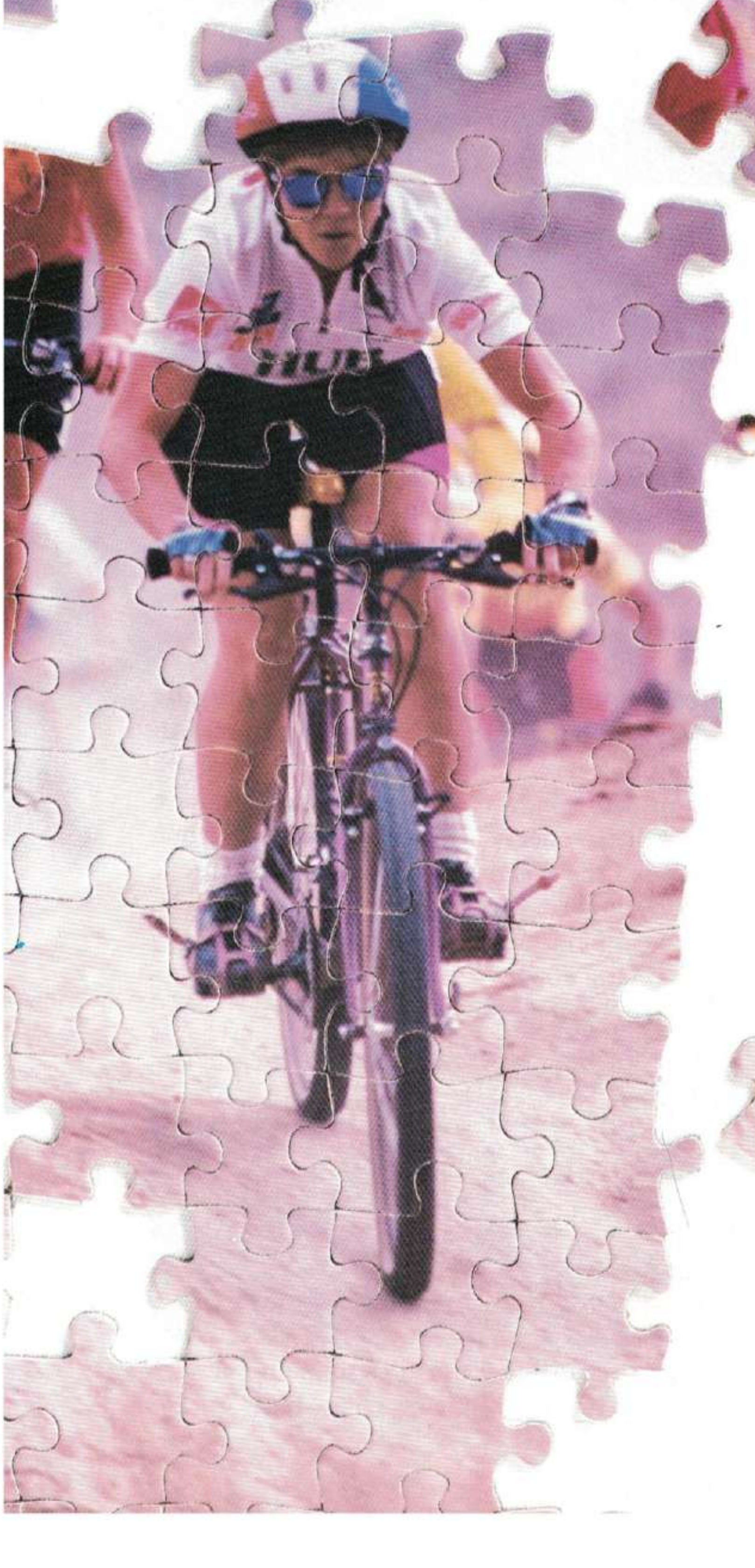
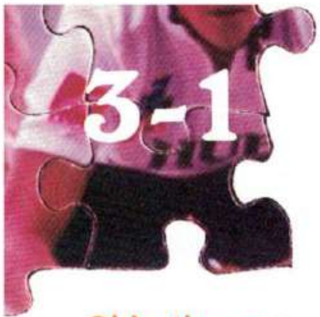
ENERGY AND WORK

UNIT 3



CONTENTS

STUDY HINT Before beginning Unit 3, scan through the lessons in the unit looking for words that you do not know. On a sheet of paper, list these words. Work with a classmate to try to define each word on your list.



3-1 What are the two basic kinds of energy?

Objective ▶ Compare potential energy and kinetic energy.

TechTerms

- **energy:** ability to do work
- **kinetic** (ki-NET-ik) **energy:** energy of motion
- **potential** (puh-TEN-shul) **energy:** stored energy

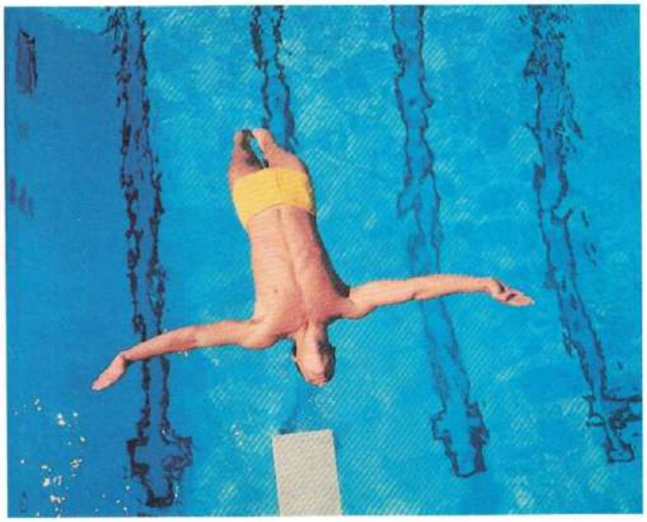
Energy The water in a waterfall has **energy.** Energy is the ability to do work. The energy of the water rushing over a waterfall can be used to make electricity. The electricity can be used to heat and light your home.

Energy is all around you. There are two basic kinds of energy. They are potential (puh-TEN-shul) energy and kinetic (ki-NET-ik) energy.

Define: What is energy?

Potential Energy A match has **potential energy.** Potential energy is stored energy. The potential energy in a match is stored in the chemicals in the match head. When you strike a match, you release this potential energy.

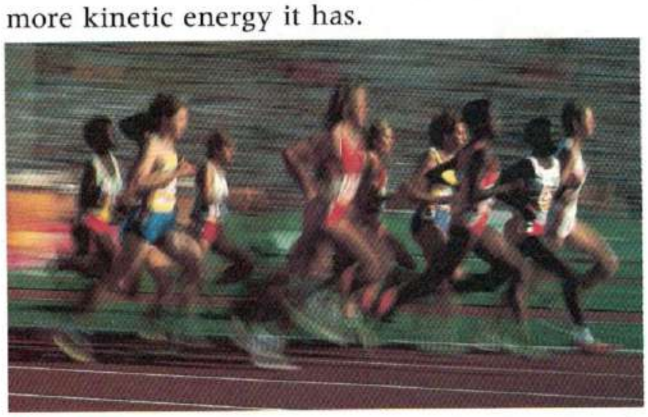
An object that is raised above the ground has potential energy. When the object falls, the energy is released. This kind of energy is called gravitational potential energy. Gravitational potential energy is also called energy of position.



Gravitational potential energy depends on weight and height. The heavier an object is, the more gravitational potential energy it has. The higher an object is above the ground, the more gravitational potential energy it has.

Identify: What kind of energy is released when you strike a match?

Kinetic Energy A moving object has **kinetic energy.** Kinetic energy is energy of motion. All moving objects have kinetic energy. When you walk or run, you have kinetic energy. You have more kinetic energy when you run than when you walk. The faster you run, the more kinetic energy you have. Kinetic energy also depends on mass. The more mass a moving object has, the more kinetic energy it has.



List: What two factors determine how much kinetic energy a moving object has?

