PHYSICS 4
CHAPTER 1 WAVE MOTION
EXERCISES

WAVE EQUATION

1. Transverse waves with a speed of 50.0 m/s are to be produced in a taut string. A 5.00-m length of string with a total mass of 0.060 0 kg is used. What is the required tension?

2. Transverse waves travel with a speed of 20.0 m/s in a string under a tension of 6.00 N. What tension is required to produce a wave speed of 30.0 m/s in the same string?

3. A 30.0-m steel wire and a 20.0-m copper wire, both with 1.00-mm diameters, are connected end to end and are stretched to a tension of 150 N. How long does it take a transverse wave to travel the entire length of the two wires?

4. Ocean waves with a crest-to-crest distance of 10.0 m can be described by the wave function $y(x, t) = 0.800 \sin [0.628(x - vt)]$ where x and y are in meters, t is in seconds, and $v = 1.20$ m/s.
(a) Sketch $y(x, t)$ at $t = 0$.
(b) Sketch $y(x, t)$ at $t = 2.00$ s.
(c) Compare the graph in part (b) with that for part (a) and explain similarities and differences.
(d) How has the wave moved between graph (a) and graph (b)?

5. A wave is described by $y = 0.020\ 0 \sin (kx - vt)$, where $k = 2.11$ rad/m, v = 3.62 rad/s, x and y are in meters, and t is in seconds. Determine
(a) the amplitude,
(b) the wavelength,
(c) the frequency, and
(d) the speed of the wave.

6. A sinusoidal wave is traveling along a rope. The oscillator that generates the wave completes 40.0 vibrations in 30.0 s. A given crest of the wave travels 425 cm along the rope in 10.0 s. What is the wavelength of the wave?

7. The wave function for a traveling wave on a taut string is (in SI units):
$y\ (x, t\ ) = 0.350 \sin(10\pi t - 3\pi x + \pi/4)$
(a) What are the speed and direction of travel of the wave?
(b) What is the vertical position of an element of the string at $t = 0$, $x = 0.100$ m?
What are
(c) the wavelength and
(d) the frequency of the wave?
(e) What is the maximum transverse speed of an element of the string?

8. When a particular wire is vibrating with a frequency of 4.00 Hz, a transverse wave of wavelength 60.0 cm is produced. Determine the speed of waves along the wire.

9. Consider the sinusoidal wave with the wave function $y = 0.150 \cos (15.7x - 50.3t)$ where x and y are in meters and t is in seconds. At a certain instant, let point A be at the origin and point B be the closest point to A along the x axis where the wave is 60.0° out of phase with A.
What is the coordinate of B?

10. A transverse wave on a string is described by the wave function $y = 0.120 \sin(\pi/8x + 4\pi t)$ where x and y are in meters and t is in seconds.
Determine
(a) the transverse speed and
(b) the transverse acceleration at $t = 0.200$ s for an element of the string located at $x = 1.60$ m.
What are
(c) the wavelength,
(d) the period, and
(e) the speed of propagation of this wave?

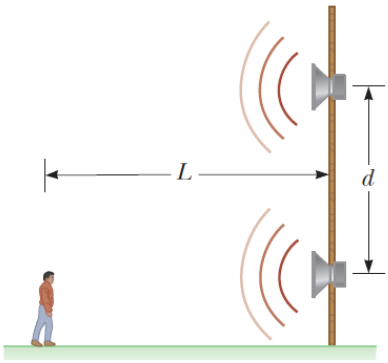
11. A transverse traveling wave on a taut wire has an amplitude of 0.200 mm and a frequency of 500 Hz. It travels with a speed of 196 m/s.
(a) Write an equation in SI units of the form $y = A \sin (kx - vt)$ for this wave.
(b) The mass per unit length of this wire is 4.10 g/m. Find the tension in the wire.
12. A steel wire of length 30.0 m and a copper wire of length 20.0 m, both with 1.00-mm diameters, are connected end to end and stretched to a tension of 150 N. During what time interval will a transverse wave travel the entire length of the two wires?
13. A transverse wave on a string is described by the wave function $y(x, t) = 0.350 \sin (1.25x + 99.6t)$ where x and y are in meters and t is in seconds. Consider the element of the string at $x = 0$.
(a) What is the time interval between the first two instants when this element has a position of $y = 0.175$ m?
(b) What distance does the wave travel during the time interval found in part (a)?
14. A sinusoidal wave in a string is described by the wave function $y = 0.150 \sin (0.800x - 50.0t)$ where x and y are in meters and t is in seconds. The mass per length of the string is 12.0 g/m.
(a) Find the maximum transverse acceleration of an element of this string.
(b) Determine the maximum transverse force on a 1.00-cm segment of the string.
(c) State how the force found in part (b) compares with the tension in the string.

