WHY DO SOME THINGS STOP WHILE OTHERS KEEP GOING?

Transfer, Transformation, and Conservation of Energy

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Investigating and Questioning Our World through Science and Technology (IQWST)

WHY DO SOME THINGS STOP WHILE OTHERS KEEP GOING?

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About the Publisher

Activate Learning is a mission-driven company that is passionate about STEM education. We make it easy for teachers to teach with quality, investigation-centered science curriculum, tools, and technology. For more information about what we do, please visit our website at http://www.activatelearning.com.

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PS2 CONTENTS

ART

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Lesson 1

Video: Isaac Newton vs. Rube Goldberg, David Dvir, 2D House

Lesson 2

Bessel Crater – National Aeronautics and Space Administration, U.S. Government

Moltke Crater – National Aeronautics and Space Administration, U.S. Government

Video: Objects in Motion – Dave G. Alciatore, Colorado State University, Department of Mechanical Engineering

Video: Energy Cart – Dave G. Alciatore, Colorado State University, Department of Mechanical Engineering

Lesson 4

Video: Basketball Bounce – Dave G. Alciatore, Colorado State University, Department of Mechanical Engineering

Video: Soccer Ball Kick – Dave G. Alciatore, Colorado State University, Department of Mechanical Engineering

Video: Inverted Racquetball Bounce – Dave G. Alciatore, Colorado State University, Department of Mechanical Engineering

Lesson 5

Video: Bouncing Ball – Created by IQWST

Video: Billiards – Dave G. Alciatore, Colorado State University, Department of Mechanical Engineering

Lesson 6

Simulation: Colliding Balls – Created by IQWST

Simulation: Molecular Motion in a Hot and Cold Solid – Created by IQWST

Simulation: Molecular Motion in a Hot and Cold Liquid – Created by IQWST

Simulation: Molecular Motion in a Hot and Cold Gas – Created by IQWST

Lesson 1

Introducing Energy

ACTIVITY 1.1 – RADIOMETER DEMONSTRATION AND NEWTON VS. GOLDBERG VIDEO

ACTIVITY 1.2 – OBSERVING SURPRISING DEVICES

What Will We Do?

We will observe six devices that behave in ways we may not expect. Then we will list questions we have about how the devices work and things we would like to know about them.

Prediction

Before you write a prediction, read the station instruction card, so you know what you are going to be doing at the station. Then predict what you expect will happen:

1. Top 1 will . . . ______________________________
2. Top 2 will . . . ______________________________
3. Pendulum 1 will . . . ______________________________
4. Pendulum 2 will . . . ______________________________
5. Pendulum 3 will . . . ______________________________
6. The rolling can will . . . ______________________________

Data Collection/Observation

1. Describe what you observed when you spun Top 1 and Top 2.

2. Record questions you have or things you would like to observe or measure in order to figure out how Top 2 works.

3. Describe what you observed when you set each pendulum in motion.

4. Record questions you have or things you would like to observe or measure in order to figure out how the pendulums work.

5. Describe what you observed when you rolled the can.

6. Record questions you have or things you would like to observe or measure in order to figure out how the rolling can works.

Conclusion

7. What do you notice that all of the devices have in common?

Reading 1.1 – Perpetual Motion Machines

Getting Ready

You probably use batteries for many things you own. Flashlights, cameras, watches, and other devices work by using batteries. Sometimes batteries stop working, and you need to buy new ones. Imagine that someone invents a battery that never stops working. If you had to choose one device to use with the battery, what would it be? Do you think such a battery could be invented someday? Explain.

As you read, think about the different machines you know of and how they help people do things. Think about whether a battery that does not stop could make some of those machines even better.

Machines Are All around You

For thousands of years people have invented machines to make their work easier. What machines have you used today? A bicycle is a machine that helps you move without walking. A washing machine washes your clothes. A dishwasher washes your dishes. Every day machines make your life easier.

You do not even see most of the machines you rely on each day. When you take a shower, a machine called a water pump lifts water so that it will pour onto your head. A machine called a generator produces the electricity that flows to your house. A machine called a flour mill grinds grains into flour that is used to make bread.

How Do Machines Work?

Even though machines do things for you, they do not work on their own. A bicycle will not move unless you push on its pedals. A car will not go without fuel. A washing machine will not wash clothes without electricity. Every machine needs something to make it work.

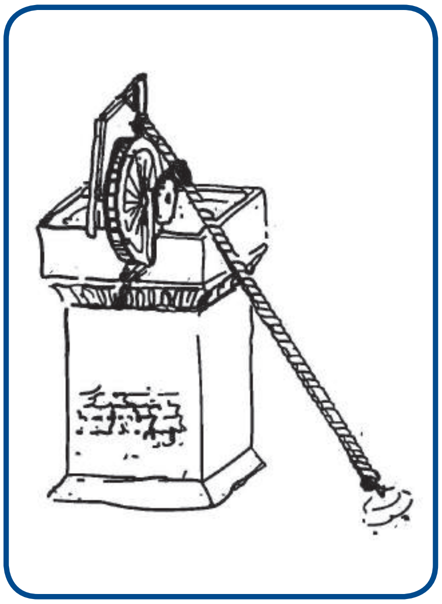
The Power of Water

For a long time, the only way to make flour for bread was to grind grain by hand. Even today, some people make their own flour by using a heavy stone to grind grain. Centuries ago, someone came up with the idea for a machine called the watermill. The idea was to place a giant waterwheel in a flowing river and to connect the wheel to a heavy grinding stone. As the flowing water turned the waterwheel, the stone would turn and grind grain into flour. The watermill was a wonderful invention. It made far more flour than any person could make on his or her own. It also made life easier because no one had to push the heavy grinding stones.

Before long, people realized that watermills could be used to do many jobs. A watermill used to make flour is called a flour mill or gristmill. A watermill used to saw logs is a sawmill. A watermill used to spin cotton is a cotton mill. Although watermills were useful, there were two problems. First, watermills could only be built near flowing rivers. Towns located far from rivers could not use watermills. Second, water moves between reservoirs, such as the atmosphere and rivers. If it does not rain for a while, there might not be enough water flowing in a river to turn the waterwheel.

Could Someone Make a Self-Powered Watermill?

Some of the world's best scientists spent years trying to figure out how to make a watermill work without a river. One of the most famous scientists ever was Leonardo da Vinci. He was among the first people to try to design a waterwheel that could run without a flowing river. His idea was to use water falling from a tower to turn the waterwheel and then fall into a pool. The waterwheel would be attached to a special screw that could lift water from the pool back up to the tower, where it could again fall down into the pool. A drawing similar to the one shown was found in one of his notebooks. His idea was very clever, but it did not work.



Many others have come up with ideas similar to da Vinci's. They all hoped to design a watermill that could power itself. The picture shows a large waterwheel turned by water falling from a higher pool to a lower pool. The large waterwheel then turns a smaller wheel attached to a pump. The pump lifts water back up to the higher pool so that it can fall on the waterwheel again. According to the sketch, if someone filled the higher pool with water, this watermill would keep on running forever. Unfortunately, like da Vinci's machine, this one did not work either.

What factors might affect how the watermill works?

Perpetual Motion Machines

Machines like the self-powered watermill are called perpetual motion machines. Perpetual means *never ending*. If someone were to invent a perpetual motion machine, it would be able to run forever without stopping. People have been trying to invent perpetual motion machines for centuries, but no one has succeeded.

Besides self-powered watermills, inventors have tried to develop self-powered windmills, clocks that do not stop, and engines that do not need fuel. Thousands of people have claimed to invent perpetual motion devices, but not one has ever worked. Today some inventors are still trying to develop perpetual motion machines that could run forever. Their dreams are to invent things like a car that will never need to be refueled, a cell phone that never needs charging, or a flashlight that never needs new batteries. Most scientists believe that these devices can never be invented.

In class, you saw several devices that did not seem to stop. You saw a top that kept spinning and a pendulum that kept swinging. These may seem like perpetual motion devices, but they are not. If you wait long enough, they will stop. One of the goals in this unit is to find out why they keep going much longer than expected. Learning about energy will help you understand why these devices go for so long. Learning about energy will also help you understand why scientists believe that perpetual motion devices will never be invented.

Most scientists believe that perpetual motion devices can never be invented, but people come up with new ideas for them all the time. Do you think people should keep trying? Why?

Lesson 2

Kinetic Energy

ACTIVITY 2.1 – OBJECTS IN MOTION

What Will We Do?

We will watch a video and determine whether the scenarios in it involve energy. This will help us learn more about energy and things that move.

Prediction

1. For each scenario in the video, decide whether it involves energy. Explain why it does or does not involve energy in the following table.

Scenario	Does It Involve Energy?	Explain Why
Moving Bus	Yes or No	
Moving Bicycle	Yes or No	
Leaves Moving in Street	Yes or No	
Moving Tree Branches	Yes or No	
Waving Hand	Yes or No	
Dropped Racquetball	Yes or No	

Scenario	Does It Involve Energy?	Explain Why
Ticking Clock	Yes or No	
Rolling Basketball	Yes or No	

2. Rank each scenario according to how much kinetic energy it involves. The scenario showing the most kinetic energy should be ranked #1.

Scenario	Energy Rank (#1=Most)	Explain Why
Moving Bus		
Moving Bicycle		
Leaves Moving in Street		
Rolling Basketball		

Homework 2.1 – Kinetic Energy

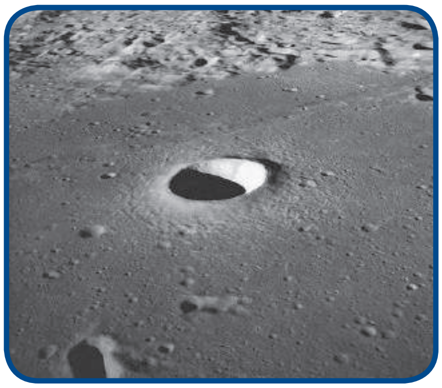
As a car travels down the highway, it travels at a constant speed of 70 miles per hour. It burns fuel as it moves. What happens to the mass of the car as the fuel is burned? How does this affect the kinetic energy of the car?

Julia enjoys bowling. One day, just for fun, she decided to try bowling with a volleyball instead of a bowling ball. Will this make it easier or harder to knock over the pins? Explain your answer.

Reading 2.1 – Impact Craters

Getting Ready

Look at the photos of impact craters on the moon. The right one is called the Bessel Crater. Its diameter is 16km. The left one is called the Moltke Crater. It has a diameter of 7km. You can see many other small impact craters. Why do you think the craters are such different sizes?



In this reading, you will learn more about factors that affect the size of craters, and you will read about a way to investigate this at home.

Impact Craters

Impact craters form when objects from space fall on the surface of a planet or a moon. These objects could be asteroids, comets, or pieces of either one. When the objects hit the surface, they are called meteorites. Meteorites create craters, which are large depressions in the ground.

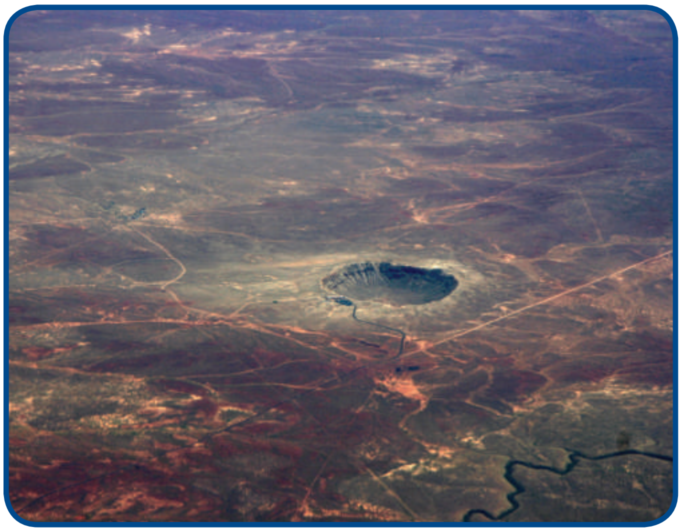
The surface of the moon is covered by impact craters of many sizes and shapes, like those in the pictures. The diameter of most craters is about ten times greater than the diameter of the meteorite that made it. Some meteorites are as small as a fingernail. When a meteorite hits the ground, the impact can be tremendous. Many meteorites actually explode on impact, or they explode just above the surface. When that happens, they leave nothing visible except a crater. Although most meteors are tinier than your fingernail, they have a lot of kinetic energy. Why?

Are There Impact Craters on Earth?

Both Earth and its moon are bombarded by lots of tiny meteors all the time, but the atmosphere prevents most of them from reaching the ground. In the past, there were many impact craters on Earth, but they were worn down by wind erosion. The moon has no atmosphere to wear down its craters, which is why the impact craters are still visible. About 150 impact craters have been recognized on Earth. One of these is Meteor Crater in Arizona. Workers in the crater area discovered fragments of the meteorite within the impact crater itself.

Investigating Impact Craters

In class, you learned how the speed and mass of an object influence its kinetic energy. When you threw down a tin can, you gave it greater speed than when you just dropped it. Throwing the can compacted the modeling clay more than dropping it did. A heavy tin can compacted the modeling clay more than a light can. If you drop any hard object on snow or on sand, you can create small impact craters similar to those created on the moon. You can create impact craters at home:



- Fill a pan with sand to a depth of about 2.5cm. Smooth the surface. Then tap the pan lightly a couple of times so the sand settles evenly.
- Take the pan outside, or set it on newspaper or a large towel.
- Choose two marbles or small rocks. One should be heavier than the other.
- Plan an experiment to investigate how the mass or speed of the marble influences the crater's size.
- Answer the following questions. Then, report the procedure and results of your experiment.

    1. What is the purpose of your investigation?

    2. Which variables will you hold constant?

    3. Which variables will you change in a controlled manner?

4. Which variables will you measure to determine the influence of those that you have changed?

5. How did you carry out the experiment? What were your results? What is your conclusion? How is your conclusion related to energy?

ACTIVITY 2.2 – INVESTIGATING KINETIC ENERGY

What Will We Do?

We will design an investigation to determine factors that affect the amount of kinetic energy a falling object has.

Prediction

1. How does the speed of a moving object affect the amount of kinetic energy it has? Describe the evidence you need to collect to test your prediction, and include a reason why you think this evidence is necessary.

2. How does the mass of a moving object affect the amount of kinetic energy it has? Describe the evidence you need to collect to test your prediction, and include a reason why you think this evidence is necessary.

Data Collection/Observation

Use the following table to record your data when investigating how the speed of the falling object affects the change in thickness of the modeling clay.

Method of Releasing the Can	Speed of Can upon Impact	Change in Thickness of Clay Ball [mm]		
		Thickness Before	Thickness After	Amount of "Squish"
Dropping	Slow			
"Throwing"	Fast			

Draw a similar table to record your data when investigating how the mass of falling objects affects the change in thickness of the modeling clay.

