SECTION 3

Conservation of Energy

Many roller coasters have a mechanism that pulls the cars up to the top of the first hill. But the cars are on their own for the rest of the ride.

As the cars go up and down the hills on the track, their potential energy is converted into kinetic energy and back again. But the cars never return to the same height at which they started. Does energy get lost somewhere along the way? No, it is just converted into other forms of energy.

What You Will Learn

- Explain how energy is conserved within a closed system.
- Explain the law of conservation of energy.
- Give examples of how thermal energy is always a result of energy conversion.
- Explain why perpetual motion is impossible.

Vocabulary

friction
law of conservation of energy

READING STRATEGY

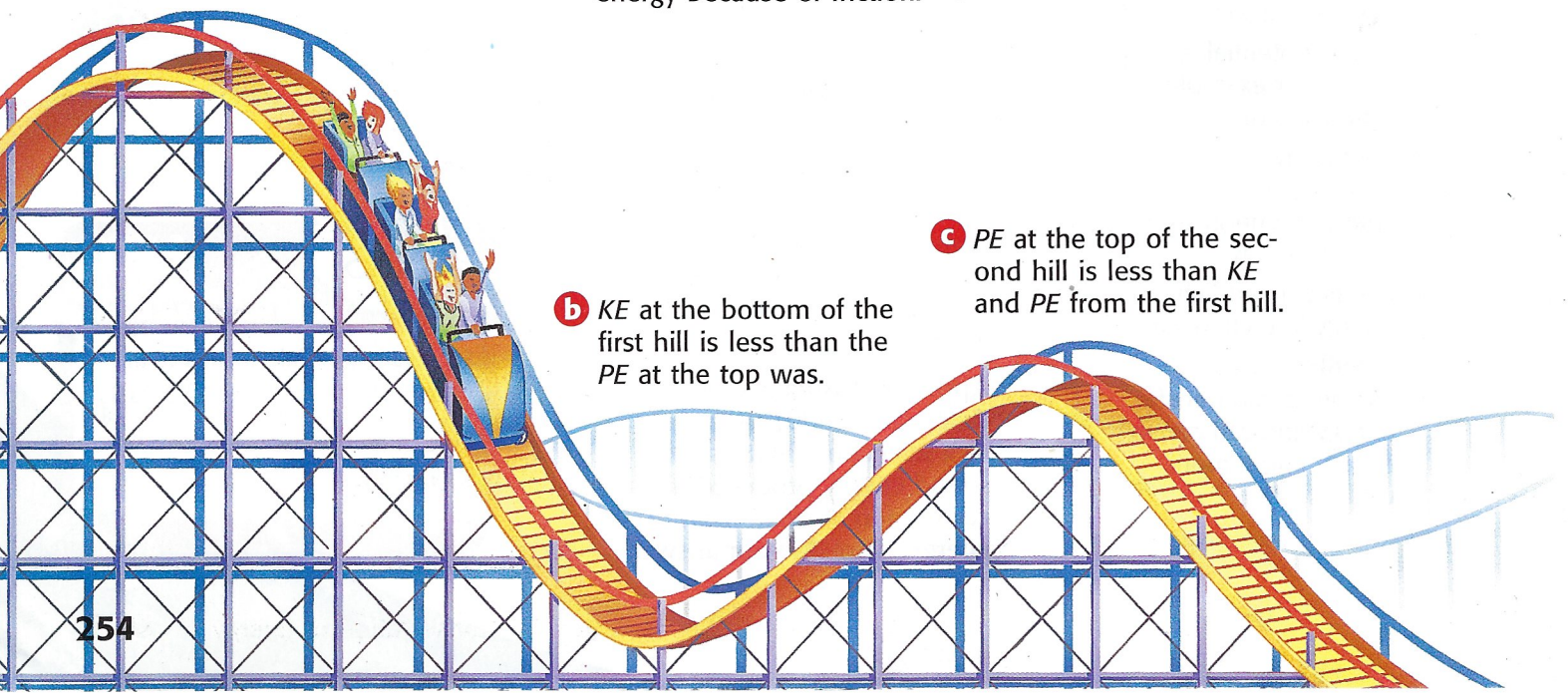
Paired Summarizing Read this section silently. In pairs, take turns summarizing the material. Stop to discuss ideas that seem confusing.

