PHYSICAL WORLD

Heat & Energy

Answers IN GENESIS™

GOD'S DESIGN®

4th Edition

Debbie & Richard Lawrence

God's Design® for the Physical World is a complete physical science curriculum for grades 3–8. The books in this series are designed for use in the Christian school and homeschool, and provide easy-to-use lessons that will encourage children to see God's hand in everything around them.

Printed January 2016

ISBN: 978-1-62691-459-9

Published by Answers in Genesis, 2800 Bullittsburg Church Rd., Petersburg KY 41080

Book design: Diane King
Editor: Gary Vaterlaus

Printed in China

AnswersInGenesis.org • GodsDesign.com

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Welcome to GOD'S DESIGN®

PHYSICAL WORLD

You are about to start an exciting series of lessons on physical science. *God's Design® for the Physical World* consists of three books: *Heat and Energy*, *Machines and Motion*, and *Inventions and Technology*. Each of these books will give you insight into how God designed and created our world and the universe in which we live.

No matter what grade you are in, third through eighth grade, you can use this book.

3rd–5th grade

Read the lesson.

- Do the activity in the light blue box (worksheets will be provided by your teacher).
- Test your knowledge by answering the **What did we learn?** questions.
- Assess your understanding by answering the **Taking it further** questions.

Be sure to read the special features and do the final project.

There are also unit quizzes and a final test to take.

6th–8th grade

Read the lesson.

- Do the activity in the light blue box (worksheets will be provided by your teacher).
- Test your knowledge by answering the **What did we learn?** questions.
- Assess your understanding by answering the **Taking it further** questions.
- Do the Challenge section in the light green box. This part of the lesson will challenge you to do more advanced activities and learn additional interesting information.

Be sure to read the special features and do the final project.

There are also unit quizzes and a final test to take.

When you truly understand how God has designed everything in our universe to work together, then you will enjoy the world around you even more. So let's get started!

