

What Is Energy?

Reading Preview

Key Concepts

- How are energy, work, and power related?
- What are the two basic kinds of energy?

Key Terms

- energy • kinetic energy
- potential energy
- gravitational potential energy
- elastic potential energy

Target Reading Skill

Using Prior Knowledge Before you read, look at the section headings and visuals to see what this section is about. Then write what you know about energy in a graphic organizer like the one below. As you read, write what you learn.

What You Know

1. The joule is the unit of work.
- 2.

What You Learned

- 1.
- 2.

When a breeze does work lifting leaves, it transfers energy to them. ►

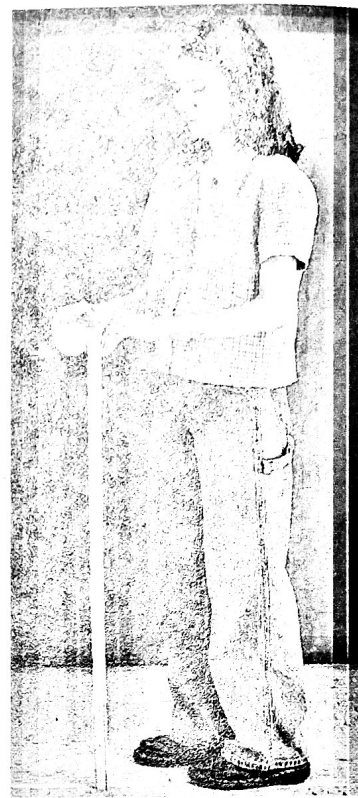
Lab zone Discover Activity

How High Does a Ball Bounce?

1. Hold a meter stick vertically, with the zero end on the ground.
2. Drop a tennis ball from the 50-cm mark and record the height to which it bounces.
3. Drop the tennis ball from the 100-cm mark and record the height to which it bounces.
4. Predict how high the ball will bounce if dropped from the 75-cm mark. Test your prediction.

Think It Over

Observing How does the height from which you drop the ball relate to the height to which the ball bounces?



Brilliant streaks of lightning flash across the night sky. The wind howls, and thunder cracks and rumbles. Then a sound like a runaway locomotive approaches, growing louder each second. Whirling winds rush through the town. Roofs are lifted off of buildings. Cars are thrown about like toys. Then, in minutes, the tornado is gone.

The next morning, a light breeze carries leaves past the debris. The wind that destroyed buildings hours before is now barely strong enough to move a leaf. Wind is just moving air, but it has energy.

Energy, Work, and Power

When wind moves a house, or even a leaf, it causes a change. In this case, the change is in the position of the object. Recall that work is done when a force moves an object through a distance. The ability to do work or cause change is called **energy**. So the wind has energy.

Work and Energy When an object or living thing does work on another object, some of its energy is transferred to that object. You can think of work, then, as the transfer of energy. When energy is transferred, the object upon which the work is done gains energy. Energy is measured in joules—the same units as work.

Power and Energy You may recall that power is the rate at which work is done. **If the transfer of energy is work, then power is the rate at which energy is transferred, or the amount of energy transferred in a unit of time.**

$$\text{Power} = \frac{\text{Energy transferred}}{\text{Time}}$$

Power is involved whenever energy is being transferred. For example, a calm breeze has power when it transfers energy to lift a leaf a certain distance. The tornado in Figure 1 transfers the same amount of energy when it lifts the leaf the same distance. However, the tornado has more power than the breeze because it transfers energy to the leaf in less time.



Reading
Checkpoint

What is power in terms of energy?

Kinetic Energy

Two basic kinds of energy are **kinetic energy** and **potential energy**. Whether energy is kinetic or potential depends on whether an object is moving or not.

A moving object, such as the wind, can do work when it strikes another object and moves it some distance. Because the moving object does work, it has energy. The energy an object has due to its motion is called **kinetic energy**. The word *kinetic* comes from the Greek word *kinetos*, which means “moving.”



