.

Materials

- Large, smooth paper clip
- Safety glasses

Vocabulary

- conversion
- friction
- molecule
- motion energy
- thermal energy

Procedure

1. Put your hands on your cheeks. Notice how your hands feel.
2. Now rub your hands together rapidly for 10 seconds. Place your hands back on your cheeks.
3. Now pick up a paper clip. How would you show the same transformation with a paper clip? Write down what you would do in the box below. Test it out. Do you see and feel the same forms of energy? Record your observations.

TEST:

OBSERVATIONS:



Station Four Guide | *THERMAL ENERGY AND MOTION ENERGY*

** Part One Conclusion

1. What forms of energy are transforming when you rub your hands together?
2. Would the winning team or the losing team notice more friction in a game of tug-of-war? Explain.
3. Using your *Forms of Energy Cards*, show the energy transformations (in order) demonstrated in this activity. Write out the transformations below.



Station Four Guide | *THERMAL ENERGY AND MOTION ENERGY*

Part Two: The Rubber Band

Cautions

- Safety glasses are very important for this exploration.
- Rubber bands can be made from latex. If you have a latex allergy, do not handle the rubber bands.

Question

What energy transformations take place when you stretch and release a rubber band multiple times?

Hypothesis

I think _____
_____.

Materials

- 1 Large rubber band
- Safety glasses

Vocabulary

- absorb
- contract
- convert
- expand
- thermal energy

Procedure

1. Put on your safety glasses. Hold the rubber band firmly with your index fingers inside the ends of the rubber band and your thumbs on the outside.
2. Place the rubber band flat against your forehead. While keeping it against your forehead, quickly stretch the rubber band to twice its original length. Hold for three seconds.
3. Repeat step 2 three times.
4. Record your observations.

OBSERVATIONS:



Station Four Guide | *THERMAL ENERGY AND MOTION ENERGY*

* ** **Part Two Conclusion**

1. Using your *Forms of Energy Cards*, show the energy transformations (in order) demonstrated in this activity. Write out the transformations below.



⚠ Caution

Question

Hypothesis

Materials

- ## Vocabulary

- absorb
- alloy
- kinetic energy
- potential energy
- reaction
- thermal energy
- titanium

✓ Procedure

- | ORIGINAL SHAPE | TWISTED, NEW SHAPE | AFTER PLACING IN HOT WATER |
|----------------|--------------------|----------------------------|
| | | |

**** Part Three Conclusion**

1. Using your *Forms of Energy Cards*, show the energy transformations (in order) demonstrated in this activity. Write out the transformations below.



Station Four Guide | *THERMAL ENERGY AND MOTION ENERGY*

Part Four: The Bi-Metal Bar

Question

How does thermal energy affect the bi-metal bar?

Hypothesis

I think _____.

Materials

- Bi-metal bar
- Candle
- Matches
- Safety glasses
- Cup of ice water

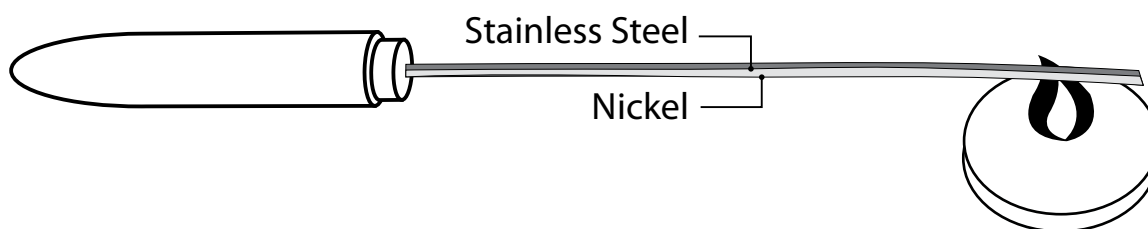
Vocabulary

- absorb
- kinetic energy
- molecules
- potential energy
- thermal energy

Procedure

1. Look at the bi-metal bar. Illustrate your observations in the box on the next page.
2. With help from an adult, light your candle.
3. Carefully hold the bi-metal bar sideways in the flame of the candle, as shown in the diagram. Record your observations.
4. Remove the bar from the flame, but do not touch the bar. Place the bar into the cup of ice water for 10 -15 seconds and observe what happens. Record your observations.

Bi-Metal Bar





Station Four Guide | *THERMAL ENERGY AND MOTION ENERGY*

Data

BI-METAL BAR

BI-METAL BAR IN FLAME

BI-METAL BAR AFTER 10-15 SECONDS IN ICE WATER



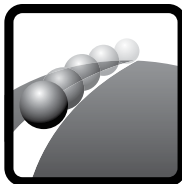
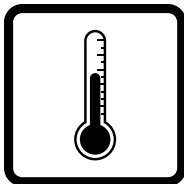
Station Four Guide | *THERMAL ENERGY AND MOTION ENERGY*

** Part Four Conclusion

1. Using your *Forms of Energy Cards*, show the energy transformations (in order) demonstrated in this activity. Write out the transformations below.

Station Four: Read

Read the *Station Four: What Was Happening?* article.



Station Four: What Was Happening?

THERMAL ENERGY AND MOTION ENERGY

Part One: Hands and Paper Clips

Friction is the force pushing against moving objects. Friction can come from something sliding across the floor, wheels rolling on the street, or even a jet airliner moving through the air. The more something moves against another material, the more friction an object feels. Moving faster will create more friction. Larger, heavier objects will feel more friction than smaller or lighter ones.

What affect does friction have on temperature?

What happened when you rubbed your hands together? They experienced friction from each other, and felt warmer. The friction comes from the skin of your left hand rubbing on the skin of your right hand. Friction makes things get hotter.

What happened with the paper clip? If you bent it back and forth, you felt the paper clip get really hot where it was bending. Even though you weren't rubbing the paper clip with anything, there was still friction inside the paper clip. Metal atoms were rubbing on each other as the paper clip was bent.

What energy transformations were occurring?

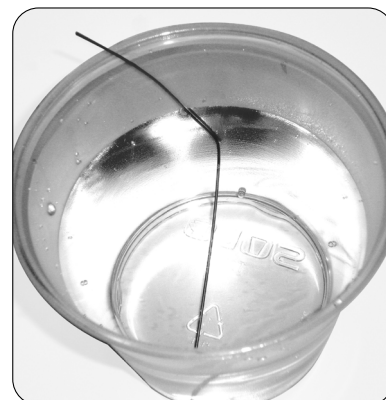
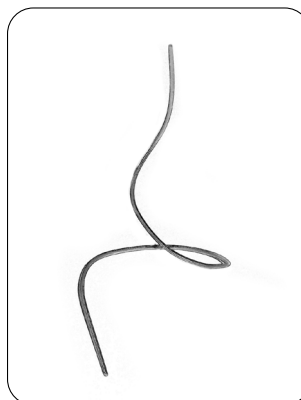
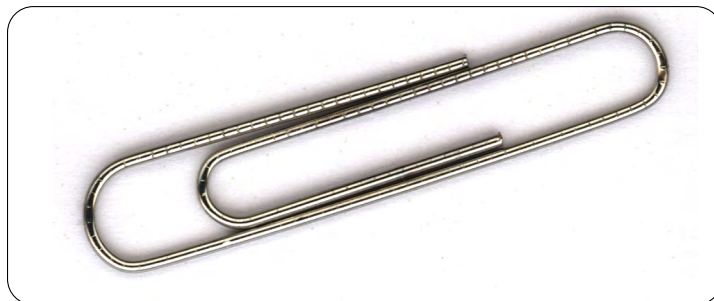
When you rubbed your hands together, and when you bent the paper clip, they were moving and experiencing friction forces. The friction caused some of the motion energy to change into thermal energy. Your hands and the paper clip got warmer.

