

MATH SKILLS● **Wave Speed**

The musical note A above middle C has a frequency of 440 Hz. If the speed of sound is known to be 350 m/s, what is the wavelength of this note?

1. List the given and unknown values.

Given: frequency, $f = 440$ Hz

wave speed, $v = 350$ m/s

Unknown: wavelength, $\lambda = ?$ m

2. Write the equation for wave speed, and rearrange it to solve for wavelength.

$$v = f \times \lambda \qquad \lambda = \frac{v}{f}$$

3. Insert the known values into the equation, and solve.

$$\lambda = \frac{350 \text{ m/s}}{440 \text{ Hz}}$$

$$\lambda = 0.80 \text{ m}$$

Your Turn to Think

1. A certain FM radio station broadcasts electromagnetic waves at a frequency of 9.05×10^7 Hz. These radio waves travel at a speed of 3.00×10^8 m/s. What is the wavelength of these radio waves?
2. A dog whistle is designed to produce a sound with a frequency beyond that which can be heard by humans (between 20 000 Hz and 27 000 Hz). If a particular whistle produces a sound with a frequency of 2.5×10^4 Hz, what is the sound's wavelength? Assume the speed of sound in air is 331 m/s.
3. The lowest pitch that the average human can hear has a frequency of 20.0 Hz. If sound with this frequency travels through air with a speed of 331 m/s, what is its wavelength?
4. A 10.0 m wire is hung from a high ceiling and held tightly below by a large mass. Standing waves are created in the wire by air currents that pass over the wire, setting it in motion. If the speed of the standing wave is 335 m/s and its frequency is 67 Hz, what is its wavelength?
5. Sonar is a device that uses reflected sound waves to measure underwater depths. If a sonar signal has a frequency of 288 Hz and the speed of sound in water is 1.45×10^3 m/s, what is the wavelength of the sonar signal?

MATH SKILLS● **Wave Speed** *continued***Sample Problem**

A buoy bobs up and down in the ocean. The waves have a wavelength of 2.5 m, and they pass the buoy at a speed of 4.0 m/s. What is the frequency of the waves? How much time does it take for one wave to pass under the buoy?

1. List the given and unknown values.

Given: wavelength, $\lambda = 2.5$ m

wave speed, $v = 4.0$ m/s

Unknown: frequency, $f = ?$ Hz

period, $T = ?$ s

2. Write the equation for wave speed, and rearrange it to solve for frequency. Write the equation for period.

$$v = f \times \lambda \qquad f = \frac{v}{\lambda}$$

$$T = \frac{1}{f}$$

3. Insert the known values into the equations, and solve.

$$f = \frac{4.0 \text{ m/s}}{2.5 \text{ m}}$$

$$f = 1.6 \text{ Hz}$$

$$T = \frac{1}{1.6 \text{ Hz}}$$

$$T = 0.62 \text{ s}$$

Your Turn to Think

- Cicadas produce a buzzing sound that has a wavelength in air of 2.69 m. If the speed of sound in air is 346 m/s, what is the frequency of the sound produced by a cicada? What is its period?
- A drum is struck, producing a wave with a wavelength of 110 cm and a speed of 2.42×10^4 m/s. What is the frequency of the wave? What is the period?
- One of the largest organ pipes is in the auditorium organ in the convention hall in Atlantic City, New Jersey. The pipe is 38.6 ft long and produces a sound with a wavelength of about 10.6 m. If the speed of sound in air is 346 m/s, what is the frequency of this sound?

MATH SKILLS● **Wave Speed** *continued*

- Yellow light with a wavelength of 5.89×10^{-7} m travels through quartz glass with a speed of 1.94×10^8 m/s. What is the frequency of the light?
- A ship anchored at sea is rocked by waves that have crests 14 m apart. The waves travel at 7.0 m/s. How often do the wave crests reach the ship?

Sample Problem

Waves in a lake are 6 m apart and pass a person on a raft every 2 s. What is the speed of the waves?

- List the given and unknown values.

Given: wavelength, $\lambda = 6$ m

period, $T = 2$ s

Unknown: wave speed, $v = ?$ m/s

- Write the equations for period and wave speed. Calculate the frequency from the period, and then determine the wave speed.

$$f = \frac{1}{T}$$

$$v = f \times \lambda$$

- Insert the known values into the equations, and solve.

$$f = \frac{1}{2 \text{ s}} = 0.5 \text{ Hz}$$

$$v = (0.5 \text{ Hz}) \times (6 \text{ m})$$

$$v = 3 \text{ m/s}$$

Your Turn to Think

- A wave with a frequency of 60.0 Hz travels through vulcanized rubber with a wavelength of 0.90 m. What is the speed of this wave?
- A wave with a frequency of 60.0 Hz travels through steel with a wavelength of 85.5 m. What is the speed of this wave?

Mixed Review

- Earthquakes generate shock waves that travel through Earth's interior to other parts of the world. The fastest of these waves are longitudinal waves, like sound waves, and are called *primary waves*, or just *p-waves*. A p-wave has a very low frequency, typically around 0.050 Hz. If the speed of a p-wave with this frequency is 8.0 km/s, what is its wavelength?

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● Wave Speed *continued*

14. Earthquakes also produce transverse waves that move more slowly than the p-waves. These waves are called *secondary waves*, or *s-waves*. If the wavelength of an s-wave is 2.3×10^4 m, and its speed is 4.5 km/s, what is its frequency?
15. A dolphin can typically hear sounds with frequencies up to 150 kHz. What is the speed of sound in water if a wave with this frequency has a wavelength of 1.0 cm?