FIGURE 1

Energy and Power

A tornado and a calm breeze each do the same amount of work if they transfer the same amount of energy to a leaf. However, the tornado has more power than the breeze because it transfers its energy in less time.

Drawing Conclusions Why is the same amount of work done on the leaf?

Math Skills

Exponents

An exponent tells how many times a number is used as a factor. For example, 3×3 can be written as 3^2 . You read this number as "three squared." An exponent of 2 indicates that the number 3 is used as a factor two times. To find the value of a squared number, multiply the number by itself.

$$3^2 = 3 \times 3 = 9$$

Practice Problem What is the value of the number 8^2 ?

FIGURE 2

Kinetic Energy

Kinetic energy increases as mass and velocity increase. **Predicting** In each example, which object will transfer more energy to the pins? Why?

Factors Affecting Kinetic Energy The kinetic energy of an object depends on both its mass and its velocity. Kinetic energy increases as mass increases. For example, think about rolling a bowling ball and a golf ball down a bowling lane at the same velocity, as shown in Figure 2. The bowling ball has more mass than the golf ball. If both balls have the same velocity, the bowling ball is more likely to knock down the pins because it has more kinetic energy than the golf ball.

Kinetic energy also increases when velocity increases. For example, suppose you have two identical bowling balls and you roll one ball so it moves at a greater velocity than the other. You must throw the ball harder to give it the greater velocity. In other words, you transfer more energy to it. Therefore, the faster ball has more kinetic energy.

Calculating Kinetic Energy There is a mathematical relationship between kinetic energy, mass, and velocity.

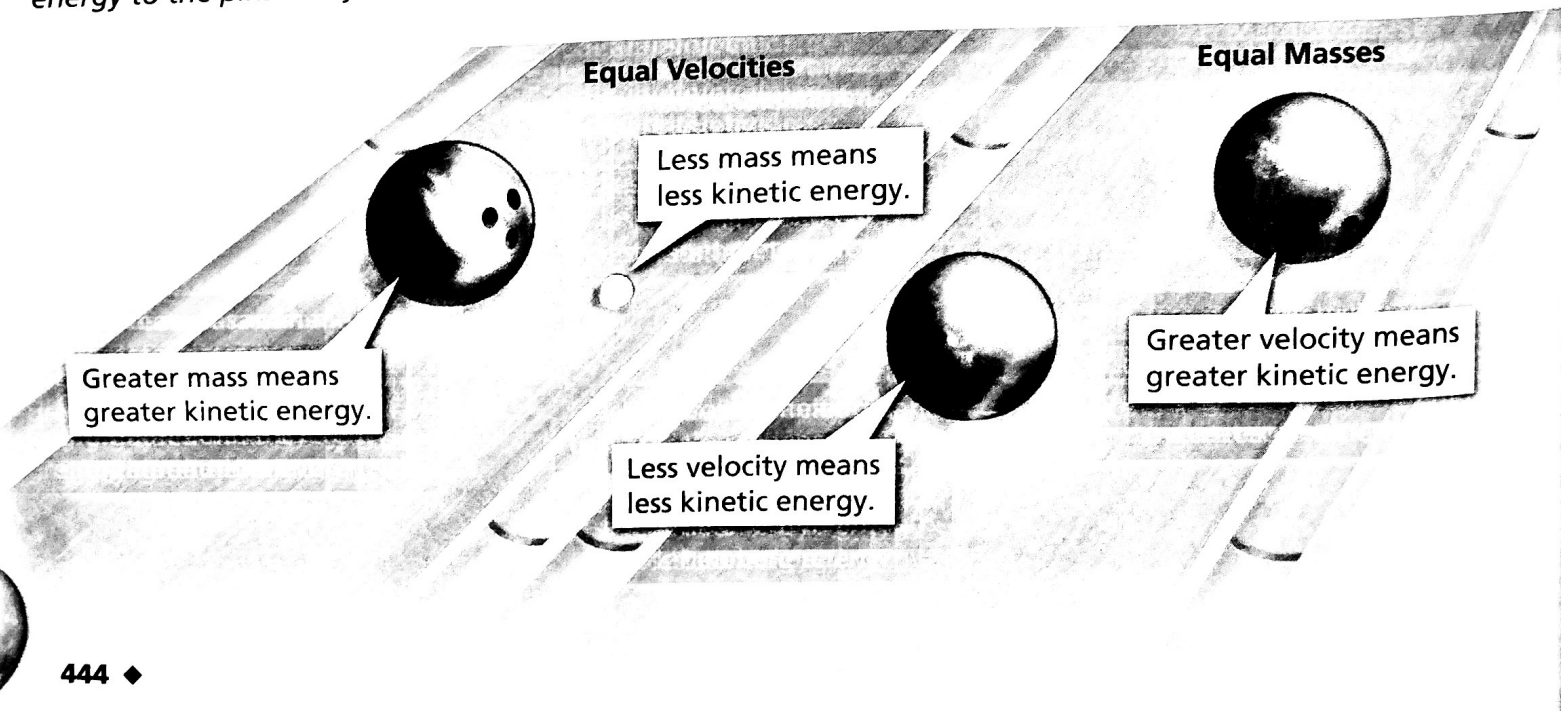
$$\text{Kinetic energy} = \frac{1}{2} \times \text{Mass} \times \text{Velocity}^2$$

