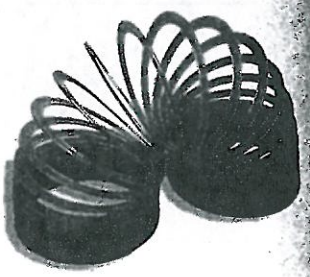
CHAPTER 14 REVIEW



Key Terms

14.1

- wave
- wave pulse
- continuous wave
- transverse wave
- longitudinal wave
- surface wave
- trough
- crest
- wavelength
- frequency

14.2

- incident wave
- reflected wave
- principle of superposition
- interference
- destructive interference
- node
- constructive interference
- antinode
- standing wave
- law of reflection
- refraction
- diffraction

Summary

14.1 Wave Properties

- Waves transfer energy without transferring matter.
- Mechanical waves require a medium.
- A continuous wave is a regularly repeating sequence of wave pulses.
- In transverse waves, the displacement of the medium is perpendicular to the direction of wave motion. In longitudinal waves, the displacement is parallel to the wave direction. In surface waves, matter is displaced in both directions.
- The wave source determines the frequency of the wave, f, which is the number of vibrations per second.
- The wavelength of a wave, λ, is the shortest distance between points where the wave pattern repeats itself.
- The medium determines wave speed, which can be calculated for continuous waves using the equation $v = \lambda f$.

14.2 Wave Behavior

- When a wave crosses a boundary between two media, it is partially transmitted and partially reflected, depending on how much the wave velocities in the two media differ.
- When a wave moves to a medium with higher wave speed, the reflected wave is inverted. When moving to a medium with lower wave speed, the displacement of the reflected wave is in the same direction as the incident wave.
- The principle of superposition states that the displacement of a medium resulting from two or more waves is the algebraic sum of the displacements of the individual waves.
- Interference occurs when two or more waves move through a medium at the same time.
- Destructive interference results in decreased wave displacement with its least amplitude at the node.
- Constructive interference results in increased wave displacement with its greatest amplitude at the antinode.
- A standing wave has stationary nodes and antinodes.
- When two-dimensional waves are reflected from boundaries, the angles of incidence and reflection are equal.
- The change in direction of waves at the boundary between two different media is called refraction.
- The spreading of waves around a barrier is called diffraction.

Reviewing Concepts

Section 14.1

1. How many general methods of energy transfer are there? Give two examples of each.
2. What is the primary difference between a mechanical wave and an electromagnetic wave?
3. What are the differences among transverse, longitudinal, and surface waves?
4. Suppose you send a pulse along a rope. How does the position of a point on the rope before the pulse arrives compare to the point's position after the pulse has passed?
5. What is the difference between a wave pulse and a continuous wave?
6. What is the difference between wave frequency and wave velocity?

7. Suppose you produce a transverse wave by shaking one end of a spring from side to side. How does the frequency of your hand compare with the frequency of the wave?
8. Waves are sent along a spring of fixed length.
   a. Can the speed of the waves in the spring be changed? Explain.
   b. Can the frequency of a wave in the spring be changed? Explain.
9. What is the difference between the speed of a transverse wave pulse down a spring and the motion of a point on the spring?
10. Suppose you are lying on a raft in a wave pool. Describe, in terms of the waves you are riding, each of the following: amplitude, period, wavelength, speed, and frequency.
11. What is the amplitude of a wave and what does it represent?
12. What is the relationship between the amplitude of a wave and the energy it carries?

Section 14.2

13. When a wave reaches the boundary of a new medium, part of the wave is reflected and part is transmitted. What determines the amount of reflection?
14. A pulse reaches the boundary of a medium in which the speed of the pulse becomes higher. Is the reflection of the pulse the same as for the incident pulse or is it inverted?
15. A pulse reaches the boundary of a medium in which the speed is lower than the speed of the medium from which it came. Is the reflected pulse erect or inverted?
16. When a wave crosses a boundary between a thin and a thick rope, its wavelength and speed change, but its frequency does not. Explain why the frequency is constant.
17. When two waves interfere, is there a loss of energy in the system? Explain.
18. What happens to a spring at the nodes of a standing wave?
19. A metal plate is held fixed in the center and sprinkled with sugar. With a violin bow, the plate is stroked along one edge and made to vibrate. The sugar begins to collect in certain areas and move away from others. Describe these regions in terms of standing waves.
20. If a string is vibrating in four parts, there are points where it can be touched without disturbing its motion. Explain. How many of these points exist?
21. How does a spring pulse reflected from a rigid wall differ from the incident pulse?
22. Is interference a property of only some types of waves or all types of waves?