SOUND WAVE
1. A sound wave from a police siren has an intensity of 100.0 W/m^2 at a certain point; a second sound wave from a nearby ambulance has an intensity level that is 10 dB greater than the police siren's sound wave at the same point.
What is the sound level of the sound wave due to the ambulance?
2. The sound level at a distance of 3.00 m from a source is 120 dB. At what distances is the sound level
(a) 100 dB and
(b) 10.0 dB?
3. A train sounds its horn as it approaches an intersection. The horn can just be heard at a level of 50 dB by an observer 10 km away.
(a) What is the average power generated by the horn?
(b) What intensity level of the horn's sound is observed by someone waiting at an intersection 50 m from the train? Treat the horn as a point source and neglect any absorption of sound by the air.
4. A commuter train passes a passenger platform at a constant speed of 40.0 m/s. The train horn is sounded at its characteristic frequency of 320 Hz.
(a) What change in frequency is detected by a person on the platform as the train passes?
(b) What wavelength is detected by a person on the platform as the train approaches?
5. Standing at a crosswalk, you hear a frequency of 560 Hz from the siren of an approaching police car. After the police car passes, the observed frequency of the siren is 480 Hz. Determine the car's speed from these observations.
6. A train is moving parallel to a highway with a constant speed of 20.0 m/s. A car is traveling in the same direction as the train with a speed of 40.0 m/s. The car horn sounds at a frequency of 510 Hz, and the train whistle sounds at a frequency of 320 Hz.
(a) When the car is behind the train, what frequency does an occupant of the car observe for the train whistle?
(b) When the car is in front of the train, what frequency does a train passenger observe for the car horn just after the car passes?
7. Two speakers are driven by a common oscillator at 800 Hz and face each other at a distance of 1.25 m. Locate the points along a line joining the two speakers where relative minima of sound pressure would be expected. (Use $v = 343$ m/s.)

INTERFERENCE AND STANDING WAVE

1. Two speakers are driven by a common oscillator at 800 Hz and face each other at a distance of 1.25 m. Locate the points along a line joining the two speakers where relative minima of sound pressure would be expected. (Use v = 343 m/s.)

2. Two speakers are driven by the same oscillator of frequency f. They are located a distance d from each other on a vertical pole. A man walks straight toward the lower speaker in a direction perpendicular to the pole as shown in the figure. Let v represent the speed of sound.



(a) How many times will he hear a minimum in sound intensity?

(b) How far is he from the pole at these moments?

3. A standing wave is established in a 120-cm-long string fixed at both ends. The string vibrates in four segments when driven at 120 Hz.

(a) Determine the wavelength.

(b) What is the fundamental frequency of the string?

4. Two identical loudspeakers are driven in phase by a common oscillator at 800 Hz and face each other at a distance of 1.25 m. Locate the points along the line joining the two speakers where relative minima of sound pressure amplitude would be expected.

5. Find the fundamental frequency and the next three frequencies that could cause a standing-wave pattern on a string that is 30.0 m long, has a mass per length of 9.00×10^{-3} kg/m, and is stretched to a tension of 20.0 N.

6. Calculate the length of a pipe that has a fundamental frequency of 240 Hz assuming the pipe is

(a) closed at one end and

(b) open at both ends.

7. The fundamental frequency of an open organ pipe corresponds to middle C (261.6 Hz on the chromatic musical scale). The third resonance of a closed organ pipe has the same frequency. What is the length of

(a) the open pipe and

(b) the closed pipe?

8. The longest pipe on a certain organ is 4.88 m. What is the fundamental frequency (at 0.00°C) if the pipe is

(a) closed at one end and

(b) open at each end?

9. A glass tube is open at one end and closed at the other by a movable piston. The tube is filled with air warmer than that at room temperature, and a 384-Hz tuning fork is held at the open end. Resonance is heard when the piston is 22.8 cm from the open end and again when it is 68.3 cm from the open end.

(a) What speed of sound is implied by these data?

(b) How far from the open end will the piston be when the next resonance is heard?

10. A glass tube (open at both ends) of length L is positioned near an audio speaker of frequency f = 680 Hz. For what values of L will the tube resonate with the speaker?

11. A student uses an audio oscillator of adjustable frequency to measure the depth of a water well. The student reports hearing two successive resonances at 51.87 Hz and 59.85 Hz.

(a) How deep is the well?

(b) How many antinodes are in the standing wave at 51.87 Hz?