## 12 <br> Waves and Sound

## 12-1 Wave Motion

Vocabulary<br>Wave: A disturbance in a medium.

In this chapter you will be working with waves that are periodic or that repeat in a regular, rhythmic pattern.

$$
\text { wave speed }=(\text { wavelength }) \text { (frequency) } \quad \text { or } \quad v=\lambda f
$$

The SI unit for wave speed is the meter per second ( $\mathrm{m} / \mathrm{s}$ ). The speed of sound in air increases with air temperature. For the following exercises, the speed of sound will be written as $340.0 \mathrm{~m} / \mathrm{s}$. All electromagnetic radiation including radio waves and light waves travel at the speed of light, $3.00 \times 10^{8} \mathrm{~m} / \mathrm{s}$.

The wavelength of a wave is the distance from one point on a wave to the next identical point on the same wave, for example, from crest to crest, trough to trough, or condensation to condensation. The symbol for wavelength is the Greek letter "lambda," $\lambda$.

The SI unit for wavelength is the meter ( $\mathbf{m}$ ), which is the same unit used for length in earlier chapters.

The SI unit for frequency is the hertz $\mathbf{( H z )}$. When talking about the broadcast frequency of a radio station, frequencies of FM radio stations are given in megahertz, or MHz , and frequencies of AM radio stations are given in kilohertz, or kHz .

$$
1 \mathrm{MHz}=1 \times 10^{6} \mathrm{~Hz} \quad \text { and } \quad 1 \mathrm{kHz}=1 \times 10^{3} \mathrm{~Hz}
$$

## Solved Examples

Example 1: Radio station WKLB in Boston broadcasts at a frequency of 99.5 MHz . What is the wavelength of the radio waves emitted by WKLB?

$$
\begin{aligned}
\text { Given: } v & =3.00 \times 10^{8} \mathrm{~m} / \mathrm{s} & & \text { Unknown: } \lambda=? \\
& f=99.5 \times 10^{6} \mathrm{~Hz} & & \text { Original equation: } v=\lambda f
\end{aligned}
$$

Solve: $\lambda=\frac{v}{f}=\frac{3.00 \times 10^{8} \mathrm{~m} / \mathrm{s}}{99.5 \times 10^{6} \mathrm{~Hz}}=3.02 \mathrm{~m}$
Therefore, the distance from one point on the wave to the next identical point on the same wave is 3.02 m .

Example 2: In California, Clay is surfing on a wave that propels him toward the beach with a speed of $5.0 \mathrm{~m} / \mathrm{s}$. The wave crests are each $20 . \mathrm{m}$ apart. a) What is the frequency of the water wave? b) What is the period?
a. Given: $v=5.0 \mathrm{~m} / \mathrm{s}$
Unknown: $f=$ ?
$\lambda=20 . \mathrm{m}$
Original equation: $v=\lambda f$

Solve: $f=\frac{v}{\lambda}=\frac{5.0 \mathrm{~m} / \mathrm{s}}{20 . m}=\mathbf{0 . 2 5} \mathrm{Hz}$
b. Given: $f=0.25 \mathrm{~Hz}$

Unknown: $T=$ ?
Original equation: $T=\frac{1}{f}$
Solve: $T=\frac{1}{f}=\frac{1}{0.25 \mathrm{~Hz}}=4.0 \mathrm{~s}$
One crest comes along every 4.0 s .

## Practice Exercises

Exercise 1: Harriet is told by her doctor that her heart rate is 70.0 beats per minute. If Harriet's average blood flow in the aorta during systole is $1.5 \times 10^{-2} \mathrm{~m} / \mathrm{s}$, what is the wavelength of the waves of blood in Harriet's aorta, created by her beating heart?

Answer: $\qquad$
Exercise 2: Dogs are able to hear much higher frequencies than humans are capable of detecting. For this reason, dog whistles that are inaudible to the human ear can be heard easily by a dog. If a dog whistle has a frequency of $3.0 \times 10^{4} \mathrm{~Hz}$, what is the wavelength of the sound emitted?

Answer:


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Exercise 3: While flying to Tucson, Connie's plane experiences turbulence that causes the coffee in her cup to oscillate back and forth 4 times each second. If the waves of coffee have a wavelength of 0.1 m , what is the speed of a wave moving through the coffee?

Answer: $\qquad$


Exercise 4: At a country music festival in New Hampshire, the Oak Ridge Boys are playing at the end of a crowded 184-m field when Ronny Fairchild hits a note on the keyboard that has a frequency of $400 . \mathrm{Hz}$. a) How many full wavelengths are there between the stage and the last row of the crowd?
b) How much delay is there between the time a note is played and the time it is heard in the last row?

Answer: a. $\qquad$
Answer: b. $\qquad$

> Chapter 12
> 1. $\quad 0.013 \mathrm{~m}$ 3. $0.4 \mathrm{~m} / \mathrm{s}$