Where Does the Energy Go?

To find out where a roller coaster's original potential energy goes, you have to think about more than just the hills of the roller coaster. Friction plays a part too. **Friction** is a force that opposes motion between two surfaces that are touching. For the roller coaster to move, energy must be used to overcome friction. There is friction between the cars' wheels and the track and between the cars and the air around them. As a result, not all of the potential energy of the cars changes into kinetic energy as the cars go down the first hill. Likewise, as you can see in **Figure 1,** not all of the kinetic energy of the cars changes back into potential energy.

Figure 1 **Energy Conversions in a Roller Coaster**

Not all of the cars' potential energy (*PE*) is converted into kinetic energy (*KE*) as the cars go down the first hill. In addition, not all of the cars' kinetic energy is converted into potential energy as the cars go up the second hill. Some of it is changed into thermal energy because of friction.



Energy Is Conserved Within a Closed System

A *closed system* is a group of objects that transfer energy only to each other. For example, a closed system that involves a roller coaster consists of the track, the cars, and the air around them. On a roller coaster, some mechanical energy (the sum of kinetic and potential energy) is always converted into thermal energy because of friction. Sound energy also comes from the energy conversions in a roller coaster. If you add together the cars' kinetic energy at the bottom of the first hill, the thermal energy due to overcoming friction, and the sound energy made, you end up with the same total amount of energy as the original amount of potential energy. In other words, energy is conserved and not lost.

friction a force that opposes motion between two surfaces that are in contact

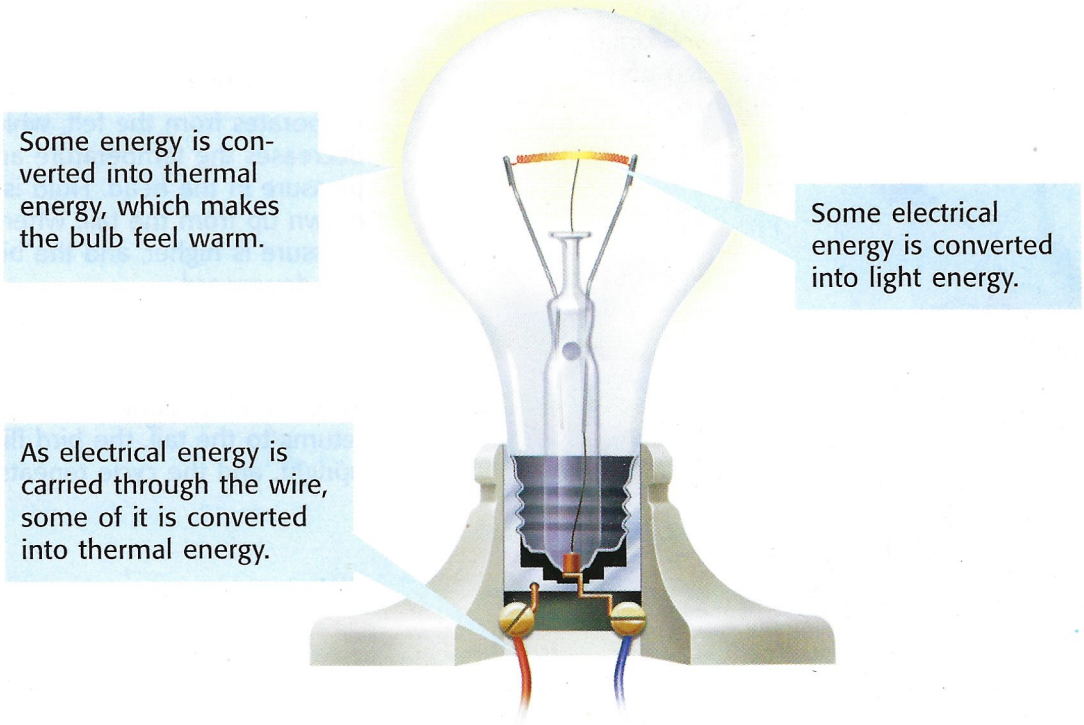
law of conservation of energy the law that states that energy cannot be created or destroyed but can be changed from one form to another

Law of Conservation of Energy

Energy is conserved in all cases. Because no exception to this rule has been found, this rule is described as a law. According to the **law of conservation of energy,** energy cannot be created or destroyed. The total amount of energy in a closed system is always the same. As **Figure 2** shows, energy can change from one form to another. But all of the different forms of energy in a system always add up to the same total amount of energy. It does not matter how many energy conversions take place.

