QUESTIONS FOR THOUGHT AND DISCUSSION

1. Present an argument to show that the maximum kinetic energy of a mass-spring vibrator is equal to the maximum potential energy. Does the total mechanical energy remain constant throughout a cycle?
2. A damped vibrator is found to decrease its amplitude by one-half every 30 s. What is its amplitude at the end of 5 min? In theory will it every stop vibrating? Will it in practice? Explain. (*Hint:* $(\frac{1}{2})^{10} = \frac{1}{1024} \simeq 0.001$.)
3. With the help of Figs. 2.10 and 2.12, make a diagram of the four independent longitudinal modes of vibration for a four-mass vibrator.
4. To excite a tuning fork in its principal mode of vibration with a minimum of "clang" sound, where should you strike it? Of the four microphone positions A, B, C, and D in Fig. 2.23, which will best pick up the sound of the fork? Why?

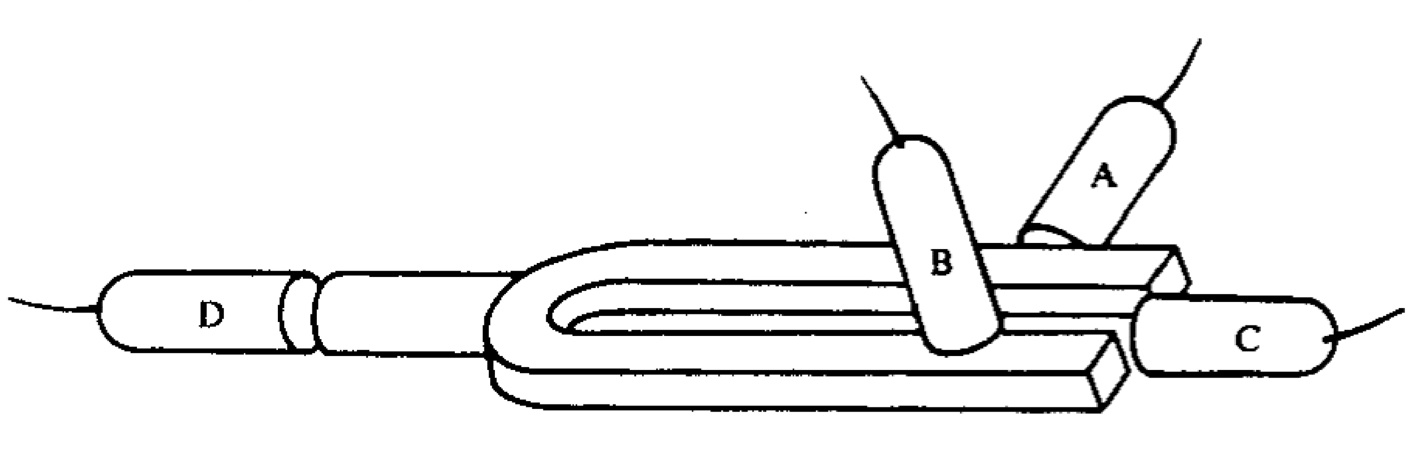

FIGURE 2.23

5. Why is the center arrow in Fig. 2.10(a) larger than the other two arrows?
6. Which Chladni patterns in Fig. 2.19 most nearly correspond to the second and fourth diagrams in Fig. 2.15? In what way are they different?

EXERCISES

1. Hanging a mass of 1 kg on a certain spring causes its length to increase 0.2 m.
   - **(a)** What is the spring constant K of that spring?
   - **(b)** At what frequency will this mass-spring system oscillate?
2. Copy the graphs of displacement and velocity shown in Fig. 2.2, and draw graphs of kinetic energy and potential to the same scale of time.
3. Most grandfather clocks have a pendulum that ticks (makes half a vibration) each second. What length of pendulum is required? (The value of g was given in Chapter 1 as 9.8 m/s^2.)
4. A bass-reflex loudspeaker enclosure (see Fig. 19.12) is essentially a Helmholtz resonator. Given the following parameters, what resonance frequency might be expected? $V = 0.5$ m^3, $a = 0.02$ m^2, $l = 0.05$ m, speed of sound $v = 343$ m/s at $T = 20$°C.
5. Calculate the maximum potential energy of the mass-spring system described in Problem 1 if its maximum displacement is 5 cm.
6. In the two-mass system shown in Fig. 2.7, each mass is 2 kg and each spring constant $K = 100$ N/m. Calculate the frequencies of modes (a) and (b).
7. Equation (2.3) for the frequency of a simple mass-spring vibrator assumes that the mass of the spring is much smaller than that of the load and thus can be neglected. This will not always be the case. The formula can be refined by letting m be the mass of the load plus one-third the mass of the spring. Suppose that the spring in the example in Section 2.1 has a mass of 100 g (K was found to be 196 N/m). Calculate the vibration frequencies with loads of 0.5 kg and 2 kg, and compare them to those given in the example.

EXPERIMENTS FOR HOME, LABORATORY, AND CLASSROOM DEMONSTRATION

Home and Classroom Demonstration

1. *Simple vibrating system: dependence of frequency on mass* Load a spring with several different masses and determine its frequency by counting oscillations during some appropriate time interval (such as a half-minute). What happens to the frequency when the mass is doubled? What happens when it is quadrupled?

2. *Simple vibrating system: dependence of frequency on spring constant* Determine the frequency of the simple vibrating system using several different spring constants. The spring constant can be determined by loading the spring with different masses and noting its static deflection, but this may not be necessary. Connecting two identical springs in series reduces the spring constant by half, whereas connecting them in parallel doubles the spring constant. What happens to the frequency when the spring constant is doubled? What happens when it is halved?