LESSON SUMMARY

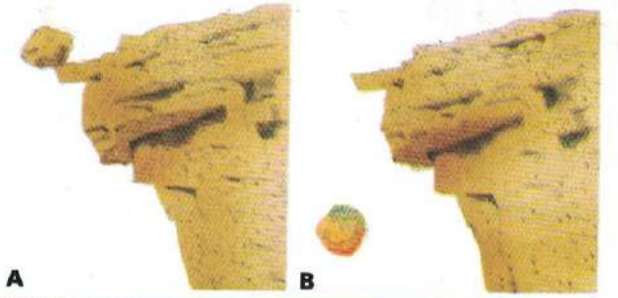
- Energy is the ability to do work.
- There are two basic kinds of energy.
- Potential energy is stored energy.
- An object that is raised above the ground has gravitational potential energy.
- Gravitational potential energy depends on weight and height.
- Kinetic energy is energy of motion.

CHECK *Complete the following.*

1. The ability to do work is ______ .
2. Two kinds of energy are potential energy and ______ energy.
3. Stored energy is ______ energy.
4. Gravitational potential energy is energy of ______ .
5. Kinetic energy is energy of ______ .
6. A diver on a diving board has ______ potential energy.

APPLY *Complete the following.*

7. **Compare:** What is the difference between potential energy and kinetic energy?
8. In which drawing below does the rock have potential energy? In which does the rock have both potential and kinetic engery? Explain.



Skill Builder

Measuring When you measure, you compare an unknown value with a known value. Potential energy is found using the following formula:

$$PE = \text{weight} \times \text{height}$$

Remember that weight is measured in newtons (N); height is measured in meters (m). Therefore, potential energy is measured in units called newton-meters, or N-m. Use the formula to find the gravitational potential energy of each of the following objects: a 50-N brick on top of a 4-m wall; a 440-N student standing on a 2-m ladder; a 780-N diver standing on a 10-m diving board.

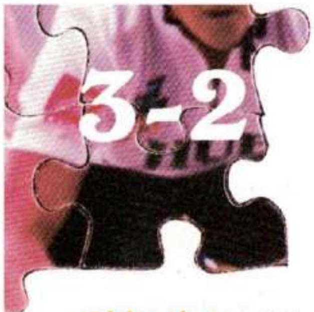
LEISURE ACTIVITY

ARCHERY

Millions of people in the United States take part in the sport of archery (AHR-chur-ee). Archery consists of target shooting with a bow and arrow. Archery is very popular in many schools and summer camps.

The basic equipment for an archery competition includes a curved bow. Most bows are made of wood and fiberglass. A bowstring is attached to each end of the bow. An arrow made of wood or lightweight aluminum is fitted into the bowstring. When the archer draws back the arrow, the bow has great potential energy. The greater the potential energy of the bow, the farther the arrow will travel. Targets are placed at different distances, from 30 m to 90 m. Archers must also wear safety equipment. This equipment includes an arm guard and a special glove to protect the fingers.

- Never point a drawn bow at any object other than the target.
- Never shoot an arrow when people or animals are in the area.
- Never shoot an arrow straight up.

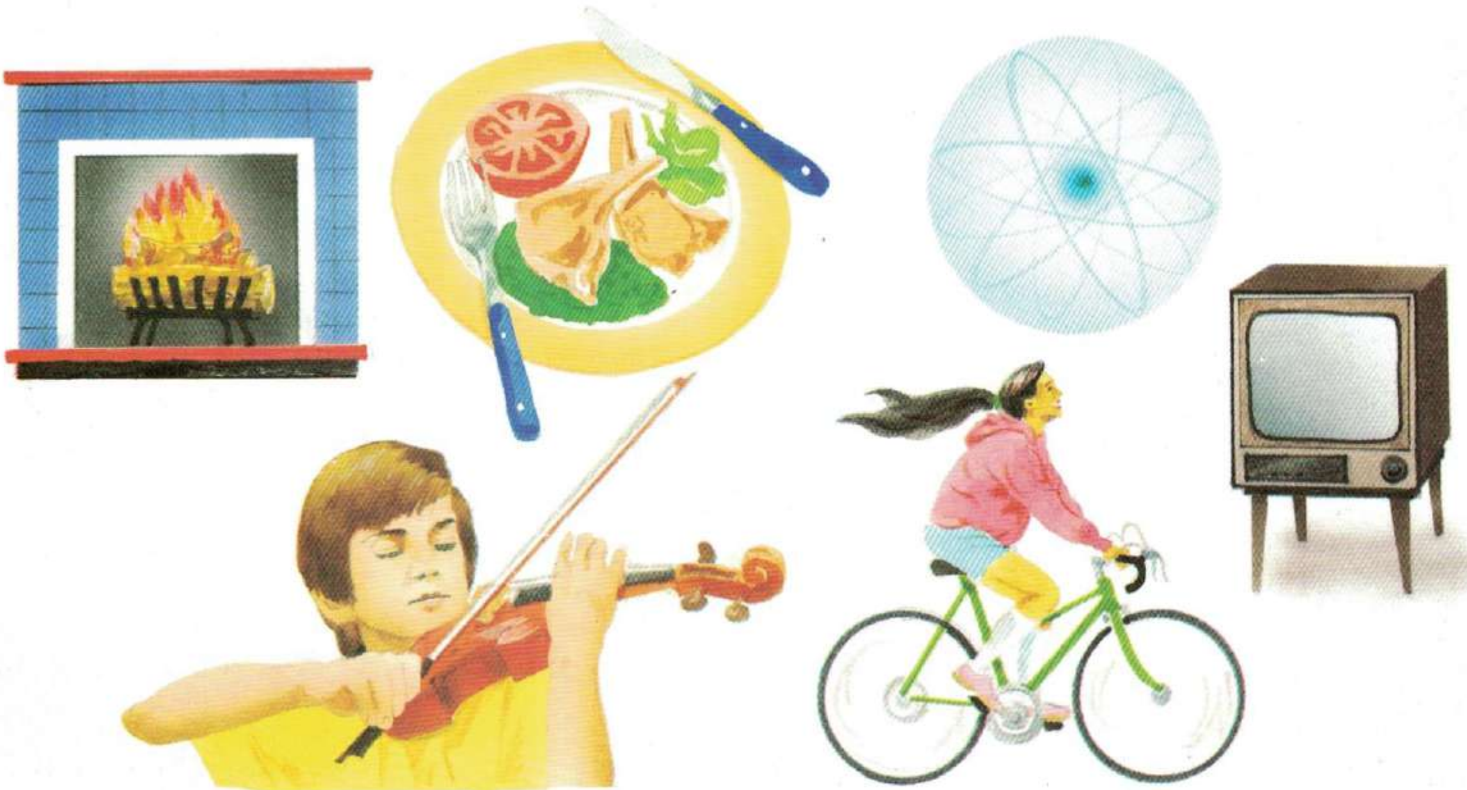


3-2 What are different forms of energy?

Objective ▸ Identify and describe different forms of energy.

Forms of Energy Your body gets energy from the food you eat. An automobile uses the energy in gasoline to make it move. A clock spring stores energy to turn the hands of the clock. These are some examples of different forms of energy. There are five main forms of energy. They are mechanical energy, electromagnetic (i-lek-troh-mag-NET-ik) energy, heat energy, chemical energy, and nuclear (NOO-klee-ur) energy.

▸ ***List:*** What are the five main forms of energy?



- **Mechanical Energy** The energy in moving things is mechanical energy. Wind, moving water, and falling rocks all have mechanical energy. When you walk, run, or ride a bicycle, you are using mechanical energy. Sound is a form of mechanical energy.
- **Electromagnetic Energy** Moving electrons have electromagnetic energy. Electricity and light are both forms of electromagnetic energy. Radios, television sets, refrigerators, and light bulbs all use electromagnetic energy.
- **Heat Energy** If you rub your hands together, they become warm. Heat energy is the energy of moving particles of matter. The faster the particles move, the more heat energy they have. All things contain some heat energy.
- **Chemical Energy** The energy that holds particles of matter together is chemical energy. The energy stored in a match head is chemical energy. The energy in fuels such as wood or coal is chemical energy.
- **Nuclear Energy** Nuclear energy is the energy stored in the nucleus of the atom. When the nucleus is split, the energy is released as heat and light. Nuclear energy also is released when the nuclei of atoms combine. The heat and light from the sun are produced from nuclear energy.