Can Mass	Mass in Grams	Change in Thickness of Clay Ball [mm]		
		Thickness Before	Thickness After	Amount of "Squish"
Light				
Heavy				

Data Analysis

For the data in each table, describe how the dependent variable changed when you changed the independent variable.

- First Data Table

- Second Data Table

Conclusion

1. How does speed affect the amount of kinetic energy in a moving object? Explain how you know by stating your claim, the evidence for your claim, and your reason why this evidence supports your claim.

2. How does mass affect the amount of kinetic energy in a moving object? Explain how you know by stating your claim, the evidence for your claim, and your reason why this evidence supports your claim.

Follow Up Question

Louis and Keisha each dropped stones from different heights onto pieces of clay to see how much the clay would be compacted. Louis dropped his stone onto a small piece of clay and noticed that the clay was smashed a lot. Keisha dropped her stone onto a large piece of clay and noticed that the clay was compacted very little.

Should Louis and Keisha conclude that Louis's stone had more kinetic energy when it hit the clay? Explain why.

ACTIVITY 2.3 – PREDICTING THE AMOUNT OF KINETIC ENERGY IN SCENARIOS

What Will We Do?

We will use what we know about the relationship we established between kinetic energy, mass, and speed to predict which objects have the most kinetic energy.

Prediction

Your teacher will show you a video of a moving cart compacting modeling clay. Using what you learned during the investigation, make a prediction, and rank the following situations in terms of

1. the amount of kinetic energy each has, and
2. the amount that the moving cart will compact the modeling clay.

Scenario	Kinetic Energy Rank (#1 = most; #3 = least)	Modeling Dough Smash Rank (#1 = most; #3 = least)
500 gram cart moving 4 km per hour		
1500 gram cart moving 4 km per hour		
1500 gram cart moving 6 km per hour		

Observation

Compare your observations from the video with your predicted rankings.

Making Sense

School bus drivers are extra careful when they cross railroad tracks. They stop before they cross railroad tracks to be sure that there is no train coming. Yet, trains typically move more slowly through towns than cars do. If trains usually move more slowly than cars, why can they do more damage if they hit something in their path?

Lesson 3

Gravitational Energy

ACTIVITY 3.1 – INVESTIGATING THE CONNECTION BETWEEN ELEVATION AND ENERGY

What Will We Do?

We will use the cans and balls of clay again to explore the relationship between elevation and energy.

Prediction

1. How will dropping a can from a higher or a lower elevation affect the impact it has on a clay ball? Explain your ideas.

2. What is the relationship between elevation and energy (think about the same can dropped from different heights)?

Procedure

Your group should have a heavy or light can, modeling clay, skewers, ruler, markers, and a calculator. Follow these steps with your teacher's instruction.

1. Shape the clay into a ball 3cm in diameter. Mark this thickness on one skewer. Write this initial thickness in the box marked T_0 in your table.

2. Hold the can at a height of 10cm above the surface, drop it, and take it away, being careful not to deform the clay any more while doing so.

   Discuss the following questions in your group:

   - How will you measure the new thickness of the clay?
   - Will you get the same results if you measure different parts of it?
   - How can you decide which result is better?

   Wait for your teacher to discuss the issue of measuring the thickness, and then continue.

3. Use another skewer and different colors of markers to measure the thickness in three different places in the clay ball and write the results in the table (boxes T_1–T_3).

4. Use a calculator to calculate the average thickness T, and write it in the table.

5. Calculate the thickness change $T_0 - T_{average}$, and write it in the table.

6. Repeat Steps 1–5, and write the results in the second row of the table.

7. Calculate the average thickness change for this height.

8. Change the height to 20cm above the surface and repeat Steps 1–7. Make sure not to mix up the results from the different heights.

Data Collection/Observation

Object Mass___ Heavy / Light___

Height of Can		T_0	T_1	T_2	T_3	$T_{Average} = T_1 + T_2 + T_3 / 3$	Thickness Change = $T_0 - T_{Average}$	Average Thickness Change
H_1 = 10cm	a							
	b							
H_2 = 20cm	a							
	b							

Conclusion

1. What are the advantages of calculating an average value when doing an experiment?

2. From which dropping height was the average thickness changed the most?

3. What can you conclude about the relation between height and energy?

Follow Up Questions

4. Your group used an object with fixed mass (heavy or light). How will the results be different for an object with a different mass?

5. In Activity 2.2 you found a relationship between speed and energy. What is the relationship between the speed of impact and the dropping height?

Homework 3.1 – Investigating the Playground—Part I

Purpose

You will design an experiment to investigate how gravitational energy changes in a piece of playground equipment. You will not actually carry out the experiment, just plan it. Think about how you can investigate the gravitational energy a child has when sliding, swinging, or jumping, or the gravitational energy a ball has when it is thrown into the hoop.

First, circle a, b, c, or d for the type of playground equipment that you plan to investigate.

a. slide

b. swing

c. ladder

d. basketball hoop

Next think about variables involved as you investigate gravitational energy. What will you measure? What will you change? What will you need to keep constant?

Notice that for each piece of equipment (a, b, c) you are investigating the energy of a person. In d, you are investigating the energy of the ball as it moves through the hoop.

In the following table, identify the variables, objects, and measurement devices you need.

Variables You Could Measure	Variables You Would Keep Constant	Variables You Would Change	Additional Objects/People Needed	Measurement Devices

Plan and write a procedure for your investigation.

Reading 3.1 – Gravitational and Kinetic Energy

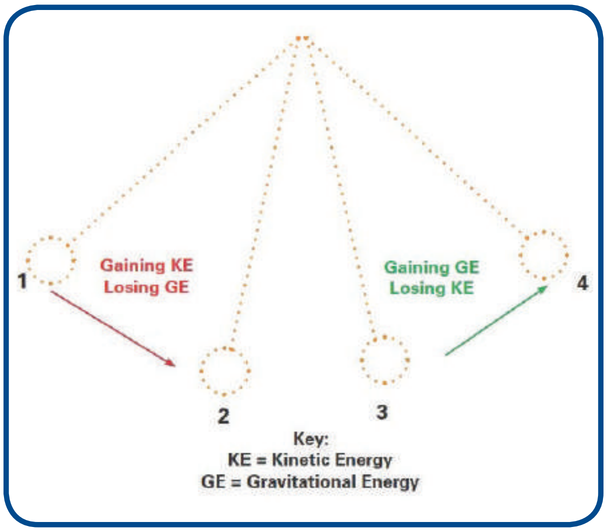
Getting Ready

Many people love roller coasters. Some people call them *scream machines*. They agree that riding a roller coaster is a thrilling experience. What you may not realize while you are going going so fast is that a roller coaster has no engine. You are not being propelled around the track by a motor or pulled by anything. A roller coaster moves on its own. How do you think that can happen?

As you read, think about the types of energy that affect what roller coasters and skateboarders can do.

How Does a Roller Coaster Work?

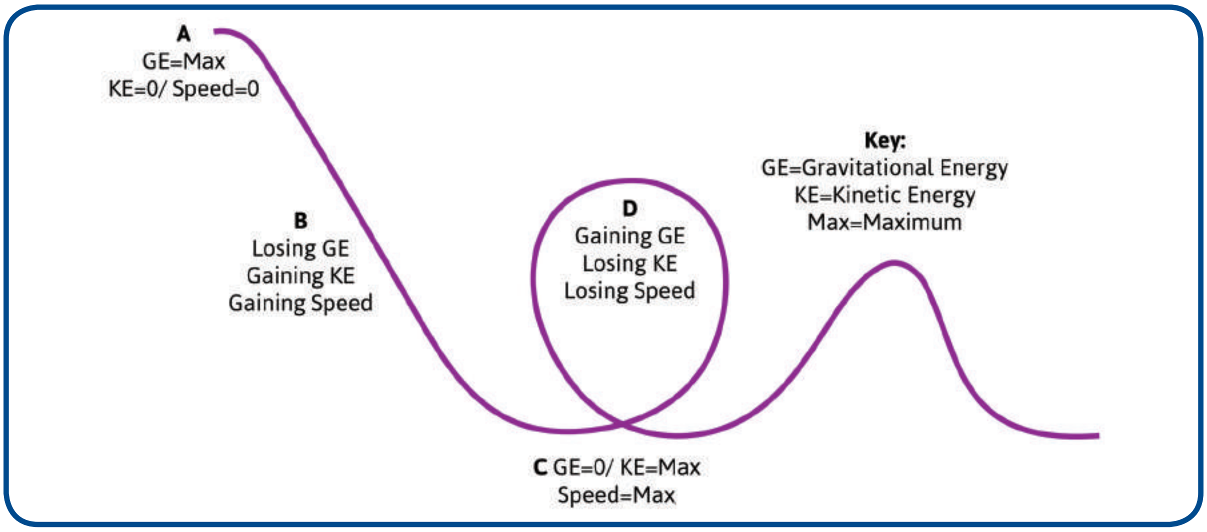
In class you investigated what happens when books fall on modeling clay. You found that the higher the book is dropped, the more gravitational energy it has and the more it compacts the clay. At the beginning of a ride, the coaster is usually pulled by a chain to the highest point of the ride. Its gravitational energy increases as it is pulled up. Once it reaches the top, it has all the energy it needs for the ride. The rest of the ride is an experience in energy conversions.



Conversions of gravitational energy into kinetic energy and back again are what make roller coasters fun. In class you saw that a pendulum moves faster near the bottom and slower at the sides. That happens because gravitational energy decreases as the pendulum goes down and is transformed into kinetic energy. When the pendulum rises back up, its kinetic energy decreases because it is being transformed back to gravitational energy. Scientists assume that the total amount of energy that the pendulum has remains unchanged.

That means when one type of energy increases, another type must decrease by the same amount.

This is also what makes a roller coaster work. At Point A in the following diagram, the top of the first hill, it has a lot of gravitational energy. The train's large amount of gravitational energy is due to the fact that it is raised high above the ground. As the train rides down the first slope, such as at Point B, it loses much of this gravitational energy and gains kinetic energy. The train speeds up as it loses height. Thus, its original gravitational energy is transformed into kinetic energy. At Point C at the bottom of the hill, the train has maximum kinetic energy because all its gravitational energy is transformed into kinetic energy. The kinetic energy allows the train to go up the loop.



As it goes up (Point D), the train gains gravitational energy and loses kinetic energy (it slows down). As the ride continues, the train is continuously losing and gaining height, gaining and losing speed. Each gain in height corresponds to a decrease in speed as kinetic energy is transformed into gravitational energy. Each loss in height corresponds to a gain in speed as gravitational energy is transformed into kinetic energy.

A roller coaster is just a machine that uses energy conversions to send a train along a track.

1. What do you think happens to the total amount of kinetic and gravitational energy that the coaster train has from the start to the end of the ride? Does it increase, decrease, or stay the same? Explain your answer.

2. Imagine a roller coaster ride in outer space. What would the roller coaster do? Why?

3. Have you ever seen a skateboard park? Skateboarders can do what they do because of energy.

a. Mark the letter A at a place in the park where a skater has the highest amount of gravitational energy. Explain your choice.

b. Mark the letter B at a place in the park where a skater will have the lowest amount of gravitational energy. Explain your choice.

c. Mark the letter C at two places in the park where a skater's gravitational energy will decrease. Explain your choice.

d. Mark the letter D at two places in the park where a skater's gravitational energy will increase. Explain your choice.

e. For each of the places you have marked, does it matter which direction the skater is coming from? Explain your response.

4. Think of another example from everyday life in which kinetic energy and gravitational energy are transformed back and forth. In the space below, draw your example, and mark the energy conversions.

Summary

In this reading you learned how understanding energy conversions can make some activities more fun. So far you have only learned about kinetic and gravitational energy, but your life involves many types of energy and conversions. Throughout this unit you will learn about other types of energy. You will be able to explain many phenomena in terms of energy conversions.

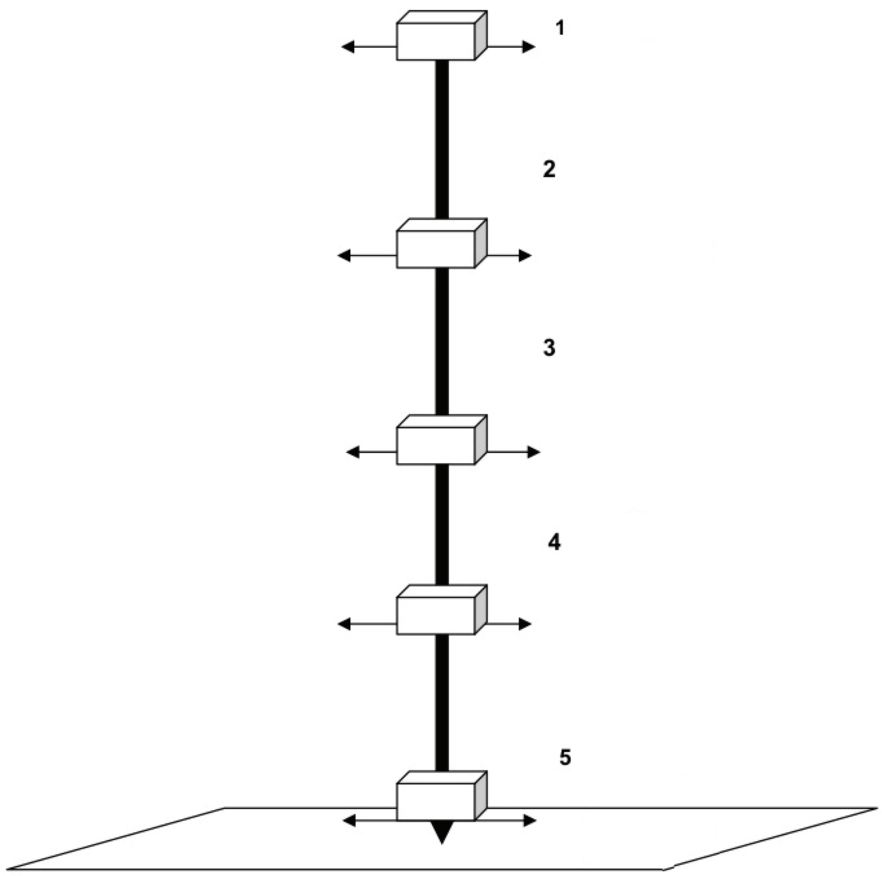
ACTIVITY 3.2 – INTRODUCING GRAVITATIONAL ENERGY, ENERGY CONVERSIONS, AND ENERGY CONVERSION DIAGRAMS

What Will We Do?

We will construct a new type of model to explain the relationship between kinetic energy and gravitational energy. It is called an energy conversion diagram.

Procedure

Your teacher showed you pie charts that represent the energy of an object before and after it falls. Add pie charts to the following diagram to represent how much gravitational energy and kinetic energy the object has at each point.



Homework 3.2 – Investigating the Playground – Part II

Purpose

Describe the energy conversions between gravitational and kinetic energy for a playground slide. Using the picture, draw an energy conversion diagram that refers to several positions along the slide where a person can be while sliding down.

