CHAPTER 8 Review

REFLECTING ON CHAPTER 8

- Periodic motion occurs when an object moves in a repeated pattern (a cycle) over equal periods of time, T.
- The frequency of the motion, f, is the number of cycles completed in 1 s. $f = \frac{1}{T}$ and is measured in hertz (Hz):
$$1\ \text{Hz} = \frac{1}{\text{s}} = \text{s}^{-1}$$
- The amplitude, A, of the vibration is the distance from the maximum displacement to the rest position.
- When an object is vibrated, even gently, at one of its natural frequencies, the amplitude of its vibration will increase, sometimes very dramatically. This phenomenon is known as resonance.
- A mechanical wave is a disturbance that transfers vibrational energy through a medium. A mechanical wave requires a medium.
- In a transverse wave, the vibration of the medium is at right angles to the direction of the wave. In a longitudinal wave, the vibration of the medium is parallel to the direction of the wave.
- The wavelength of a wave, λ, is the shortest distance between two points in the medium that are vibrating in phase; for example, the distance between two adjacent crests (or troughs).
- The vibrating source that produces the wave determines the frequency, f, of the wave. The frequency is equal to the number of wavelengths produced in 1 s.
- A wave travels with a constant speed in a homogeneous medium predicted by the wave equation $v = f\lambda$.
- When a wave passes from one medium into another, it is partially transmitted and partially reflected.
- If two waves are moving toward each other, they pass through each other without any permanent change in either wave.
- According to the principle of superposition, when two or more component waves are at the same point in a medium at the same time, the resultant displacement of the medium is equal to the sum of the amplitudes of the component waves.
- Interference occurs when two or more waves meet at the same point in a medium.
- Interference may be either constructive or destructive.
- A standing wave with stationary nodes and antinodes is produced when two periodic waves with the same shape, amplitude, and wavelength travel in opposite directions in the same linear medium. Adjacent nodes are spaced half a wavelength ($\frac{1}{2}\lambda$) apart, as are adjacent antinodes.
- Standing waves can be set up in a linear medium by vibrating one end of the medium at the natural frequency for the medium. The lowest natural frequency is referred to as the fundamental.
- Waves that originate from a point source move outward in circular wavefronts because the speed of the wave in the medium is the same in all directions.
- Two-dimensional waves are reflected from straight barriers so that the angle of reflection is equal to the angle of incidence. Straight waves are reflected from a parabolic barrier so that they converge through a single point.
- When straight waves pass through an opening in a barrier, they diffract around the edges of the barrier and spread out in all directions. Diffraction is greater for smaller openings and larger wavelengths.
- The circular waves moving out from two point sources will produce two-dimensional interference patterns consisting of nodal and antinodal lines. If the two sources are vibrating in phase, there will be an antinodal line along the perpendicular bisector of the lines.

Knowledge/Understanding

1. Explain in your own words what periodic motion is. What quantities involved in periodic motion are variables? What concepts do we use to describe these variables?
2. How are frequency and period related? What is a hertz?
3. What is resonance, and how is it related to the natural frequency of an object?
4. In your own words, explain what a wave is. How do transverse and longitudinal waves differ?
5. What determines the frequency of a wave?
6. How could you increase the speed of a wave pulse in a large-diameter spring?
7. Both amplitude and wavelength are linear measurements used to describe waves. Explain the difference between these measurements. If you wanted to increase the amplitude of a wave in a large-diameter spring, what would you do? If you wanted to increase the wavelength of a wave in the spring, what would you do?
8. If the frequency of a wave travelling in a rope is doubled, what will happen to the speed of the wave? What will happen to the wavelength of the wave?
9. A 1 cm-high wave crest is travelling toward a 2 cm-high wave crest in the same spring. What will be produced when they meet? What kind of interference is this?
10. A 1-cm high wave crest is travelling toward a 2-cm deep wave trough in the same medium. What will be produced when they meet? What kind of interference is this?
11. What is a standing wave? What conditions are necessary to produce a standing wave? What are nodes? How far apart are adjacent nodes?
12. What happens to straight waves when they pass through an opening in a barrier? What do we call this effect?