Part Two: The Rubber Band

How can stretching and contracting a material change its temperature?

This experiment shows an energy transformation that released and absorbed energy.

When you quickly stretched the rubber band against your forehead, and when you let it contract, what did you feel? When you stretched the rubber band it felt warmer and when you let it contract it should have felt cooler. Stretching and contracting a material like the rubber in the rubber band will cause energy changes. Stretching it causes the molecules in the band to stretch out and to release thermal energy. Letting it contract causes them to move closer and absorb thermal energy.



Left: The nitinol wire is bent and twisted before being placed in hot water.

Right: Thermal energy is transformed into motion as the nitinol wire is placed in hot water, causing it to return to its original shape.

This same thing happens to materials other than rubber bands. When your muscles are not warmed up, it may be harder to get them moving. Once they are warmed up, they can expand and contract more easily to do work, like running and kicking a ball.

Part Three: The Live Wire

How is the live wire affected by temperature?

The live wire is made of a mixture of metals, called an alloy. The alloy in the live wire is called nitinol (nī-tīn-ōl). It is a mixture of nickel and titanium. Nitinol is special because its atoms remember how they are arranged and the wire will "remember" its shape.

When it is heated to a certain temperature, the wire goes back into its original shape. You could bend the wire into curlicues, circles, wavy shapes, and as long as it could move freely, the wire would straighten itself out when you put it in warm water.

Nitinol wire has many uses. It can be used on robot arms in space, for braces on teeth, and keeping greenhouses cool. If a greenhouse gets too hot, the nitinol springs a window or vent open. Hot air can rise up and out of the greenhouse, lowering the temperature.

What energy transformations occurred?

The atoms in the live wire are vibrating in place a little bit. They are unable to move around freely. If the wire is bent, and kept cool, the atoms do not have enough energy to move back into place. Placing the wire in warm water gives the atoms enough energy to return the wire to its original straight shape. The nitinol wire transforms thermal energy into motion energy.

Part Four: The Bi-Metal Bar

How is the bi-metal bar affected by temperature?

When solid objects are heated, they expand. Some objects expand more than others. Bridges and sidewalks are built with gaps between them. The gaps allow them to expand in hot weather and contract in cold weather without damage. The bi-metal bar also expands when it is heated, but it is different from the iron beams used to build bridges. The bi-metal bar is a sandwich of two metals, stainless steel and nickel.

Different materials expand or stretch different amounts. When you placed the bi-metal bar in the candle flame, what happened? The temperature of the bar increased. One metal expanded more with the temperature going up. This caused the bar to bend. When you placed the hot bi-metal bar in the cold water, it straightened out because the two metals also contracted differently – one contracted more than the other and bent the bar back.



The stainless steel expands more than nickel when hot. It also contracts more than nickel when cool. When you heated a small portion of the bi-metal bar, the side with the stainless steel stretched more than the side with the nickel, and it bent the bar. When the bar was cooled, it straightened out because the stainless steel contracted more than the nickel.

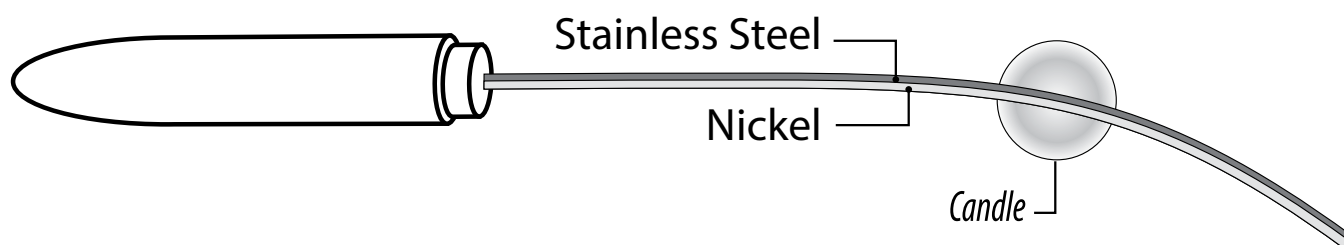
Blinking holiday lights work the same way. The metal in the blinker bulb gets hot from the electricity and bends, turning the electricity flow off. When it cools it straightens back out and electricity flows back through the metal again. This happens over and over to make the light twinkle. The next time you hang holiday lights that blink, try to find the bulb that has the bi-metal strip inside that causes the blinking.

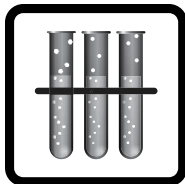
What energy transformations occurred?

Thermal energy in the candle flame was absorbed by the bi-metal bar and made the metals in the bi-metal bar expand and move.

Why the Bi-Metal Bar Bends

Metals expand at different rates when heated, causing the bi-metal bar to bend when placed over the flame.





Station Five Guide

CHEMICAL ENERGY

Part One: Glow Sticks

🔍 Question

How is chemical energy in the glow stick affected by thermal energy in hot and cold water?

💡 Hypothesis

I think the chemical energy in the glow stick will make the glow stick _____ when it is snapped.

I think the thermal energy of the hot water will make the glow stick _____.

I think the thermal energy of the cold water will make the glow stick _____.

📋 Materials

- 1 Unbroken glow stick (will remain unbroken)
- 2 Glow sticks of the same color (will be 'cracked')
- 1 Cup of hot water
- 1 Cup of ice water
- Colored pencils (optional)

📖 Vocabulary

- | | |
|---------------------|------------------|
| ▪ chemical energy | ▪ radiant energy |
| ▪ chemical reaction | ▪ reaction |
| ▪ convert | ▪ thermal energy |
| ▪ molecule | |

✓ Procedure

1. Look at an unused glow stick carefully. Record and illustrate your observations. What do you see inside the glow stick?

ILLUSTRATIONS AND OBSERVATIONS:



Station Five Guide | *CHEMICAL ENERGY*

2. Bend the other two glow sticks until the inside container cracks. Record or illustrate what the glow sticks look like now.

ILLUSTRATIONS AND OBSERVATIONS:

3. Place one cracked glow stick in the ice water.
4. Place the other cracked glow stick in the hot water.
5. Wait a minute or two. Record or illustrate your observations.

ILLUSTRATIONS AND OBSERVATIONS:



Station Five Guide | *CHEMICAL ENERGY*

*** Part One Conclusion

1. Referring to your observations, how did thermal energy affect the chemical energy in the glow sticks?

2. Using your *Forms of Energy Cards*, show the energy transformations (in order) demonstrated in this activity. Write out the transformations below.



Station Five Guide | *CHEMICAL ENERGY*

Part Two: The Apple Battery

Question

How will an apple produce electricity with different metals?

Hypothesis

(Use the words **a lot**, **a little**, or **no** to complete the statements below)

- I think the apple will produce _____ electricity when the large nail and thick copper wire are pushed into the apple 2 cm.
- I think the apple will produce _____ electricity when the large nail and thick copper wire are pushed into the apple 4 cm.
- I think the apple will produce _____ electricity when the large nail and thick copper wire are touching inside the apple.