ACTIVITY 3.3 – INVESTIGATING HOW A PENDULUM WORKS

What Will We Do?

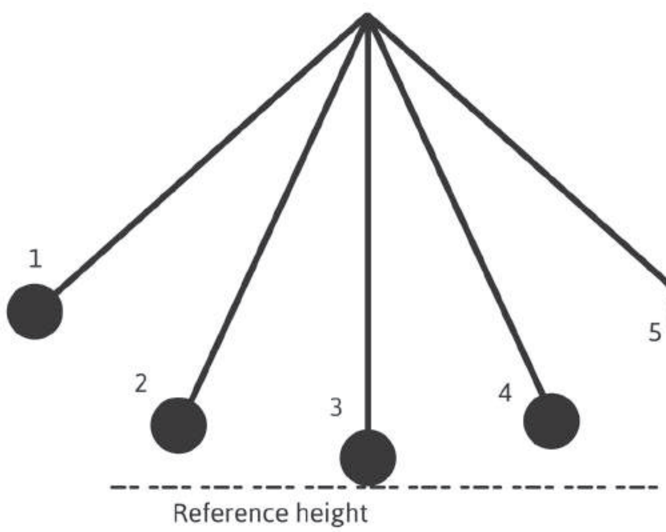
We will develop and use a model to explain the gravitational and kinetic energy conversions in a pendulum.

Procedure

1. In the following diagram, the circles represent five different positions of the pendulum as it swings.
   Position 1 is the point where the pendulum is released; position 3 is the lowest point; position 5 is the highest point the pendulum reaches on the other side; position 2 is somewhere between 1 and 3, while position 4 is somewhere between 3 and 5.

2. For each position, draw a pie chart that will describe the relative amounts of gravitational and kinetic energy that the pendulum has at that position.

3. Identify the points where there is the most and the least kinetic energy and gravitational energy.



4. Use the claim, evidence, and reasoning framework to explain what happens to the pendulum's energy as it swings from position 1 to 5.

Position 1

a. Claim – What types of energy are involved?

b. Evidence – How do you know?

c. Reasoning – What is happening with the energy?

Position 2

a. Claim – What types of energy are involved?

b. Evidence – How do you know?

c. Reasoning – What is happening with the energy?

Position 3

a. Claim – What types of energy are involved?

b. Evidence – How do you know?

c. Reasoning – What is happening with the energy?

Position 4

a. Claim – What types of energy are involved?

b. Evidence – How do you know?

c. Reasoning – What is happening?

Position 5

a. Claim – What types of energy are involved?

b. Evidence – How do you know?

c. Reasoning – What is happening with energy?

Conclusion

Describe how the pendulum works.

LESSON 4

Elastic Energy

ACTIVITY 4.1 – WHAT HAPPENS TO A BALL AS IT BOUNCES?

What Will We Do?

We will use energy conversion diagrams as models to represent and explain what happens when a ball bounces.

Procedure – Part I

1. Using the diagram of a bouncing ball that your teacher made, fill in the following pie charts that represent the energy the ball has at different points. Remember to add a key to your pie charts.

2. At each point, consider the following:
   a. Which energy types are involved?
   b. Which type is greater and why?
   c. Which type is increasing and which is decreasing?

Procedure – Part II

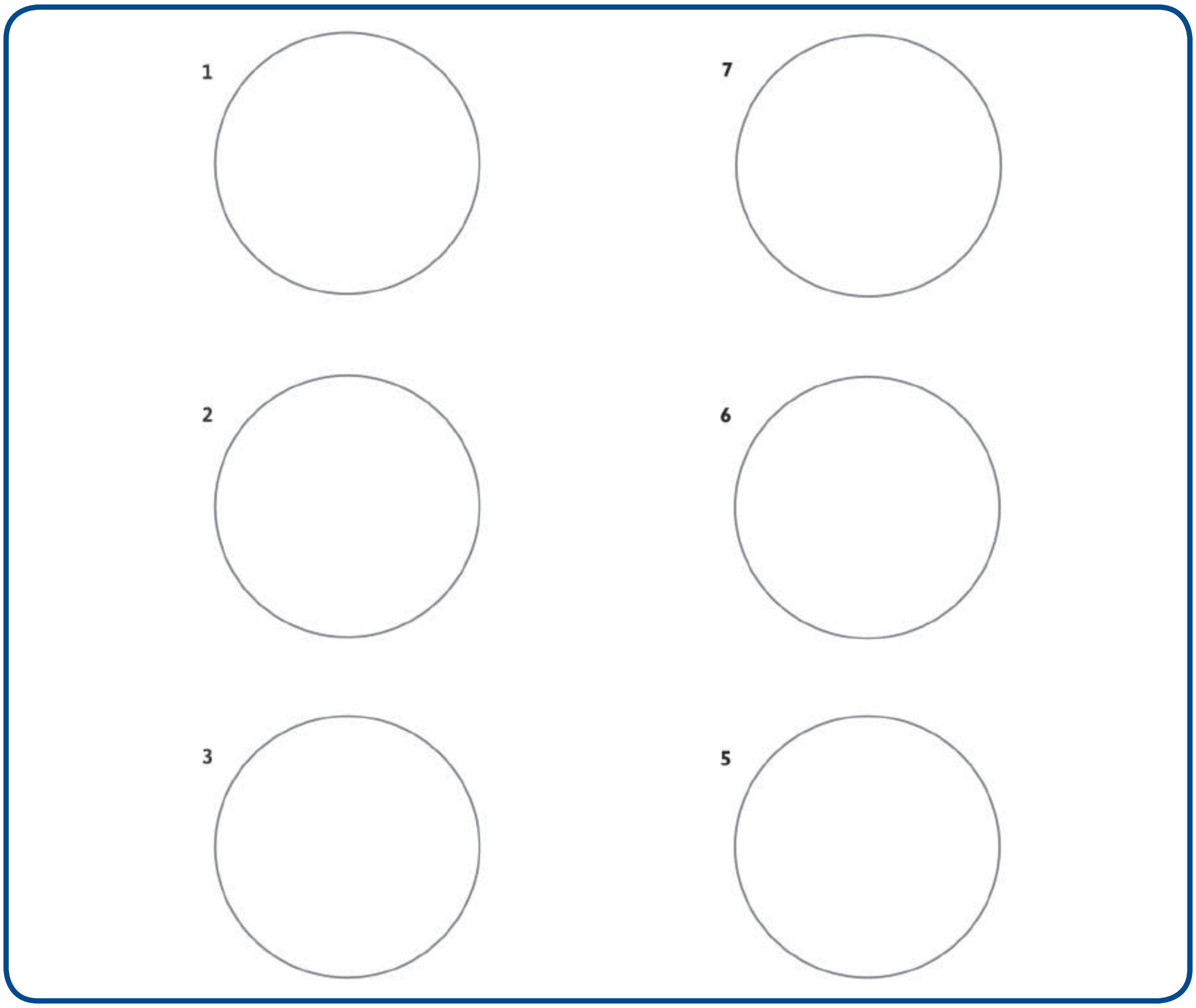
Watch the videos of bouncing balls in slow motion. Then complete the diagrams representing what happens to the ball's energy during the bounce.

Conclusion

1. Summarize what happens to a ball's energy when it bounces.

2. What do you still need to learn in order to explain the bounce?

3. Do you feel comfortable using energy conversion diagrams to represent how energy changes from one form to the other? If not, explain what is unclear to you.


1
7
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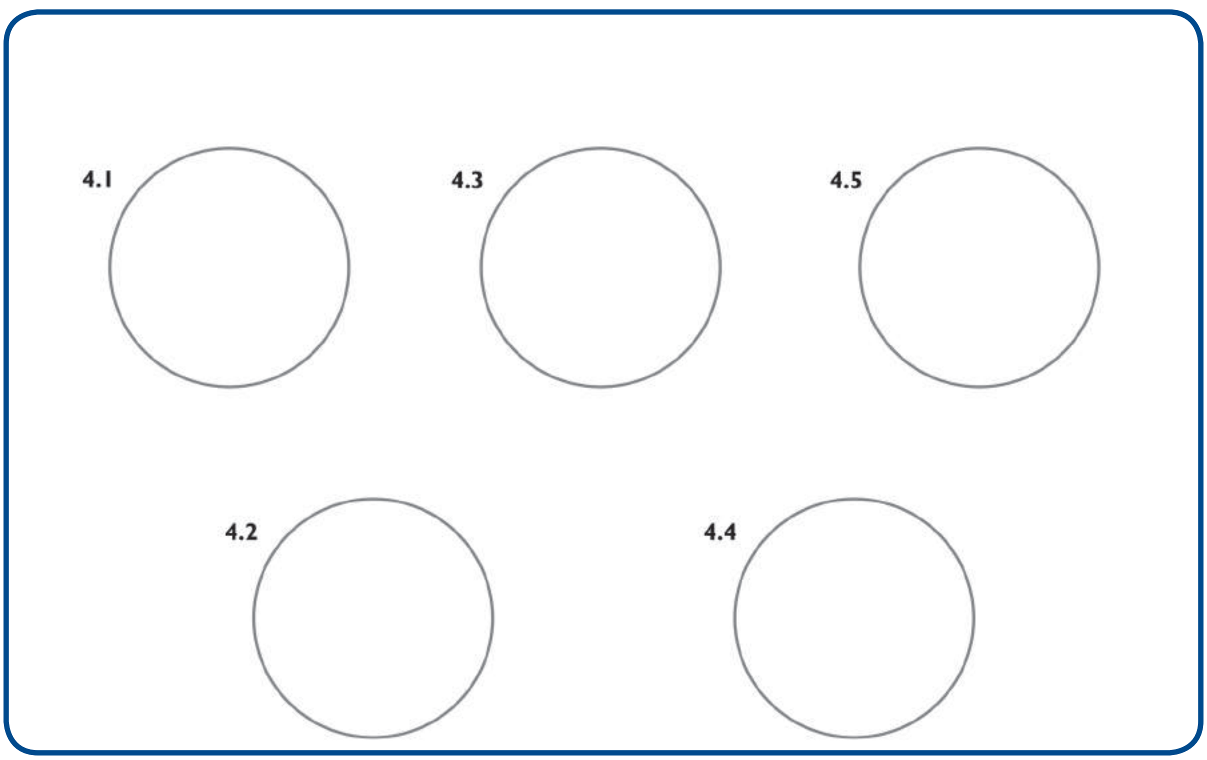
4.1
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Reading 4.1 – Elasticity and the Body

Getting Ready

You have probably heard someone say that it is important to warm up before doing physical activity. Warming up usually involves stretching. Did you know that regularly stretching can improve the elasticity of your muscles? In fact, stretching affects more than just your muscles. It affects tissues, skin, and even your bones. Elasticity is important to your body for many reasons. Why do you think elasticity is important to your body? As you read, try to understand how the activities you did in class help to explain what your body can do.

Elasticity and Muscles

In class you stretched rubber bands and saw that they returned to their original shape when you let go. Stretching your muscles is similar to stretching rubber bands. Stretching is good for the body, but stretching too far can hurt your muscles. This is because muscles have an elastic limit. In fact, all objects have elastic limits. The limit is the point at which an object stops stretching and starts to tear. At that point, an object cannot return to its original shape. Going beyond the elastic limit of a muscle can cause parts of the muscle to tear. This is different from just feeling sore after a lot of physical activity.

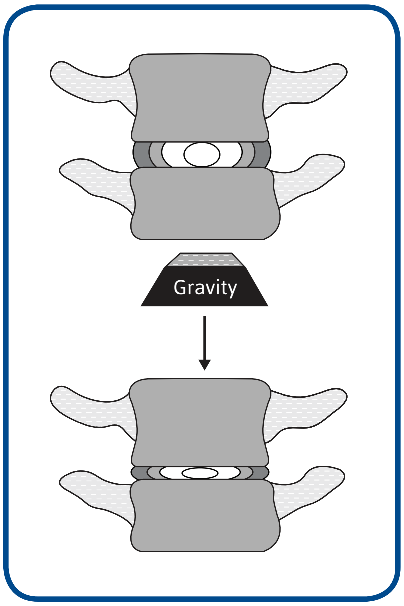
List some different muscles that you typically stretch after engaging in physical activity.

Elasticity and Connective Tissues

Connective tissues in your body connect bones to other bones, and bones to muscles. Connective tissues include tendons, ligaments, and cartilage. Some cartilage and ligaments have a protein called elastin in them that makes them elastic. They can easily be stretched or compressed and then return to their original shape. This allows them to be good shock absorbers, just like pillows. Imagine you fall on a hard surface or on a hard surface covered with pillows. In which case will you hurt less? Likewise, when you exercise, you put lots of stress on your bones. The cartilage and ligaments between your bones easily deform and soften much of this stress that might have otherwise caused the bones to break.

Gravity

Class Connection: Rigidity Affects Elastic Energy



The stress that your body feels from moving around and jumping is the result of a constant series of energy conversions from kinetic and gravitational energy into elastic energy and back again. With all of these energy conversions happening it is important to have shock absorbers that can handle the stress. This is especially important in our backs, because so much of our weight is supported there. In between each of our back bones (called *vertebrae*) are small circular pieces of cartilage called *discs*. These discs are responsible for distributing the impact that your body feels every time you take a step. With each step, pressure is put on these discs, compressing them and transforming kinetic energy into elastic energy. When the pressure is released, the discs decompress (return to their original shape) and their elastic energy is transformed back into kinetic energy.

Do you remember the slow-motion videos you saw in class? Do you remember the ball that got compressed and then decompressed? That is what happens to your discs as you walk. What is amazing is that if you take care of your body, these discs will transform kinetic and gravitational energy into elastic energy and back for most of your life without wearing out. There are very few man-made materials that can be deformed so often without becoming less elastic, losing their ability to return back to their original shape.

Where else would cartilage with elastin be helpful in keeping bones safe from absorbing too much energy?

Elasticity and Skin

What will happen if you pull on the skin on your face and let go of it? Because skin is very elastic, it will go right back to its original shape. If our skin was not elastic, it would sag. Skin has elastin in it just like some kinds of cartilage have it. Over time, though, skin loses its elasticity. Explain why you think people get wrinkles as they age.

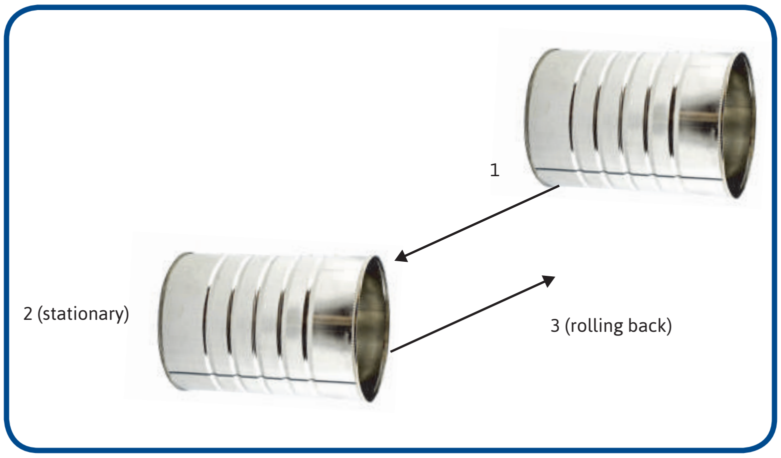
When the child in the picture lets go of his cheek and the skin moves back to its original shape, its elastic energy is transformed into kinetic energy. However, once his cheek is where it should be, it no longer moves. Where did the energy it had when it was stretched and when it was moving go? You should be able to answer this after the next lesson.

