EXERCISES

Conceptual Questions

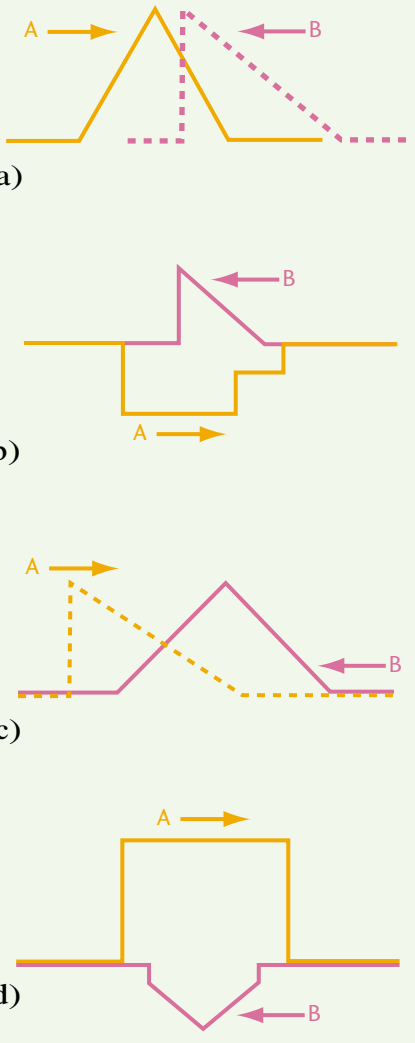
1. Describe some cases of mechanical resonance that have not been discussed in the text. Be sure to use the specific physics terminology.
2. Apparently, some singers can shatter a wine glass with their singing voice. To which topic is this ability related? What qualities would a singer's voice need to have to be able to shatter glass?
3. Your car's rearview mirror vibrates only when you drive at a certain speed. Explain.
4. When your car is stuck in an ice rut, the principle of resonance could be used to help you out. Explain how a few well-timed pushes could move a heavy car.
5. Explain how beat frequency can be used to tune an instrument.
6. Sound is caused by a vibration. In each of the following cases, describe what is vibrating:
   a) Blowing over a pop bottle
   b) A drum
   c) An organ
   d) A piano
   e) A knock on the door
7. When filling your car with gasoline, in the last few seconds before filling the tank, a noise with a rising pitch comes from the tank. Explain.
8. Some guitar strings are either wound with extra material or are made from different substances. Explain why this would affect the pitch of different strings.
9. A car muffler is a closed chamber made up of open tubes of various lengths for the exhaust gases to pass through. Describe how the principle of superposition can be used with these "air columns" to reduce the noise of the car's exhaust system.

Problems

14.2 The Principle of Superposition

10. Use the principle of superposition to determine the resulting wave pulse when the two pulses meet each other, as shown in Fig. 14.41.

Fig.14.41



11. Explain why an oscilloscope, a device that displays a transverse wave, is used to study sound, which is a longitudinal wave.
12. With a quick sketch of an oscilloscope, illustrate
    a) a transverse wave of wavelength 4 cm and amplitude 1.5 cm.

b) a wave with half the frequency of a).
c) Sketch a) as a longitudinal wave.

14.3 Sound Waves and Matter

13. A sound wave of speed 341 m/s and a wavelength of 0.33 m enters a low-pressure area where the speed decreases to 335 m/s. What is the resulting wavelength?

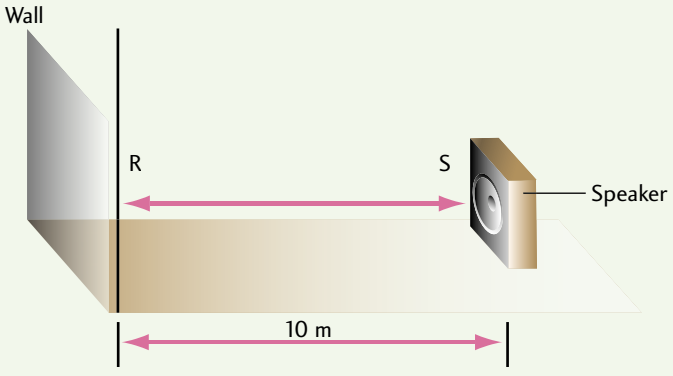
14. Use the parameters given in Problem 17 to calculate the frequency of each wave. Explain why listening to an outdoor concert does not affect the pitch of the sound heard by the audience.