Materials

- 1 Small nail
- 1 Large nail
- 1 Tin wire
- 1 Thick copper wire
- 1 Thin copper wire
- 1 DC microammeter
- Ruler
- 1 Apple
- 2 Alligator clips
- Permanent marker
- Safety glasses

Vocabulary

- absorb
- chemical energy
- circuit
- conduct
- conversion
- current
- electricity
- energy flow
- transform

Procedure

1. Use the ruler and permanent marker to make marks at 2 cm and 4 cm on one end of each nail and wire.
2. Insert the large nail and thick copper wire into the apple to the 2 cm mark. (Do not let the ends of the metals touch.)
3. Attach the end of one alligator clip to the positive (red) terminal of the microammeter, and the other end of the clip to the thick copper wire.
4. Attach one end of the second alligator clip to the negative (black) terminal of the microammeter, and the other end to the nail. Draw what you see.

DRAW OBSERVATIONS:



Station Five Guide | *CHEMICAL ENERGY*

- Record the reading on the microammeter in your data table.
- Push the nail and the wire into the apple to the 4 cm mark. Record the reading on the microammeter into your data table.
- Push the nail and the wire into the apple so the ends are touching. Record observations.
- Remove the thick copper wire and replace it with a thin copper wire.
- Reattach the alligator clips and repeat steps 5-7.
- Remove the large nail and replace it with a small nail.
- Reattach the alligator clips and repeat steps 5-7.
- Go back to your drawing at step 4 and include arrows to show the flow of the electric current.
- Try a combination of metals and distances you have not tried yet. Record the reading in the data table.

Data

(record the number with the micro amps as seen on the microammeter)

LARGE NAIL AND THICK COPPER WIRE		LARGE NAIL AND THIN COPPER WIRE	SMALL NAIL AND THIN COPPER WIRE
2 cm			
4 cm			
METALS TOUCHING			
COMBINATION OF METALS		MICROAMMETER READING	
2 COPPER WIRES			
2 NAILS			
YOUR CHOICE			

** Part Two Conclusion

- How did you know the direction of the flow of electricity?
- Which combinations of metals produced the most electricity? Which produced the least? Why?



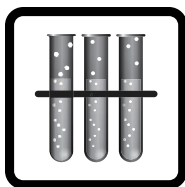
Station Five Guide | *CHEMICAL ENERGY*

3. Which foods do you think would work as well or better than an apple to make a battery?

4. Using your *Forms of Energy Cards*, show the energy transformations (in order) demonstrated in this activity. Write out the transformations below.

Station Five: Read

Read the *Station Five: What Was Happening?* article.



Station Five: What Was Happening?

CHEMICAL ENERGY

Part One: Glow Sticks

What is in a glow stick?

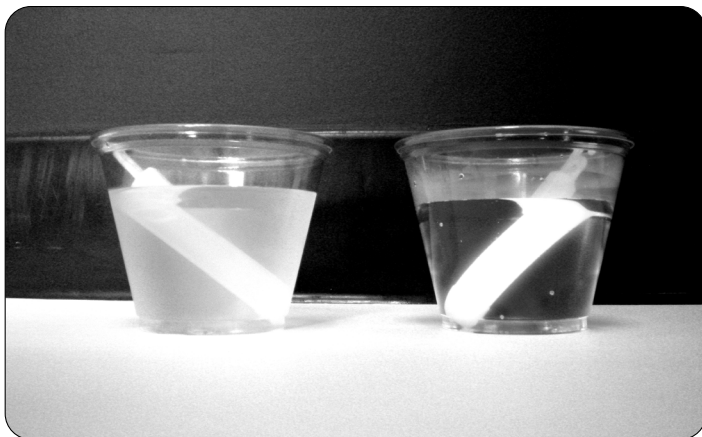
The glow sticks are filled with a chemical compound and a fluorescent dye. Inside the glow stick you can see a small container. This container contains a different compound called hydrogen peroxide. The two chemicals do not touch each other until the inside container is broken to let them mix.

What is chemical energy?

Chemical energy is the energy stored in the bonds between molecules. In the glow sticks there is a certain amount of energy used to keep the compounds together. When you break the inside container, the chemicals mix together to form new chemicals. These new chemicals use less energy to hold the compounds together. The remaining energy is released as light.

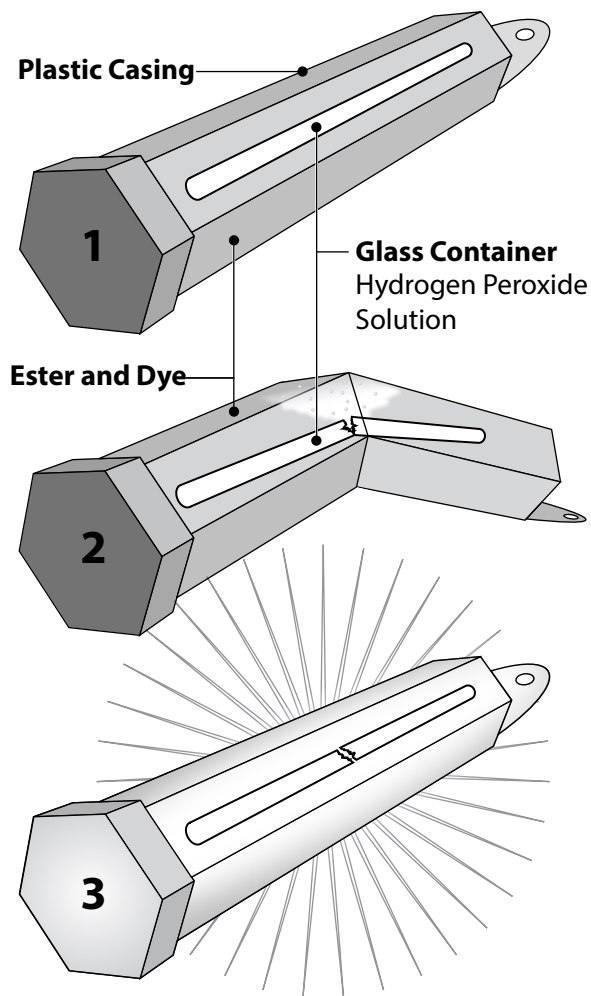
What energy transformations do we see?

The chemical energy transforms to radiant energy. We placed one glow stick in cold water. The cold water absorbed some of the heat energy from the glow stick, which slowed down the reaction. The glow stick then was not as bright. We placed one glow stick in hot water. The glow stick absorbed some of the heat energy from the hot water. The added energy made the chemicals react faster, producing more light.



The glow stick in the hot water (right) glows brighter than the glow stick in the cold water (left) because the higher temperature increases the speed of the chemical reaction.

How a Glow Stick Works



1. The glow stick is filled with a chemical compound called an ester and dye. Inside, a small glass container is filled with hydrogen peroxide.
2. When the glow stick is bent and the container is broken, the chemicals from the ampule and the glow stick mix, causing a chemical reaction.
3. During the chemical reaction, energy is released as light.

Part Two: The Apple Battery

Where do we see chemical energy in the apple battery?

The juice in the apple contains a type of acid called malic acid. Nails are often made of steel. This steel is coated in a metal like zinc to keep it from rusting. When the zinc on the nail and the copper wire were pushed into the apple, chemical reactions took place. These reactions allowed the electrons to move freely through the juice.