Homework 4.1 – Elastic Energy

The purpose of today's lesson was to explain how the rolling can from Lesson 1 works. After learning about elastic energy, you should be able to explain how the can works using an energy conversion diagram.

1. Draw energy conversion diagrams for positions 1–3.

2. You may choose to do the exercise below before you write an explanation for Question 3. This will help you create a first draft.



Position 1

a. Claim – What types of energy are involved?

b. Evidence – How do you know?

c. Reasoning – What Scientific Principles can you draw on to explain what is happening?

Position 2

a. Claim – What types of energy are involved?

b. Evidence – How do you know?

c. Reasoning – What Scientific Principles can you draw on to explain what is happening?

Position 3

a. Claim – What types of energy are involved?

b. Evidence – How do you know?

c. Reasoning – What Scientific Principles can you draw on to explain what is happening?

3. Use your model to explain the following: What causes the rollback can to roll, stop, and roll back again?

ACTIVITY 4.2 – INVESTIGATING ELASTIC ENERGY

What Will We Do?

We will observe elastic energy in several objects. Then, we will compare it with kinetic energy and gravitational energy.

Procedure

First, try to stretch, or squeeze, or bounce each object. Record your observations.

Object	Springs	Guitar Strings	Inverted Half-Ball	Tennis Shoe
Material It Is Made of				
Evidence for Elastic Energy: Can the Object Be Deformed? How?				
Evidence for Elastic Energy: Does the Object Return to Its Original Shape?				
Evidence for Changes in Gravitational Energy				
Evidence for Kinetic Energy				

1. What do the objects that you observed have in common?

2. What energy conversions did you identify when you explored these items?

3. How do elastic energy, kinetic energy, and gravitational energy differ from each other?

Conclusion

What are the characteristics of elastic energy?

ACTIVITY 4.3 – WHAT DETERMINES HOW MUCH ELASTIC ENERGY AN OBJECT CAN HAVE?

Your teacher will provide instructions for this page.

LESSON 5

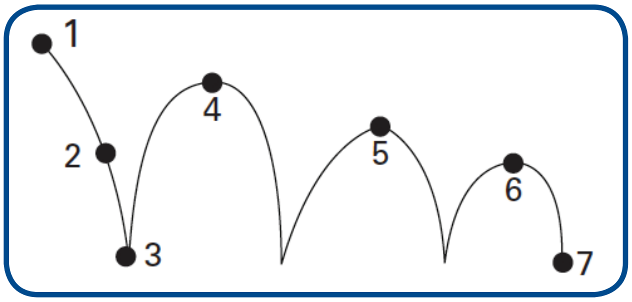
Energy Systems, Transfer, and Conservation

ACTIVITY 5.1 – REVISITING THE BOUNCING BALL

What Will We Do?

We will start figuring out why, from an energy perspective, a ball stops bouncing.

Procedure



1. Why do you think a ball stops bouncing?

2. Your teacher showed you an animation of a ball bouncing until it stopped. What types of energy do you think the ball had at points 1–7? What types of energy conversions occurred between these points?

Types of Energy						
Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7

Kinds of Energy Conversions					
1 → 2	2 → 3	3 → 4	4 → 5	5 → 6	6 → 7

3. Is the gravitational energy at point 4 greater than, less than, or the same as at point 1? Explain.

4. At which point does the ball have the most kinetic energy—point 1, point 4, point 5, or point 6? Explain.

5. Does the ball have any elastic energy at points 1, 4, 5, and 6? Explain.

6. Has any energy gone missing after point 3? Explain.

Conclusion

Can you explain why a ball stops bouncing? If yes, do so. If no, explain what you are missing to be able to do so.

Reading 5.1 – Energy Transfer

Getting Ready

Imagine a summer baseball game. Joe is standing at the plate, looking at the pitcher. The audience is cheering. The pitcher throws a fast ball that curves as it approaches the batter. Joe hesitates; then he swings the bat at the last moment. The bat hits the ball. The ball goes flying high. Joe runs toward first base, then second base. The crowd screams. The ball slowly curves over the outfield and lands in the bleachers. It is a home run!

An ordinary description of a baseball game, like the one above, may make you think about the way things move. You might think about how the ball moves and about how the bat moves.

1. Why can a person hit a ball farther if it is pitched fast than if it is pitched slowly?

2. What would happen if the person did not move the bat, but kept the bat still when the ball hit it?

In this reading, you will find out whether your ideas are correct. A fun way to do that is to actually try it. If you can, get a baseball and bat. Ask someone to help you. One of you should hold the bat still while the other throws the ball at the bat. Do not move the bat. It is important that the ball hits the bat without the bat moving. Watch closely what happens to the ball and the bat when they meet. You may want to repeat this a few times, to see what happens to each of them. Then, try swinging the bat really slowly to see what happens to both the ball and the bat when they meet.

You might not be able to do this activity at home. If you know someone who likes baseball, you could ask that person about the questions. Otherwise, go to the next section and skip the next two questions.

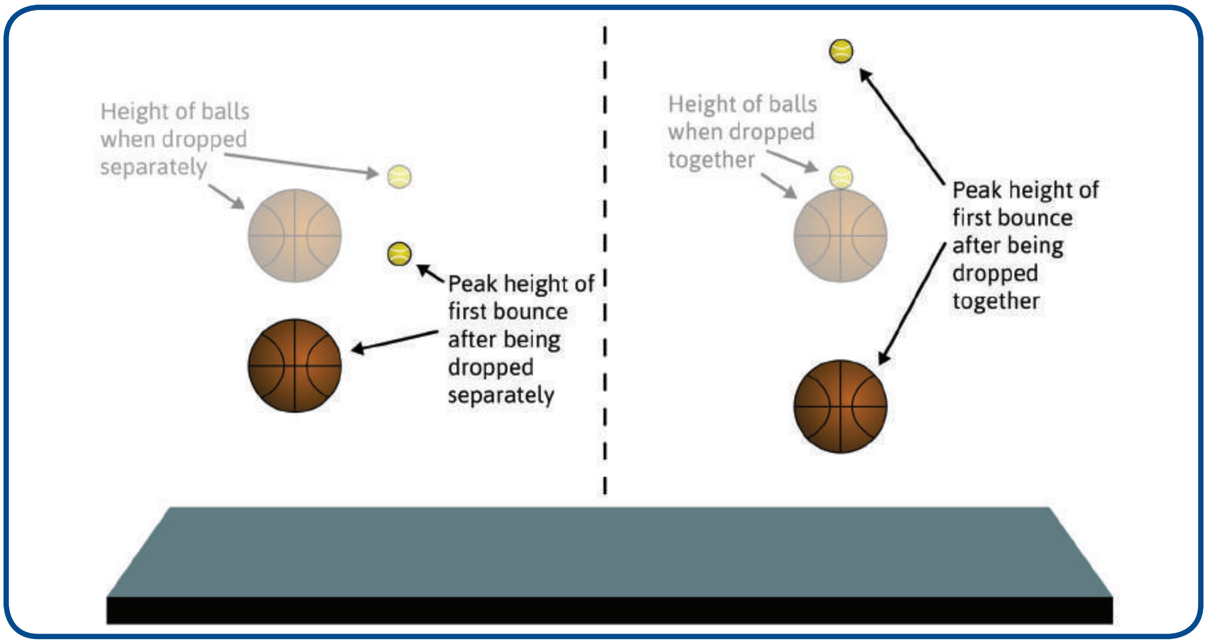
3. When did the ball fly further—when it hit the moving bat or the bat that did not move?

4. What happened to the bat as the bat and ball met while you held the bat without moving it? What happened to the bat as it met the ball the second time? Use the concept of kinetic energy to explain the difference in what happened to the bat.

In class, you learned that energy can be transformed from one type to another. For example, the gravitational energy of a swinging pendulum is transformed into kinetic energy and then back again. You also learned that energy can be transferred from one object to another. You saw that when you bounce a basketball and racquetball together, some of the kinetic energy of the basketball is transferred to the racquetball. The racquetball bounces higher than when it started because it has more kinetic energy than before. The basketball, however, bounces lower than when it started because it has less kinetic energy than before.

A similar thing happened in the video you watched, showing the collision between two billiard balls.

In the video, you saw that when the moving billiard ball hit the nonmoving ball, the moving ball transferred its kinetic energy to the ball that was at rest, making the moving ball stop and the other ball move.



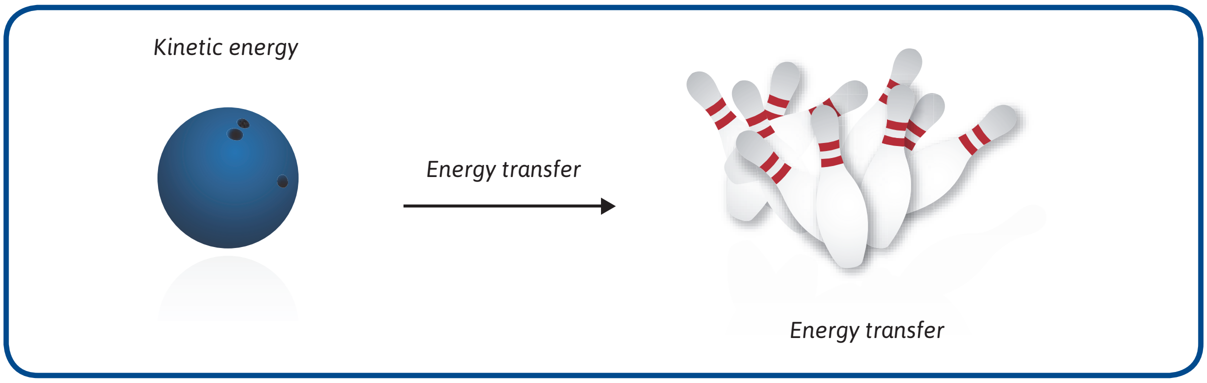
Think about the baseball and the bat.

5. What type of energy is transferred from the swinging bat to the ball? What evidence do you have to support this claim?

6. How can the answer to question five explain the difference between the ball's motion after hitting a stationary bat and the ball's motion after hitting a moving bat?

The Transfer of Energy in Other Ball Games

Every ball game involves the transfer of energy. When a player hits, kicks, or throws a ball, she transfers kinetic energy to the ball. That is why the ball moves. In some games, the goal is for the ball to transfer its kinetic energy to another object. In bowling, for example, when the ball hits the pins, it transfers some of its kinetic energy to the pins, making them fall down.



Think of another ball game you know and describe the energy transfers and conversions involved in the game. Describe it in writing or by drawing. Use the energy transfer diagram previously shown as an example.

The Domino Effect

Have you ever lined up dominoes and then tapped the first one? One by one, they all fall, creating something that looks like a wave.

If you have enough dominoes and patience, arrange the dominoes in special shapes and obtain beautiful waves in different directions and different colors. If you have some dominoes at home you can try it. You can also watch the following video on the Internet: http://www.youtube.com/watch?v=SZPjJt4Sn8s&NR=1. This phenomenon is called the *domino effect*.

The term *domino effect* can be used not only with dominoes but also with every phenomenon in which a small change causes a chain of events that leads to a much bigger result. You can watch a video clip showing a sophisticated example of a domino effect which consists of diet cola and candy at http://video.google.com/videoplay?doc id=-274981837129821058.

The domino effect (with real dominoes) is another example of the conversion and transfer of energy.

7. What type of energy does the first standing domino have?

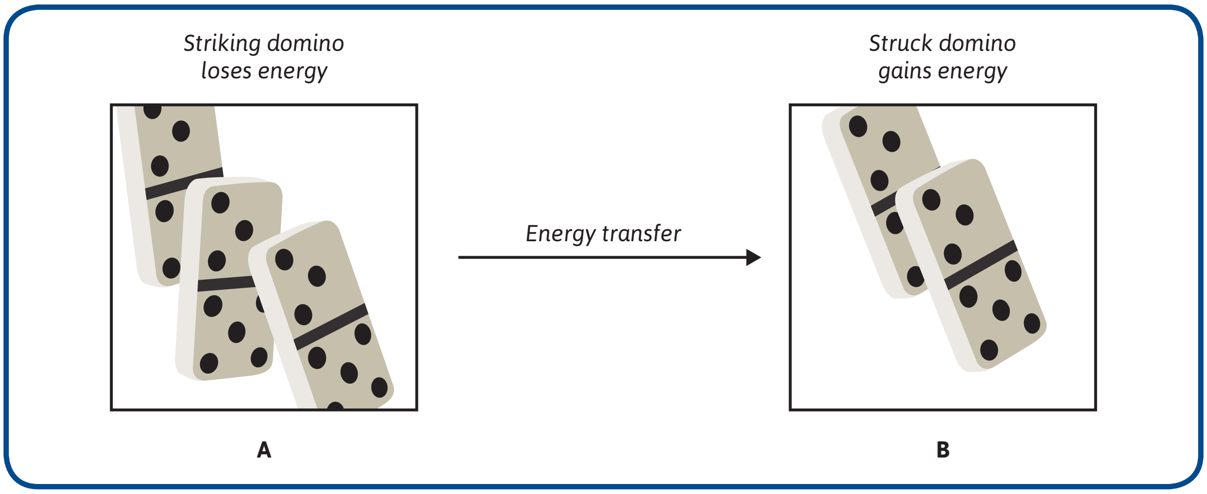
8. What happens to this energy when the first domino is pushed?