LESSON SUMMARY

- There are five main forms of energy.
- Mechanical energy is the energy in moving things.
- Electromagnetic energy is the energy in moving electrons.
- Heat energy is the energy in moving particles of matter.
- Chemical energy is the energy that holds particles of matter together.
- Nuclear energy is the energy stored in the nuclei of atoms.

CHECK *Complete the following.*

1. Where does your body get energy from?
2. How many basic forms of energy are there?
3. What is mechanical energy?
4. What kind of energy is light?
5. What kind of energy is produced when you rub your hands together?
6. What kind of energy is released when wood burns?
7. What is nuclear energy?

APPLY *Complete the following.*

8. **Classify:** Of the five basic forms of energy, which forms are potential energy? Which are kinetic energy? Explain your answers.
9. **Identify each of the objects as a source of mechanical, electromagnetic, heat, chemical, or nuclear energy. Some of the objects may be sources of more than one form of energy. Explain your answers.**
   - **a.** gasoline
   - **b.** burning wood
   - **c.** lightning
   - **d.** dynamite explosion
   - **e.** river
   - **f.** sun

Designing an Experiment

Design an experiment to solve the problem.

PROBLEM: How can you show that sound is a form of mechanical energy?

Your experiment should:

1. List the materials you would need.
2. Identify safety precautions that should be followed.
3. List a step-by-step procedure.
4. Describe how you would record your data.

TECHNOLOGY AND SOCIETY

NUCLEAR REACTORS

Nuclear energy can be released in two types of nuclear reactions. In one reaction, a large atomic nucleus is split into smaller nuclei. This is called nuclear fission. In the other reaction, two small nuclei are joined to form a larger nucleus. This is nuclear fusion. In both fission and fusion reactions, a great deal of energy is released. This energy can be used to produce electricity. Today, only nuclear fission is used as a source of energy. Scientists are still trying to find ways to control nuclear fusion reactions.

Nuclear energy is used to produce electricity in nuclear reactors. The fuel used in most nuclear reactors is uranium. Carefully controlled fission reactions in the uranium fuel release large amounts of heat energy. This heat energy is then used to make steam. The steam turns turbines and generates electricity.

Nuclear reactors have some safety problems. One major problem is that they produce dangerous waste products. For this reason, many people are against using nuclear reactors to produce electricity. What do you think?

How does energy change form?

Objective ▶ Identify and give examples of energy changing form.

TechTerm

- ▶ **thermal** (THUR-mul) **pollution:** damage that occurs when waste heat enters the environment

Changing Potential and Kinetic Energy

Energy can change from one form to another. Potential energy and kinetic energy are always changing form. Think of a pendulum (PEN-joo-lum). Figure 1 shows a swinging pendulum. As the pendulum swings, potential energy is changed into kinetic energy and back into potential energy. The pendulum has the greatest amount of potential energy at the top of its swing. It has the greatest amount of kinetic energy at the bottom of its swing.

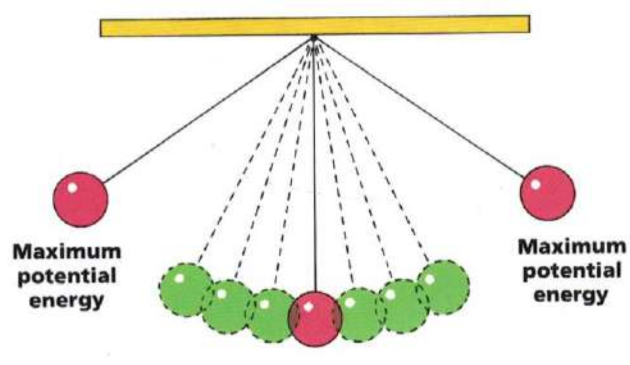


Figure 1

Analyze: When does a swinging pendulum have the least amount of kinetic energy?

Changing Forms of Energy You can observe many examples of changing forms of energy all around you. When you turn on an electric light, electrical energy is changed into light energy and heat energy. When you start an automobile, the engine changes the chemical energy in gasoline into mechanical energy. Nuclear reactors change nuclear energy into electrical energy. Your muscles change the chemical energy in food into mechanical energy.

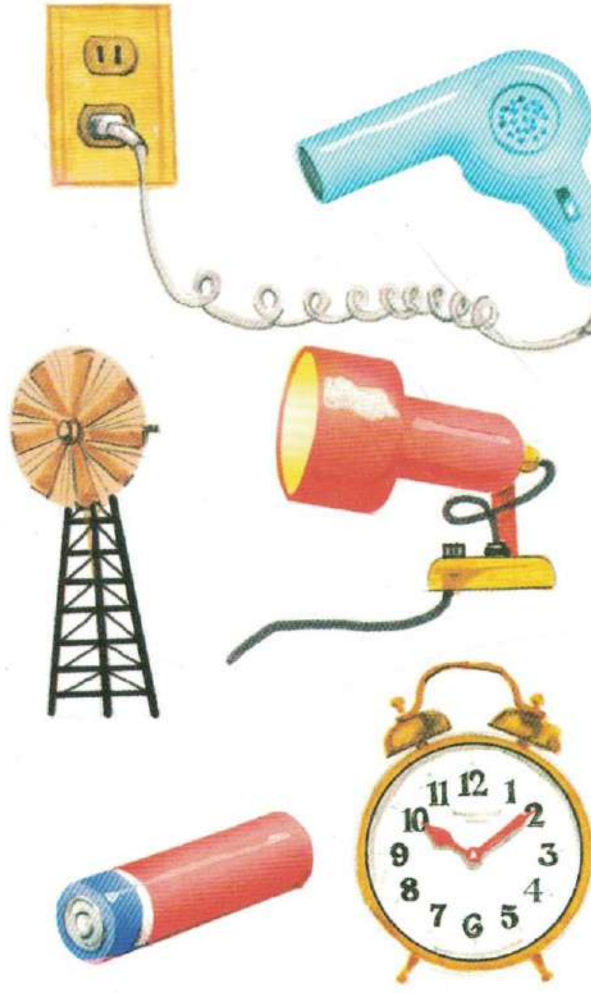


Figure 2

Identify: What energy change takes place when you turn on an electric light?

Waste Heat When energy changes form, some of the energy is always changed into heat. Most of this heat energy is wasted. When waste heat energy escapes into the environment, it causes **thermal** (THUR-mul) **pollution.** For example, the water in lakes and rivers is used to remove waste heat from power plants. The waste heat makes the water warmer. The water may become too warm for living things. If the water gets too warm, fishes in the lakes and rivers may die.

Define: What is thermal pollution?

LESSON SUMMARY

- Energy can change from one form to another.
- Energy changes can be observed all around you.
- When energy changes form, some of the energy is always changed into heat energy.

CHECK *Complete the following.*

1. A pendulum has the greatest amount of ______ energy at the top of its swing.
2. When a pendulum is at the ______ of its swing, it has the greatest amount of kinetic energy.
3. When you turn on a light, electrical energy is changed into light and ______ .
4. An automobile engine changes ______ energy into mechanical energy.
5. The ______ energy in food is changed into mechanical energy by your muscles.
6. A nuclear reactor changes nuclear energy into ______ energy.
7. When energy changes form, ______ energy is always produced.

APPLY *Complete the following.*

8. Describe how heat energy is wasted in each of the following: **a.** automobiles; **b.** television sets; **c.** electric lights.
9. **Interpret:** Look at Figure 2 on page 46. Identify and describe the different examples of energy changing form shown in the picture.

Ideas in Action

IDEA: Many appliances in your house probably waste heat energy.