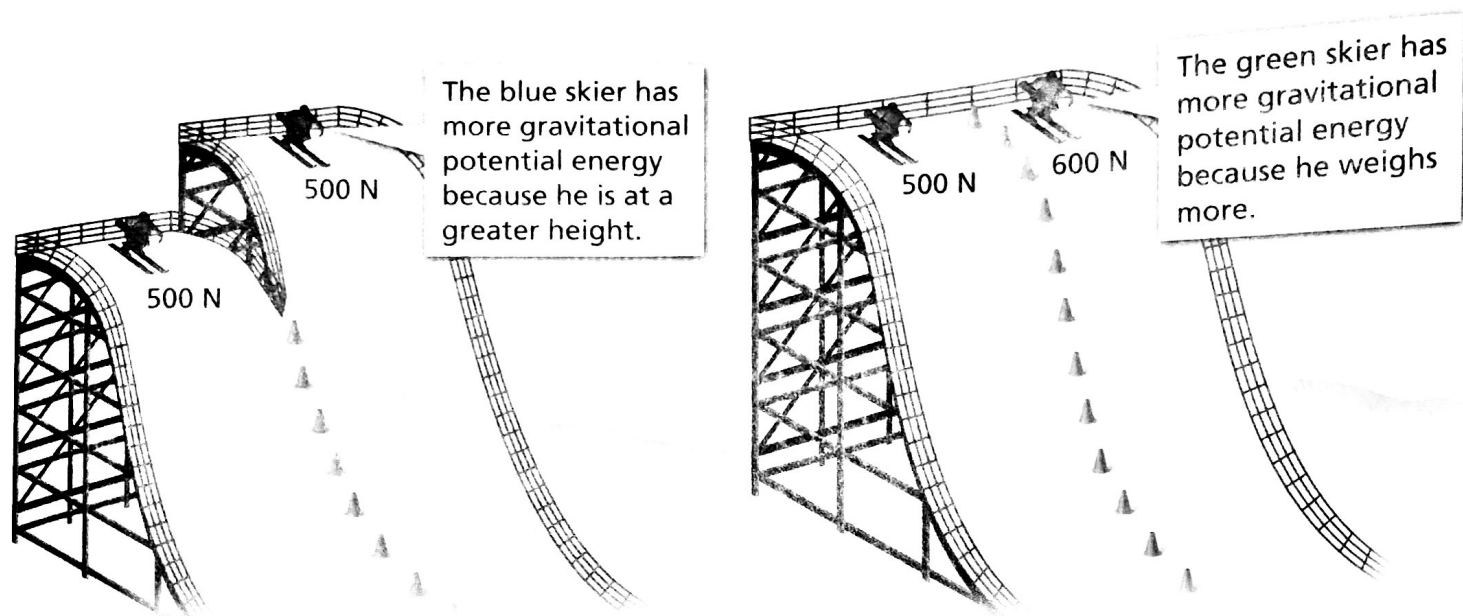
Do changes in velocity and mass have the same effect on kinetic energy? No—changing the velocity of an object will have a greater effect on its kinetic energy than changing its mass by the same factor. This is because velocity is squared in the kinetic energy equation. For instance, doubling the mass of an object will double its kinetic energy. But doubling its velocity will quadruple its kinetic energy.