9. What happens to the kinetic energy of the first domino when it hits the second domino?

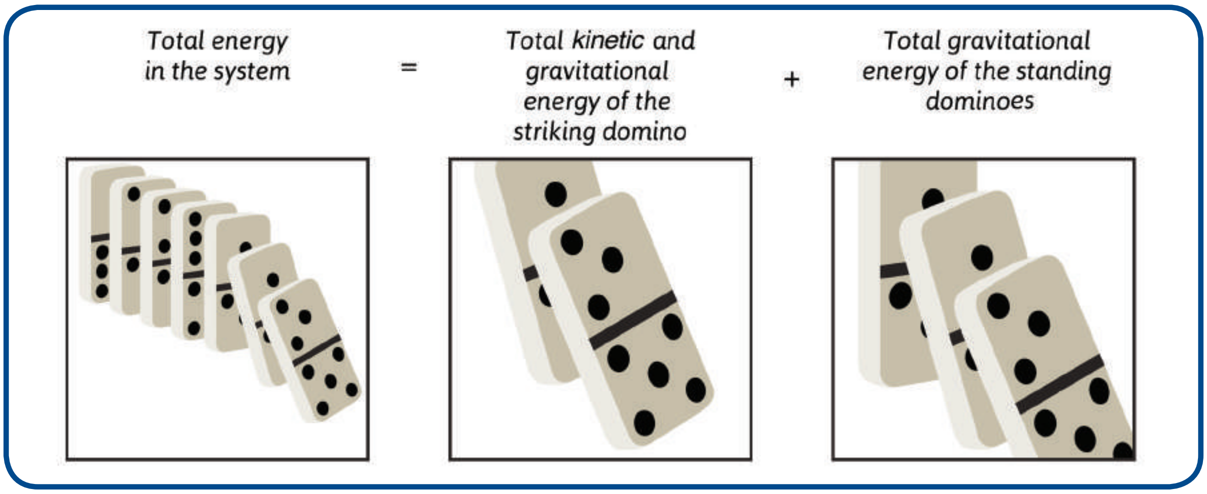
10. What happens to the energy of the standing domino when the former domino hits it?

Energy Conservation in Systems

If you think of each domino separately, the amount of energy each domino has seems to change. Look at the domino marked A in the following image. This domino's energy increases when it is struck by a falling domino that transfers some of its kinetic energy to it. Now look at the domino marked B in the image. This domino's energy decreases when it strikes the domino coming after it, transferring some of its kinetic energy to it.



If you think of all the dominoes together as a system, the total amount of energy of all the dominoes does not change. The energy is simply transferred from one domino to another.



11. Think again about the baseball and bat. If you think of the bat and the baseball separately, what happens to the energy of each of them when they hit each other?

12. If you think of the ball and bat together as a system, what happens to the total energy of the system when the ball hits the bat?

Why Do Things Stop?

If nobody catches a ball, it hits the ground, bounces a couple of times, and then stops. What happens to its energy? Where does it all go? The following paragraph gives you a hint.

You learned that energy may also be transferred to an object's surroundings. For example, a swinging pendulum gradually transfers all its kinetic energy to the surrounding air molecules. The pendulum slows down until it finally stops, losing energy all the time, while the air molecules gain kinetic energy and move faster than they did before.

13. Why does the ball stop?

ACTIVITY 5.2 – DEMONSTRATION: BOUNCING TWO BALLS TOGETHER

What Will We Do?

We will observe a demonstration of a racquetball and basketball bouncing together, at the same time. After making observations, we will develop an energy transfer diagram as a model to explain what happened.

Prediction

After your teacher illustrates what he or she is going to do, predict what you think will happen to the larger ball and the smaller ball.

The larger ball will . . . ______________________________

The smaller ball will . . . ______________________________

After they bounce the first time . . . ______________________________

Procedure

1. Record observation of basketball bouncing only.
2. Record observation of racquetball bouncing only.
3. Record observation of basketball when bounced alongside the racquetball.
4. Record observation of racquetball and basketball bouncing together.

Data Collection/Observation

	Height of Bounce of Basketball	Height of Bounce of Racquetball	Basketball Bounce Height Alongside Racquetball	Racquetball Bounce Height with Basketball
First Bounce				
Second Bounce				

1. Describe the amount of energy the racquetball had after it was bounced with the basketball.

2. Explain your observation of what happened to the racquetball when it was bounced with the basketball.

3. Explain your observation of what happened to the basketball when it was bounced with the racquetball.

In this lesson, you have been introduced to a new concept called *energy transfer*. Energy transfer occurs when energy moves from one object to another.

Follow Up Questions

1. Draw an energy transfer diagram for the billiard balls you observed in Video 5.2.

2. In Lesson 2, you dropped a heavy tin can onto a ball of modeling clay. Draw an energy transfer diagram for the tin can and the modeling clay.

ACTIVITY 5.3 – OBSERVING OBJECTS THAT SLOW DOWN BEFORE THEY STOP

What Will We Do?

We will analyze data in order to explain why things stop.

Prediction

What will happen to the pendulum while it swings?

Procedure

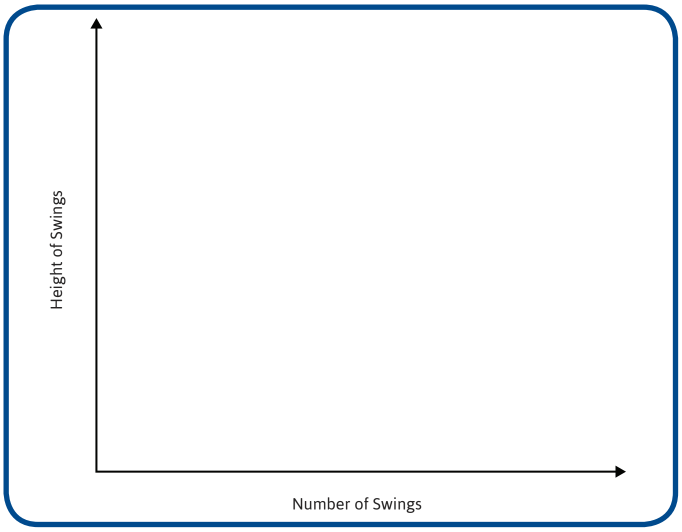
1. Gather these materials: a pendulum, a meterstick, and a large piece of poster paper.
2. Choose a location in the room near a wall or the side of a filing cabinet and attach the paper to the flat surface.
3. Place the pendulum next to the paper. Mark the paper with the height of the pendulum when it does not move. Lift the bob of the pendulum to the side. Make a mark on the sheet of paper that indicates the height the pendulum starts at.
4. Release the bob so the pendulum swings.
5. Count 20 swings from side to side. Then, without touching the pendulum, mark on the paper the highest point the pendulum reaches. Let it swing another 20 swings and again mark its highest point. Repeat this another three times.
6. Let the pendulum stop and measure the heights of the consecutive highest points from the lowest point of the pendulum. Record your measurements in the data table.

Data Collection/Observation

Swing Number	Height of Swing

Conclusion

1. Using the data in the table, construct a graph of the maximum height versus the number of the swing.



2. What happened to the maximum height of consecutive swings?

3. What happened to the maximum gravitational energy of each swing?

4. How does the energy of the pendulum when it has stopped swinging compare to when it began swinging?

Follow Up

1. List and describe the types of energy conversions that you have studied that occur in a swinging pendulum.

2. Of the energy conversions you listed in question 1, what evidence do you have that each type of energy conversion occurs in a pendulum?

3. Were there other things that interacted with the pendulum?

4. Draw an energy transfer diagram for the pendulum and air.

ACTIVITY 5.4 – ENERGY TRANSFER AND SYSTEMS

What Will We Do?

We will explain what a system is, and we will use an energy transfer diagram to describe what happens to the energy when a racquetball and basketball are bounced together.

Procedure

In Activity 5.2, you recorded observations of the basketball and racquetball bouncing. Draw an energy transfer diagram for the basketball and racquetball.

If you think of the basketball and racquetball separately, the amount of energy seems to change—increasing for one and decreasing for the other. If you think of both balls together, the amount of energy seems to be the same—it is simply transferred from one ball to another. When you think of things together in this way, it is called a *system*. If you think of both the basketball and racquetball together as a system, then the energy in that system is conserved when one ball hits the other.

Follow Up

1. You observed that the basketball and racquetball eventually stop bouncing. What other objects are in the system with the basketball and racquetball?

2. A system can be made of one or more objects. Thinking of the possible systems that can be made of objects involved in the basketball and racquetball demonstration, in which systems does

   - the energy decrease?

   - the energy increase?

   - the energy stay the same?

LESSON 6

Thermal Energy

ACTIVITY 6.1 – COLLIDING BALLS

What Will We Do?

We will investigate energy conversions and learn about a new type of energy.

Procedure

A volunteer will hold two steel balls on a table. A second volunteer will hold two metersticks so that they create a rail to roll the steel balls on. A third volunteer will hold a sheet of paper vertically just above the center of the metersticks. The first volunteer will roll the balls towards the other so that they strike each other with the paper between them.

Prediction

Predict what will happen to the piece of paper between the two steel balls.

Data Collection/Observation

The third volunteer will show the sheet of paper to the rest of the class. What happened to the paper? Describe what you observed.

Draw an energy transfer diagram for a system composed of both balls but not the paper.

Draw an energy conversion diagram for one of the balls. Does it make a difference for which ball you draw the diagram?

Conclusion

1. Do the steel balls have more or less energy after they hit each other with the paper between them? Think about the kinetic and elastic energy the balls had before and after they hit the paper.

2. Does each ball lose or gain energy?

3. Where did the missing energy go? Could it have become another type of energy?

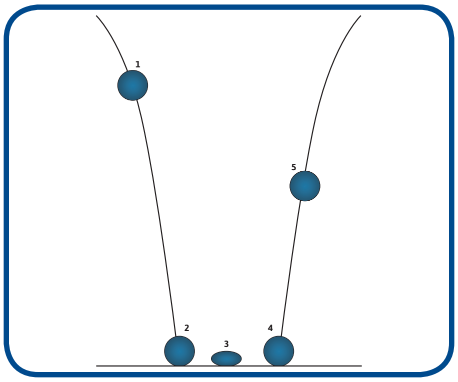
4. Which type of energy is the unknown energy? What is your evidence?

Follow Up

Could two racquetballs be used to replace the steel balls in this experiment and achieve the same result? Why?

Homework 6.1 – Add Thermal Energy in the Energy Conversion Diagrams

In Lesson 4, you learned about energy conversions as a ball bounces. You drew diagrams that included gravitational, kinetic, and elastic energy. Now, you've learned that thermal energy is also involved. Read the steps below, and draw new diagrams, adding thermal energy where it is needed.



1. As the ball falls, gravitational energy decreases and kinetic energy increases.

2. Right before the ball hits the ground, all of the gravitational energy has become kinetic energy.

3. When the ball hits the ground, it gets compressed. At the most compressed point, the kinetic energy has been converted into elastic energy and thermal energy.

4. The ball begins to decompress and when it is fully decompressed, all of its elastic energy has turned back into kinetic energy. It does not have as much kinetic energy as it had when it struck the ground because some of it has been converted into thermal energy, which is not converted back into kinetic energy.

5. As the ball moves up into the air, its kinetic energy turns into gravitational energy until it has reached its highest point. It still has some thermal energy.

Reading 6.1 – Potential Energy

Getting Ready

Did you ever wonder how a bomb can cause such huge damage and yet, as long as it is not activated, it just lies someplace, not harming any one? When a bomb explodes, fragments of it and hot gases fly outward at a tremendous speed, destroying anything in their path. These fragments and hot gases have a lot of kinetic energy. Where does all this kinetic energy come from? A bomb has the potential ability to cause a lot of damage, that is, it has the potential to lead to a disaster by releasing huge amounts of kinetic energy. This potential ability is due to the bomb's potential energy.

We use the term *potential* in other fields of life to describe things that are not fulfilled. For example, when someone is very talented at playing the guitar but does not do anything about it, we say she has a lot of musical potential. The bomb's potential energy has the potential to become kinetic energy, but as long as the bomb is not activated, this does not happen.

Describe another example of something that has the potential to do something.

Types of Potential Energy

It is possible to divide all types of energy into two groups—kinetic energies and potential energies. You have already learned about kinetic energy. This is the energy of objects in motion. Thermal energy is also a form of kinetic energy. Thermal energy is the name given to the kinetic energy of nanoscopic particles moving randomly within a material. It is related to the temperature of the material.

You have also learned about kinds of potential energy. For example, you learned about gravitational energy, which is related to the elevation of an object. When you hold something in your hand, it has gravitational energy. When you drop the object, its gravitational energy is converted into kinetic energy. As long as you hold the object in your hand, this will not happen. The gravitational energy has the potential to become kinetic energy, but it will not unless the object is dropped. Physicists say that gravitational energy is a type of potential energy because it has the potential to become kinetic energy. Look at the photographs of the child with an ice-cream cone. In the first photo, the cone has potential energy. In the second photo, the energy is converted into kinetic energy.

What happens to the kinetic and gravitational energies of the ice-cream cone when it is falling? Do they increase or decrease?

Another type of potential energy that you have learned about is elastic energy. In class, when you stretched a rubber band, it had elastic energy. When it was released, it flew off and had kinetic energy. Where did this kinetic energy come from? The rubber band's elastic energy was converted into kinetic energy. So elastic energy has the potential to become kinetic energy, but this does not happen until the rubber band is released. Like gravitational energy, elastic energy is also a type of potential energy. The same thing is true for the compressed spring, or the inverted half-ball, you saw in class. Each one had potential elastic energy which was converted into kinetic energy.

Sometimes people say g*ravitational potential energy*, or *potential gravitational energy*, or *gravitational energy*. These are all the same type of energy with slightly different names. In this unit, you will always use the shortest names, such as gravitational energy, elastic energy, and kinetic energy. Because there are many types of potential energy, you will need to be specific about which one you refer to. Just saying that something has potential energy does not describe everything you have learned about types of potential energy.

Complete the following table. For each type of energy, mark if it is potential or kinetic and give an example of a situation involving this type of energy. The situations you choose may involve other types of energy as well.

	Kinetic Energy (yes or no)	**Potential Energy (yes or no)**	**Example**
Gravitational Energy			
Elastic Energy			
Thermal Energy			

Energy and Forces

You have learned about two types of potential energy: gravitational and elastic. They both have the potential to become kinetic energy. What else is common to gravitational and elastic energy?

All types of potential energy are associated with forces. These forces act between two objects. For example, an ice-cream cone has gravitational energy because it is subjected to the force of gravity. Where does this force come from? Gravitational energy comes from the earth. So the force of gravity acts between the ice-cream cone and Earth, attracting each one to the other.

When a rubber band is stretched, a force acts between the rubber particles that attract the particles towards each other. This force is the source of the elastic energy. When a spring is compressed, there is a force between the metal particles in the spring, pushing them away from each other. An object's potential energy depends on the distance between it and the other body that is the source of the force it feels. The further the ice-cream cone is from Earth, the greater its potential energy. Potential energy is dependent on an object's position and not its motion. However, kinetic energy is dependent on an object's motion and not its position.

There are many other types of energy that you will learn about, but each energy type is either kinetic or potential. It cannot be both. For example, you will learn about sound energy. Is it a potential energy or a kinetic energy? Does it involve the motion of something or the location of something? Explain your ideas.

Summary

1. Complete the following sentences using these words: *position, kinetic, force*, and *potential*.

    a. Gravitational energy and elastic energy are types of ______________ energy.

    b. Potential energy is associated with a ___________ acting between two objects.

    c. An object's potential energy is related to its _____________.

    d. Potential energy can be converted/transformed into ____________ energy.

2. Look at the picture and explain what kind of energy is involved.

a. Is this energy potential or kinetic? Explain your answer.

b. Draw another situation that describes a type of potential energy.

