chapter 4

Work and Energy

section 3 Conservation of Energy

What You'll Learn

- how power is related to energy
- how energy is conserved

Before You Read

The motion of objects appear to change all the time. Imagine a person swinging on a swing. Explain the person's motion while swinging.

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Mark the Text

Identify the Main Point Highlight the main point in each paragraph. Highlight in a different color a detail or example that helps explain the main point.

Reading Check

1. **Explain** What does the law of conservation of energy state?

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Read to Learn

The Law of Conservation of Energy

As a batted ball speeds up or slows down, its kinetic and potential energy are always changing. But the amount of mechanical energy always stays the same. The kinetic and potential energy continually change form back and forth and no energy is destroyed.

This is true for all forms of energy. Energy can change from one form to another, but the total amount of energy never changes. Another way to say this is that energy is conserved. The **law of conservation of energy** states that energy cannot be created or destroyed. This means that the total amount of energy in the universe is always the same. It just changes from one form to another.

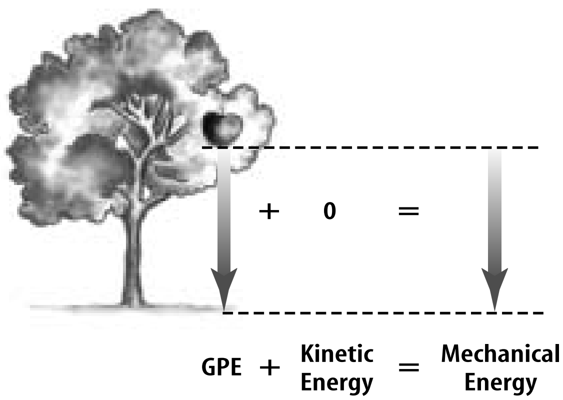
You might have heard the phrase *energy conservation* before. Conserving energy means reducing the need for energy so we use fewer energy resources such as coal and oil. The law of conservation of energy and conserving energy are not the same. The law of conservation of energy describes what happens to energy as it changes form or is transferred from one object to another.

Changes Between Kinetic and Potential Energy

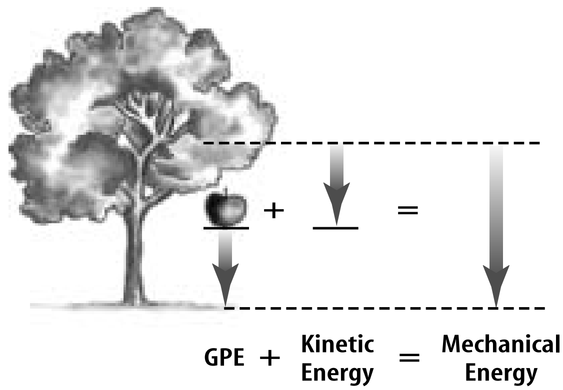
Recall that a rubber band has elastic potential energy. When a stretched rubber band is let go, the potential energy is changed into kinetic energy. **Mechanical energy** is the total amount of potential and kinetic energy in a system. The mechanical energy of the rubber band is the total of its potential energy and its kinetic energy at any one time. Mechanical energy comes from where an object is and the movement of the object.

Does mechanical energy change?

What happens to the mechanical energy of an object as its potential energy is changed into kinetic energy? Look at the apple in the tree below. It has gravitational potential energy because Earth is pulling down on it. The apple does not have kinetic energy while it hangs in the tree. The apple's gravitational potential energy and its mechanical energy are the same.



Look at the apple in the second figure. As it falls, the apple loses height, so its gravitational potential energy becomes less. As the velocity of the apple increases, its kinetic energy increases. The potential energy of the apple is being changed to kinetic energy. However, the mechanical energy will not change. The form of the energy changes, but the total amount of the energy remains the same.



FOLDABLES™

C Collect Information Make note cards from two half-sheets of paper as shown. Write on each note card what you learn about mechanical energy and the law of conservation of energy.

Think it Over

2. **Explain** Does the mechanical energy of an apple falling from a tree change? Explain.