What is electrical energy?

Electrical energy is the movement of electrons. Lightning and electricity are examples.

What is a circuit?

A circuit is a path that an electric current can follow.

How do electrons flow in the apple battery?

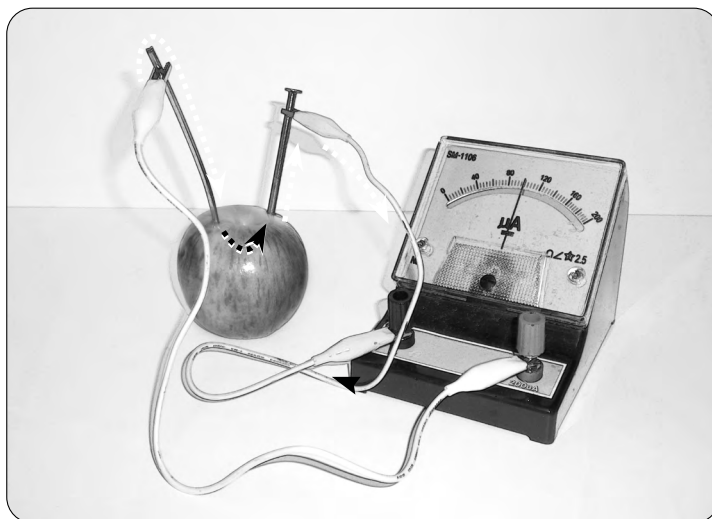
The reactions between the acid in the apple and the two metals creates an electrical charge. The electrons flowed from the zinc coated nail through the microammeter to the copper wire and back through the apple to the nail. The farther you pushed the nail and copper wire into the apple, the greater the flow of electrons. This was visible through the higher reading on the meter. When the nail and the copper pieces touch, no current goes through the meter.

What transformation of energy is visible?

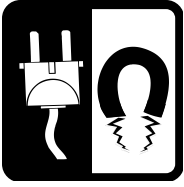
The chemical energy in the apple is converted to electrical energy.

What happened when you changed which metals were used?

When you attached the two copper wires to the microammeter, there should not have been any current. If you attached both nails to the microammeter, current was not produced in this case either. The combination of metals will determine whether the electron flow will occur and in which direction. A battery needs two different metals and an acid to work.



Two metals react with the acid in the apple to produce an electric current.



Station Six Guide

ELECTRICAL ENERGY

Part One: Battery and Compass

⚠ Caution

The battery, when attached in the holder, can become hot over time. Remove the battery from the holder when finished. Also be careful where the un-insulated wire connects to the holder. It will also get very hot.

❓ Question

How does an electric current affect the needle of a compass?

💡 Hypothesis

I think _____.

📋 Materials

- Heavy-gauge coated wire
- D Battery
- D Battery holder
- Compass

🗉 Vocabulary

- attract
- conduct
- electricity
- electromagnet
- energy transformation
- magnetic field
- repel

✓ Procedure

1. Place the battery in the battery holder.
2. Clip one end of the wire onto each end of the battery holder.
3. Move the battery and wire over the compass. Observe the movement of the needle. Record your observations.

OBSERVATIONS:



Station Six Guide | *ELECTRICAL ENERGY*

4. Place the compass over the wire. Observe the movement of the needle. Record your observations.

OBSERVATIONS:

**** Part One Conclusion**

1. What makes a compass needle move? Explain using your observations.

2. How does an electric current affect a compass? Explain using your observations.



Station Six Guide | *ELECTRICAL ENERGY*

3. Could you have electricity without magnetism? Explain why or why not using your observations.

4. Using your *Forms of Energy Cards*, show the energy transformations (in order) demonstrated in this activity. Write out the transformations below.



Station Six Guide | *ELECTRICAL ENERGY*

Part Two: Motors and Batteries

Question

What is the relationship between motors and batteries?

Hypothesis

I think _____.

Materials

- Hand generated flashlight
- 2 Motors (1 disassembled)
- 1 9-volt Battery
- 2 Alligator clips
- Masking tape

Vocabulary

- chemical energy
- conduct
- electricity
- electromagnet
- energy transformation
- generator
- kinetic energy
- potential energy
- shaft
- transform
- turbine

Procedure

1. Observe (but do not shake) the hand generated flashlight. Pay attention to the coils of wire and the magnets.
2. Draw the hand generated flashlight in the box below and label the magnet and coils of wire.

FLASHLIGHT:



Station Six Guide | *ELECTRICAL ENERGY*

3. Shake the handle of the flashlight several times and observe what happens. Record your observations.

OBSERVATIONS:

4. Set the flashlight aside. Look at the two motors. Take the disassembled motor apart by pulling out the shaft. Observe the coil of wires and metal pieces attached to it. Look inside the outer shell of the motor and find the two regular magnets.

5. Illustrate and label a picture of all the parts of this motor in the box below.

DISASSEMBLED MOTOR:

6. Fold a small piece of masking tape and put it on the shaft of the assembled motor. This will act as a flag so that you can observe motion easily. (Make sure not to put so much on that it stops the shaft from turning.)



Station Six Guide | *ELECTRICAL ENERGY*

7. Using the alligator clips, connect the posts on the assembled motor to the posts on the 9-volt battery. What happens? Record your observations.

MOTOR AND BATTERY:

8. Experiment and find at least one way to make the flag on the shaft turn in the opposite direction. Observe and draw a picture in the box below that shows what you figured out.

SOLUTION:



Station Six Guide | *ELECTRICAL ENERGY*

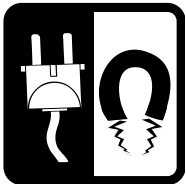
** Part Two Conclusion

1. How do motors and batteries work together?

2. Using your *Forms of Energy Cards*, show the energy transformations (in order) demonstrated in this activity. Write out the transformations below.

Station Six: Read

Read the *Station Six: What Was Happening?* article.



Station Six: What Was Happening?

ELECTRICAL ENERGY

Part One: Battery and Compass

How did electric current affect the compass?

When you used the battery, wire, and compass, you were able to change electrical energy into motion. When the wire was connected to the battery, an electric current moved through the wire. A magnetic field formed around the wire. The needle of the compass moved when it was placed under or over the wire's magnetic field.

What energy transformations were occurring?

What happens when two magnets are put together? They either attract or repel each other. That is what is happening with the compass needle because of the magnetic field around the wire.

In this activity we changed chemical energy (inside the battery) to electrical energy to motion energy.



Electric current flows through the wire, turning it into an electromagnet. The magnetic field around the wire interacts with the needle in the compass, causing it to move.

Part Two: Motors and Batteries

What is a motor made of?

Many toys have motors like the ones we used in this activity. There are two types of magnets in the motor. Coils of wire covered in metal are attached to the motor shaft. These coils become magnets when electricity goes through the wire. These magnets are called electromagnets. They can be turned on and off. There are also regular magnets on the outside shell of the motor. They can't be turned on and off.

When the poles of the magnets are the same, they will repel each other. This is what turns the shaft.

The electricity is flowing in one direction in the motor. Two ways to get the shaft to turn in the opposite direction are: 1. Change which wire is clipped to each post on the battery, and 2. Clip the wires to the opposite posts on the motor.

What energy transformations are we seeing?