UNIT 1

Forms of Energy

1 Forms of Energy • 8

2 Mechanical Energy • 11

3 Chemical Energy • 15

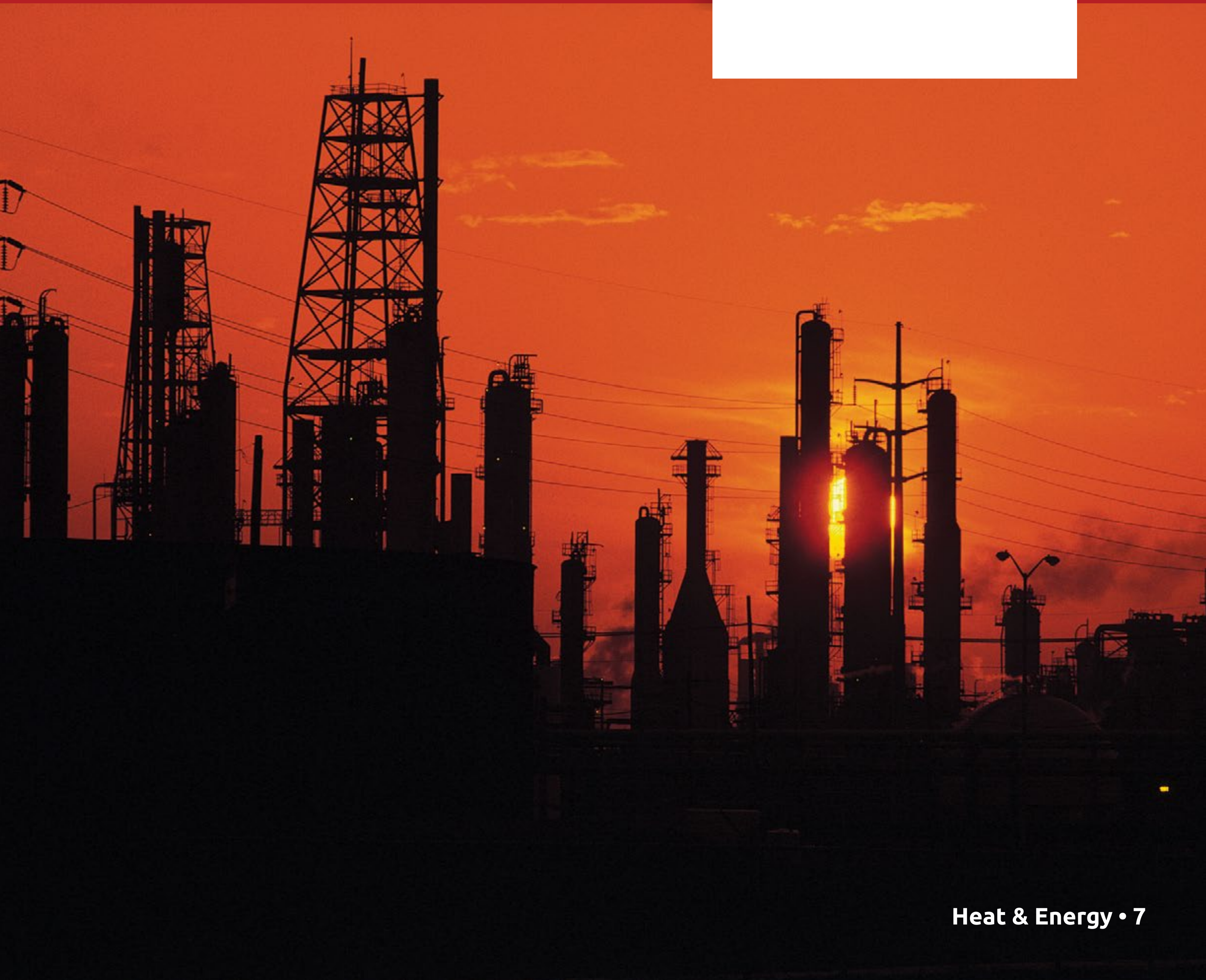
4 Nuclear Energy • 17

5 Nuclear Weapons • 20

◊ **Identify**, with examples, the different forms of energy.

◊ **Distinguish** between kinetic and potential energy.

◊ **Distinguish** between chemical energy and nuclear energy.



1

Forms of Energy

It works!

What is energy, and what types of energy are there?

Words to know:

energy
mechanical energy
chemical energy
nuclear energy
thermal energy
electrical energy
magnetism
sound energy
light energy

Challenge words:

first law of thermodynamics

What do you think of when you hear the word *energy*? Do you think of running around the block or playing football? It certainly takes energy to perform physical activities. Maybe you think of the amount of gasoline it takes to drive a car. Your car needs energy to transport you from one place to another. Or maybe you thought of the energy needed to heat your home in the winter. All of these are examples of energy, but what is energy from a scientific point of view? The scientific definition of **energy** is the ability to perform work.

As you have already seen in the previous examples, there are many different types of energy. Energy is found in different forms, such as light, heat, sound, and motion. Although there are many forms of energy, they can all be put into two categories: kinetic and potential. Kinetic energy is energy that is in motion. Potential energy is stored energy. Forms of kinetic energy include mechanical, thermal, electrical, sound, and light energy. Forms of potential energy include chemical, nuclear, and gravitational energy. Each form of energy was designed by God to supply the energy needs of our world.

Mechanical energy is the sum of kinetic and potential energy in an object. In other words, it is energy in an object due to its motion or position, or both. An object that possesses mechanical energy is able to do work. In fact, mechanical energy is often defined as the ability to do work. Our car uses mechanical energy to move us from one place to another. A crane uses mechanical energy to pick up a giant iron beam. Most mechanical energy is produced when a different form of energy is converted into mechanical energy.

Chemical energy is energy that is stored or released during chemical reactions. This energy is stored in the bonds between the atoms in molecules. Chemical energy is associated with the energy levels of the electrons in atoms. As the electrons are forced into a higher energy level, they store energy. When they return to a lower energy level, they release energy. Photosynthesis and digestion are two of the most common chemical reactions that store and/or release chemical energy. Burning, or combustion, is also an example of the release of chemical energy.

Nuclear energy is also associated with the energy of atoms. However, **nuclear energy** is stored in the nucleus of the atom instead of the electrons. Nuclear energy can be released either by fission, which is the splitting of a nucleus into smaller particles, or by fusion, which is the combining of smaller particles to form a new nucleus. Tremendous amounts of energy are stored in the nuclei of atoms.

Thermal energy is also known as heat. It is the energy of moving atoms and molecules. Thermal energy is mechanical energy on an atomic or molecular scale. The more thermal energy an object's atoms contain, the higher its temperature will be. As the temperature goes up, the molecules or atoms move faster. As the molecules slow down, the temperature also goes down.