ACTION: Look around your house. Make a list of things that waste heat energy. Does the waste heat cause any problems in your home environment? Is there any way you can reduce the amount of heat that is wasted?

Ideas in Action

IDEA: Energy is changing from one form to another all around you.

ACTION: Identify as many examples of energy changing form as you can.

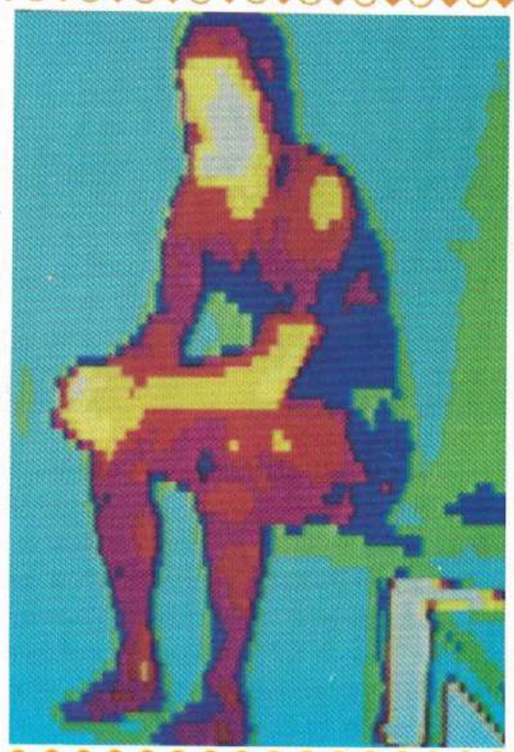
SCIENCE CONNECTION

THERMOGRAPHY

All objects give off some heat energy. Hot objects give off more heat energy than cool objects. A technique called thermography (thur-MAHG-ruh-fee) can detect differences in heat energy. A device called a thermograph turns the invisible heat energy into a visible picture. This "heat picture" is called a thermogram. Thermography is used in medicine, industry, and many other fields.

In medicine, doctors use thermography to diagnose certain illnesses, such as breast cancer, arthritis, and circulatory system problems. Thermography can be used to find leaks in home insulation that allow heat to escape from a house. Pollution-control technicians can use thermography to find sources of thermal pollution in bodies of water.

A thermograph looks like a small television camera. Inside the thermograph, heat energy is changed into electrical energy. The electrical signals form pictures on a television screen. Different temperatures appear as different colors on the thermogram.



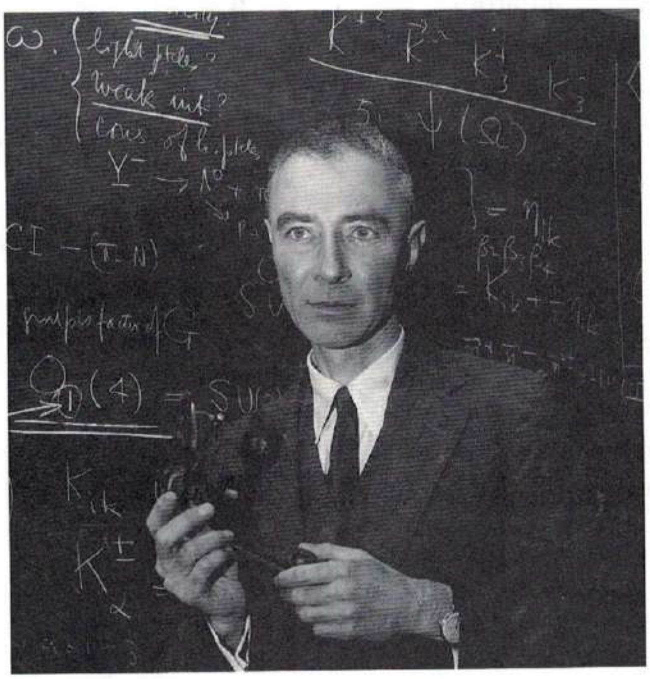
3-4 What is conservation of energy?

Objective ▶ State the law of conservation of energy.

TechTerms

- ▶ **law of conservation of energy:** energy cannot be made or destroyed, but only changed in form
- ▶ **scientific theory:** idea supported by evidence over a period of time

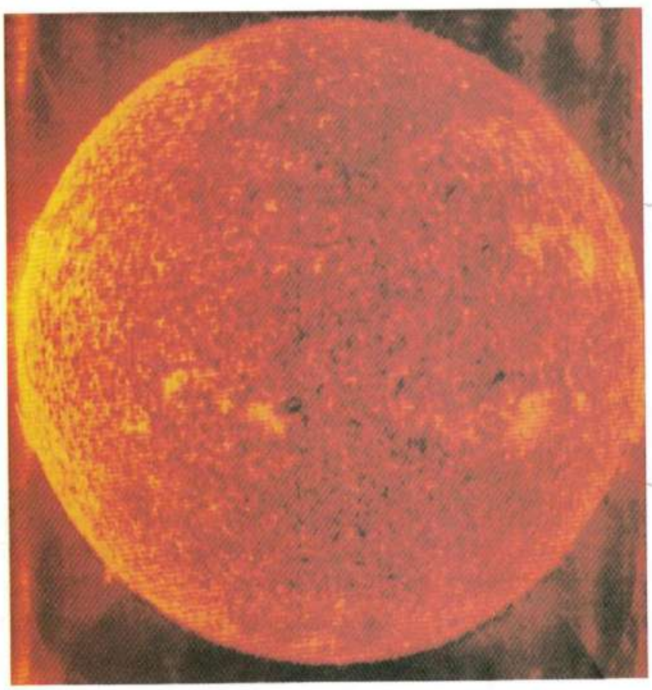
Conservation of Energy You know that energy can change from one form to another. Energy also can move from place to place. However, energy can never be lost. Energy can never be made or destroyed. Energy can only be changed in form. This is the **law of conservation of energy.**



A **scientific theory,** such as the law of conservation of energy, is an idea supported by evidence over a period of time. Scientists have studied energy for many years. They have done many experiments and made many observations about energy. As a result of these experiments and observations, scientists were able to state the law of conservation of energy.

State: What is the law of conservation of energy?

Energy from the Sun Before 1905, the law of conservation of energy did not seem to apply to nuclear energy. In the sun, nuclear energy is changed into heat energy and light energy. The sun seemed to be producing too much energy. In 1905, Albert Einstein showed that matter and energy are two forms of the same thing. Matter can be changed into energy, and energy can be changed into matter.



The total amount of matter and energy in the universe does not change. Einstein stated this idea in the equation

$$E = mc^2$$

In this equation, E is energy, m is matter, or mass, and c is the speed of light. Einstein's equation showed that a small amount of matter could be changed into a huge amount of energy. This is what happens in the sun.

Identify: What is Einstein's equation?

LESSON SUMMARY

- The law of conservation of energy states that energy can never be made or destroyed, but only changed in form.
- The law of conservation of energy is an example of a scientific theory.
- Matter can be changed into energy, and energy can be changed into matter.
- The total amount of matter and energy in the universe does not change.

CHECK *Write true if the statement is true. If the statement is false, change the underlined term to make the statement true.*

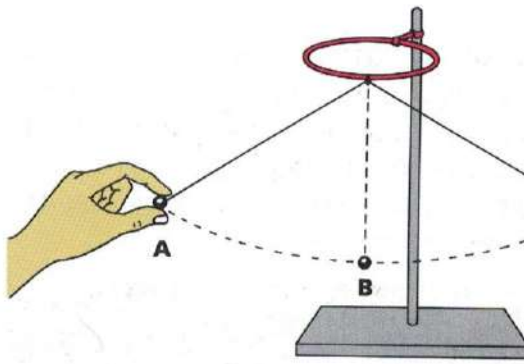
1. Energy cannot change from one form to another.
2. Energy can move from place to place.
3. The law of conservation of energy is an example of a scientific hypothesis.
4. A scientific theory is an idea supported by evidence over a period of time.
5. The law of conservation of energy did not seem to apply to chemical energy.
6. In Einstein's equation, *E* stands for energy.