Applying Concepts

23. Suppose you hold a 1-m metal bar in your hand and hit its end with a hammer, first, in a direction parallel to its length, second, in a direction at right angles to its length. Describe the waves you produce in the two cases.
24. Suppose you repeatedly dip your finger into a sink full of water to make circular waves. What happens to the wavelength as you move your finger faster?
25. What happens to the period of a wave as the frequency increases?
26. What happens to the wavelength of a wave as the frequency increases?
27. Suppose you make a single pulse on a stretched spring. How much energy is required to make a pulse with twice the amplitude?
28. Sonar is the detection of sound waves reflected off boundaries in water. A region of warm water in a cold lake can produce a reflection, as can the bottom of the lake. Which would you expect to produce the stronger echo? Explain.
29. You can make water slosh back and forth in a shallow pan only if you shake the pan with the correct frequency. Explain.
30. AM-radio signals have wavelengths between 600 m and 200 m, whereas FM signals have wavelengths of about 3 m, **Figure 14–19**. Explain why AM signals can often be heard behind hills whereas FM signals cannot.

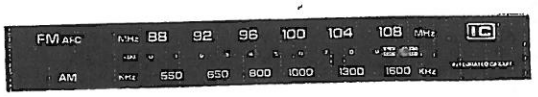


FIGURE 14–19

31. In each of the four waves in **Figure 14–20,** the pulse on the left is the original pulse moving toward the right. The center pulse is a reflected pulse; the pulse on the right is a transmitted pulse. Describe the boundaries at A, B, C, and D.

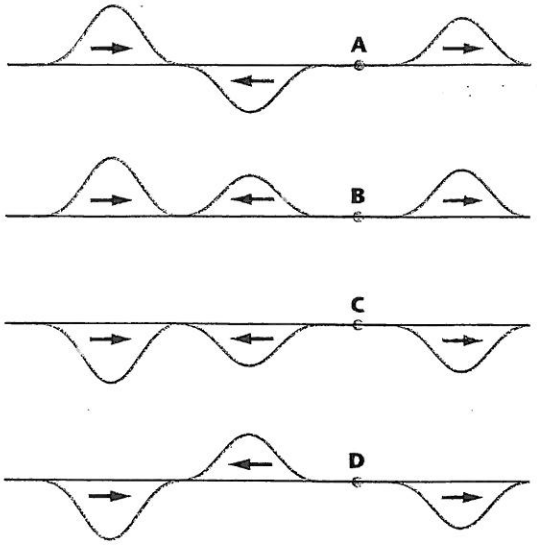


FIGURE 14–20

Problems

Section 14.1

LEVEL 1

32. The Sears Building in Chicago sways back and forth in the wind with a frequency of about 0.10 Hz. What is its period of vibration?
33. An ocean wave has a length of 10.0 m. A wave passes a fixed location every 2.0 s. What is the speed of the wave?
34. Water waves in a shallow dish are 6.0 cm long. At one point, the water oscillates up and down at a rate of 4.8 oscillations per second.
    a. What is the speed of the water waves?
    b. What is the period of the water waves?
35. Water waves in a lake travel 4.4 m in 1.8 s. The period of oscillation is 1.2 s.
    a. What is the speed of the water waves?
    b. What is their wavelength?
36. The frequency of yellow light is 5.0×10^{14} Hz. Find the wavelength of yellow light. The speed of light is 300 000 km/s.
37. AM-radio signals are broadcast at frequencies between 550 kHz and 1600 kHz (kilohertz) and travel 3.0×10^8 m/s.
    a. What is the range of wavelengths for these signals?
    b. FM frequencies range between 88 MHz and 108 MHz (megahertz) and travel at the same speed. What is the range of FM wavelengths?
38. A sonar signal of frequency 1.00×10^6 Hz has a wavelength of 1.50 mm in water.
    a. What is the speed of the signal in water?
    b. What is its period in water?
    c. What is its period in air?
39. A sound wave of wavelength 0.70 m and velocity 330 m/s is produced for 0.50 s.
    a. What is the frequency of the wave?
    b. How many complete waves are emitted in this time interval?
    c. After 0.50 s, how far is the front of the wave from the source of the sound?
40. The speed of sound in water is 1498 m/s. A sonar signal is sent straight down from a ship at a point just below the water surface, and 1.80 s later the reflected signal is detected. How deep is the ocean beneath the ship?
41. The time needed for a water wave to change from the equilibrium level to the crest is 0.18 s.
    a. What fraction of a wavelength is this?
    b. What is the period of the wave?
    c. What is the frequency of the wave?

LEVEL 2

42. Pepe and Alfredo are resting on an offshore raft after a swim. They estimate that 3.0 m separates a trough and an adjacent crest of surface waves on the lake. They count 14 crests that pass by the raft in 20.0 s. Calculate how fast the waves are moving.
43. The velocity of the transverse waves produced by an earthquake is 8.9 km/s, and that of the longitudinal waves is 5.1 km/s. A seismograph records the arrival of the transverse waves 73 s before the arrival of the longitudinal waves. How far away was the earthquake?
44. The velocity of a wave on a string depends on how hard the string is stretched, and on the