Name _____ Date _____ Class _____

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?

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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

6. 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?
7. 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?
8. 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?

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Wave Speed *continued*

9. 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?

10. 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?

1. List the given and unknown values.

Given: *wavelength*, $\lambda = 6$ m

period, $T = 2$ s

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

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

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

$$v = f \times \lambda$$

3. 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

11. 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?

12. 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

13. 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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MATH SKILLS

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?