APPLY *Complete the following.*

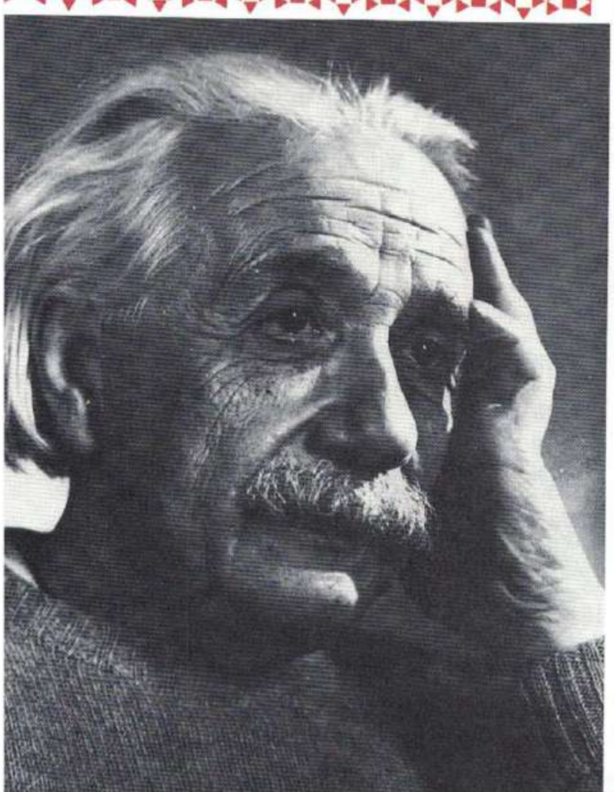
7. **Analyze:** Describe the changes in kinetic and potential energy that take place as a basketball is thrown through a hoop and caught again. How do these changes in energy support the law of conservation of energy?
8. **Interpret:** How does Einstein's equation explain how the sun produces energy in the form of heat and light?

State the Problem

Study the illustration below. State the problem for this experiment.



PEOPLE IN SCIENCE



ALBERT EINSTEIN (1879–1955)

Albert Einstein was one of the greatest scientists who ever lived. His ideas changed the way people think about the universe. Einstein was born in Ulm, Germany. He became interested in science as a young boy. When Einstein was five years old, his father showed him a pocket compass. Einstein was fascinated to see that the compass needle always pointed in the same direction. This experience sparked his interest in science.

Einstein is probably best known for his theory of relativity and the famous equation, $E = mc^2$. However, he also wrote important papers about the nature of light and the movement of particles in a liquid or gas. His theories about matter and energy were the basis for controlling the release of nuclear energy from the atom. In 1921, Einstein received the Nobel Prize in physics.

Einstein worked and taught in Switzerland and Germany. Just before World War II, Einstein left Germany and came to the United States. He became an American citizen in 1940. Einstein spent the rest of his life at the Institute for Advanced Study in Princeton, New Jersey.

3-5 What is work?

Objective ▸ Relate work, force, and distance.

TechTerm

▸ **work:** force times distance

Work When are you doing **work**? Work is done when a force moves an object a certain distance. This relationship can be shown in the equation

$$\text{work} = \text{force} \times \text{distance}$$

Suppose two boys pushed a car stuck in the mud. They were not able to move the car. They were very tired afterwards. Did the boys do any work? The answer is no. For work to be done, something must be moved. The boys used a great deal of force, but the car did not move. Work was not done.

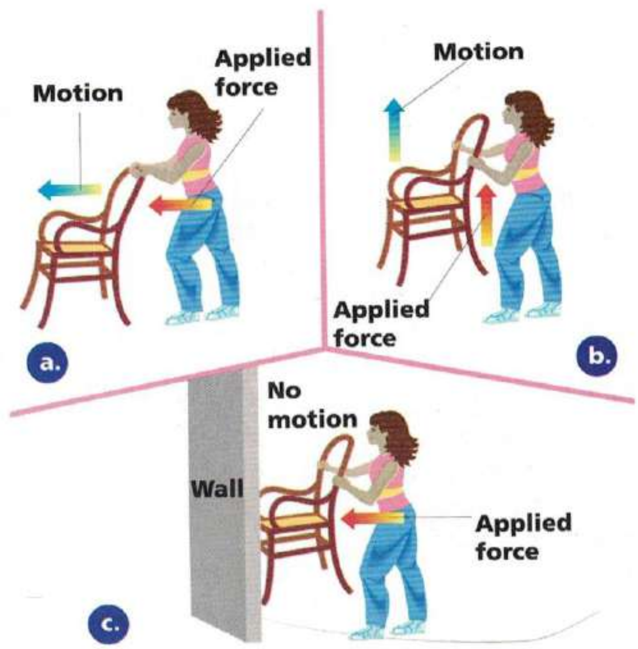
Describe: What is the relationship between work, force, and distance?

Work and Energy Remember that energy is the ability to do work. However, energy can be used without doing work. When a force moves an object, work is done. Anything that can make something else move has energy. A moving baseball bat has energy. It can do work. When the bat hits a ball, the ball moves. The energy stored in gasoline can do work. It can make a car move. The boys pushing the car used energy. However, no work was done because the car did not move. If you hold a heavy bag of groceries, your muscles are using energy. However, you are not doing work because the bag does not move.

Explain: Why does a moving baseball bat have energy?

Direction of Motion For work to be done, a force must make an object move in the same direction as the force. Suppose you pushed a chair across the floor. Have you done any work? The answer is yes. The direction of the motion was the same as the direction of the applied force. See Picture A. Suppose you lifted a chair. You again did work. You used a force to lift the chair, and it moved in the direction of the force. See Picture B.

Finally, suppose you pushed the chair against the wall. You used force, but there was no motion in the direction of the force. So, no work was done. See Picture C.



Explain: Why is work done when you push a chair across the floor?

LESSON SUMMARY

- Work is done when a force moves an object a certain distance.
- Energy can be used without doing work.
- For work to be done, the direction of the applied force must be the same as the direction of motion.

CHECK *Complete the following.*

1. Work = force × ______ .
2. Work is not done unless something is ______ .
3. The ability to do work is ______ .
4. For work to be done, the direction of the ______ must be the same as the direction of motion.
5. The stored ______ in gasoline can make a car move.

APPLY *Complete the following.*

6. Is work being done in each of the following examples? Explain your answers.
   - **a.** A boy holds a heavy package for one hour.
   - **b.** A girl coasts downhill on a bicycle.
   - **c.** A football player kicks a field goal.
   - **d.** A boy carries his baby sister across the room.
   - **e.** A girl hits a tennis ball over the net.

Health and Safety Tip

Always be careful when picking up a heavy box or other object from the floor. You should bend your knees and use your leg muscles, not your back muscles, to lift the object. Use library references to find out other ways to prevent back injuries when doing work.

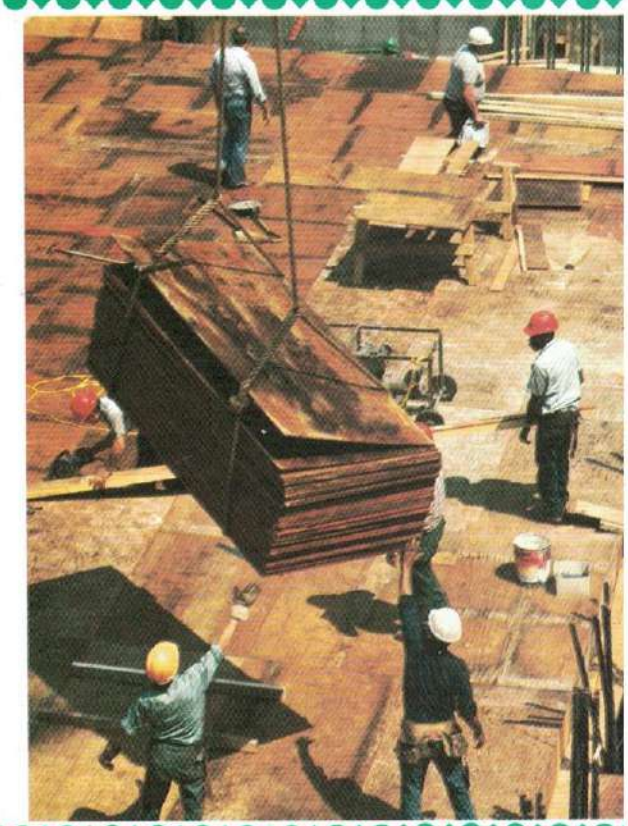
CAREER IN PHYSICAL SCIENCE

CONSTRUCTION WORKER

Every year, millions of homes, office buildings, and bridges are built in the United States. The construction industry provides thousands of jobs in many interesting and varied projects. Jobs available on building sites include crane operator, contractor, structural engineer, and carpenter.

