14.B PRACTICE

stretch of the rubber band. How can you tell from the graph whether or not the rubber band obeys Hooke's law?

If the graph is a straight line, the rubber band obeys Hooke's law. If the graph is curved, it does not.

11. **Pendulum** How must the length of a pendulum be changed to double its period? How must the length be changed to halve the period?

$PE_{sp} = \frac{1}{2}kx^2$, so

$$\frac{PE_1}{PE_2} = \frac{x_1^2}{x_2^2}$$

$$= \frac{(0.40\text{ m})^2}{(0.20\text{ m})^2}$$

$$= 4.0$$

The energy of the first spring is 4.0 times greater than the energy of the second spring.

12. **Energy of a Spring** What is the difference between the energy stored in a spring that is stretched 0.40 m and the energy stored in the same spring when it is stretched 0.20 m?

$T = 2\pi\sqrt{\frac{l}{g}}$, so $\frac{T_2}{T_1} = \sqrt{\frac{l_2}{l_1}}$

To double the period:

$$\frac{T_2}{T_1} = \sqrt{\frac{l_2}{l_1}} = 2, \text{ so } \frac{l_2}{l_1} = 4$$

The length must be quadrupled.

To halve the period:

$$\frac{T_2}{T_1} = \sqrt{\frac{l_2}{l_1}} = \frac{1}{2}, \text{ so } \frac{l_2}{l_1} = \frac{1}{4}$$

The length is reduced to one-fourth its original length.

13. **Resonance** If a car's wheel is out of balance, the car will shake strongly at a specific speed, but not when it is moving faster or slower than that speed. Explain.

At that speed, the tire's rotation frequency matches the resonant frequency of the car.

14. **Critical Thinking** How is uniform circular motion similar to simple harmonic motion? How are they different?

Both are periodic motions. In uniform circular motion, the accelerating force is not proportional to the displacement. Also, simple harmonic motion is one-dimensional and uniform circular motion is two-dimensional.

Practice Problems

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15. A sound wave produced by a clock chime is heard 515 m away 1.50 s later.

a. What is the speed of sound of the clock's chime in air?

$$v = \frac{d}{t}$$

$$= \frac{515\text{ m}}{1.50\text{ s}}$$

$$= 343\text{ m/s}$$

b. The sound wave has a frequency of 436 Hz. What is the period of the wave?

$$T = \frac{1}{f}$$

$$= \frac{1}{436\text{ Hz}}$$

$$= 2.29\times10^{-3}\text{ s}$$

c. What is the wave's wavelength?

$\lambda = \frac{v}{f}$ $v = \lambda f$

$$= \frac{343\text{ m/s}}{436\text{ Hz}}$$

$$= 0.787\text{ m}$$

16. A hiker shouts toward a vertical cliff 465 m away. The echo is heard 2.75 s later.

a. What is the speed of sound of the hiker's voice in air?

$$v = \frac{d}{t} = \frac{(2)(465\text{ m})}{2.75\text{ s}} = 338\text{ m/s}$$

b. The wavelength of the sound is 0.750 m. What is its frequency?

$v = \lambda f$, so $f = \frac{v}{\lambda} = \frac{338 \text{ m/s}}{0.750 \text{ m}} = 451 \text{ Hz}$

c. What is the period of the wave?

$T = \frac{1}{f} = \frac{1}{451 \text{ Hz}} = 2.22 \times 10^{-3} \text{ s}$

17. If you want to increase the wavelength of waves in a rope, should you shake it at a higher or lower frequency?

at a lower frequency, because wavelength varies inversely with frequency

18. What is the speed of a periodic wave disturbance that has a frequency of 3.50 Hz and a wavelength of 0.700 m?

$v = \lambda f = (0.700 \text{ m})(3.50 \text{ Hz}) = 2.45 \text{ m/s}$

19. The speed of a transverse wave in a string is 15.0 m/s. If a source produces a disturbance that has a frequency of 6.00 Hz, what is its wavelength?

$v = \lambda f$, so $\lambda = \frac{v}{f} = \frac{15.0 \text{ m/s}}{6.00 \text{ Hz}} = 2.50 \text{ m}$

20. Five pulses are generated every 0.100 s in a tank of water. What is the speed of propagation of the wave if the wavelength of the surface wave is 1.20 cm?

$\frac{0.100 \text{ s}}{5 \text{ pulses}} = 0.0200 \text{ s/pulse}$, so

$T = 0.0200 \text{ s}$

$\lambda = vT$, so

$v = \frac{\lambda}{T}$

$= \frac{1.20 \text{ cm}}{0.0200 \text{ s}} = 60.0 \text{ cm/s} = 0.600 \text{ m/s}$

$\lambda = 1.20 \text{ cm} = .0120 \text{ m}$

$t = 0.100 \text{ s}$ for 5 pulses

$\frac{.0120 \text{ m}}{.025}$

21. A periodic longitudinal wave that has a frequency of 20.0 Hz travels along a coil spring. If the distance between successive compressions is 0.600 m, what is the speed of the wave?

$v = \lambda f = (0.600 \text{ m})(20.0 \text{ Hz}) = 12.0 \text{ m/s}$

$f = 20 \text{ Hz}$

$\lambda = .6 \text{ m}$

$v = ?$

Section Review

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22. Speed in Different Media If you pull on one end of a coiled-spring toy, does the pulse reach the other end instantaneously? What happens if you pull on a rope? What happens if you hit the end of a metal rod? Compare and contrast the pulses traveling through these three materials.

It takes time for the pulse to reach the other end in each case. It travels faster on the rope than on the spring, and fastest in the metal rod.

23. Wave Characteristics You are creating transverse waves in a rope by shaking your hand from side to side. Without changing the distance that your hand moves, you begin to shake it faster and faster. What happens to the amplitude, wavelength, frequency, period, and velocity of the wave?

The amplitude and velocity remain unchanged, but the frequency increases while the period and the wavelength decrease.

24. Waves Moving Energy Suppose that you and your lab partner are asked to demonstrate that a transverse wave transports energy without transferring matter. How could you do it?

Tie a piece of yarn somewhere near the middle of a rope. With your partner holding one end of the rope, shake the other end up and down to create a transverse wave. Note that while the wave moves down the rope, the yarn moves up and down but stays in the same place on the rope.

25. Longitudinal Waves Describe longitudinal waves. What types of media transmit longitudinal waves?

In longitudinal waves, the particles of the medium vibrate in a direction parallel to the motion of the wave.