ACTIVITY 6.2 – THERMAL ENERGY: SOLIDS

What Will We Do?

We will connect ideas about temperature, kinetic energy, thermal energy, and molecules.

Procedure

1. Watch a computer simulation that demonstrates the molecular motion of a solid.
2. Watch another computer simulation of molecular motion of the same solid at a higher temperature.

Data Collection/Observation

1. Are the molecules inside the solid stationary or in continuous motion? What energy do molecules have?
2. What is the difference between the molecular motion of a solid at a high temperature and the same solid at a lower temperature?

Conclusion

The thermal energy of an object is the sum of the kinetic energies of all the particles that make up the object. The greater the kinetic energy of the particles, the greater the object's thermal energy will be.

When does an object have more thermal energy, when it is hot or cold? Why?

Follow Up

Do all solids have thermal energy? Why?

ACTIVITY 6.3 – MOLECULES IN MOTION: LIQUIDS AND GASES

What Will We Do?

We will investigate the relationship between temperature, kinetic energy, thermal energy, and molecules in liquids and gases.

Procedure and Observation/Data Collection

1. Fill a beaker with 150mL of cold water. Use a thermometer to measure the temperature of the water.

2. Use a pipette to carefully add one drop of food coloring to the beaker. Do not stir. Observe what happens to the food coloring. Write down what happens to the food coloring.

3. Fill another beaker with 150mL of hot water. Be careful not to burn yourself. Use a thermometer to measure the temperature of the water. Record the temperature.

4. Use a pipette to carefully add one drop of food coloring. Do not stir. Observe what happens to the food coloring. Write down what happens to the food coloring.

5. Watch a computer simulation that demonstrates the molecular motion of a liquid at high and low temperatures. Do the molecules of the liquid move faster at the high or low temperature?

6. Watch a computer simulation that demonstrates the molecular motion of a gas at high and low temperatures. Do the molecules of the gas move faster at the high or low temperature?

Conclusion

1. Do the water molecules collide with food-coloring molecules?

2. If the water molecules move faster, will they collide with the food-coloring molecules more vigorously and frequently?

3. If the food-coloring molecules are hit more vigorously, will they spread out faster?

4. Why does the food coloring spread out faster in hot water than in cold water?

5. Do water molecules move faster at high temperatures or at low temperatures?

ACTIVITY 6.4 – WHAT DETERMINES HOW MUCH THERMAL ENERGY AN OBJECT HAS?

What Will We Do?

We will look at a few scenarios and determine which object has more thermal energy.

Procedure

1. Use your knowledge of mass and temperature to decide which object will have the most thermal energy. Place a check mark in the box to the right of the item that will have the most thermal energy.

a)  ☐  ☐

Large amount of water Temp 30°C — Small amount of water Temp 30°C

c)  ☐  ☐

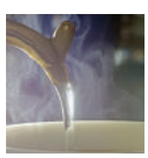
Small Mosquito A Temp 35°C — Large Mosquito A Temp 40°C

b)  ☐  ☐

Cube Temp 30°C — Same Cube B Temp 60°C

d)  ☐  ☐

A cup of hot tea or a tub of cool water? *(This is hard to determine, but great for discussion.)*

e)  ☐  ☐  ☐

Equal masses of steam, liquid water, or ice

2. Which of the following has more thermal energy—a cup of boiling water or a bathtub full of warm water? Explain.

Conclusion

What determines how much thermal energy an object has?

Lesson 7

Can Sound Make Things Stop?

ACTIVITY 7.1 – WHAT IS SOUND ENERGY?

What Will We Do?

Consider how sound energy is involved in making things stop.

Part 1

Most drums typically make sharp sounds that fade away quickly. Those that fade away slowly usually make mellower sounds.

1. What happens to the skin of a drum when you strike it? In which way does it move?

2. What does the drumskin do to the air molecules around it as it vibrates?

3. When does the air around the drum have more kinetic energy, before it was struck or after?

4. Where does this kinetic energy of the air come from?

5. If the air is getting energy from the drum, what should be happening to the energy of the drum?

6. If the drum skin's energy decreases, what should happen to its vibrations?

7. How can we tell this is happening? Does the drum skin stop vibrating or does it keep going?

8. Which drum makes a sound that fades away faster—one that makes a loud sound or one that makes a more mellow sound? Why?

Part 2

1. What other devices do you know that have sound energy?

2. Where does the sound energy of a bouncing racquetball come from?

3. Does this sound energy have something to do with why the ball stops bouncing?

4. Draw an energy transfer diagram that shows a bouncing ball transferring energy to its surroundings. This energy transfer diagram should consider kinetic, gravitational, elastic, thermal, and sound energy.

Conclusion

1. Why, when popped, does a fully-inflated balloon make a louder noise than a partially-inflated balloon? Use energy considerations in your answer.

Reading 7.1 – Sound Energy

Getting Ready

In class, you learned that sound is caused by air particles moving back and forth together in a manner called a wave. You discovered that by emitting sound, an object transfers energy to its surroundings. This sound energy is actually the kinetic energy of the air particles surrounding the object moving in a coordinated manner. You know that sound can travel in gases because you know that sound travels in air, and air is made mostly of gases. Do you think sound can travel in liquids? Why? Do you think sound can travel in solids? Why?

Try This at Home

Are air particles the only particles that can transfer sound energy? Can sound travel only in air or can it travel in liquids and solids as well? Here are some experiments to try at home.

1. Next time you take a bath, fill it up deep enough that the water covers your ears. Then knock on the side of the tub, under the water. Can you hear a knocking sound?
2. What does that mean about sound traveling in liquids?
3. Place one of your ears flat on a table and close the other ear with your finger. Then knock on the table. Can you hear the knocking sound?

4. What does that mean about sound traveling in solids?

5. You may have seen old movies in which a person put his ear next to the ground as a way to tell if someone was coming. Do you think that worked? Why?

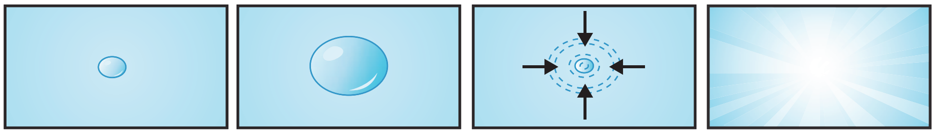
6. What kind of energy was transferred to your ear when you had your head in water and when you listened with your ear on a table?

7. Each of these energy transfers involved particles. What kind of particles were they?

Sonic Weapons in the Sea

People usually think that the world under the oceans is silent. You already know that sound can travel in water, so you should not be surprised to discover that sound is essential for some creatures living in the seas. Some kinds of whales and dolphins use sound to communicate with each other under the water. Another sea creature that uses sound is the pistol shrimp or snapping shrimp. This shrimp uses sound energy as a weapon to help get food. Pistol shrimp have two claws, one resembling a boxing glove. When the shrimp snaps shut the claw, it produces a sharp cracking sound. This sound stuns the prey so the shrimp can grab it.

The cracking sound does not come from the snap of the claw but from tiny bubbles as the claw closes rapidly. When the bubbles are made, they first expand and then collapse suddenly, emitting a sound with enough energy to stun a small creature. Recently, scientists discovered that when the bubbles collapse, they not only emit sound but also a flash of light. This flash of light is very short. It is not visible to the naked eye, and it most likely has no significance to the shrimp or the prey. If you have access to the Internet, watch this amazing video showing the shrimp's sound weapon in action: http://www.youtube.com/watch?v=eKPrGxB1Kzc.



From left to right: creation of bubble, epansion, quick and sudden collapse, emission of sound and light.

Ultrasound

Humans can hear the pistol shrimp's cracking sound, but humans cannot hear all sounds. As you learned when you studied light, some light is not visible to humans. Human eyes are not sensitive to all wavelengths of light. In the same way, some sounds are inaudible to humans because their ears are not sensitive to all wavelengths of sound. *Ultrasound* is the name given to a group of these sounds. You may have heard of ultrasound used in some medical tests. It is a very high-pitched sound, higher than human ears can detect. Animals, such as dogs, bats, dolphins, and whales can hear ultrasound. Some animals even emit ultrasound in order to find their way around and to catch food.

How Do People Use Ultrasound?

Although people cannot hear ultrasound, they can use it to view things they cannot see with the naked eye. One example is Sound Navigation and Ranging (SONAR) systems that are used for underwater navigation. In SONAR, ultrasound is emitted in a particular direction. If there is an object in the path of this sound, part of it will be reflected back as an echo. The echoes are detected by the SONAR device. By measuring the difference in time between the sound being emitted and the echo being received, it is possible to determine how far away an object is. The longer it takes for an echo to return, the further away the object creating the echo is. SONAR helps a submarine know if something like a rock or another submarine is in its path.

Use what you learned about SONAR to draw a model explaining how bats can find their way around using ultrasound. Think about the models you may have previously made that showed how your eyes use light to see something.

How Do Doctors Use Ultrasound?

Ultrasonic devices are also used by doctors to see inside the human body. Using ultrasound, doctors can see a fetus in its mother's womb and can see blood flowing through veins. The ultrasonic waves reflected from these parts are detected by a device. The device translates the sound waves into an image on a monitor, similar to a television or computer screen. Like SONAR, the image is based on the time it takes the sound waves to return to the device after they are emitted.

The image here shows a fetus in its mother's womb as it looks on a screen.

Summary

In this reading, you have learned that sound can travel in liquids and solids as well as in gases like air. You have also learned about different uses for ultrasound, which is a type of sound that humans cannot hear. In each use, ultrasound was either transmitted through something, absorbed by something, reflected and scattered by something, or a combination of these. In this way, sound is similar to light. You have learned that light can be scattered/reflected, transmitted, and absorbed. This is true of anything that travels as a wave. It can be scattered/reflected, transmitted, and absorbed.

Make a list of the different uses for ultrasound that you have learned about. For each use, tell whether the ultrasound waves are reflected/scattered, transmitted, absorbed, or a combination of the three. Tell what object(s) do the scattering, reflecting, transmitting, or absorbing. You might find it helpful to make a table to organize this information.

LESSON 8

Chemical Energy

ACTIVITY 8.1 – THERMAL ENERGY IN CHEMICAL REACTIONS

What Will We Do?

We will investigate temperature, energy, and a chemical reaction.

Procedure

1. Your teacher will give you a beaker with 5g of cupric chloride dissolved in 50mL of water.
2. Carefully use a thermometer to measure the temperature of the solution. Record in the table.
3. Put 0.5g of aluminum foil into the solution. Use the stirring rod or spoon to immerse the foil in the solution. Observe what occurs and record what you see.
4. After all the aluminum foil has disappeared, measure the new temperature of the solution and record the reading in the table.

Data Collection/Observation

What did you observe?

Initial Temperature	Temperature after Immersing the Foil	Temperature Change

Conclusion

Use the words *chemical reaction*, *temperature*, and *thermal energy* to describe what happened in this investigation.

ACTIVITY 8.2 – THE PAPER CUP

What Will We Do?

We will investigate energy transformations during a chemical reaction, as a candle burns.

Safety

Keep hair, sleeves, and papers away from the flame. Be careful not to burn the paper cups.

Procedure

1. Set up the equipment for the experiment.

   a. Suspend the paper cup on the ring support with the thread coming through the hole in the bottom of the cup.

   b. Put a tea light under the cup.

2. Predict what will happen to the cup when you light the candle. Explain.

3. Wait until the cup is almost motionless. Light the candle.

4. Observe what happens.

Observation

1. What happened to the cup during this activity?

2. Did the cup have kinetic energy before you lit the candle? Did it have kinetic energy after the candle was lit? When did it have more kinetic energy?

3. Did a chemical reaction occur while the candle was burning? How do you know?

4. Where did the kinetic energy of the rotating cup come from? How do you know?

Conclusion

What made the paper cup rotate?

What energy transformations took place in transforming chemical energy into kinetic energy? How many energy transformations can you list in this process?

ACTIVITY 8.3 – HOW MUCH CHEMICAL ENERGY IS THERE?

What Will We Do?

We will investigate what influences the amount of chemical energy that is transformed into thermal energy.

Prediction

What factors do you think will influence the amount of chemical energy being transformed during chemical reactions? For example, how could you make the temperature of the solution increase more?

Procedure

Experiment #1: Investigating the influence of the mass of a substance on the amount of chemical energy the substance has.

1. Your teacher will give you a beaker with 5g of cupric chloride dissolved in 50mL of water.

2. Use a thermometer to measure the temperature of the solution and record the temperature in Table 1 below.

3. Put 0.75g of aluminum foil (prepared by the teacher) in the cupric chloride solution. Use the stirring rod or spoon to immerse the foil in the solution. Observe what occurs and record what you see in Table 1.

4. Use a thermometer to measure the temperature of the solution. After all the aluminum foil has disappeared, record the reading of the thermometer in the Table 1.
   What did you observe?

Table 1

Initial Temperature	Temperature after Immersing the Foil	Temperature Change

Experiment #2: Investigating whether the type of substance influences the amount of chemical energy the substance has.

1. Your teacher will give you a beaker with 5g of cupric chloride dissolved in 50mL water.
2. Use a thermometer to measure the temperature of the solution. Record in Table 2.
3. Put 0.5g of steel wool in the solution. Use the stirring rod or spoon to immerse the steel wool in the solution. Make and record observations in Table 2.
4. Use a thermometer to measure the temperature of the solution. Record in Table 2.

Table 2

Initial Temperature	Temperature after Immersing the Foil	Temperature Change

Conclusion

What factors determine the amount of chemical energy an object has?

Follow Up

Give an example of chemical energy in your daily life.

Reading 8.3 – Fuels

Getting Ready

What do you already know about fuel? Make a list below of some types of fuel and what they are used for. For example, what kind of fuel heats the place you live? What kind of fuel can be used for cooking? Think of things that use fuel and what type of fuel they use.

In this reading you will learn about different types of fuel and why they work differently for different purposes; but all fuels also have some things in common. As you read, pay attention to how different types of fuel compare to one another. At the end of the reading you will be asked to tell what is similar and what is different about several types of fuel.

Chemical Energy

In class you learned that chemical energy is the energy of substances that is transformed into other energy types during chemical reactions. You may also have learned that burning is one type of chemical reaction. When something burns, the substances it is made of undergo a chemical reaction with oxygen. Fuels such as alcohol, gasoline, propane, butane, and kerosene have chemical energy. When any fuel burns, its chemical energy is transformed into thermal energy that people use for many purposes. For example, thermal energy can heat your home in the winter and make cars and buses run.

As you discussed in class, the amount of chemical energy an object has is determined by its mass and what it is made of. A way to talk in science about what something is made of is to talk about its chemical composition. Chemical composition refers to which atoms make up the molecules in a substance and how those atoms are arranged. In this reading, you will learn about several types of fuels. As you compare their chemical structures, you will learn why these differences result in different amounts of chemical energy and other properties.