Some jobs in the construction industry, such as structural engineer, require four years of college. Others, such as crane operator, involve on-the-job training or training at a technical school. Construction workers may work for large construction companies or small, private contractors.

Contractors plan buildings to be safe and practical for their intended use. Structural engineers choose the best materials for a job. Crane operators move heavy building equipment from the ground to the top of a building under construction. All construction workers must be aware of safety at all times.



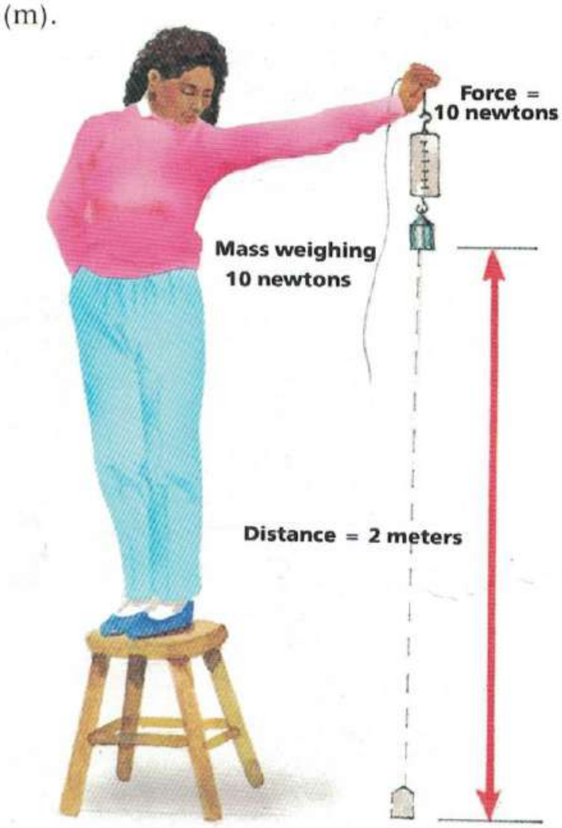
3-6 How can work be measured?

Objective ▶ Use the proper unit to measure work.

TechTerm

- ▶ **joule** (JOOL): metric unit of work; equal to 1 N-m (newton-meter)

Measuring Work To measure work, you must know two things. First, you must know the force used to move an object. Force can be measured with a spring scale. The unit of force is the newton (N). Second, you must know the distance that the object was moved. Distance is measured in meters (m).



Work can be measured in newton-meters (N-m). Work is equal to force times distance.

$$W = F \times d$$

In this equation, W is work. F is force and d is distance. Suppose you lift an object weighing 10 N. Remember that weight is a force. You lift the object a distance of 2 m. To measure the amount of work done, multiply the force times the distance:

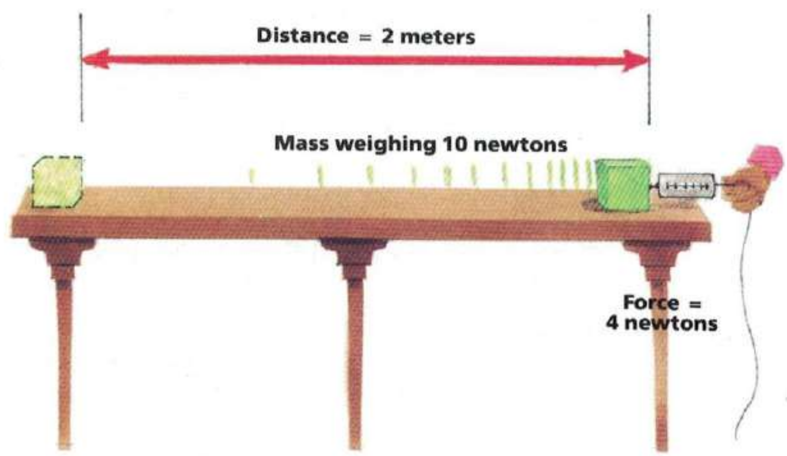
$$W = F \times d$$
$$W = 10 \text{ N} \times 2 \text{ m}$$
$$W = 20 \text{ N-m}$$

List: What two things must you know in order to measure work?

Unit of Work Scientists use a unit called a **joule** (JOOL) to measure work. One joule (1 J) of work is done when a force of 1 N moves an object a distance of 1 m. One joule is equal to 1 N-m of work.

Identify: What unit is used to measure work?

Direction of Force To measure work, you must measure the force applied in the direction of motion. Suppose you used a spring scale to pull a 10-N box a distance of 2 m along a table top. How much work have you done? In this case, the weight of 10 N does not count. You must multiply the force shown on the spring scale times the distance. Suppose the applied force shown on the spring scale is 4 N. Then the work done equals 4 N × 2 m = 8 N-m, or 8 J.



Calculate: How much work is done if you use 5 N of force to push a 20-N chair 3 m across the floor?

LESSON SUMMARY

- To measure work, you must know the force in newtons and the distance in meters.
- Work can be measured in newton-meters (N-m).
- The unit of work is the joule (J); 1 J = 1 N-m.
- When measuring work, you must measure the force applied in the direction of motion.

CHECK *Complete the following.*

1. The unit of force is the ______ .
2. To measure work, you must know both force and ______ .
3. Work can be measured in newton-______ .
4. The unit of work is the ______ .
5. One joule is equal to 1 ______ .
6. To measure work, you must know the amount of force applied in the direction of ______ .

APPLY *Complete the following.*

7. **Calculate:** How much work is done in each of the following examples? Show all of your calculations.
   a. A child uses 4 N of force to pull a wagon a distance of 2 m along a sidewalk.
   b. A construction worker uses 30 N of force to drag a piece of equipment a distance of 3 m.
8. **Compare:** In which case is more work done? Explain your answers.
   a. You lift a 40-N object 2 m straight up.
   b. You use 10 N of force to pull the same 40-N object 2 m across the floor.

InfoSearch

Read the passage. Ask two questions about the topic that you cannot answer from the information in the passage.

James Prescott Joule The metric unit of work, the joule, is named after James Prescott Joule. Joule was a physicist. He was born in England in 1818. Joule was one of the four scientists who helped state the law of conservation of energy. Joule's law is also named after him. This law states that heat is produced when electricity flows through a wire.

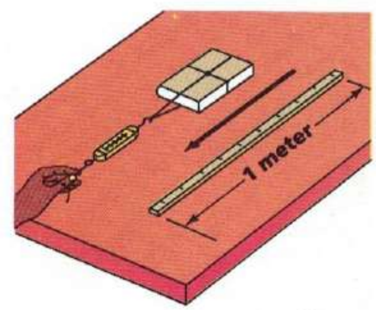
SEARCH: Use library references to find answers to your questions.

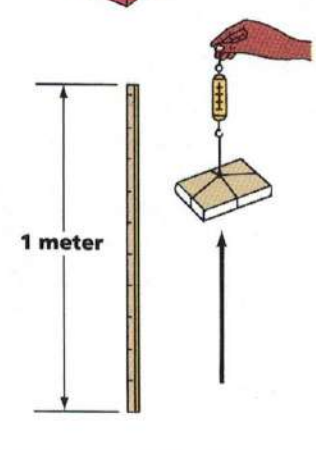
ACTIVITY

MEASURING WORK

You will need a book, string, a spring scale, and a meterstick.

