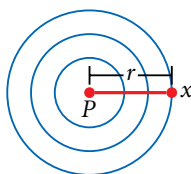


20. Why are pushes given to a playground swing more effective if they are given at certain, regular intervals than if they are given at random positions in the swing's cycle?
21. Although soldiers are usually required to march together in step, they must break their march when crossing a bridge. Explain the possible danger of crossing a rickety bridge without taking this precaution.

## Practice Problems

For problems 22–23, see Sample Problem A.

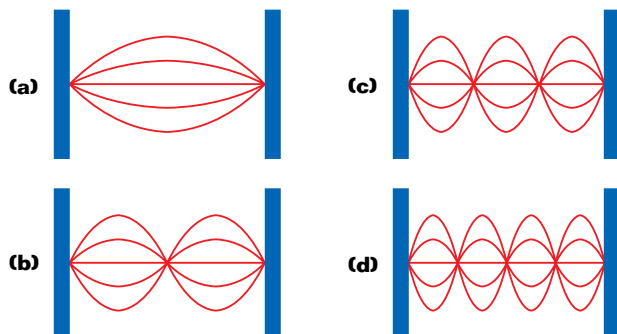
22. A baseball coach shouts loudly at an umpire standing 5.0 meters away. If the sound power produced by the coach is  $3.1 \times 10^{-3}$  W, what is the decibel level of the sound when it reaches the umpire? (Hint: Use Table 2 in this chapter.)
23. A stereo speaker represented by *P* in the figure on the right emits sound waves with a power output of 100.0 W. What is the intensity of the sound waves at point *x* when  $r = 10.0$  m?



## HARMONICS

### Review Questions

24. What is fundamental frequency? How are harmonics related to the fundamental frequency?
25. The figures below show a stretched string vibrating in several of its modes. If the length of the string is 2.0 m, what is the wavelength of the wave on the string in (a), (b), (c), and (d)?



26. Why does a pipe closed at one end have a different harmonic series than an open pipe?
27. Explain why a saxophone sounds different from a clarinet, even when they sound the same fundamental frequency at the same decibel level.

## Conceptual Questions

28. Why does a vibrating guitar string sound louder when it is on the instrument than it does when it is stretched on a work bench?
29. Two violin players tuning their instruments together hear six beats in 2 s. What is the frequency difference between the two violins?
30. What is the purpose of the slide on a trombone and the valves on a trumpet?
31. A student records the first 10 harmonics for a pipe. Is it possible to determine whether the pipe is open or closed by comparing the difference in frequencies between the adjacent harmonics with the fundamental frequency? Explain.
32. A flute is similar to a pipe open at both ends, while a clarinet is similar to a pipe closed at one end. Explain why the fundamental frequency of a flute is about twice that of the clarinet, even though the length of these two instruments is approximately the same.
33. The fundamental frequency of any note produced by a flute will vary slightly with temperature changes in the air. For any given note, will an increase in temperature produce a slightly higher fundamental frequency or a slightly lower one?

## Practice Problems

For problems 34–35, see Sample Problem B.

34. What are the first three harmonics of a note produced on a 31.0 cm long violin string if waves on this string have a speed of 274.4 m/s?
35. The human ear canal is about 2.8 cm long and can be regarded as a tube open at one end and closed at the eardrum. What is the frequency around which we would expect hearing to be best when the speed of sound in air is 340 m/s? (Hint: Find the fundamental frequency for the ear canal.)