Alcohol

Alcohol is a substance composed of three elements—oxygen, carbon, and hydrogen. There are actually many different types of alcohol. The type typically used in chemistry labs, which you may have in your school lab, and found in alcoholic drinks, is ethanol. It is a colorless liquid that has a strong odor and can be made as sugar ferments. When alcohol burns, it combines with oxygen and releases carbon dioxide and water; much of its chemical energy is transformed into thermal energy. When burned completely, 1g of pure alcohol releases 7,100 Calories of thermal energy.

Calories is one of the units in which energy is measured, just like mass can be measured in pounds or grams; temperature in degrees Fahrenheit, Celsius, or Kelvin; and length in inches, miles, or meters.

Other Common Fuels

Propane, butane, gasoline, diesel, and kerosene belong to a group of substances called hydrocarbons. Hydrocarbons are made only of hydrogen and carbon atoms. Propane and butane are pure substances, which means that each one of them is made of only one type of molecule—propane molecules or butane molecules. In contrast, gasoline, diesel, and kerosene are not pure substances; they are mixtures of more than one substance.

Propane and butane are different substances. Even though they have the same type of atoms, they have different numbers of carbon and hydrogen atoms, and those atoms are arranged differently into molecules.

Butane = 4 carbon atoms, 10 hydrogen atoms. Its chemical formula is C_4H_{10}. Propane = 3 carbon atoms and 8 hydrogen atoms. Its chemical formula is C_3H_8.

Both propane and butane are gases at room temperature. Both of them can easily be cooled into liquids and compressed for easy storage and transportation. They are both used as fuels for engines, barbecues, home furnaces, and more. Sometimes they are mixed and sold as Liquefied Petroleum Gas. You might have seen them for sale at gas stations, or places that sell barbecue or camping supplies.

Propane and butane combine with oxygen (burn) in the same way that alcohol does. The chemical reaction produces water and carbon dioxide. Much of the chemical energy in the fuel is transformed into thermal energy. When 1g of propane is burned, it gives off 11,900 Calories of thermal energy. Burning 1g of butane releases 11,800 Calories of heat.

What type of energy do ethanol, propane, and butane all have? Which one gives off the most thermal energy as it burns? What variable needs to be kept unchanged to make sure this comparison is fair?

What Else Happens When Fuels Burn?

When there is not enough oxygen available while burning propane or butane, the products of the chemical reaction will still include carbon dioxide and water, but also carbon monoxide and pure carbon. These two substances are pollutants. Carbon monoxide is odorless, but it can kill, so it is dangerous. You may know about detectors for homes and how birds are used as detectors in underground mines. Perhaps you are familiar with a car safety manual about carbon monoxide and why cars should not be left running inside a closed garage. Without enough oxygen, the chemical reaction changes in important ways. Carbon monoxide is a deadly product of the reaction, and carbon is a dirty product. Carbon in this form is soot, a product that leaves a black mark wherever it has touched.

Gasoline, diesel, and kerosene are all mixtures of other hydrocarbons. They give off a lot of thermal energy as they burn. Compare the Calories from burning each of these fuels:

1g of gasoline releases 11,300 Calories

1g of diesel releases 10,700 Calories

1g of kerosene releases 10,300 Calories

Gasoline and diesel fuel are often used for vehicles. The density of diesel is greater than that of gasoline. This means that the mass of 1 liter of diesel is greater than the mass of 1 liter of gasoline. Although 1 liter of gasoline has less mass, it releases more thermal energy.

The pollution resulting from burning diesel is greater than from burning gasoline. Kerosene was once widely used for heating, cooking, and fuel for lamps before people had electricity. It produces even more pollution than gasoline and diesel.

What are some ways that propane, butane, gasoline, diesel, and kerosene can be compared? You may compare them using a list, or you might choose to make a chart.

ACTIVITY 8.4 – CHEMICAL ENERGY TRANSFORMATIONS

What Will We Do?

We will investigate transformations of chemical energy into other energy types.

Procedure

For each of the phenomena shown in the projected images, indicate the energy transformations you identify. Explain your ideas in the third column.

#	Phenomenon	Energy Transformations	Explanation

Conclusion

What is common among all these phenomena?

Follow Up

How does what you learned about chemical energy help you answer the Driving Question: Why Do Some Things Stop While Others Keep Going?

Homework 8.4 – Energy Types and Their Factors

In the left column of the table below are listed some energy types you have learned about. For each type of energy, fill in the right column with the factors that determine how much of that type of energy an object has.

Energy Type	Factors Determining the Amount of Energy
Kinetic energy	
Gravitational energy	
Elastic energy	
Thermal energy	
Chemical energy	

LESSON 9

Electrical Energy

ACTIVITY 9.1 – HOW CAN I MOVE ENERGY?

What Will We Do?

We will identify conditions that are required for electrical energy to be present in an electrical circuit.

Procedure

1. The materials that you need for this activity are one AA battery, a motor, two connecting wires, and a battery holder.
2. Connect these materials to make the motor run. (Note the negative [-] and the positive [+] terminals on the battery.)
3. Once you have your circuit ready, touch the motor carefully and notice the sound it makes.

Observations

1. Draw a diagram that shows the connections in your circuit.
2. What do you feel when you touch the motor? Use energy to explain why you feel this.
3. What will happen if you use other materials, such as rubber or paper, instead of wires to connect the motor to the battery?

Conclusion

1. What are the conditions that are required for electrical energy to be present in an electrical circuit?

2. How is energy transferred from the energy source to the motor? Use an energy transfer diagram in your explanation.

Homework 9.1 – Electricity in Our Homes

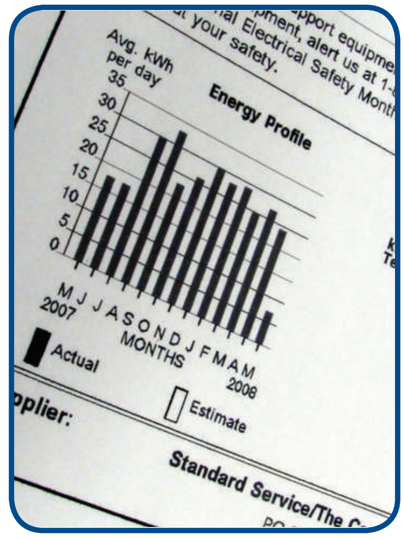
1. Electricity is widely used at homes to operate many devices and equipment. The following table shows some of these devices.

   a. Describe what kind of energy transformations happen in each machine.

   b. List the indicators that support the energy transformations you noted in the table.

Machine	Energy Transformations	Indicators
 Hair Dryer		
 Stereo		
 Microwave		
 AA Battery Charger		
 Washing Machine		

2. Electricity bills can be expensive. Look at the following graph that shows a family's usage of electricity during a full year. Answer the questions that follow.



   a. According to the graph, does this family use the same amount of electricity each month? How do you know?

   b. Does this family live in an area with a hot or cold climate? How do you know?

   c. Suggest ways that might help this family reduce their annual electricity bill.

ACTIVITY 9.2 – THE HOMEMADE BATTERY

What Will We Do?

We will investigate how chemical energy could be transformed to electrical energy by building our own battery.

Procedure

1. Mix 50g salt with about 400mL of water in a 500mL beaker. Stir to dissolve the salt.

2. Roll part of your strip of magnesium tape into a loose coil. Leave approximately 10cm straight so that it will stick out above the salt solution.

3. Place one clip lead on a piece of steel wool. Clip the second lead to the strip of magnesium tape.

4. Clip the free leads to the DC motor.

5. Put the steel wool and the magnesium in the salt solution. Make sure the leads do not come in contact with the salt water, and the steel wool and the magnesium do not touch each other.

Observations

1. After connecting the DC motor to the magnesium iron battery, write your observations. If nothing happens, try moving the steel wool or the magnesium tape around in the salt solution.

2. What are the similarities and the differences between this battery and the AA battery?

3. What would happen if you made a bigger magnesium-iron battery? Explain.

Conclusion

1. What can you conclude about the energy transformations in this activity and in batteries in general?

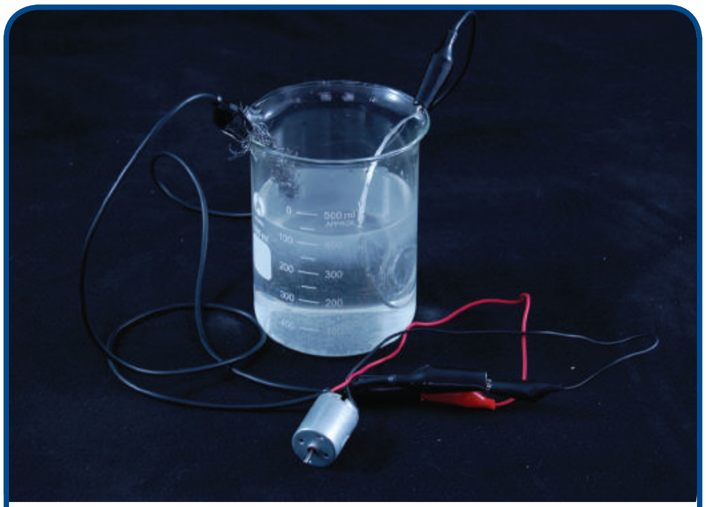
2. What is a “dead” battery?

Reading 9.2 – Batteries and Hydrogen Cells

Getting Ready

In class today, you learned about batteries as a source for electrical energy. What kinds of batteries do you know of?

As you read, think about where batteries get their energy, and how this information about batteries helps you understand why some things stop and others keep going.



Example of a Magnesium-Iron Battery

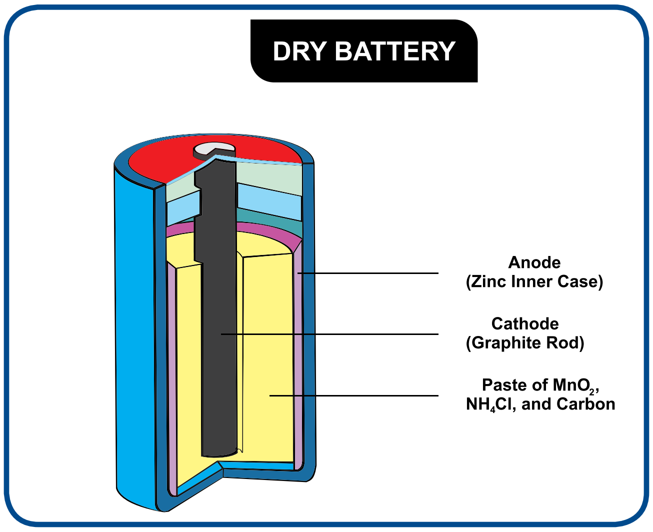
Where Does Electricity Come From?

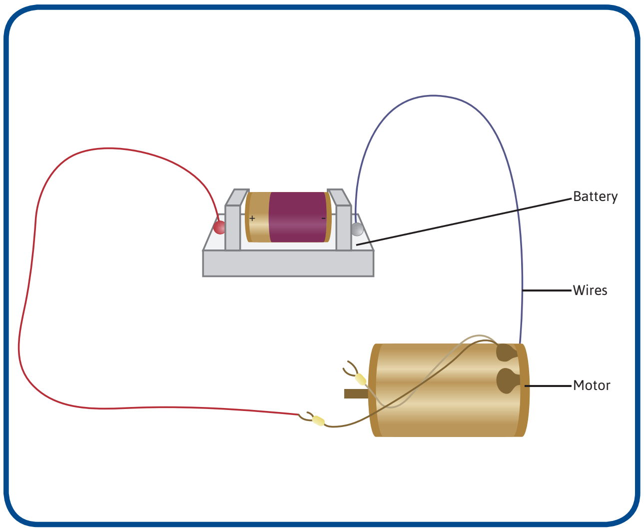
All matter is made of different combinations of atoms. All atoms contain particles called *electrons* that are even tinier than the atom. They are too small to see with even the most powerful microscope. Since all materials are made of atoms, there are electrons everywhere. Electrons are in the water you drink, the air you breathe, the food you eat, and every kind of matter that you touch. In some materials, such as metals, these electrons move easily from one place to another. These materials are called conductors. In other materials, called *insulators*, electrons cannot move freely. Examples of insulators are wood, rubber, glass, and some plastics. Why do you think electrical outlets are made of plastic? This is because plastic is an insulator so you will not get a shock when plugging an appliance into an outlet. On the other hand, people use copper and aluminum cables to carry electricity to homes because they are good conductors.

The chemicals your battery used were magnesium and iron. When you put these materials together, a chemical reaction happened. When a chemical reaction happens, atoms rearrange to form new substances. In this process chemical energy is transformed into others types of energy. The chemical energy in the battery was transformed into electrical energy. This electrical energy allowed the electrons to move from one place to another in a conductor. This motion of electrons is called electricity or *electrical current*. The detector that was connected to the battery detected the electrical current.

AA Batteries

In Activity 9.1 an electric motor ran when an AA battery was connected to it with wires. An AA battery is made of a carbon rod, a zinc can, and a chemical between them. The following diagram shows how electrical current flows through the wires from the battery to the motor and makes it run. This is called a *closed circuit*. The red arrows show the direction of the electrical current. Look again at the diagram. When you connect an AA battery in a closed circuit, a chemical reaction happens inside of it. The chemical reaction lets electrons flow from the carbon rod to the zinc can through the chemical separating them. From the can, the electrons flow out from one side of the battery into the circuit and come back to the battery at its other side. From there they return to the carbon rod. When the electrons go through the motor, their electrical energy is transformed into three types of energy—kinetic energy, which makes the motor run; thermal energy, which makes the motor warm up; and sound energy, which makes the motor hum.





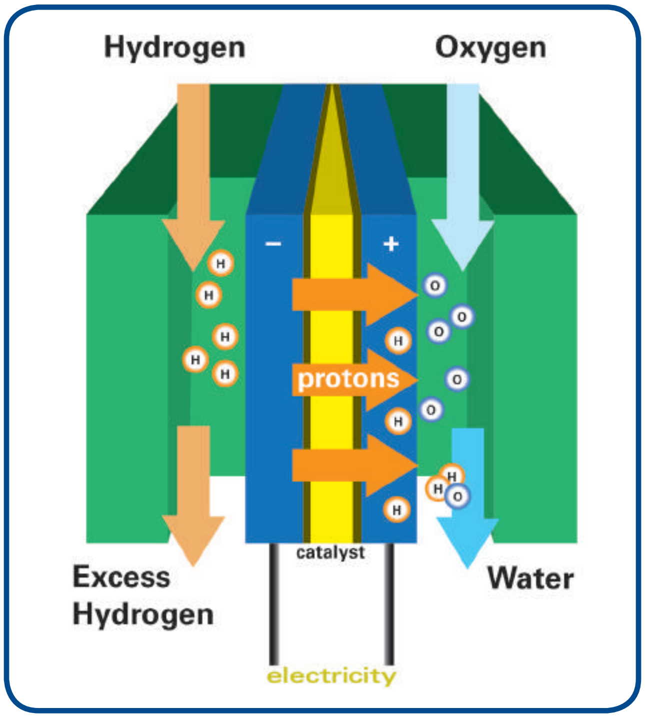
What energy transformations do you think occur in an electric circuit consisting of an electric motor and a battery?