1. Tie a piece of string around a book.
2. Attach a spring scale to the book using the string.
3. Using the spring scale, lift the book a distance of 1 m. Record the amount of force shown on the spring scale. Calculate the amount of work done in joules.
4. Using the spring scale, pull the book a distance of 1 m across your desk or table top. Record the amount of force shown on the spring scale. Calculate and record the amount of work done in joules.





Questions

1. How much work did you do when you lifted the book?
2. How much work did you do when you pulled the book across your desk?
3. Did you do the same amount of work in steps 3 and 4?

3-7 What is power?

Objective ▸ Explain how to measure power.

TechTerms

- **power:** amount of work done per unit of time
- **watt:** metric unit of power; equal to 1 J/sec

Power The amount of work done per unit of time is called **power**. In science, the term "power" describes the rate at which you do work. Suppose you took 30 minutes to shovel snow from a sidewalk. Your neighbor used a snow-blower and cleared the sidewalk in 10 minutes. If you both did the same amount of work, which one of you used more power? Your neighbor, who did the work in less time, used more power.

Define: What is power?

Measuring Power To measure power, you must know two things. First, you must know the amount of work done. Second, you must know the time needed to do the work. The formula used to measure power is

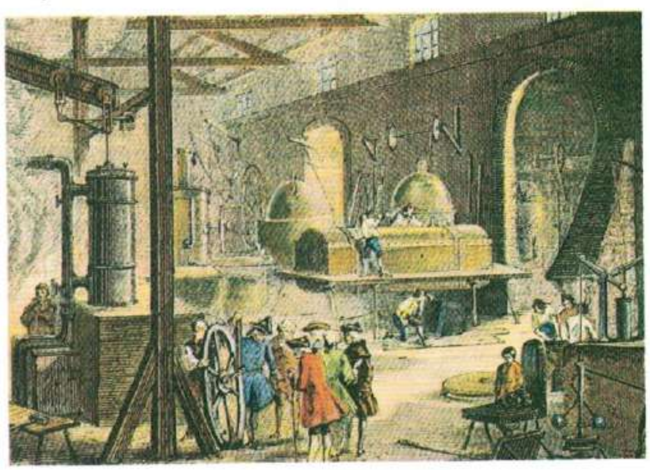
$$\text{power} = \text{work}/\text{time}$$

Remember that work is equal to force times distance. The formula for power can also be written as follows:

$$\text{power} = (\text{force} \times \text{distance})/\text{time}$$

Identify: What is the formula used to measure power?

Unit of Power The metric unit of power is the **watt** (W). Power is equal to work divided by time. The unit of work is the newton-meter, or joule. The unit of time is the second. Therefore, one watt (1 W) is equal to 1 N-m/sec, or 1 J/sec. The watt is named after James Watt. Watt was a Scottish engineer who built the first useful steam engine.



Large amounts of power are measured in kilowatts (kW). One kilowatt (1 kW) is equal to 1000 W. You are probably familiar with watts and kilowatts as units of electric power. For example, light bulbs are rated as 60 W, 100 W, or 250 W.

Identify: What is the unit of power?

LESSON SUMMARY

- Power is the amount of work done per unit of time.
- Power = work/time, or (force × distance)/time.
- The metric unit of power is the watt (W).
- Large amounts of power are measured in kilowatts (kW).

CHECK *Complete the following.*

1. The rate at which work is done is ______ .
2. Power is the amount of work done per unit of ______ .
3. To measure power, you must know the amount of ______ and the time needed.
4. Power = (force × ______)/time.
5. The metric unit of power is the ______ .
6. One ______ is equal to 1000 W.
7. One watt is equal to 1 N-m/sec, or 1 ______ /sec.
8. The unit of power is named after James ______ .

APPLY *Complete the following.*

9. **Calculate:** Find the amount of power used in each of the following examples. Show your calculations.
   - **a.** You use a force of 10 N to move a box 100 m in 10 sec.
   - **b.** An athlete lifting weights does 900 J of work in 1 sec.
   - **c.** A truck does 30,000 J of work in 15 sec.
   - **d.** A furniture mover uses a force of 150 N to push a heavy trunk 5 m across the floor in 5 sec.

Designing an Experiment

Design an experiment to solve the problem.

PROBLEM: How much power, in watts, do you use when you climb a flight of stairs?

Your experiment should:

1. List the materials you would need.
2. Identify safety precautions that should be followed.
3. List a step-by-step procedure.
4. Describe how you would record your data.

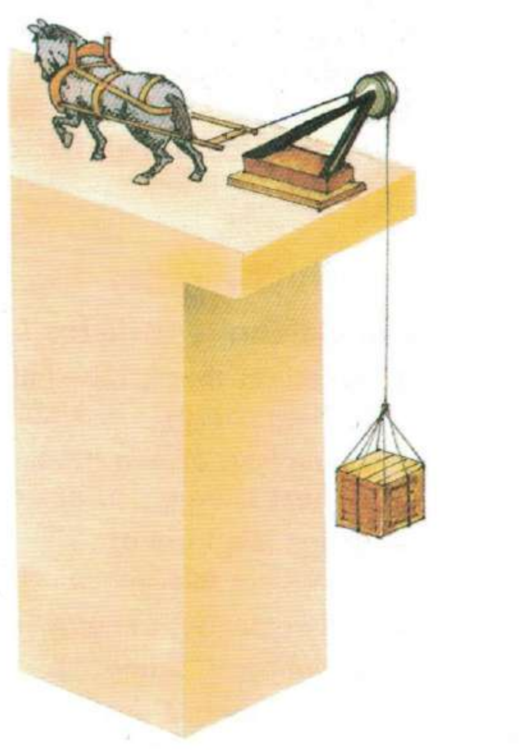
LOOKING BACK IN SCIENCE

HORSEPOWER

You are probably familiar with the term "horsepower." Engines and motors are commonly rated in horsepower. An automobile engine, for example, may have about 100 horsepower. A train engine may produce 10,000 horsepower. Where does this unit of power come from?

James Watt was the first person to use the term "horsepower." Watt was a Scottish engineer and inventor. In the 1760s, he built the first practical steam engine. Watt wanted to use a unit of power for his engine that would be familiar to most people. He decided to use the power of a horse as the standard unit of power for the steam engine. Watt found that a strong horse could lift a 750-N load a distance of 1 m in 1 sec. In other words, a horse produced 750 J/sec of power. Watt defined this amount of power as one horsepower (hp).

Today, the unit of power is the watt (W). It is named in honor of James Watt. One watt is equal to 1 J/sec. Therefore, 1 hp (750 J/sec) is equal to 750 W. Real horses are no longer used as a standard of power. However, ratings for engines, motors, and power plants are still commonly given in terms of horsepower.



UNIT 3 Challenges

STUDY HINT Before you begin the Unit Challenges, review the TechTerms and Lesson Summary for each lesson in this unit.

TechTerms

energy (42)
joule (52)
kinetic energy (42)
law of conservation of energy (48)
potential energy (42)
power (54)
scientific theory (48)
thermal pollution (46)
watt (54)
work (50)

TechTerm Challenges

Matching *Write the TechTerm that matches each description.*

1. stored energy
2. ability to do work
3. force times distance
4. energy of motion
5. metric unit of work
6. metric unit of power
7. work done per unit time

Fill In *Write the TechTerm that best completes each statement.*

1. The moving water in a waterfall has ______ .
2. The ______ in a match is stored in the chemicals in the match head.
3. The faster you run, the more ______ you have.
4. Waste heat that escapes into the environment can cause ______ .
5. The ______ states that energy cannot be made or destroyed, but only changed in form.
6. An idea supported by evidence over a period of time is a ______ .
7. When you use force to move an object, you are doing ______ .
8. The ______ is the unit used to measure work.
9. The rate at which you do work is called ______ .
10. The unit of power is the ______ .