The battery and motor take electrical energy and transform it into motion.



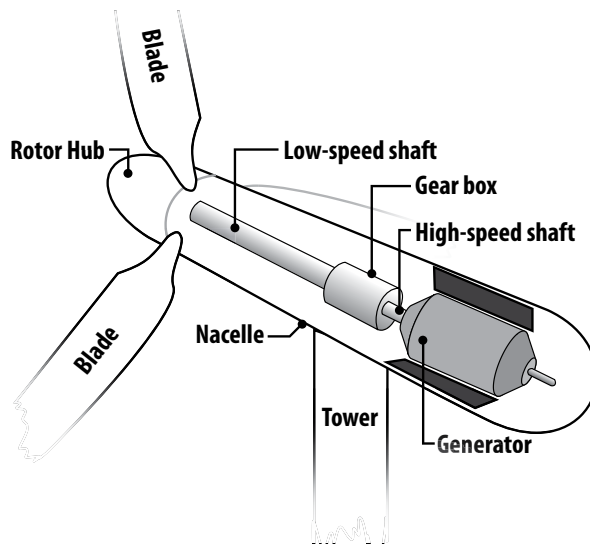
How is a motor like a generator?

We have learned that electrical energy can be transformed into motion energy in a motor. Motion energy can also be transformed into electrical energy in a generator or in your flashlight. Electricity moves a motor. Moving a motor can make electricity. A device that uses motion to make electricity is called a generator.

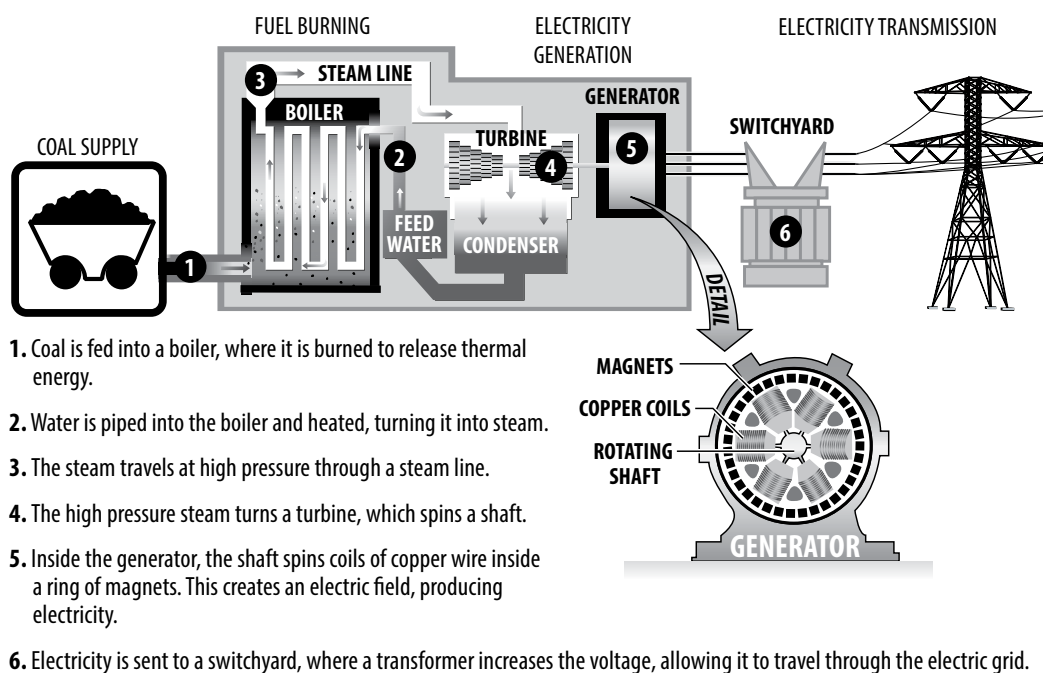
Have you ever seen a wind turbine? The wind turns the blades of the turbine. The blades are hooked to a shaft. Electricity is produced when the turbine turns the shaft in the generator containing the copper wire coil inside the magnets.

In a coal-fired power plant, coal is burned as a fuel to boil water and change it to steam. The moving steam is used to turn the turbine, which is hooked to a generator. In the generator are coils of wire and magnets. Electricity is produced. Before it comes into our homes, the electricity goes through transformers to weaken its strength.

Energy Transformations in a Wind Turbine: Motion to Electrical Energy



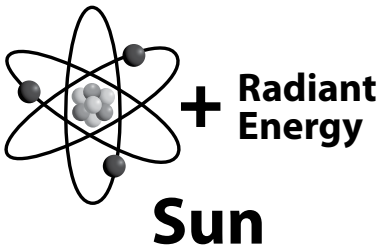
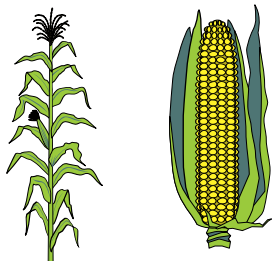


Energy Transformations Inside a Coal Power Plant: Chemical to Thermal to Motion to Electrical Energy





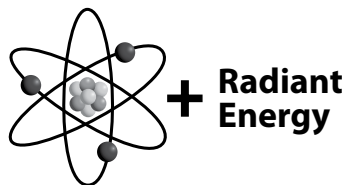
Energy Flow Cards

SET 1

1  Sun	Through the process of fusion, I convert nuclear energy into radiant energy.
1  Green Plant	Through the process of photosynthesis, I convert radiant energy into chemical energy and store it in my cells.
1  Mouse	I store chemical energy from food in my cells and turn some of it into other forms of energy.
1  Snake	I store chemical energy from food in my cells and turn some of it into other forms of energy.

SET 2

2



Sun

Through the process of fusion, I convert nuclear energy into radiant energy.

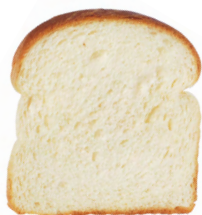
2



Wheat

Through the process of photosynthesis, I convert radiant energy into chemical energy and store it in my cells.

2



Bread

I have chemical energy stored in my cells.

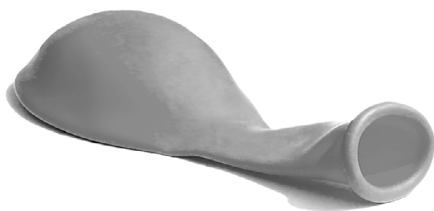
2



Human Being

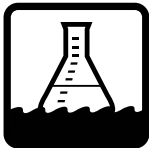
I store chemical energy from food in my cells and turn some of it into other forms of energy.

2



Balloon

I store elastic energy when I am stretched and when I'm let go, I release thermal and motion energy.