Inquiry

13. Suppose an upright wave pulse travels from a spring where its speed is 20 cm/s into a second spring where its speed is 10 cm/s.
    - **(a)** What will happen to its frequency and wavelength in the second spring?
    - **(b)** Describe what the two springs will look like 2 s after the incident pulse has reached the boundary between the two springs.
    - **(c)** Suppose the wave pulse had gone from the 10 cm/s spring into the 20 cm/s spring. Describe and draw the two springs, 2 s after the incident pulse had reached the boundary between the two springs.
14. A large erect wave pulse is moving to the left on a large spring at the same time that a smaller inverted wave pulse is moving to the right. Draw what the spring would look like
    - **(a)** shortly before they meet
    - **(b)** shortly after they meet
15. Design an experiment to determine the speed of a wave. You are free to select any equipment you need in your summarized design.

Communication

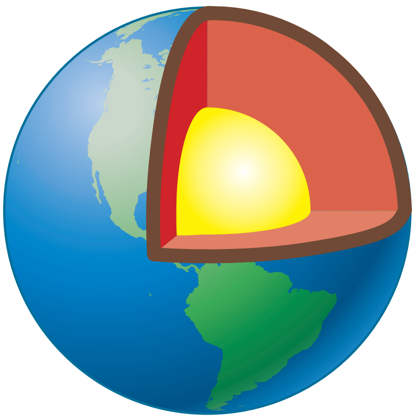
16. Sketch a diagram illustrating how a straight wavefront is reflected from a straight barrier. (Be sure to include the rays that indicate the direction in which the wavefront is moving.)
17. Sketch a diagram illustrating how a straight wavefront is reflected from a parabolic barrier.
18. Sketch the kind of interference pattern produced by two in-phase point sources in a two-dimensional medium.
    - **(a)** What kind of interference will there be on the perpendicular bisector of the line connecting the two sources? Why is this?
    - **(b)** Even though the two sources are in phase and produce crests and troughs at the same time, there are nodal lines in the pattern where destructive interference occurs. Explain why this is the case.

Making Connections

19. The speed of a wave in a string depends on its tension (the greater the tension, the greater the speed) and its mass per unit length (the greater the mass per unit length, the lower the speed). Multi-stringed musical instruments, such as the

guitar or violin, typically play high frequency notes on strings that are under considerable tension and are relatively thin. They play low frequency notes on strings that are under less tension and relatively thick. Explain why this is the case. (You may want to examine a guitar or violin to help you with this question.)

20. Scientists have no way of observing Earth's centre directly. What data, then, gave them evidence that Earth has a solid core surrounded by a thick layer of molten, liquid rock? The answer lies in the study of earthquakes and the types of waves that they generate. Research earthquake waves and how these waves were used to hypothesize the characteristics of our Earth's core.



Problems for Understanding

21. A pendulum takes 1.0 s to swing from the rest line to it's highest point. What is the frequency of the pendulum?

22. By what factor will the wavelength change if the period of a wave is doubled?

23. A wave with an amplitude of 50.0 cm travels down a 8.0 m spring in 4.5 s. The person who creates the wave moves her hand through 4 cycles in 1 second. What is the wavelength?

24. A sound wave has a frequency of 60.0 Hz. What is its period? If the speed of sound in air is 343 m/s, what is the wavelength of the sound wave?

25. Water waves in a ripple tank are 2.6 cm long. The straight wave generator used to produce the waves sends out 60 wave crests in 42 s.
(a) Determine the frequency of the wave.
(b) Determine the speed of the wave.

26. A rope is 1.0 m long and the speed of a wave in the rope is 3.2 m/s. What is the frequency of the fundamental mode of vibration?

27. A tsunami travelled 3700 km in 5.2 h. If its frequency was 2.9×10^{-4} Hz, what was its wavelength?

28. A storm produces waves of length 3.5 m in the centre of a bay. The waves travel a distance of 0.50 km in 2.00 min.
(a) What is the frequency of the waves?
(b) What is the period of the waves?

29. A grandfather clock has a long pendulum with an adjustable mass that is responsible for the clock's ability to keep regular time. This pendulum is supposed to have a period of 1.00 s. You discover that the pendulum executes 117 compete vibrations in 2.00 min.
(a) Calculate the period of the pendulum.
(b) Calculate the percentage error in the time the clock records.
(c) How many hours slow will the clock be after a year?
(d) How might you adjust the pendulum so that its period is exactly 1.00 s?