

Chapter 9 Energy

Summary

THE BIG IDEA : Energy can change from one form to another without a net loss or gain.

9.1 Work

- ✓ Work is done when a force acts on an object and the object moves in the direction of the force.
- Work is the product of the force on an object and the distance through which the object is moved.
 - In the simplest case, when the force is constant, the motion takes place in a straight line in the direction of the force: work = force \times distance. In equation form, $W = Fd$.
 - Work generally falls into two categories: work done against another force and work done to change the speed of an object. In both categories, work involves a transfer of energy between something and its surroundings.
 - The unit of work is the newton-meter (N·m), also called the **joule**. One joule (J) of work is done when a force of 1 N is exerted over a distance of 1 m.

9.2 Power

- ✓ Power equals the amount of work done divided by the time interval during which the work is done.
- Power is the rate at which work is done:

$$\text{power} = \frac{\text{work done}}{\text{time interval}}$$

- A high-power engine does work rapidly. If an engine has twice the power of another engine, this means that it can do twice the work in the same amount of time or the same amount of work in half the time.
- The unit of power is the joule per second, which is also known as the **watt**. One watt (W) of power is expended when one joule of work is done in one second.
- In the United States, we customarily rate engines in units of horsepower and electricity in kilowatts, but either may be used. One horsepower (hp) is the same as 0.75 kW.

9.3 Mechanical Energy

- ✓ The two forms of mechanical energy are kinetic energy and potential energy.
- The property of an object or system that enables it to do work is **energy**.
 - Like work, energy is measured in joules.
 - **Mechanical energy** is the energy due to the position of something or the movement of something.

Chapter 9 Energy

9.4 Potential Energy

- ✓ Three examples of potential energy are elastic potential energy, chemical energy, and gravitational potential energy.
- Energy that is stored and held in readiness is called **potential energy** (PE) because in the stored state it has the potential for doing work.
- A stretched or compressed spring, a bow that is drawn back, and a stretched rubber band have *elastic potential energy*.
- The chemical energy in fuels is potential energy at the submicroscopic level. This energy is available when a chemical change in the fuels takes place.
- The potential energy due to the elevated position of an object is *gravitational potential energy*.
- The amount of gravitational potential energy possessed by an elevated object is equal to the work done against gravity in lifting it. Gravitational potential energy = weight \times height. In equation form, $PE = mgh$. The height in this equation is the distance above some chosen reference level.

9.5 Kinetic Energy

- ✓ The kinetic energy of a moving object is equal to the work required to bring it to its speed from rest, or the work the object can do while being brought to rest.
- The energy of motion is **kinetic energy** (KE).
- The kinetic energy of an object is equal to half the object's mass multiplied by the square of its speed. In equation form, this is
$$KE = \frac{1}{2} mv^2.$$
- The net force on an object multiplied by the distance along which the force acts equals the object's kinetic energy. In equation form, this is
$$Fd = \frac{1}{2} mv^2.$$

Chapter 9 Energy

Exercises

9.1 Work (pages 145–146)

1. Circle the letter next to the correct mathematical equation for work.
 - a. work = force ÷ distance
 - b. work = distance ÷ force
 - c. work = force × distance
 - d. work = force × distance²
2. You can use the equation in Question 1 to calculate work when the force is _____ and the motion takes place in _____.
3. You do work if you lift a book one meter above the ground. How does the amount of work change in each of the following cases?
 - a. You lift the book twice as high. _____
 - b. You lift two identical books one meter above the ground. _____
4. Complete the table by naming the two general categories of work and giving an example of each.

Category of Work	Example

5. The unit of work is the _____.
6. Suppose that you apply a 50-N horizontal force to a 25-kg box, pushing the box 6 meters across the floor. How much work do you do on the box?

9.2 Power (pages 146–147)

7. Power is the rate at which _____ is done.
8. Power equals _____ divided by _____.
9. The unit of power is the _____.
10. One megawatt (MW) equals _____ watts.
11. In the United States, we customarily rate engines in units of _____, which is equivalent to _____ kilowatt.

9.3 Mechanical Energy (page 147)

12. Define energy.

13. What is the SI unit of energy? _____

Chapter 9 Energy

14. Mechanical energy is the energy due to the _____ or _____ of something.
15. What are the two forms of mechanical energy?
- a. _____
 - b. _____

9.4 Potential Energy (pages 148–149)

16. On each line, write *elastic*, *chemical*, or *gravitational* to identify the type of potential energy described.

- _____ a. fossil fuels
- _____ b. a compressed spring
- _____ c. water in a reservoir
- _____ d. a stretched rubber band
- _____ e. food
- _____ f. a bow drawn back
- _____ g. electric batteries

17. The amount of gravitational potential energy possessed by an elevated object is equal to the work done against _____ in lifting it.

18. What are two ways to calculate gravitational potential energy?

- a. _____ × height
- b. _____ × _____ × height

19. Explain what the height is when you calculate an object's gravitational potential energy.

20. How do hydroelectric power stations make use of gravitational potential energy?

9.5 Kinetic Energy (page 150)

21. Kinetic energy is energy of _____.

22. Circle the letter for the equation you can use to find the kinetic energy of an object.

- a. $KE = 2mv$
- b. $KE = \frac{1}{2}mv$
- c. $KE = 2mv^2$
- d. $KE = \frac{1}{2}mv^2$

23. Kinetic energy equals the _____ on an object multiplied by the distance the object moves.

24. Is the following sentence true or false? If the speed of an object doubles, the kinetic energy of the object also doubles. _____