SCIENCE OF ENERGY BINGO

- A. Knows what type of reaction releases thermal energy
- B. Knows the form of energy that comes from the sun
- C. Knows one way to store energy
- D. Knows the form in which our bodies store energy
- E. Knows the force responsible for the attraction between the Earth and nearby masses
- F. Knows why rubbing your hands together makes them warm
- G. Can name a form of kinetic energy
- H. Has visited a thermal power plant
- I. Knows where most energy on Earth originates
- J. Knows what type of reaction absorbs thermal energy
- K. Has used a radiant clothes dryer
- L. Knows what form of energy is stored in most energy sources
- M. Knows how an electric generator works
- N. Knows what device turns energy from the sun directly into electricity
- O. Can name a form of potential energy
- P. Knows what energy can be transformed into

A NAME	B NAME	C NAME	D NAME
E NAME	F NAME	G NAME	H NAME
I NAME	J NAME	K NAME	L NAME
M NAME	N NAME	O NAME	P NAME



Forms of Energy in the Round Cards

<p>I have chemical energy.</p> <p>Who has the process where very small nuclei are combined into large nuclei?</p>	<p>I have the Law of Conservation of Energy.</p> <p>Who has the movement of objects or substances from one place to another?</p>
<p>I have nuclear fusion.</p> <p>Who has stored energy?</p>	<p>I have motion.</p> <p>Who has the process by which plants convert radiant energy into chemical energy?</p>
<p>I have potential energy.</p> <p>Who has a material that moves thermal or electrical energy well?</p>	<p>I have photosynthesis.</p> <p>Who has a chemical process that releases thermal (heat) energy?</p>
<p>I have conductor.</p> <p>Who has the form of energy that includes visible light?</p>	<p>I have exothermic process.</p> <p>Who has the form of energy that is the movement of electrons?</p>
<p>I have radiant energy.</p> <p>Who has the concept that energy is neither created nor destroyed?</p>	<p>I have electrical energy.</p> <p>Who has the change where one or more substances become one or more new substances?</p>

I have chemical change.

Who has the form of energy commonly referred to as heat?

I have inertia.

Who has energy that is stored in objects when stretched or compressed?

I have thermal energy.

Who has the ability to cause change or do work?

I have elastic energy.

Who has the force of attraction between any two objects?

I have energy.

Who has a device that converts radiant energy into electrical energy?

I have gravity.

Who has the process of splitting large nuclei to release energy?

I have photovoltaic cell.

Who has the energy of moving things?

I have nuclear fission.

Who has the form of energy that is stored in the nucleus of an atom?

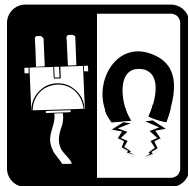
I have kinetic energy.

Who has what must be overcome to change the speed or direction of an object?

I have nuclear energy.

Who has a material that does not transfer thermal or electrical energy well?

<p>I have insulator.</p> <p>Who has the process by which thermal energy is transferred by moving through a gas or liquid?</p>	<p>I have friction.</p> <p>Who has a change where no new substance is formed?</p>
<p>I have convection.</p> <p>Who has a device that converts motion into electrical energy?</p>	<p>I have physical change.</p> <p>Who has a chemical process that absorbs thermal (heat) energy?</p>
<p>I have generator.</p> <p>Who has the movement of energy through substances in longitudinal waves?</p>	<p>I have endothermic process.</p> <p>Who has the portion of radiant energy that lets us see?</p>
<p>I have sound.</p> <p>Who has radiant energy bouncing off an object?</p>	<p>I have visible light.</p> <p>Who has the process by which thermal energy is transferred between objects that are touching?</p>
<p>I have reflection.</p> <p>Who has a force that opposes motion?</p>	<p>I have conduction.</p> <p>Who has the form of energy stored in the bonds between atoms and molecules?</p>



Electricity Production Simulation

(BASED ON A CLASS OF 24 STUDENTS)

The teacher assigns the following roles:

- 3 students representing plants that will turn into coal
- 1 student to represent the sun
- 3 students to represent the miners
- 3 students to represent the train taking the coal to the power plant
- 2 students to unload the coal from the train and put it under the boiler
- 1 student to represent the boiler
- 1 student to represent the pipes leading to the turbine
- 1 student to represent the turbine
- 3 students to represent the generator
- 1 student to represent the power lines out of the power plant
- 1 student to represent the transformer
- 1 student to represent the power lines into the house
- 3 students to represent electrical items in a house (toaster, fan, TV, etc.)

(The teacher has the students standing in a circle in the room. As the teacher narrates the story, the students move to show their part in electricity production. Create props or costumes to enhance the story.)

Millions of years ago, the sun was shining and plants were growing. (The sun puts his hands up in a circle around his head. The plants go from squatting to standing up.)

Then the plants died. (Plants fall to the ground.)

Over the years, the plants decayed and pressure was put upon them, turning them into coal. (The teacher pretends to push down on them.)

Miners come and dig out the coal and then they load it on a train. (Miners pretend to be mining out the coal and shoveling it onto the train that is made up of three students.)

The train takes the coal to the coal power plant. (Have the three students travel to the power plant making the sound of a train.)

The coal is unloaded at the power plant and burned beneath the boiler. (Students pretend to shovel coal under the outstretched curved arms of the student representing the boiler.)

The water in the boiler boils and the steam goes through the pipes and turns the turbine. (The boiler makes a bubbling sound, the person representing the pipes has outstretched arms and makes a hissing sound. The person representing the turbine has arms close to body but hands sticking out to be the blades. The pipe steam pushes on the hands and the turbine turns.)

The turbine is hooked to the generator. When the turbine turns, the shaft in the generator turns with the coils of wire and magnets. (The person who is the shaft turns their outstretched arm around and around. The other two students represent the wire and magnets and walk around the shaft.)

Electricity is now produced in the generator and is sent out at high voltage through the power lines. (The power line person has both arms outstretched and moving really fast back and forth.)

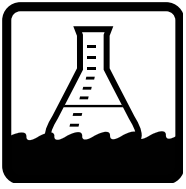
The transformer reduces the voltage. (The transformer has both arms outstretched. The arm that is closest to the power line is moving back and forth quickly. The other arm is going much slower.)

The electricity travels to the home. (The power line student moves outstretched arms slowly.)

Items in the house that run by electricity now have power. (Student representing a fan turns in circles, the toaster pops up from a squatting position and the TV comes on. The student representing the TV can start talking like a commercial or show.)

Extensions

- Use additional students to represent the cooling towers and smoke stacks at a coal power plant.
- Simulate power from windmills by starting at the part where the turbine turns.
- Have students illustrate the process after completing the simulation.
- Students may write a paragraph that explains the illustrations.