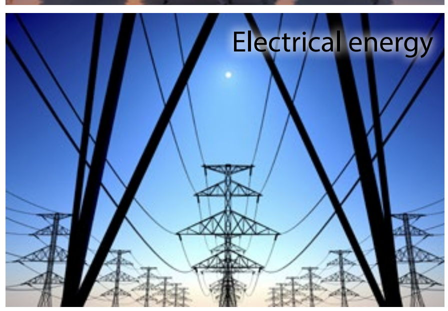
Electrical energy usually involves the flow of electrons. Electrons can easily move through conductors such as copper and aluminum. This is the form of energy we use most often in our homes and buildings. When the electricity is shut off for some unexpected reason, it becomes very difficult to do many of the normal everyday activities because our society is very dependent on electricity.

Magnetism is a force you are probably familiar with. It is

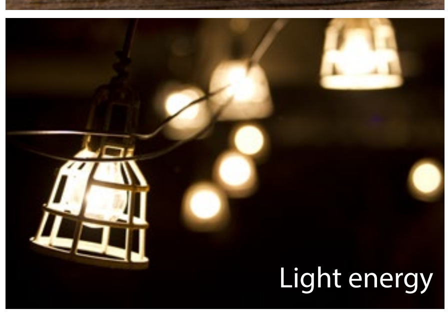

Mechanical energy


Chemical energy


Nuclear energy


Electrical energy


Magnetism


Light energy

very closely related to electricity. **Magnetism** is caused by electric currents. The Earth itself has magnetic fields, most likely due to the flow of electrical ions in the planet's liquid outer core.

The forms of energy mentioned so far are easily seen as energy. We often see how electricity is used to make the various appliances in our homes work for us. We also know that if we put gas in our car, the chemicals in the gas are converted into mechanical energy. But, you may not associate sound and light with energy, because we do not see them producing work as readily as other forms of energy. Nevertheless, they are definitely forms of energy.

Sound energy is energy that travels in waves through matter such as air, water, or wood. The speed of the sound waves depends on the type of matter through which they are traveling. In general, most humans can detect sound waves that vibrate at frequencies between 20 and 20,000 vibrations per second (called Hertz). Many animals can hear sound waves at higher or lower frequencies than humans can.

And finally, **light energy** is energy that also travels in waves but does not need to move through a medium. Light is one form of electromagnetic radiation that can travel through empty space. Other forms of electromagnetic radiation include radio waves, infrared, ultraviolet, X-rays, and gamma rays. Light waves can travel through the vacuum of space at speeds up to 186,000 miles per second or about 300 million meters per second.

Conversion of energy

Energy is easily converted from one form to another. We need different kinds of energy for different functions. We need heat energy to warm our homes and cook our food. We need mechanical energy to wash our clothes and vacuum our carpets. We need light energy to light up our homes when the sun goes down. Many of these functions begin with electricity that enters our home and is then converted to the form in which we want to use it. To understand the many conversions that energy experiences, complete the "Energy Conversion" worksheet.

Probably the most important source of energy for the Earth is the sun. The sun converts approximately 657 million tons of hydrogen into 653 million tons of helium every second! The remaining 4 million tons of matter are converted into energy including heat, light, and electrical energy. A portion of this energy travels across the vacuum of space to Earth and heats and lights our world, providing the energy needed for photosynthesis and life. God has provided our world with many important sources of energy to more than adequately meet our needs.

What did we learn?

- What is the scientific definition of energy?
- What are some of the types of energy recognized by scientists?
- Which types of energy can be converted into other types of energy?

Taking it further

- Which types of energy are defined by the energy in the atoms or parts of atoms?
- Which types of energy can travel through space?
- If the sound of a solar flare was loud enough, could we hear it on earth?
- What is the final form of almost all energy?
- If most energy ends up lost, how do we keep everything working on earth?