Reading
Checkpoint

Which has a greater effect on an object's kinetic energy—doubling its mass or doubling its velocity?





Potential Energy

An object does not have to be moving to have energy. Some objects have stored energy as a result of their positions or shapes. When you lift a book up to your desk from the floor or compress a spring to wind a toy, you transfer energy to it. The energy you transfer is stored, or held in readiness. It might be used later when the book falls to the floor or the spring unwinds. Stored energy that results from the position or shape of an object is called **potential energy**. This type of energy has the potential to do work.

Gravitational Potential Energy Potential energy related to an object's height is called **gravitational potential energy**. The gravitational potential energy of an object is equal to the work done to lift it. Remember that $\text{Work} = \text{Force} \times \text{Distance}$. The force you use to lift the object is equal to its weight. The distance you move the object is its height. You can calculate an object's gravitational potential energy using this formula.

$$\text{Gravitational potential energy} = \text{Weight} \times \text{Height}$$

For example, the red skier on the left in Figure 3 weighs 500 newtons. If the ski jump is 40 meters high, then the skier has $500 \text{ newtons} \times 40 \text{ meters}$, or 20,000 J, of gravitational potential energy.

The more an object weighs, or the greater the object's height, the greater its gravitational potential energy. At the same height, a 600-newton skier has more gravitational potential energy than a 500-newton skier. Similarly, a 500-newton skier has more gravitational potential energy on a high ski jump than on a low one.

FIGURE 3

Gravitational Potential Energy

Gravitational potential energy increases as weight and height increase.

Interpreting Diagrams Does the red skier have more gravitational potential energy on the higher ski jump or the lower one? Why?

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FIGURE 4
Elastic Potential Energy
 The energy stored in a stretched object, such as a bow, is elastic potential energy. **Interpreting Photographs** When the energy stored in the bow is released, how is it used?

Elastic Potential Energy An object gains a different type of potential energy when it is stretched. The potential energy associated with objects that can be stretched or compressed is called **elastic potential energy**. For example, when an archer pulls back an arrow, the bow changes shape. The bow now has potential energy. When the archer releases the string, the stored energy sends the arrow flying to its target.



Reading Checkpoint

What type of energy does a bow have when you pull back an arrow?

Section 1 Assessment

Target Reading Skill

Using Prior Knowledge Review your graphic organizer and revise it based on what you just learned in the section.

Reviewing Key Concepts

1. **a. Defining** What is energy?
- b. Describing** How are energy, work, and power related?
- c. Applying Concepts** If a handsaw does the same amount of work on a log as a chainsaw does, which has a greater power? Why?
2. **a. Identifying** What is kinetic energy? What is potential energy?

- b. Explaining** What factors affect an object's kinetic energy?
- c. Problem Solving** At a given height above Earth, how would you determine the potential energy of a sky diver? The kinetic energy of a sky diver?

Math

Practice

3. **Exponents** What is the value of the number 10^2 ?
4. **Exponents** What number when squared gives you the value 36?