Forms of Energy Fun

Energy Crossword

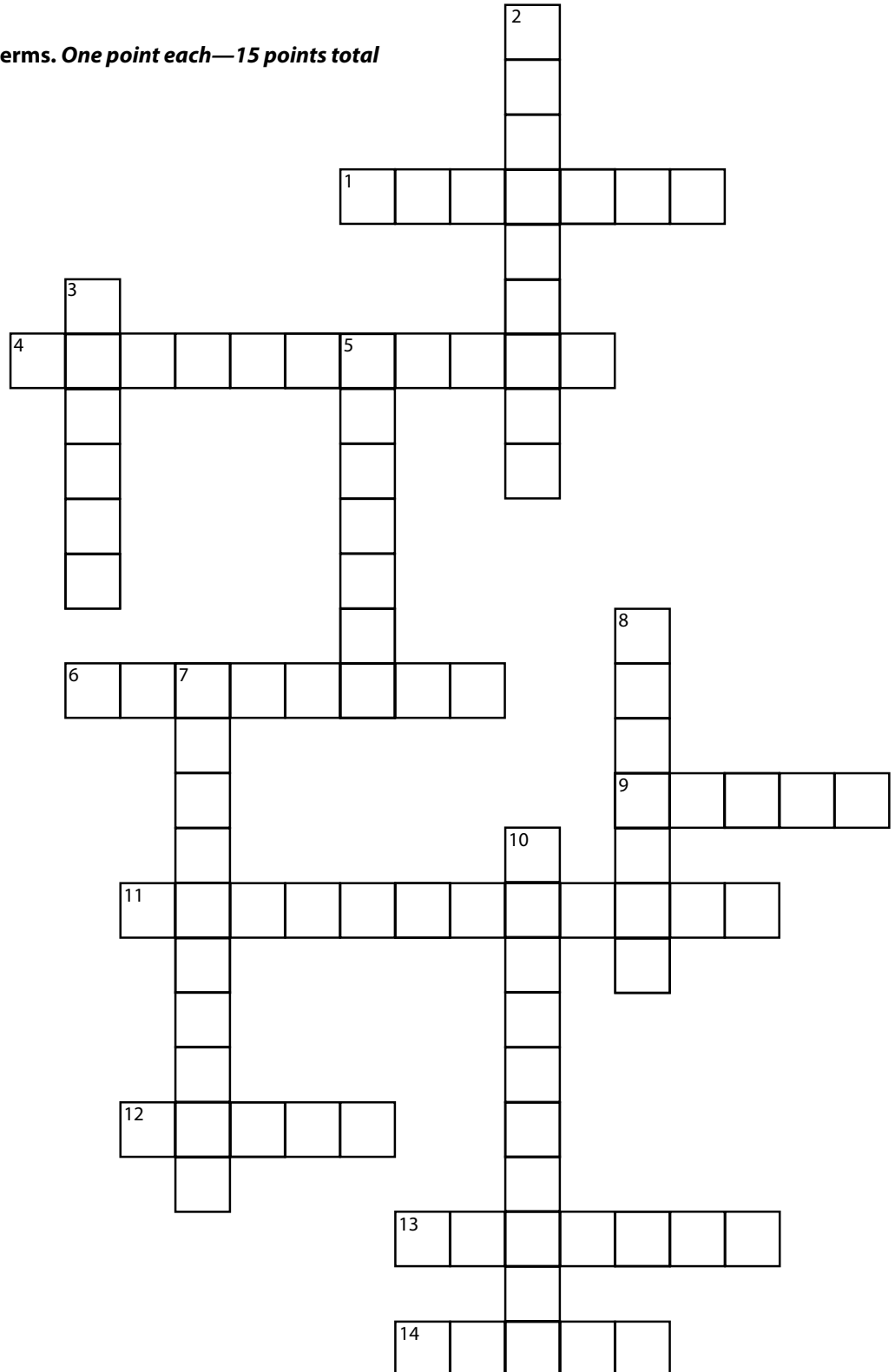
Fill in the boxes with forms of energy terms. *One point each—15 points total*

Across ►

1. The energy of moving things
4. A chemical reaction that absorbs heat
6. The energy stored in the bonds of molecules
9. Chemicals _____ to produce energy
11. A cell that converts solar energy to electricity
12. Radiant energy
13. Energy locked in the nucleus of an atom
14. From the sun

Down ▼

2. Energy of position
3. The ability to do work
5. _____ energy has the potential to move after stretching
7. Chemical reaction that releases heat
8. Heat
10. Energy of moving electrons



Unscramble the five words that describe what energy does, then use the letters with the dots underneath to figure out the mystery word. *Two points each—12 points total*

A H T E

--	--	--	--

●

H I L T G

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●

R W O G

--	--	--	--

●

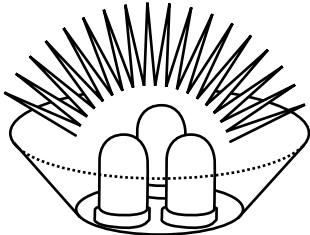
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Fill in the blanks to show the energy transformations made by each object. *One point for each blank—38 points total*

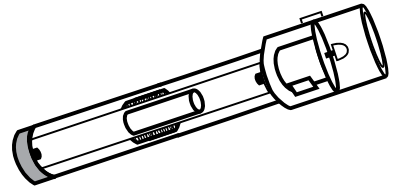
1. PV Cell _____ energy to _____ energy
2. Battery _____ energy to _____ energy
3. Bicycle _____ energy to _____ energy
4. Wind Turbine _____ energy to _____ energy
5. Hand Warmer _____ energy to _____ energy
6. Glow Stick _____ energy to _____ energy
7. Flashlight _____ energy to _____ and _____ energy
8. Radiometer _____ energy to _____ and _____ energy
9. BBQ Grill _____ energy to _____ and _____ energy
10. Sun _____ energy to _____ and _____ energy
11. Firefly _____ energy to _____ and _____ energy
12. Athlete _____ energy to _____ and _____ energy
13. Car Engine _____ energy to _____ and _____ and _____ energy
14. Firecracker _____ energy to _____ and _____ and _____ energy

Energy Flow

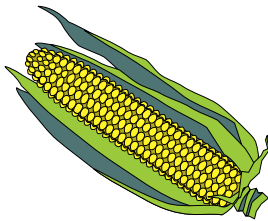
Unscramble the energy flow so that the forms of energy are in the proper order. Number the pictures from 1 to 8 on the lines to the right of the pictures, with number one as the beginning of the flow. *Two points each—16 points total*



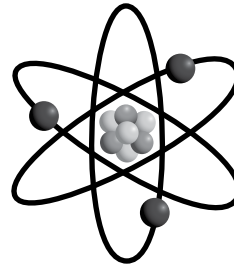
Radiant (light) Energy _____



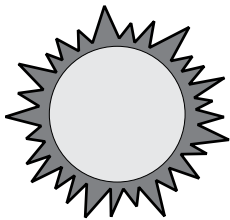
Motion Energy _____



Chemical Energy _____



Nuclear Energy _____



Radiant Energy _____



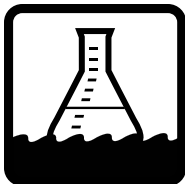
Electrical Energy _____



Chemical Energy _____



Electrical Energy _____



Design Your Own Investigations

What new questions do you have? Brainstorm new investigation questions for each station.

Station 1: I wonder what would happen if ...

Station 2: I wonder what would happen if ...

Station 3: I wonder what would happen if ...

Station 4: I wonder what would happen if ...

Station 5: I wonder what would happen if ...

Station 6: I wonder what would happen if ...