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Picture This

3. **Interpret** What do the arrows in the figures mean?

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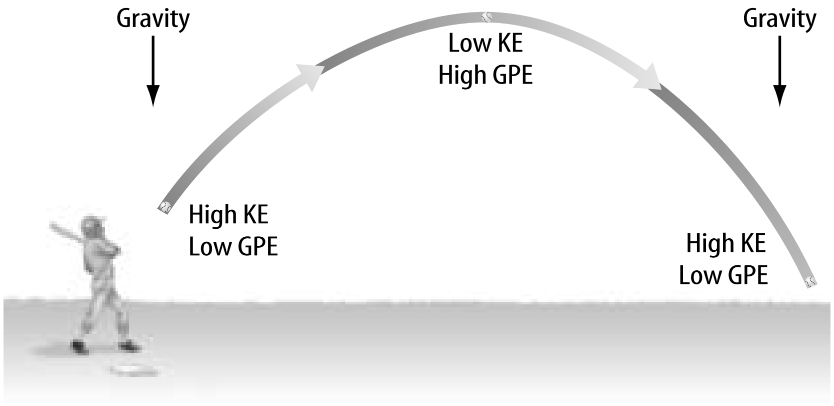
How does energy change in projectile motion?

Energy changes also occur during projectile motion. During projectile motion, an object moves through the air in a curved path. Look at the figure below. As the ball leaves the bat, it has mostly kinetic energy. As the ball rises, its gravitational potential energy becomes greater, but its kinetic energy becomes less due to decreasing speed. As the ball falls, its gravitational potential energy becomes less, but its kinetic energy becomes greater due to increasing speed. However, the total mechanical energy of the ball does not change as the ball moves through the air.



Picture This

4. Observe What does the symbol KE represent in the figure?

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What happens to the energy of a swing?

When you ride on a swing, part of the fun is the way you feel just as you drop from the highest part of the swing's path. Energy is constantly changing during this ride on a swing. The push that gets you moving is kinetic energy. As the swing rises, you lose speed. This means the kinetic energy is changing into gravitational potential energy. At the top of the path, the GPE is its greatest and the kinetic energy is at its lowest. As the swing starts its downward path and its speed increases, the GPE changes into kinetic energy. At the bottom of the swing's path, the kinetic energy is greatest and the GPE is at its lowest. As you swing back and forth, kinetic and potential energy are constantly changing back and forth.

Think it Over

5. Analyze Why is kinetic energy at its lowest at the top of the swing?

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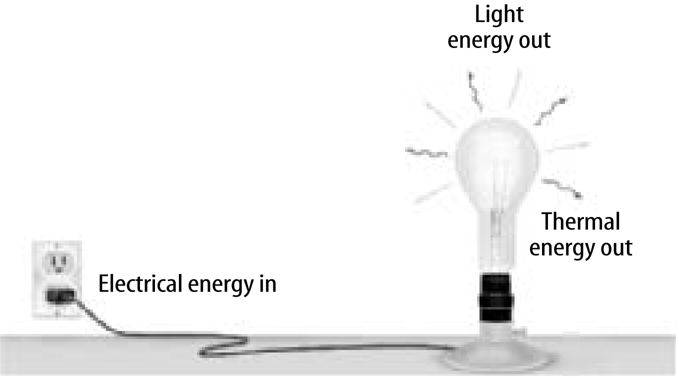
How does friction affect energy?

Suppose you are swinging on a swing. If you stop pumping and no one is pushing you, you will soon stop swinging. It would seem that the mechanical (kinetic and potential) energy of the swing is lost. Wouldn't this go against the law of conservation of energy?

If the energy of the swing decreases, then the energy of some other object must increase by the same amount. What object has an energy increase? With every motion, the swing's ropes or chains rub on their hooks, and air pushes on the rider. Friction and air resistance cause the temperature of the hooks and air to increase a little. The mechanical energy is not destroyed. It is changed into thermal energy. So, the total amount of energy stays the same—it just changes forms.