14.4 Standing Waves — A Special Case of Interference

15. A xylophone bar resonates with a particular sound because a standing wave has been set up in it. The bar behaves like an open air column because each end is free to vibrate. A 20.0 cm bar resonates with its fifth resonant length at 22.0°C. What is the frequency that is heard?

16. Using Fig. 14.43, draw a transverse standing wave between the speaker and the wall that would result from the sound reflections. Assume that the air temperature is 30°C and the speaker generates a 175 Hz note.

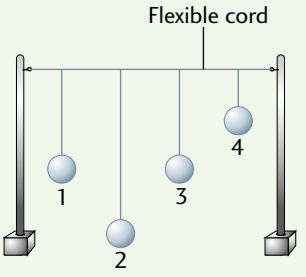
Fig.14.43



14.5 Resonance

17. If pendulum 1 in Fig. 14.44 is set in motion, which of the other three pendulums would also move? What principle is at work here?

Fig.14.44



18. A big gravel truck rumbles by your house, causing your window to vibrate enough to make a loud tone. Explain what is happening.

14.6 Acoustic Resonance and Musical Instruments

19. An air column that is open at both ends has a distance of 24.0 cm from one resonant length to another. What is the wavelength of sound that is in resonance with this tube? How would the wavelength be affected if the tube was closed at one end?

20. Water is slowly drained out of a tube until the air column is 8.0 cm long. A loud sound is then heard.
    a) What is the wavelength of the sound that is produced by resonance?
    b) How long would the tube have to be for the same note to resonate at the third resonant length?

21. A tuning fork vibrating with a frequency of 950 Hz is held near the end of an open air column that has been adjusted to its first resonant length at 25.0°C.
    a) What is the speed of sound in the room?
    b) What is the wavelength of the sound produced?
    c) How long is the tube in centimetres?

22. A 1024 Hz tuning fork is held up to a closed air column (closed at one end and open at the other) at 30.0°C. What is the minimum length of an air column that would resonate with this frequency?

23. Organ pipes, open at one end, resonate best at their first resonant length. Two pipes have length 23.0 cm and 30.0 cm respectively.
    a) What is the wavelength of the sound emitted by each pipe?
    b) What are the respective frequencies if the speed of sound is 341 m/s?
    c) What is the air temperature in this church?

24. One of the tubes in Pan's flute measures 10 cm from one open end to the other. The air temperature is 20.0°C.
    a) What is the fundamental wavelength of the note that is heard?
    b) What is the corresponding frequency?

25. A tuning fork was sounded over an adjustable closed air column. It was found that the difference between the second and fifth resonant length was 90.0 cm. What was the frequency of the tuning fork if the experiment was done in a lab with air temperature 25.0°C?

26. Hollow tube chimes are made of metal and are open at each end. These columns resonate best at their third resonant length. One chime is 2.5 m long and the air temperature is 25.0°C.
    a) What is the speed of sound?
    b) What is the wavelength of the sound produced?
    c) What is the frequency of the sound that is heard?

27. A guitar string is struck and found to have a frequency of 2048 Hz. If both the tension and the length are doubled, what is the new frequency of the string?

28. A string that is 90.0 cm long with a diameter of 0.75 mm and a tension of 60.0 N has a frequency of 1000 Hz. What new frequency is heard in each of the following situations?
    a) The length is increased to 100.0 cm.
    b) The tension is increased to 80.0 N
    c) The diameter is increased to 0.77 mm.
    d) Both factors in parts a) and b) are done together.

