

# CHAPTER 12: Sound

## Problems

[Unless stated otherwise, assume  $T = 20^\circ\text{C}$  and  $v_{\text{sound}} = 343\text{ m/s}$

### 12–1 Characteristics of Sound

2. (I) A sailor strikes the side of his ship just below the waterline. He hears the echo of the sound reflected from the ocean floor directly below 2.5 s later. How deep is the ocean at this point? Assume the speed of sound in seawater is 1560 m/s (Table 12–1) and does not vary significantly with depth.

Material	Speed (m/s)
Air	343
Air (0°C)	331
Helium	1005
Hydrogen	1300
Water	1440
Sea water	1560
Iron and steel	≈ 5000
Glass	≈ 4500
Aluminum	≈ 5100
Hardwood	≈ 4000
Concrete	≈ 3000

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5. (II) A stone is dropped from the top of a cliff. The splash it makes when striking the water below is heard 3.5 s later. How high is the cliff?

6. (II) A person, with his ear to the ground, sees a huge stone strike the concrete pavement. A moment later two sounds are heard from the impact: one travels in the air and the other in the concrete, and they are 1.1 s apart. How far away did the impact occur? See Table 12–1.

### 12–4 Sources of Sound: Strings and Air Columns

24. (I) The A string on a violin has a fundamental frequency of 440 Hz. The length of the vibrating portion is 32 cm, and it has a mass of 0.35 g. Under what tension must the string be placed?
26. (I) (a) What resonant frequency would you expect from blowing across the top of an empty soda bottle that is 18 cm deep, if you assumed it was a closed tube? (b) How would that change if it was one-third full of soda?
28. (II) A tight guitar string has a frequency of 540 Hz as its third harmonic. What will be its fundamental frequency if it is fingered at a length of only 60% of its original length?
29. (II) An unfingered guitar string is 0.73 m long and is tuned to play E above middle C (330 Hz). (a) How far from the end of this string must the finger be placed to play A above middle C (440 Hz)? (b)

What is the wavelength on the string of this 440-Hz wave? (c) What are the frequency and wavelength of the sound wave produced in air at 20°C by this fingered string?

34. (II) A particular organ pipe can resonate at 264 Hz, 440 Hz, and 616 Hz, but not at any other frequencies in between. (a) Show why this is an open or a closed pipe. (b) What is the fundamental frequency of this pipe?
36. (II) A pipe in air at 20°C is to be designed to produce two successive harmonics at 240 Hz and 280 Hz. How long must the pipe be, and is it open or closed?

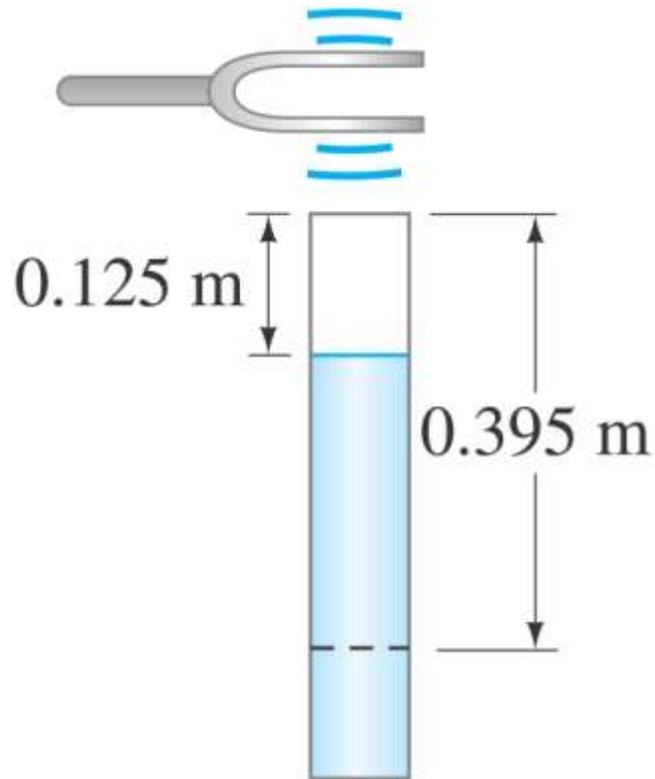
### 12–6 Interference; Beats

42. (II) A guitar string produces 4 beats/s when sounded with a 350-Hz tuning fork and 9 beats/s when sounded with a 355-Hz tuning fork. What is the vibrational frequency of the string? Explain your reasoning.
44. (II) How many beats will be heard if two identical flutes each try to play middle C (262 Hz), but one is at 5.0°C and the other at 25.0°C?

### 12–7 Doppler Effect

49. (I) The predominant frequency of a certain fire engine's siren is 1550 Hz when at rest. What frequency do you detect if you move with a speed of 30.0 m/s (a) toward the fire engine, and (b) away from it?
52. (II) Two automobiles are equipped with the same single frequency horn. When one is at rest and the other is moving toward the first at 15 m/s, the driver at rest hears a beat frequency of 5.5 Hz. What is the frequency the horns emit? Assume  $T = 20^\circ\text{C}$ .
58. (III) A factory whistle emits sound of frequency 570 Hz. When the wind velocity is 12.0 m/s from the north, what frequency will observers hear who are located, at rest, (a) due north, (b) due south, (c) due east, and (d) due west, of the whistle? What frequency is heard by a cyclist heading (e) north or (f) west, toward the whistle at 15.0 m/s? Assume  $T = 20^\circ\text{C}$ .

76. A tuning fork is set into vibration above a vertical open tube filled with water (Fig. 12–35). The water level is allowed to drop slowly. As it does so, the air in the tube above the water level is heard to resonate with the tuning fork when the distance from the tube opening to the water level is 0.125 m and again at 0.395 m. What is the frequency of the tuning fork?



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