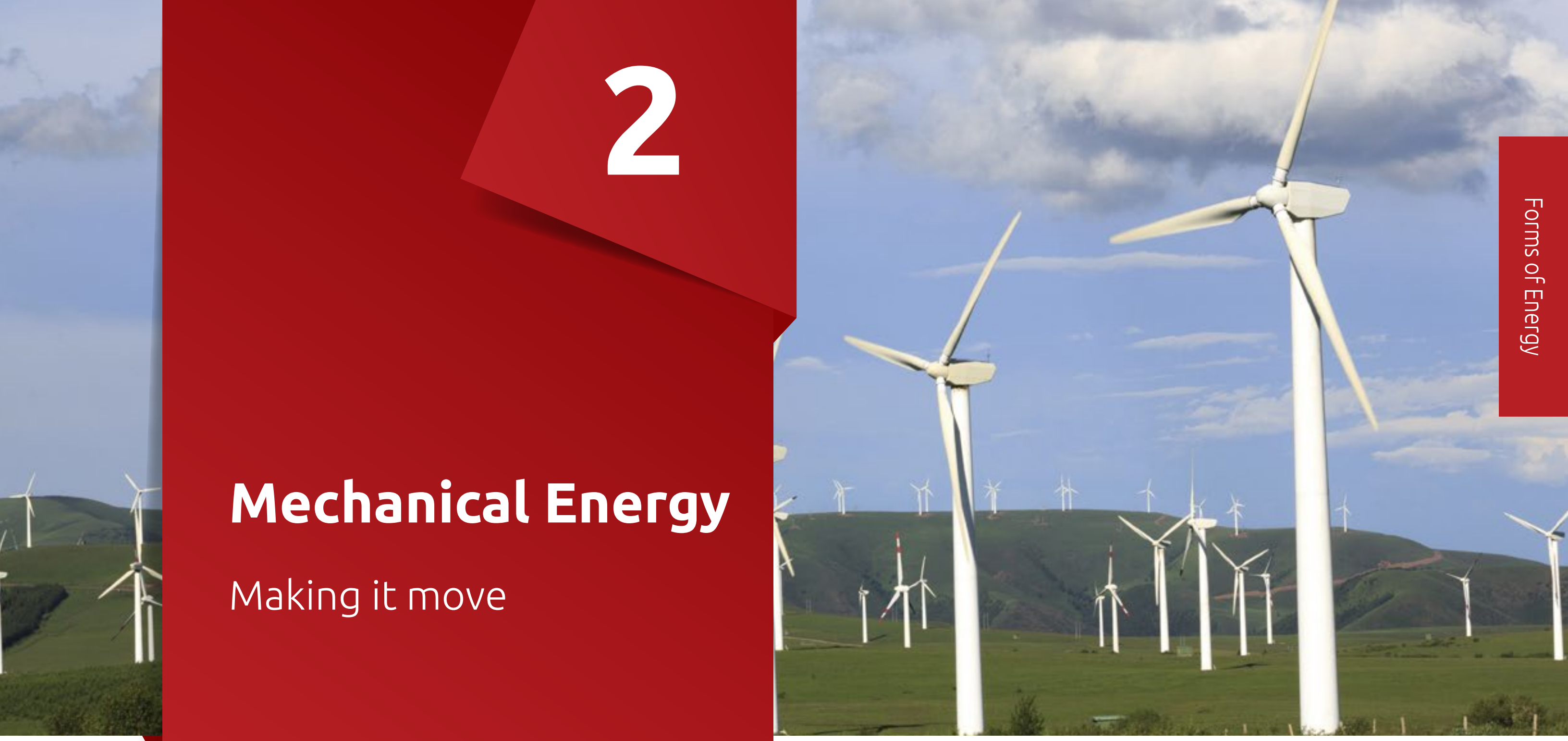
Energy chains

The **first law of thermodynamics** states that mass and energy cannot be created or destroyed; they can only change form. This is considered a scientific law because this is what has been observed time after time in scientific experiments. Energy is converted from one form to another, but no new energy is created in any known process. Since this is true, what is the ultimate source of all energy on earth?

Energy can easily change forms, so it is easy to trace the chain of energy in most processes. For example, let's look at the energy chain for a flashlight. At creation, God placed certain materials in the crust of the Earth. Man extracts these materials and manufactures batteries. The batteries provide chemical energy that is converted into electrical energy. The electrical energy is converted inside the flashlight into light and heat.

Earth's crust => Mining of raw material => Manufacturing of batteries => Chemical energy => Electrical energy => Light and heat

This is a fairly simple energy chain. Other energy chains are more complex. On a copy of the "Energy Chains" worksheet, draw the energy chain for a coal-powered power plant. Include where the energy came from that is in the coal, and how the energy is used after it leaves the power plant.



2

Mechanical Energy

Making it move

What is mechanical energy, and how do we use it?

Words to know:

kinetic energy | potential energy

Have you every seen pictures of an area that has been struck by a hurricane? The houses and trees are smashed and torn to pieces. This type of storm has a very large amount of mechanical energy. Mechanical energy is the energy possessed by moving objects or objects that have the potential to move. The wind and the water in a hurricane have a large amount of energy; therefore, they can cause a large amount of destruction. However, most mechanical energy is not used for destructive purposes. God has designed the world so that mechanical energy can be very beneficial to man, and man has become very ingenious in finding ways to harness this energy.

