Holt Physics
Problem 13B

HARMONICS

PROBLEM

The tallest load-bearing columns are part of the Temple of Amun in Egypt, built in 1270 B.C. Find the height of these columns if a standing wave with a frequency of 47.8 Hz is generated in an open pipe that is as tall as the columns. The sixth harmonic is generated. The speed of sound in air is 334 m/s.

SOLUTION

Given: $f_6 = 47.8$ Hz $v = 334$ m/s

$n =$ number of the harmonic $= 6$

Unknown: $L = ?$

When the pipe is open, the wavelength associated with the first harmonic (fundamental frequency) is twice the length of the pipe.

$$f_n = n \frac{v}{2L}, n = 1, 2, 3, \ldots$$

$$L = n \frac{v}{2f_n} = (6) \frac{(334 \text{m/s})}{2(47.8 \text{ Hz})} = \boxed{21.0 \text{ m}}$$

ADDITIONAL PRACTICE

1. A 47.0 m alphorn was made in Idaho in 1989. Considering that an alphorn behaves like a pipe with one end closed, find the frequency of the fifteenth harmonic. The speed of sound in air is 334 m/s.

2. A power-plant chimney in Spain is 3.50×10^2 m high. If a standing wave with a frequency of 35.5 Hz is generated in an open pipe with a length equal to the chimney's height and the 75th harmonic is present, what is the speed of sound?

3. The unsupported flagpole built for Canada's Expo 86 has a mass of more than 5.0×10^4 kg and a height of 86 m. If a standing wave with a 19th harmonic is produced in an 86 m open pipe, what is its wavelength?

4. The world's largest organ was completed in 1930 in Atlantic City, New Jersey. Its shortest pipe is 4.7 mm long. If one end of this pipe is closed, what is the number of harmonics created by an ultrasound with a wavelength of 3.76 mm?

5. A fully functional acoustic guitar over 8.0 m in length is on display in Bristol, England. Suppose a string of this guitar is 7.80 m long and the speed of waves on the string is 5.00×10^2 m/s. If a third harmonic is generated on this string, what is the wavelength of the sound produced in air? The speed of sound in air is 334 m/s.