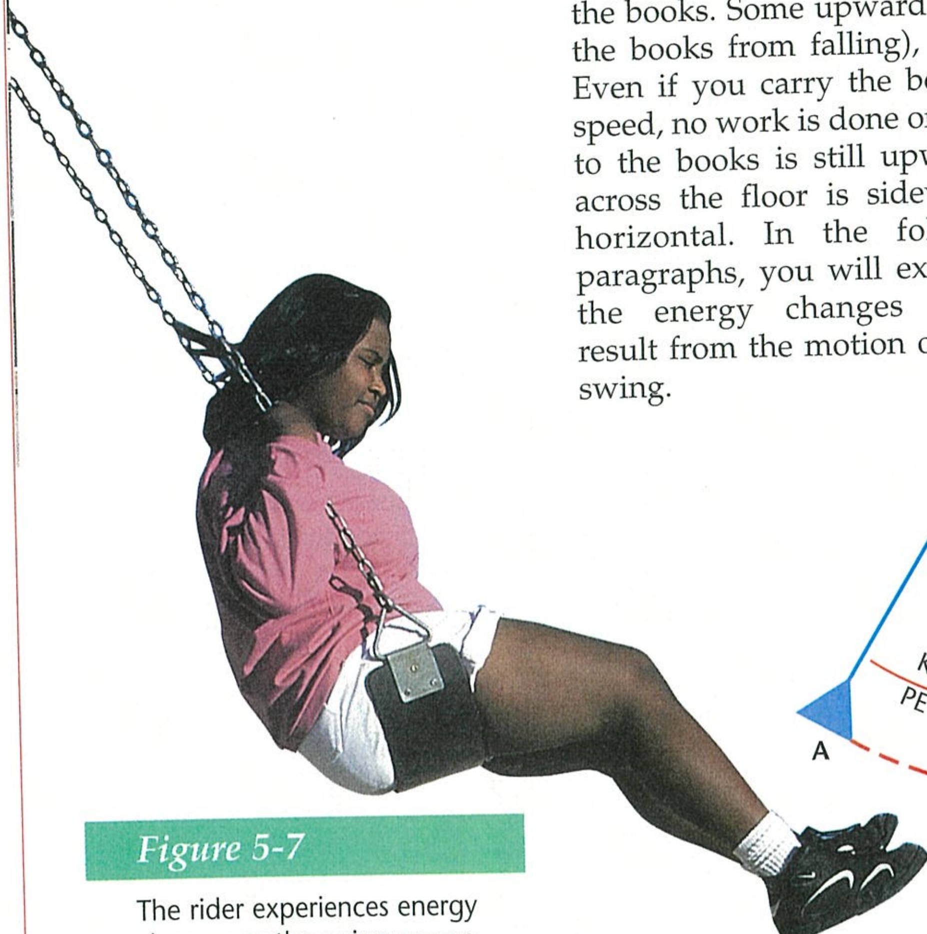
There are two factors to keep in mind when deciding whether work is being done: something has to move, and the motion must be *in the same direction* as the applied force. If you pick up a pile of books from the floor, work is done on the books. They move upward, in the direction of the applied force. If you hold the books in your arms, no work is done on the books. Some upward force is still being applied (to keep the books from falling), but no movement is taking place. Even if you carry the books across the floor at a constant speed, no work is done on the books. The force being applied to the books is still upward, or vertical, but your motion across the floor is sideward, or horizontal. In the following paragraphs, you will examine the energy changes that result from the motion of a swing.



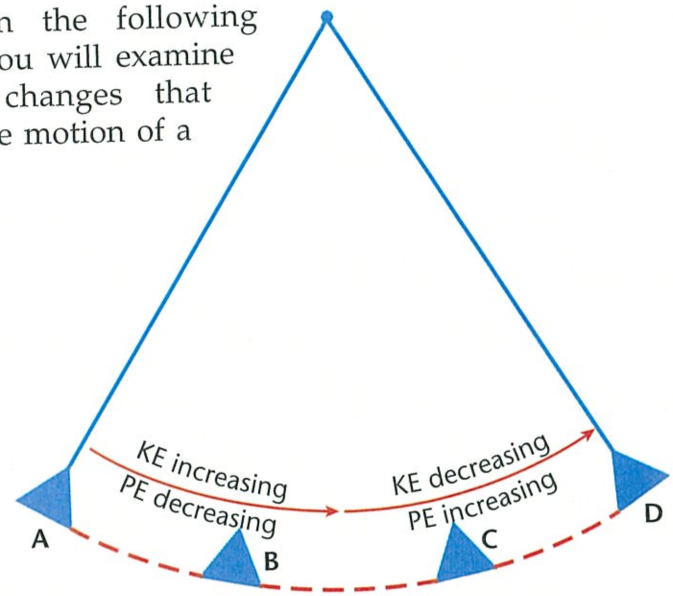


Figure 5-7

The rider experiences energy changes as the swing moves.