For example, the energy of water flowing down a mountain can be used in a hydroelectric plant to generate electricity. Similarly, man has been using the energy in wind to turn windmills for many different purposes. Windmills have been used to grind grain, to generate electricity, and to run a pump that pumps water into animal water troughs. In recent years, giant wind generators have been built all over the country. There are more than 1,100 wind farm locations in the U.S., and that number is growing every year. Most of these wind generators are located in areas with low population density such as the plains of Kansas, Texas, and Oklahoma. Often wind generators are built on farmland and have very little impact on the farmer. As you drive across the country you are likely to see large fields of giant windmills spinning in the wind. As the blades spin, they turn a generator that generates electricity. That electricity is then sent to homes and businesses.

Not all mechanical energy comes from nature. Obviously, God designed man and the animals to be able to move about. But many of the objects that

Hydroelectric plant

Fun Fact

The Gansu Wind Farm Project in China is the world's largest wind farm with over 3,500 individual wind turbines.

contain mechanical energy were given that energy by human design. Man has designed a multitude of machines that perform work. From power tools to kitchen appliances, people enjoy the benefits of mechanical energy.

Mechanical energy can be found in two forms. If an object is moving, it has **kinetic energy**. A rock rolling down the hill is using its mechanical energy. A boy running across the yard is also using mechanical energy. But objects that have the potential to move also contain mechanical energy. The rock had mechanical energy before it started rolling down the hill. That energy was in the form of **potential energy**. Anything that is raised above ground level has gravitational potential energy. The higher it is lifted, the more potential energy it has. Compressed or stretched springs also contain mechanical potential energy. As soon as the force holding them is released, the springs move back toward their natural state, thus releasing the mechanical energy.

Fun Fact

Some fun water energy facts:

- Water energy was used at least 2,000 years ago when the Greeks used water to turn wheels to grind their grain.
- Water wheels became very popular during the industrial revolution when they were used for saw mills, to spin thread, and to run pumps.
- The first hydroelectric plant was built in the 1880s.
- One of the largest hydroelectric dam projects, Hoover Dam, was started in 1931 and is still in operation today.
- In 1940, about 40% of the electricity in the U.S. was generated by hydroelectric plants.
- Today, only about 7% of U.S. electricity is hydroelectric.
- About 60% of Canadian electricity is hydroelectric.

Many of the principles of physics are based on the ideas of kinetic and potential energy. Because the scope of this book is to examine the various kinds of energy, these physical principles and ideas are covered in greater detail in the book *God's Design for Physical Science: Machines and Motion.*

Observing mechanical energy

Purpose: To observe mechanical energy

Materials: two pennies

Procedure:

1. Place a penny on a table. Does the penny have any mechanical energy? You might be inclined to say no because the penny is not moving.
2. Push the penny toward the edge of the table until it falls off.
3. Now place the penny back on the table. Take a second penny and quickly slide it across the table so that it hits the first penny.

Questions:

- Did the penny have mechanical energy as it was falling?
- Did the penny have mechanical energy before it fell?
- How did the penny get the potential energy?
- What happened when the pennies collided?
- Explain where the mechanical energy came from and where it went.