Content Challenges

Multiple Choice *Write the letter of the term or phrase that best completes each statement.*

1. An object that is raised above the ground has
   a. heat energy. **b.** kinetic energy. **c.** potential energy. **d.** nuclear energy.
2. All moving objects have
   a. heat energy. **b.** kinetic energy. **c.** potential energy. **d.** nuclear energy.
3. Sound is a form of
   a. nuclear energy. **b.** electromagnetic energy. **c.** chemical energy. **d.** mechanical energy.
4. Electromagnetic energy includes electricity and
   a. light. **b.** sound. **c.** heat. **d.** atoms.
5. An automobile engine changes chemical energy into
   a. electricity. **b.** nuclear energy. **c.** mechanical energy. **d.** light.

6. A scientific theory is the result of experiments and
   a. guesses. **b.** observations. **c.** predictions. **d.** hypotheses.
7. In the sun, nuclear energy is changed into light energy and
   a. sound energy. **b.** chemical energy. **c.** electrical energy. **d.** heat energy.
8. Work = force times
   a. distance. **b.** mass. **c.** power. **d.** energy.
9. Work is measured in units called
   a. watts. **b.** meters. **c.** joules. **d.** newtons.
10. One watt is equal to
    a. 1 m/sec. **b.** 1 J/sec. **c.** 1 N/sec. **d.** 1 kW/sec.

True/False *Write true if the statement is true. If the statement is false, change the underlined term to make the statement true.*

1. Energy is the ability to do work.
2. Stored energy is kinetic energy.
3. Potential energy is energy of motion.
4. There are six main forms of energy.
5. The energy stored in atoms is nuclear energy.
6. When energy changes form, some energy is always lost as sound.
7. Energy cannot be made or destroyed.
8. Matter and energy are not two forms of the same thing.
9. Energy cannot be used without doing work.
10. To measure work, you must know force and time.
11. To measure power, you must know the amount of work and the time.
12. Large amounts of power are measured in kilowatts.

Understanding the Features

Reading Critically *Use the feature reading selections to answer the following. Page numbers for the features are in parentheses.*

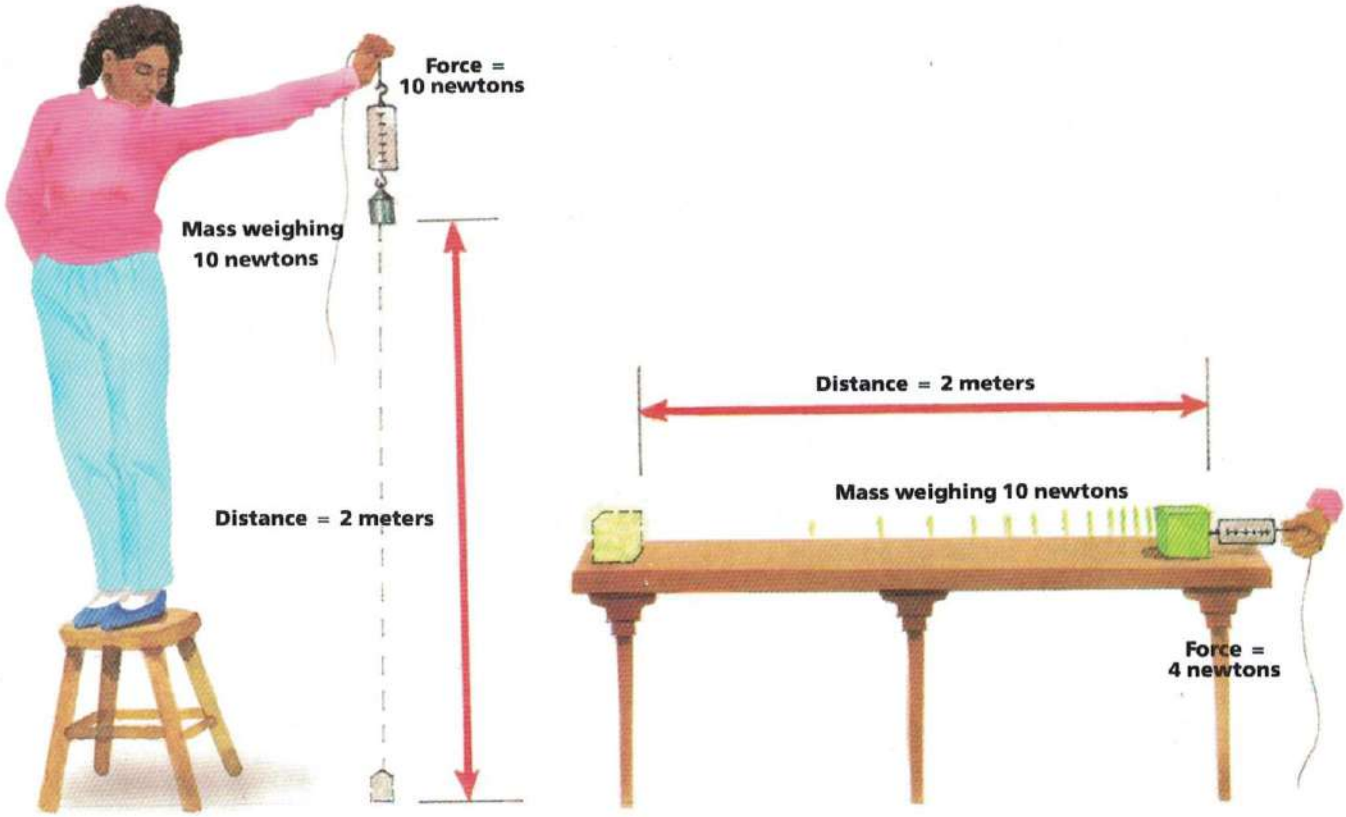
1. What are two items of safety equipment worn by archers? (43)
2. What happens in a nuclear fusion reaction? (45)
3. What is a thermograph? (47)
4. In what year did Albert Einstein receive the Nobel Prize for physics? (49)
5. **Infer:** Why must construction workers be aware of safety at all times? (51)
6. **Hypothesize:** Why do you think James Watt chose the power of a horse as a standard unit of power? (55)

Concept Challenges

Critical Thinking *Answer each of the following in complete sentences.*

1. Explain the difference between potential energy and kinetic energy.
2. Describe the changes in potential and kinetic energy that take place in a swinging pendulum.
3. How does Einstein's equation, $E = mc^2$, support the law of conservation of energy?
4. How is it possible for you to use energy without doing any work?
5. What is the relationship between work and power?
6. Why is gravitational potential energy called energy of position?

Interpreting a Diagram *Use the diagrams showing a person lifting an object and pulling an object to complete the following.*



1. What is the weight of the object in the left-hand diagram?
2. What distance is this object being lifted?
3. How much force is needed to lift this object?
4. How much work is being done to lift this object?
5. What is the weight of the object in the right-hand diagram?
6. What distance is this object being pulled?
7. How much force is needed to pull this object?
8. How much work is being done to pull this object?
9. Is the amount of work being done in the two diagrams the same or different? Explain.

Finding Out More

1. **Classify:** Collect pictures from newspapers and magazines showing different forms of energy. Label each picture with the form of energy shown. Use your pictures to make a poster illustrating all of the different forms of energy.
2. Different units can be used to measure energy. Use library references to find out how the following units are used: kilowatt-hour, calorie, BTU. Write a report of your findings.
3. The power obtained from falling water is called hydroelectric power. Find out how the water behind a dam is used to generate electricity in a hydroelectric power plant. Draw a labeled diagram of a hydroelectric plant. Where in the United States are most hydroelectric power plants located? What are some advantages and disadvantages of hydroelectric power?
4. Create a bulletin board display for your classroom showing examples of energy changing form.
5. Write or visit your local electric company. Find out how the company generates electricity for your community.