Chapter 17 End-of-Chapter Problems

Halliday & Resnick, 10th Edition

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Hit me where it Matters

Where needed in the problems, use
speed of sound in air = 343 m/s
and
density of air = 1.21 kg/m^3
unless otherwise specified.

1 Problem 1

Two spectators at a soccer game see, and a moment later hear, the ball being kicked on the playing field. The time delay for spectator A is 0.23 s, and for spectator B it is 0.12 s. Sight lines from the two spectators to the player kicking the ball meet at an angle of 90°. How far are (a) spectator A and (b) spectator B from the player? (c) How far are the spectators from each other?

1.1 Solution (a)

This is a simple question to answer. The distance traveled to A would be equal to the speed of sound times the time taken to travel the distance.

$$x = vt = (343\,\mathrm{m/s})(0.23\,\mathrm{s}) = \boxed{78.89\,\mathrm{m}} \tag{1}$$

1.2 Solution (b)

The is calculatable the same way.

$$y = vt = (343\,\mathrm{m/s})(0.12\,\mathrm{s}) = \boxed{41.16\,\mathrm{m}} \tag{2}$$

1.3 Solution (c)

The 90 degree angle of their sight lines makes the triange of the two spectators and the ball a right triangle, so we can use the Pythagorean theorem to find the distance between the spectators.

$$h = \sqrt{x^2 + y^2} = \sqrt{(78.89\,\mathrm{m})^2 + (41.16\,\mathrm{m})^2} = \boxed{88.98\,\mathrm{m}} \tag{3}$$

2 Problem 3

When the door of the Chapel of the Mausoleum in Hamilton, Scotland, is slammed shut, the last echo heard by someone standing just inside the door reportedly comes 15 s later. (a) If that echo were due to a single reflection off a wall opposite the door, how far from the door is the wall? (b) If, instead, the wall is 25.7 m away, how many reflections (back and forth) occur?

2.1 Solution (a)

Use the speed and the time taken to calculate the distance covered.

$$\Delta s = vt = (343 \, \text{m/s})(15 \, \text{s}) = 5145 \, \text{m} \tag{4}$$

This is twice the length of the church, so if we divide this by two, we will get the length of the church.

$$L = \frac{\Delta s}{2} = \frac{5145 \, \text{m}}{2} = \boxed{2572.5 \, \text{m}} \tag{5}$$

2.2 Solution (b)

We can divide the total distance covered by the length of the church to fnd the number of reflections.

$$n = \frac{5145 \, \text{m}}{25.7 \, \text{m}} = 200.19 \tag{6}$$

$$\lfloor n \rfloor = \boxed{200} \tag{7}$$

3 Problem 5

Earthquakes generate sound waves inside Earth. Unlike a gas, Earth can experience both transverse (S) and longitudinal (P) sound waves. Typically, the speed of S waves is about 4.5 km/s, and that of P waves 8.0 km/s. A seismograph records P and S waves from an earthquake. The first P waves arrive 3.0 min before the first S waves. If the waves travel in a straight line, how far away did the earthquake occur?

3.1 Solution

3.0 minutes is equivalent to 180 seconds. If the time it takes the longitudinal wave to reach the scale is t, the time it takes the transverse wave would be $t + 180\,\mathrm{s}$. We can use this in an equation for distance from velocity.

$$\Delta x = vt \tag{8}$$
$$x = (8.0\,\mathrm{km/s})t \tag{9}$$
$$x = (4.5\,\mathrm{km/s})(t + 180\,\mathrm{s}) \tag{10}$$

Use the transistive property and solve for the time.

$$(8.0\,\mathrm{km/s})t = (4.5\,\mathrm{km/s})(t + 180\,\mathrm{s}) \tag{11}$$
$$(3.5\,\mathrm{km/s})t = 810\,\mathrm{km} = \frac{810}{3.5}\,\mathrm{s} \tag{12}$$

Substitute this into the first equation for the distance covered.

$$x = (8.0\,\mathrm{km/s})(\frac{810}{3.5}\,\mathrm{s}) = \boxed{1851\,\mathrm{km}} \tag{13}$$

4 Problem 7

A stone is dropped into a well. The splash is heard 3.00 s later. What is the depth of the well?

4.1 Solution

5   Problem 11

Diagnostic ultrasound of frequency 4.50 MHz is used to examine tumors in soft tissue. (a) What is the wavelength in air of such a sound wave? (b) If the speed of sound in tissue is 1500 m/s, what is the wavelength of this wave in tissue?

5.1   Solution

6 Problem 15

6.1 Solution

7 Problem 17

7.1 Solution

8 Problem 19

8.1 Solution

9 Problem 20

9.1 Solution

10 Problem 25

10.1 Solution

11 Problem 27

11.1 Solution

12 Problem 29

12.1 Solution

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