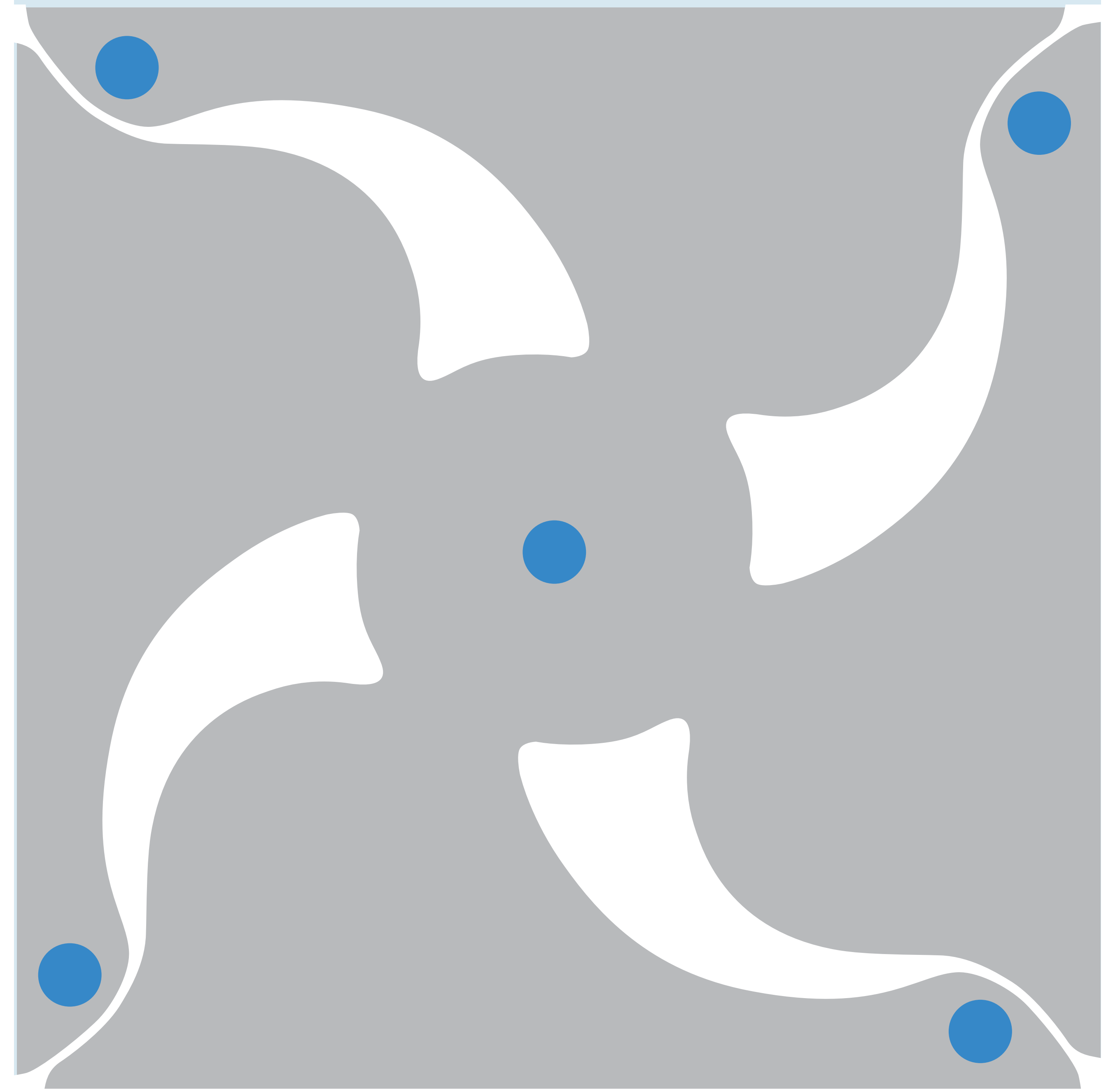
Harnessing wind energy

Purpose: To make your own windmill

Materials: piece of paper, straight pin, soda straw

Procedure:

1. Trace the pattern below onto a piece of paper or print out a copy of the Windmill Pattern from the Student Supplement CD.
2. Carefully cut out and discard the white areas.
3. Gently fold all of the remaining "arms" toward the center, with the dark parts on the inside, matching the dots to the center dot.
4. Tape each arm in place.
5. Stick a straight pin through the center and into a soda straw near one end of the straw. Now you can blow on the paper and watch it spin. This is the idea behind wind generators.



What did we learn?

- What is mechanical energy?
- What are the two forms of mechanical energy?
- What are some forces in nature that possess mechanical energy?

Taking it further

- Which has more potential energy, a book on the floor or a book on a table?
- List at least three ways that machines designed by humans use mechanical energy to make your life easier.
- When does a roller coaster have the most and the least potential energy?
- Give another example of potential energy being converted into kinetic energy.

Potential energy

Purpose: To understand the role of height in potential energy

Materials: marble, books, cardboard or wood, "Potential Energy" worksheet

Procedure:

1. Using books and a piece of cardboard or wood, construct a ramp on the floor that is 1 inch high and 10 or more inches long.
2. Release a marble from the top of the ramp and let it roll down the ramp and across the floor until it stops. Measure how far the marble rolled. Record your measurements on a copy of the "Potential Energy" worksheet.
3. Now, add one or more books to raise the height of the ramp to 2 inches.
4. Again, let the same marble roll from the top of the ramp down and across the floor until it stops. Measure how far the marble rolled this time.
5. Repeat the experiment with a ramp that is 3 inches high. Measure how far the marble rolled from this taller ramp.

Conclusion: The marble rolls farther from a higher starting point because it possesses more potential energy than it did at a lower starting point.