MIXED REVIEW

36. A pipe that is open at both ends has a fundamental frequency of 320 Hz when the speed of sound in air is 331 m/s.

a. What is the length of this pipe?

b. What are the next two harmonics?

37. When two tuning forks of 132 Hz and 137 Hz, respectively, are sounded simultaneously, how many beats per second are heard?

38. The range of human hearing extends from approximately 20 Hz to 20 000 Hz. Find the wavelengths of these extremes when the speed of sound in air is equal to 343 m/s.

39. A dolphin in 25°C sea water emits a sound directed toward the bottom of the ocean 150 m below. How much time passes before it hears an echo? (See **Table 1** in this chapter for the speed of the sound.)

40. An open organ pipe is 2.46 m long, and the speed of the air in the pipe is 345 m/s.

a. What is the fundamental frequency of this pipe?

b. How many harmonics are possible in the normal hearing range, 20 Hz to 20 000 Hz?

41. The fundamental frequency of an open organ pipe corresponds to the note middle C (f = 261.6 Hz on the chromatic musical scale). The third harmonic (f_3) of another organ pipe that is closed at one end has the same frequency. Compare the lengths of these two pipes.

42. Some studies indicate that the upper frequency limit of hearing is determined by the diameter of the eardrum. The wavelength of the sound wave and the diameter of the eardrum are approximately equal at this upper limit. If this is so, what is the diameter of the eardrum of a person capable of hearing 2.0×10^4 Hz? Assume 378 m/s is the speed of sound in the ear.

43. The decibel level of the noise from a jet aircraft is 130 dB when measured 20.0 m from the aircraft.

a. How much sound power does the jet aircraft emit?

b. How much sound power would strike the eardrum of an airport worker 20.0 m from the aircraft? (Use the diameter found in item 42 to calculate the area of the eardrum.)

Graphing Calculator Practice

Doppler Effect

As you learned earlier in this chapter, relative motion between a source of sound and an observer can create changes in the observed frequency. This frequency shift is known as the *Doppler effect*. The frequencies heard by the observer can be described by the following two equations, where f' represents the apparent frequency and f represents the actual frequency.

$$f' = f\left(\frac{v_{sound}}{v_{sound} - v_{source}}\right)$$

$$f' = f\left(\frac{v_{sound}}{v_{sound} + v_{source}}\right)$$

The first equation applies when the source of sound is approaching the observer, and the second equation applies when the source of sound is moving away from the observer.

In this graphing calculator activity, you will graph these two equations and will analyze the graphs to determine the apparent frequencies for various situations.

Visit go.hrw.com and type in the keyword **HF6SNDX** to find this graphing calculator activity. Refer to **Appendix B** for instructions on downloading the program for this activity.