

Holt Physics

Problem 12D**WAVE SPEED****PROBLEM**

The world's largest guitar was built by high school students in Indiana. Although the guitar can be played with strings that are 9.0 m long, it is not an easy task. The fundamental vibration that can be induced on each string has a wavelength equal to twice the string's length. Suppose the bass string makes a sound that has a frequency of 50.0 Hz. Find the speed of the wave in the string.

SOLUTION

Given: $f = 50.0 \text{ Hz}$ $L = 9.0 \text{ m}$

Unknown: $v = ?$

Use the equation for the speed of a wave. The wavelength is equal to twice the length of the string ($\lambda = 2L$).

$$v = f\lambda = f(2L) = (50.0 \text{ Hz})[(2)(9.0 \text{ m})] = \boxed{9.0 \times 10^2 \text{ m/s}}$$

ADDITIONAL PRACTICE

- The largest reliably measured depth of the Pacific Ocean is about $1.09 \times 10^4 \text{ m}$. How many wavelengths of sound waves with a frequency of $2.50 \times 10^2 \text{ Hz}$ would fit into this distance? The speed of sound in sea water is about 1530 m/s.
- Cicadas produce a sound that has a frequency of 123 Hz. What is the wavelength of this sound in the air? The speed of sound in air is 334 m/s.
- Human fingers are very sensitive, detecting vibrations with amplitudes as low as $2.0 \times 10^{-5} \text{ m}$. Consider a sound wave with a wavelength exactly 1000 times greater than the lowest amplitude detectable by fingers. What is this wave's frequency? Would it be audible to the human ear?
- The highest-pitched sound that a human ear can detect is about 21 kHz. On the other hand, dolphins can hear ultrasound with frequencies up to 280 kHz. What is the speed of sound in water if the wavelength of ultrasound with a frequency of $2.80 \times 10^5 \text{ Hz}$ is 0.510 cm? How long would it take this sound wave to travel to a dolphin 3.00 km away?
- A nineteenth-century fisherman's cottage in England is only 2.54 m long. Suppose a fisherman whistles inside the cottage, producing a note that has a wavelength that exactly matches the length of the house. What is the whistle's frequency? The speed of sound in air is 334 m/s.
- The lowest vocal note in the classical repertoire is low D ($f = 73.4 \text{ Hz}$), which occurs in an aria in Mozart's opera *Die Entführung aus dem Serail*. If low D has a wavelength of 4.50 m, what is the speed of sound in air?