A At the rider's highest point, the mechanical energy is entirely potential.

B As she falls toward the bottom of the path, the rider accelerates and gains kinetic energy. Because the rider is not as high, her potential energy decreases by the same amount.

C As it rises toward the opposite side, the swing begins to slow down and lose kinetic energy. As it gains height, it also increases in potential energy.

D As the rider reaches the peak and prepares to fall again in the opposite direction, the mechanical energy of the swing is entirely potential.

Conservation of Energy

Perhaps you have ridden on a playground swing like the person in **Figure 5-7.** Try to remember what it was like swinging back and forth, high and low. Now think about the energy changes involved in such a ride.

The ride starts with a push to get you moving—to give you some kinetic energy. As the swing rises, kinetic energy changes to potential energy of position. At the top of each swing, potential energy is greatest. Then, as the swing moves downward, potential energy changes to kinetic energy. At the bottom of each swing, kinetic energy is greatest and potential energy is at its minimum.

As the swing continues to move back and forth, energy is converted from kinetic to potential to kinetic, over and over again. Taken together, the potential and kinetic energy of the swing make up its mechanical energy. **Mechanical energy** is the total amount of kinetic and potential energy in a system.

CONNECT TO

LIFE SCIENCE

A roller coaster lifts you high above the ground and also moves you at high speeds. Your body experiences many changes in kinetic and potential energy. ***Hypothesize*** the point at which your body has the most kinetic energy.

Conserving Energy—A Natural Law

Scientists have learned that in any given situation, energy may change from one form to another, but the total amount of energy remains constant. In other words, energy is conserved. This fact is recognized as a law of nature. According to the **law of conservation of energy,** energy may change form but it cannot be created or destroyed under ordinary conditions. This law applies to closed systems, in which energy cannot enter or leave the system.

Suppose the law of conservation of energy is applied to the swing. Would you expect the swing to continue moving back and forth forever? You know this doesn't happen. The swing slows down and comes to a stop. Where does the energy go?

If you think about it, friction and air resistance are constantly acting on the swing and rider just as they are also acting on the skateboarder in **Figure 5-8.** These unbalanced forces cause some of the mechanical energy of the swing to change to thermal energy—heat. With every pass of the swing, the temperatures of the swing, the rider, and the air around them go up a little bit. So the mechanical energy of the swing isn't lost, it is converted to thermal energy. Thermal energy is discussed in the next section.