29. A fundamental frequency of 550 Hz is played on a guitar string.
    a) What is the first harmonic frequency of the string?
    b) The tension of the string is doubled. What is the new fundamental frequency of the string?

30. The distance between the first and third nodes of a standing wave in a violin string is 4.0 cm.
    a) Draw a scale diagram to illustrate the string.
    b) What is the wavelength of the sound wave that is produced?
    c) What is the frequency of the note that is heard if the speed of sound is 345 m/s?

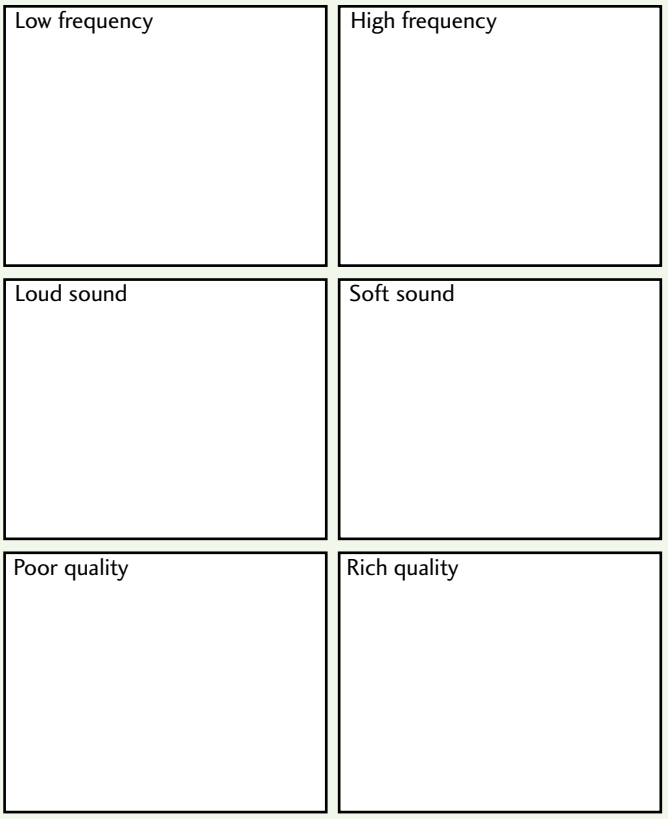
31. A string under a tension of 170 N has a frequency of 300 Hz. What will its frequency become if the tension is increased to 340 N?

32. Two steel strings of equal diameter and tension have a length of 0.75 m and 0.95 m respectively. If the frequency of the first string is 250 Hz, what is the frequency of the second string?

14.7 Music

33. In your notebook, draw a simple sketch of a wave form that illustrates the characteristics of sound indicated in each box in Fig. 14.42. Start with a single wavelength. Under each sketch, write a brief description of the waveform you have drawn.

Fig.14.42



34. Explain the role of harmonics in the quality of a musical note.

35. Why is a xylophone built with removable bars if they can't be interchanged?

36. The note C (f = 512 Hz) is played on a piano. Calculate the frequencies that would correspond to this note's second, fourth, and fifth harmonics.

14.8 Special Cases of Interference

37. Calculate the beat frequencies that are heard when the following pairs of frequencies are sounded together:
    a) 312 Hz and 300 Hz
    b) 852 Hz and 857 Hz
    c) 1024 Hz and 1000 Hz

38. Liona Boyd, a famous Canadian guitarist, tunes her guitar's A string with a 440 Hz tuning fork. Beats are heard at a frequency of 4 Hz. To give herself more information, Ms. Boyd wraps a piece of masking tape around one of the tuning fork tines and continues tuning. This time, a beat frequency of 5 Hz is heard. Is more information required to find the specific frequency of the string? What are the possible frequencies of the string? In each case, what should Ms. Boyd do to tune the string?

39. A 512 Hz tuning fork is struck with another tuning fork and beats are heard with a beat frequency of 3 Hz. What are the possible frequencies of the unknown tuning fork?