Glossary

absorb	the ability of a substance or material to take in another substance or energy, like a sponge taking in water
alternating current (AC)	electricity in which the electrons change direction at regular intervals; used to move energy from one place to another, usually through a wire; the electricity used in homes to operate lights, televisions, and other household devices
atom	the smallest part of all matter
attract	pull toward
Celsius	temperature scale in which the freezing point of water is 0° and the boiling point of water is 100°
chemical energy	the energy stored in substances; the energy held in the atomic bonds that hold atoms to each other
chemical reaction	a change or process in which new substances are formed
collision	when two objects hit each other and transfer energy
compress	to press or squeeze together
conduct	to transfer energy from one place to another
contract	to shorten the length of an object
conversion	to change from one thing to another
convert	to change the physical or chemical properties of a substance
current	the flow of energy from one place to another
direct current (DC)	the flow of electricity through a conductor, in which electric charges move in only one direction
energy transformation	energy changing from one form to another; see transformation
elastic energy	energy stored in an object when force is applied, to stretch or compress it
electrical energy	the energy of moving electrons; a secondary source of energy
electricity	the energy of moving electrons
electrode	the positive or negative terminal of a battery or of another electrical device
electrolyte	a chemical compound that dissolves to conduct electricity
electromagnet	a magnet created by the flow of electrons through a conductor or wire
endothermic	a change where energy is absorbed; this is usually felt as a loss of heat from the surroundings or the feeling of cold
energy	the ability to do work or make change
energy flow	the process of energy moving from one place or object to another
energy level	location within an atom where electrons are held
ester	a chemical compound made from an alcohol and an acid
exothermic	a change where energy is released; this is usually felt as heat
expand	to increase the size of an object
Fahrenheit	temperature scale commonly used in the U.S. in which the freezing point of water is 32° and the boiling point is 212°
fission	a nuclear reaction that breaks apart an atom
friction	a force that opposes motion
fusion	a nuclear reaction that combines two atoms together to make another larger atom
generator	a device that changes motion into electricity
gravitational potential energy	energy of place or position

heat	energy that flows from one object to another because of a difference in temperature
hypothesis	an educated guess that answers a scientific problem or question
iron oxide	a chemical compound composed of iron and oxygen, commonly called rust
kilowatt-hour	a unit to measure electricity used
kinetic energy	the energy of motion
Law of Conservation of Energy	states that energy cannot be created or destroyed, it can only change form or be transferred
magnetic field	the region of magnetic force around a magnet
mass	the amount of matter in an object
molecular	a description of the smallest parts of matter, or a molecule; shape or size
molecule	composed of two or more atoms that are chemically bonded to each other and act as a single particle; the smallest part of a substance that has all of the properties of that substance
motion energy	the movement of a substance from one place to another
nickel	a metal that is silver in color and bendable
nonrenewable resource	a natural resource that cannot be replaced or would take millions of years to replace; nonrenewable energy resources are petroleum, natural gas, coal, propane, and uranium
nuclear energy	the energy contained in the nucleus of an atom; used commonly in reactors to heat water into steam, which can then be used to generate electricity
photovoltaic cell	a device made of silicon and other substances used to generate electricity from sunlight
potential energy	energy that is stored in an object based upon its position
prediction	a thoughtful guess about the future
radiant energy	electromagnetic energy that travels in waves such as light, x-rays, and microwaves
reaction	a response that is produced by the action of another object or force
rebound	to spring back, or the motion of an object after it hits another object
renewable resource	a natural resource that can be easily replaced over a short period of time; renewable energy resources are wind, geothermal, solar, hydropower, and biomass
repel	to push away
retention	to hold onto something
shaft	a long, narrow section of a motor or generator that can rotate
silicon	second most plentiful element on Earth; major component of sand and used in PV cells
temperature	the measure of the average kinetic energy of particles in a substance
thermal energy	the sum of energy of the molecules making up a substance; for this unit, it is used to mean heat
titanium	a silvery-gray, metallic element that is lightweight and strong; number 81 on the periodic table of elements
transform	to change the structure, shape, or composition of a substance, or to change energy from one form to another
transformation	the act of changing the structure, shape, or composition of an object, or one form of energy into another
turbine	a rotating object that changes the motion of wind, water, or steam into electricity
vacuum	a space with no air or gas



YOUTH AWARDS PROGRAM FOR ENERGY ACHIEVEMENT

NEED's annual Youth Awards Program for Energy Achievement rewards students for their efforts in energy outreach and student leadership.

The Youth Awards Program is great for all schools—new to energy education, or veteran. Projects and outreach completed for the program provide opportunity for enrichment and engagement, as well as an opportunity for your students, classroom, and school to shine. Youth Awards projects can be completed by afterschool/out-of-school time programs, community groups, and even families!

What's involved?

Students and teachers set goals and objectives and keep a record of their activities. Students create a digital project to submit for judging. In April, digital projects are uploaded to the online submission site.

Check out:

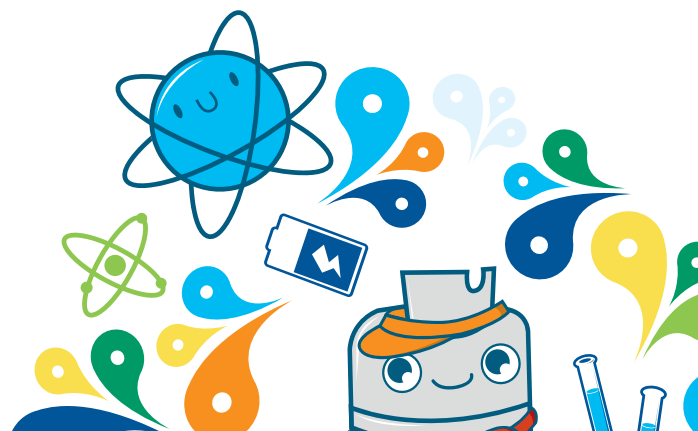
For more information and project submission details, we invite you to visit <https://youthawards.need.org>. Be sure to explore the site to view past winning projects and garner inspiration!

YOUTH ENERGY CONFERENCE & AWARDS

The NEED Youth Energy Conference and Awards gives students more opportunities to learn about energy and to explore energy in STEM (science, technology, engineering, and math).

The annual June conference has students from across the country working in groups on an Energy Challenge designed to stretch their minds and energy knowledge. The conference culminates with the Youth Awards Ceremony recognizing student work throughout the year and during the conference.

For More Info:
www.need.org/youthenergyconference





Elementary Science of Energy Evaluation Form

State: _____ Grade Level: _____ Number of Students: _____

- | | | |
|--|------------------------------|-----------------------------|
| 1. Did you conduct the entire unit? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 2. Were the instructions clear and easy to follow? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 3. Did the activities meet your academic objectives? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 4. Were the activities age appropriate? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 5. Were the allotted times sufficient to conduct the activities? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 6. Were the activities easy to use? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 7. Was the preparation required acceptable for the activities? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 8. Were the students interested and motivated? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 9. Was the energy knowledge content age appropriate? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |
| 10. Would you teach this unit again? | <input type="checkbox"/> Yes | <input type="checkbox"/> No |

Please explain any 'no' statement below

How would you rate the unit overall? ☐ excellent ☐ good ☐ fair ☐ poor

How would your students rate the unit overall? ☐ excellent ☐ good ☐ fair ☐ poor

What would make the unit more useful to you?

Other Comments:

Please fax or mail to: **The NEED Project**

8408 Kao Circle
Manassas, VA 20110

FAX: 1-800-847-1820

Email: info@need.org



National Sponsors and Partners

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EnergizeCT	NCi - Northeast Construction	U.S. Department of Energy-Office of Energy Efficiency and Renewable Energy
ENGIE	North Shore Gas	U.S. Department of Energy - Solar Decathlon
Entergy	Offshore Technology Conference	U.S. Department of Energy - Water Power Technologies Office
Equinix	Ohio Energy Project	U.S. Department of Energy-Wind for Schools
Eversource	Oklahoma Gas and Electric Energy Corporation	U.S. Energy Information Administration
Exelon	Omaha Public Power District	United States Virgin Islands Energy Office
Exelon Foundation	Ormat	Vineyard Wind
Foundation for Environmental Education	Pacific Gas and Electric Company	Virginia Cooperative Extension
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Generac	Peoples Gas	Vistra Energy
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