Reading Check **Why is the conservation of energy considered a scientific law?** (*See the Appendix for answers to Reading Checks.*)

Figure 2 **Energy Conservation in a Light Bulb**



No Conversion Without Thermal Energy

Any time one form of energy is converted into another form, some of the original energy always gets converted into thermal energy. The thermal energy due to friction that results from energy conversions is not useful energy. That is, this thermal energy is not used to do work. Think about a car. You put gas into a car. But not all of the gasoline's chemical energy makes the car move. Some wasted thermal energy will always result from the energy conversions. Much of this energy leaves through the radiator and the exhaust pipe.

Perpetual Motion? No Way!

People have sometimes tried to make a machine that would run forever without any additional energy. This perpetual (puhr PECH oo uhl) motion machine would put out exactly as much energy as it takes in. But that's impossible, because some waste thermal energy always results from energy conversions. The only way a machine can keep moving is to have a constant supply of energy. For example, the "drinking bird" shown in **Figure 3** uses thermal energy from the air to evaporate the water from its head. So, it is not a perpetual motion machine.

Reading Check **Why is "perpetual motion" impossible?**

SCHOOL to HOME

Energy Conversions

With an adult, find three examples of energy conversions that take place in your home. In your **science journal,** write down the kinds of energy that go into each conversion and the kinds of energy that result. For each type of energy that is output, indicate whether the energy is useful.

ACTIVITY

Figure 3 **The "Drinking Bird"**

1. When the bird "drinks," the felt covering its head gets wet.
2. When the bird is upright, water evaporates from the felt, which decreases the temperature and pressure in the head. Fluid is drawn up from the tail, where pressure is higher, and the bird tips downward.
3. After the bird "drinks," fluid returns to the tail, the bird flips upright, and the cycle repeats.

Making Conversions Efficient

You may have heard that a car is energy efficient if it gets good gas mileage, and that your home may be energy efficient if it is well insulated. In terms of energy conversions, *energy efficiency* (e FISH uhn see) is a comparison of the amount of energy before a conversion with the amount of useful energy after a conversion. A car with high energy efficiency can go farther than other cars with the same amount of gas.

Energy conversions that are more efficient end up wasting less energy. Look at **Figure 4.** Newer cars tend to be more energy efficient than older cars. One reason is the smooth, aerodynamic (ER oh die NAM ik) shape of newer cars. The smooth shape reduces friction between the car and the surrounding air. Because these cars move through air more easily, they use less energy to overcome friction. So, they are more efficient. Improving the efficiency of machines, such as cars, is important because greater efficiency results in less waste. If less energy is wasted, less energy is needed to operate a machine.

Figure 4 *The shape of newer cars reduces friction between the body of the car and the air.*

More aerodynamic car

Less aerodynamic car

SECTION Review

Summary

- Because of friction, some energy is always converted into thermal energy during an energy conversion.
- Energy is conserved within a closed system. According to the law of conservation of energy, energy cannot be created or destroyed.
- Perpetual motion is impossible because some of the energy put into a machine is converted into thermal energy because of friction.

Using Key Terms

1. Use the following terms in the same sentence: *friction* and *the law of conservation of energy.*

Understanding Key Ideas

2. Perpetual motion is impossible because
   - **a.** things tend to slow down.
   - **b.** energy is lost.
   - **c.** machines are very inefficient.
   - **d.** machines have friction.
3. Describe the energy conversions that take place on a roller coaster, and explain how energy is conserved.

Math Skills

4. A bike is pedaled with 80 J of energy and then coasts. It does 60 J of work in moving forward until it stops. How much of the energy that was put into the bike became thermal energy?

Critical Thinking

5. **Evaluating Conclusions** Imagine that you drop a ball. It bounces a few times and then it stops. Your friend says that the energy that the ball had is gone. Where did the energy go? Evaluate your friend's statement based on energy conservation.
6. **Evaluating Assumptions** If someone says that a car has high energy output, can you conclude that the car is efficient? Explain.