As long as there is a closed circuit and a chemical reaction in the battery, electrons will be driven to flow through the circuit and transfer energy to the motor. When the chemicals start being used up, it becomes harder and harder for the battery to provide the same amount of energy to drive electrons around the circuit. This is why a motor will not run as quickly with a used battery as it does with a new one. Once the chemicals inside a battery are gone, people call it a dead battery because it is not able to produce electricity anymore.

Why do you think a D battery lasts longer than an AA battery?

Batteries and Our Environment

Batteries are simple and convenient to use, but they have some big drawbacks. One of these drawbacks is that their chemicals are often poisonous and can pollute the environment. This means that it is important to get rid of used batteries in a way that does not endanger the environment. Using rechargeable batteries instead of regular batteries can help some. The advantage of rechargeable batteries is that they can be reused instead of just throwing them away. Rechargeable batteries are expensive, and their chemicals are also poisonous, so using rechargeable batteries does not completely solve this environmental problem.



Hydrogen cells are another way to use chemical energy to generate electricity. Hydrogen cells are environmentally very clean. They can be used over and over again and do not use poisonous chemicals. Small fuel cells can power electric cars. Large fuel cells can provide electricity in out-of-the-way places where there are no power lines. Portable fuel cells are being used to provide power for laptop computers and some cell phones.

Hydrogen cells operate similar to a regular battery. They also use chemicals to generate electricity. Unlike a battery, however, a hydrogen cell does not run out of chemicals or require recharging. It uses an external chemical (hydrogen) rather than internal chemicals to generate electricity. The cell continues to work as long as it is supplied with hydrogen.

A hydrogen cell consists of two metals sandwiched around a chemical, just like in a battery. However, unlike a battery, no electric flow will be generated unless hydrogen passes over one of the metals and oxygen over the other. The oxygen comes from the air surrounding the battery, but the hydrogen is supplied from a fuel tank. A chemical reaction occurs that pushes electrons through an electric circuit connected to the hydrogen cell. This chemical reaction also combines the hydrogen flowing over one metal with the oxygen flowing over the other metal to form water.

What are the similarities and differences between a battery and a hydrogen cell?

Homework 9.2 – Why Do Some Things Work Longer?

In the first lesson of this unit you saw some devices that keep working for a long time. Using what you have learned about energy, explain why they kept working for a long time.

1. Draw energy transfer diagrams for the "Jupiter" pendulum and "Secret" top that keep working for a long time.

2. Why do the pendulum and top keep working longer than the other devices? Write a full explanation.

ACTIVITY 9.3 – WHAT DOES AN ELECTRICAL GENERATOR DO?

Lesson 10

Can Light Make Things Stop or Start?

ACTIVITY 10.1 – HOW LIGHT MAKES THINGS HAPPEN

What Will We Do?

We will investigate other energy transformations of light.

Procedure

For each picture below, name the type of energy into which light energy is transformed.

Object		Energy Transformations
	Plant	
	Camera	
	Suntan	
	Solar Cooker	

Conclusion

Can light be considered a type of energy? Explain your answer.

Reading 10.1 – Solar Power Plants

Getting Ready

In class today, you considered how light energy can make things happen. What are some reasons why people would want hot water or steam?

There are many reasons why it is useful to heat water, but one of the main reasons is that steam can be used to generate electricity. Virtually all of the electricity that you use to light up a room, keep food cold in a refrigerator, or watch television was originally generated by a machine called a *steam turbine*. You do not have a steam turbine in your home, but somewhere there is a steam turbine that generates electricity and sends it to your house through wires. A steam turbine is a machine with giant fan blades inside of it. When these fan blades turn, the machine uses the turning motion to generate electricity. What makes the fan blades inside a steam turbine turn?

Think of the blades inside the steam turbine like a giant pinwheel. When you blow on a pinwheel, the air that you breathe out hits the blades of the pinwheel and turns it. Imagine that instead you held the pinwheel above a boiling pot of water. The steam rising from the water could make the pinwheel turn.

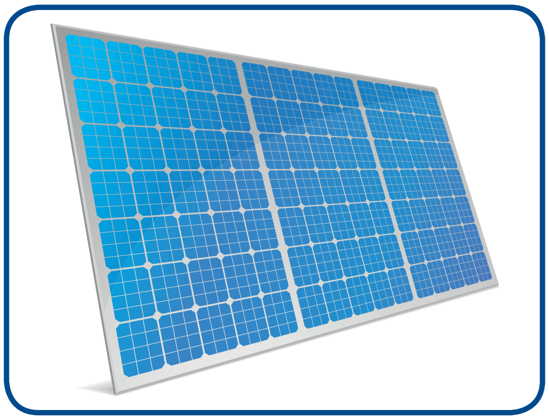
Making a pinwheel turn by holding it above a pot of boiling water is the same idea as using steam to turn the fan blades inside a steam turbine. How can enough water be heated to operate a steam turbine to generate electricity for people's homes?

Most of the electricity generated in the United States is produced by coal power plants, which burn coal to heat water until it becomes steam. Of course, burning coal is not the only way to heat water.

Some power plants, called *solar power towers*, use light energy from the sun to heat water until it becomes steam. A solar power tower uses thousands of mirrors to reflect light from the sun to a central tower that contains water. When the reflected light hits the central tower, it is absorbed and its energy is transferred to the water as thermal energy. The water inside is heated until it becomes steam. The steam is then transported through pipes to a steam turbine, which transforms its energy into electrical energy.

One drawback of a solar power tower is that it can only heat water to produce steam during the day. Once the steam cools down and becomes water again, there is no way to turn the steam turbines. People still need electricity at nighttime or when the sun is blocked by clouds. To produce electricity at these times, some solar power towers heat a special fluid instead of heating water. Once the special fluid becomes heated in the tower, it can be transported through pipes to come in contact with a reservoir of water, where it transfers its thermal energy to the water to make steam. Since the fluid can remain very hot at night, it can be used to heat water into steam even when the sun is not shining.

A solar power tower is not the only way to use light energy from the sun to generate electricity. Another type of solar power plant uses long rows of curved mirrors to reflect the sun's light onto a pipe that contains a fluid. Just like in a solar power tower, this fluid is then transported to a pool, where it transfers its thermal energy to water, heating it into steam that can be used to turn a turbine to generate electricity.



Another idea for using light energy from the sun to generate electricity does not involve heating water at all. In a solar chimney, light energy from the sun is transferred and transformed into thermal energy from air underneath a large glass roof. As this hot air rises, it is forced through a giant chimney. As the heated air rises through the chimney, it turns the fan blades on a turbine, generating electricity. The air's thermal energy is transferred to the turbine as kinetic energy where it is transformed into electrical energy. Since the sun can only heat air during the day, solar chimneys have pipes filled with water (or a special fluid) under the glass roof that will remain hot during the night. Since the fluid in the pipes is still hot at night, the air under the roof will still be heated and forced up the chimney, allowing the solar chimney to produce electricity.

Besides producing steam to generate electricity, what are some other ways that people might be able to benefit from water heated by light energy from the sun?

Homework 10.1 – How Light Makes Things Happen

In this lesson you learned that when light energy is absorbed it is transformed into other types of energy. Here is another example.

Solar water heaters are widely used in California because it is very sunny there. Solar water heaters are often placed on the roof, where sunlight can be directly absorbed. People in Southern California have been using solar water heaters for over a hundred years. By using solar water heaters, people do not need to pay for the gas or electricity that power most water heaters.

1. When the water in the water heater gets hot, what type of energy increases?

2. Assuming energy conservation, if one type of energy increases, another type must decrease or the additional energy must have come from somewhere. Did another type of energy decrease? Explain.

3. Does a solar water heater work at night? Why?

4. If you look at the picture of the solar water heater, you should notice two dark rectangles below the water storage tank. These are called the solar collectors. Why are they made of a dark material?

Lesson 11

Concluding the Unit

ACTIVITY 11.1 – REVISITING LEARNING SETS 1–3

Question	Answer	Evidence
Why do some things stop while others keep going?		
Why does one pendulum stop and the other keep going?		
How does the rolling can work?		
How does the spinning top work?		

Question	Answer	Evidence
What are the energy transformations in a bouncing ball? Or, why does a bouncing ball stop?		
What are the factors that determine how much kinetic energy an object has?		
What are the factors that determine how much gravitational energy an object has?		
What are the factors that determine how much elastic energy an object has?		
What are the factors that determine how much thermal energy an object has?		
What are the factors that determine how much chemical energy an object has?		
Which factors determine the presence of electrical energy?		
What is similar between sound energy and light energy?		

Reading 11.1 – Examples of Energy Resources

Getting Ready

Examples of Energy Sources

In Lesson 9 you learned that batteries provide electrical energy to electrical circuits. Where does this energy come from? Are there other sources of energy? Can energy be created or does it just get transferred from place to place and transformed from one type to another? In this reading, you will learn about some examples of energy resources.

Gasoline

Gasoline has chemical energy that is transformed into thermal energy when it is burned. One of the major uses of gasoline is as an energy source for vehicles like cars and buses. Most of the thermal energy generated by burning gasoline is transformed into kinetic energy in an engine. Some of this energy is transferred by the car's drive shaft to the wheels, making the car move. Some of the pistons' kinetic energy is also transformed into electrical energy by a generator attached to the engine.

The chemical energy in gasoline is transformed into both kinetic and electrical energy in cars. Some of the thermal energy is also transferred to water in pipes that can be used to heat the inside of the car in winter.

Where do you think the energy gasoline has comes from?

An energy resource is any type of energy source that can be found in nature. The following are some examples of energy resources.

Wind

Wind is the flow of air. Since air is matter, it has mass, and when it flows it has kinetic energy.

This kinetic energy can be transformed into electrical energy by a wind turbine. By turning the blades of the turbine, some of the wind's kinetic energy is transferred to the turbine. The turbine is connected to a generator which transforms this kinetic energy into electrical energy.

Before people knew about electricity, windmills were used to grind grains, pump water, or saw wood. Holland is famous for its wide use of windmills. Using wind energy generates no pollution.

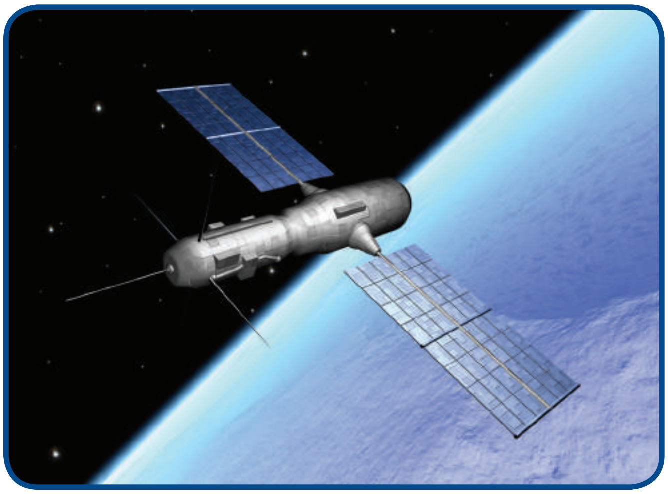
Coal

Coal is usually found in solid form underground. Coal was formed from the remains of ancient plants that were compressed, hardened, and chemically changed through geological processes. It is called a fossil fuel, as is petroleum, because it is made from ancient plants. When coal is burned, its chemical energy is transformed into thermal energy which can be used to heat steam and drive a turbine that is connected to a generator. Coal is not a clean fuel. Burning coal releases many byproducts that are responsible for much of Earth's air pollution. Coal does not release thermal energy as efficiently as gasoline does. Burning one kilogram of gasoline releases more thermal energy than burning one kilogram of coal. Another drawback of coal is its solid state, which prevents it from being used in car engines. Many scientists are trying to find ways to liquefy coal so that it can be used in cars and release fewer pollutants when being burned.

Petroleum

Petroleum is found as a liquid underground. Like coal, it was formed from the remains of ancient plants. When refined, petroleum can be used to make gasoline, diesel, kerosene, and other chemicals. It is the major energy resource we use today. Until a few years ago it was abundantly available, but now the deposits of it underground are being used up.

Sunlight



Sunlight is the source of light energy. It can be transformed to many other types of energy. In fact, it is the source of almost all the energy of the various energy resources on our planet. For example, fossil fuels, such as coal and petroleum, originate from dead plants and animals. But as you learned in biology, those animals first got their energy from plants, and the plants got their energy from the sun. Sunlight can be directly transformed into thermal energy to heat water to run a steam turbine to generate electricity or to keep a house warm. Sunlight can also be directly transformed into electrical energy by solar cells. Solar cells are widely used in spacecraft and satellites, since in outer space there are no clouds or atmosphere to block, scatter, reflect, or absorb the light from the sun. Sunlight will be available for millions of years, and using it does not cause pollution.

Waterfalls

The gravitational energy of water is transformed into kinetic energy as water falls in a waterfall. In a hydroelectric power station, this falling water hits the blades of a turbine, making the turbine spin, transferring some of its kinetic energy to the turbine. The turbine is connected to a generator where its kinetic energy is transformed into electrical energy. Hydroelectric plants transform gravitational energy into electrical energy. In some cases, people build a dam on a river to make the water rise higher and then let it fall to form a waterfall to cause the turbines to turn, generating electricity. Generating electricity from waterfalls is clean. Although building a dam can be harmful to the local ecosystem, waterfalls themselves create no polluting byproducts. As long as the river filling the basin next to the dam continues to flow, the hydroelectric plant can continue providing electricity.

Uranium

Nuclear energy is a type of energy that you have not studied in class. Nuclear energy is similar to chemical energy in that all substances have it. However, transforming a substance's nuclear energy into other types of energy is possible with only a few substances. One of these substances is uranium, which is a metal. Nuclear energy is very concentrated. That means the amount of nuclear energy one kilogram of uranium has is much, much greater (over a million times greater) than the amount of chemical energy one kilogram of gasoline or any other non-nuclear fuel has. Uranium can be found in nature in certain rocks, but it can be used as an energy source only after it is purified. Uranium releases its nuclear energy when a nuclear reaction occurs, just as gasoline releases its chemical energy when a chemical reaction occurs. The nuclear energy released is transformed into thermal energy which drives a turbine which is connected to a generator. Nuclear reactions have many harmful byproducts. For example, radiation can be very harmful. If not properly contained, radiation can cause cancer and other illnesses. Therefore, one of the big problems of nuclear power plants is how to safely deal with the radiation that it produces.

Natural Gas

Natural gas is a fossil fuel like coal and petroleum, but in a gaseous state. Natural gas can be burned to release thermal energy. It is often used for household cooking and heating. Compared to coal and petroleum, natural gas causes less pollution. Natural gas is often found in the same areas as petroleum and coal.

Why are some energy resources more expensive to use than others?