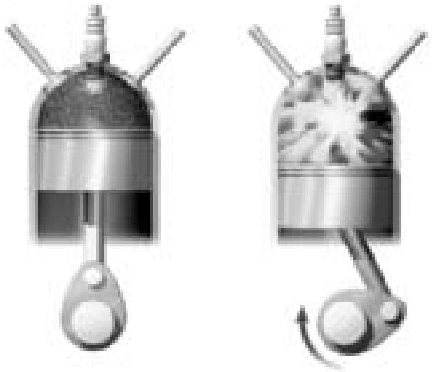
How can electrical energy change?

Every day you use items that change energy from electricity into light, sound, thermal energy, radiant energy, and motion. In the figure you can see that electricity is changed into light and thermal energy in a lightbulb.



How can chemical energy change?

Chemical energy can be changed into kinetic energy. A fuel, such as gasoline, stores energy in the form of chemical potential energy. Cars and buses usually run on gasoline. As shown in the figure, an electrical spark causes a small amount of fuel in the engine to burn. This changes the chemical potential energy stored in the gasoline molecules into thermal energy. The thermal energy heats up gases and they expand. The expanding gases cause parts of the car to move. The moving parts have kinetic energy. Chemical energy has been changed into thermal energy and then into kinetic energy. ✔



Picture This

6. Relate Name other items that change electrical energy into thermal energy.

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Reading Check

7. List three forms of energy that are involved in the running of a car engine.

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Picture This

8. Identify Circle the moving parts in the figure. What type of energy is this?

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How does your body store and use energy?

Your body requires energy to stand still. The law of conservation of energy applies to the chemical and physical changes that are going on in your body. Your body stores potential energy in the form of fat and other chemical compounds. The potential energy is the fuel for processes such as the beating of your heart, digesting of food, and moving muscles.

Green plants convert radiant energy into chemical potential energy and store it as sugar.

Power

Suppose you and a friend want to see who can push a box of books up a ramp faster. Each box of books weighs the same. You each push your box the same distance, but your friend pushes her box faster than you do. You both do the same amount of work on the boxes because the force and the distance are the same. The only difference is how long it takes to do the work. Your friend has more power than you because she can do the work faster than you can. **Power** is the rate at which energy is converted. Something has more power if it can do the same amount of work in less time.

How do you calculate power?

To calculate power, divide the amount of work done by the time it takes to do the work. Below is the power equation.

$$\textbf{Power} \text{ (in watts)} = \frac{\textbf{energy} \text{ (in joules)}}{\textbf{time} \text{ (in seconds)}}$$

$$P = \frac{E}{t}$$

The SI unit for power is the watt (W). One watt equals one joule of work done in one second. The watt is a very small unit. Power usually is given in kilowatts. One kilowatt equals 1,000 watts.

Find the power of a machine that can do 5,000 joules of work in 20 seconds. Use the power equation.

$$P = \frac{W}{t}$$

$$P = \frac{5000 \text{ joules}}{20 \text{ seconds}}$$

$$P = 250 \text{ watts}$$

The power of the machine is 250 watts.

Think it Over

9. **Apply** How are work and power related?

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After You Read

Mini Glossary

law of conservation of energy: energy may change from one form to another, but the total amount of energy never changes.

mechanical energy: the total amount of potential and kinetic energy in a system

power: the rate at which energy is converted

1. Review the terms and their definitions in the Mini Glossary. Describe a real-world example in which the amount of potential and kinetic energy change, but the total amount of mechanical energy stays the same.

2. A 20 watt lightbulb uses 20 joules of energy every second. A person expends 50 watts of energy per stair when climbing up stairs. How long could you light the lightbulb if the energy used to climb 20 stairs were converted to electricity?

Power Equation

$$\text{Power (in watts)} = \frac{\text{Energy (in joules)}}{\text{time (in seconds)}}$$

$$P = \frac{E}{t}$$

3. Mark the Text Think about what you have learned. How did highlighting the main points and details or examples help you learn the new material?

End of Section