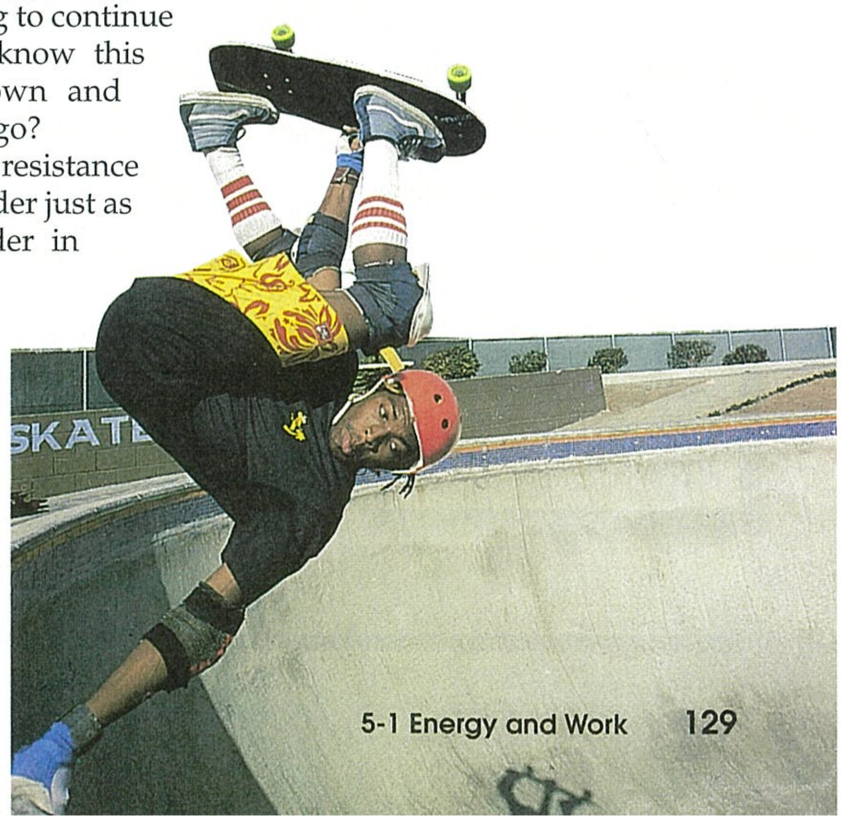


Figure 5-8

Gravity provides the force to move the skateboarder down the ramp. *What energy changes are taking place?*

INTEGRATION
Life Science

The Human Body—Balancing the Energy Equation

What forms of energy discussed in this chapter can you find in the human body? With your right hand, reach up and feel your left shoulder. Even with that simple action, you participate in the conversion of stored potential energy within your body to the kinetic energy of your moving arm as you do work on it. Did your shoulder feel warm to your hand? Some of the potential energy stored in your body is used to maintain a nearly constant internal temperature. Some of this energy is also converted to the excess heat that your body gives off to its surroundings. Even the person resting in **Figure 5-9** requires energy conversions.

Figure 5-9
Even a person at rest is using energy. *Describe several ways that energy is being used in her body.*

The complex chemical and physical processes of your body also obey the laws of physics, including the law of conservation of energy. In your body, stored energy (such as that found in fat) is lost when work is done or heat is lost by your body to your surroundings. To maintain a healthy weight, you must have a proper balance between energy taken in and energy lost from your body as work or heat.

Food—Our Chemical Potential Energy

What did you eat for breakfast this morning? Your body has been busy chemically changing your food into molecules that can combine with oxygen and be used as fuel. Even if you did not eat breakfast this morning, your body converts energy stored in fat for its immediate needs until you eat again. You are probably familiar with the food Calorie, a unit used by nutritionists to measure how much energy we get from specific foods. One Calorie is actually equivalent to a kilocalorie, or about 4180 joules. Every gram of fat a person consumes can supply nine Calories of energy. Carbohydrates and proteins each supply about four Calories of energy per gram.

Why does your body need such an energy supply? Food supplies the fuel used to maintain a nearly constant body temperature, to help your organs function, and to do work as you move your body. **Table 5-1** shows the amount of energy used in doing various activities. The energy needs of an individual are based upon factors such as body size, age,

USING MATH

A small bag of potato chips has about 270 Calories. Using **Table 5-1**, calculate how many minutes you would have to walk to "burn off" these Calories.

Table 5-1

Calories Used in 1 Hour			
Type of Activity	Body Frames		
	Small	Medium	Large
Sleeping	48	56	64
Sitting	72	84	96
Eating	84	98	112
Standing	96	112	123
Walking	180	210	240
Playing tennis	380	420	460
Bicycling fast	500	600	700
Running	700	850	1000

gender, heredity, and level of daily activity. In this section, you have learned about the sources and uses of energy and the different forms it takes.

Section Wrap-up

Review

1. Imagine that you're standing on a stepladder and you drop a basketball. The first bounce will be highest. Each bounce after that will be lower until the ball stops bouncing. Describe the energy changes that take place, starting with dropping the ball.
2. A game-show contestant won a prize by pushing a bowling ball 20 m using his nose. The amount of work done was 1470 J. How much force did the person exert on the ball?
3. **Think Critically:** Much discussion has focused on the need to drive more efficient cars and use less electricity. If the law of conservation of energy is true, why are people concerned about energy usage?

Skill Builder

Comparing and Contrasting

Compare and contrast the everyday meaning of work with the scientific definition of that term. Give examples of work in the everyday sense that would not be considered work in the scientific sense. If you need help, refer to Comparing and Contrasting in the **Skill Handbook.**

Science Journal

Your body used energy to move you into the room today. Where did this energy come from? In your Science Journal, write a paragraph describing where you acquired this energy. Trace it back through as many transformations as you can.