

REVIEW AND SYNTHESIS: CHAPTERS 9–12

Review Exercises

1. **Strategy** The magnitude of the buoyant force on an object in water is equal to the weight of the water displaced by the object.

Solution

(a) Lead is much denser than aluminum, so for the same mass, its volume is much less. Therefore, aluminum has the larger buoyant force acting on it; since it is less dense it occupies more volume.

(b) Steel is denser than wood. Even though the wood is floating, it displaces more water than does the steel. Therefore, wood has the larger buoyant force acting on it; since it displaces more water than the steel.

(c) Lead: $\rho_w g V_{\text{Pb}} = \rho_w g \frac{m_{\text{Pb}}}{\rho_{\text{Pb}}} = (1.00 \times 10^3 \text{ kg/m}^3)(9.80 \text{ m/s}^2) \frac{1.0 \text{ kg}}{11,300 \text{ kg/m}^3} = \boxed{0.87 \text{ N}}$

Aluminum: $\rho_w g V_{\text{Al}} = \rho_w g \frac{m_{\text{Al}}}{\rho_{\text{Al}}} = (1.00 \times 10^3 \text{ kg/m}^3)(9.80 \text{ m/s}^2) \frac{1.0 \text{ kg}}{2702 \text{ kg/m}^3} = \boxed{3.6 \text{ N}}$

Steel: $\rho_w g V_{\text{Steel}} = \rho_w g \frac{m_{\text{Steel}}}{\rho_{\text{Steel}}} = (1.00 \times 10^3 \text{ kg/m}^3)(9.80 \text{ m/s}^2) \frac{1.0 \text{ kg}}{7860 \text{ kg/m}^3} = \boxed{1.2 \text{ N}}$

Wood: $mg = (1.0 \text{ kg})(9.80 \text{ m/s}^2) = \boxed{9.8 \text{ N}}$ (Since the wood is floating, the buoyant force is equal to its weight.)

2. (a) **Strategy** The relationship between the fraction of a floating object's volume that is submerged to the ratio of the object's density to the fluid in which it floats is $V_f/V_o = \rho_o/\rho_f$.

Solution Find the percentage of the plastic that is submerged in the water.

$$\frac{V_{\text{submerged}}}{V_{\text{plastic}}} = \frac{\rho_{\text{plastic}}}{\rho_{\text{water}}} = \frac{890 \text{ kg/m}^3}{1.00 \times 10^3 \text{ kg/m}^3} = 0.89, \text{ or } \boxed{89\%}$$

- (b) **Strategy and Solution**

In Figure C, the plastic will actually rise. Think about it this way. In Figure B, the part of the plastic above the water has a buoyant force from the air lifting it up. Since air is not very dense, this force is not very strong. Diagram C is correct. The oil is very dense so the buoyant force from the oil is strong and the plastic rises.

- (c) **Strategy** The buoyant forces of the water and oil on the plastic are equal to the total buoyant force on the plastic.

Solution Let V_w and V_o be the volume of the plastic within the water and oil, respectively. Then, the total volume is $V_p = V_o + V_w$. Find the percentage of the plastic submerged in the water.

$$\begin{aligned}\rho_w g V_w + \rho_o g V_o &= \rho_p g V_p \\ \rho_w V_w + \rho_o (V_p - V_w) &= \rho_p V_p \\ \rho_w V_w - \rho_o V_w &= \rho_p V_p - \rho_o V_p \\ \frac{V_w}{V_p} &= \frac{\rho_p - \rho_o}{\rho_w - \rho_o} = \frac{890 - 830}{1000 - 830} = 0.35, \text{ or } \boxed{35\%}\end{aligned}$$

3. **Strategy** Use the continuity equation for incompressible fluids and Bernoulli's equation.

Solution Let the entrance point be 1 and the faucet be 2. Find v_1 , the speed of the water in the main pipe.

$$A_1 v_1 = A_2 v_2, \text{ so } v_2 = \frac{A_1}{A_2} v_1 = \frac{r_1^2}{r_2^2} v_1.$$

$$P_1 + \rho g y_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2} \rho v_2^2$$

$$v_1^2 = \frac{2(P_2 - P_1)}{\rho} + 2g(y_2 - y_1) + \left(\frac{r_1^2}{r_2^2} v_1\right)^2$$

$$\left(\frac{r_1^2}{r_2^2} v_1\right)^2 - v_1^2 = \frac{2(P_1 - P_2)}{\rho} - 2g(y_2 - y_1)$$

$$v_1 = \sqrt{\left[\frac{2(P_1 - P_2)}{\rho} - 2g(y_2 - y_1)\right] \left[\left(\frac{r_1}{r_2}\right)^4 - 1\right]^{-1}}$$

$$v_1 = \sqrt{\left[\frac{2(52.0 \times 10^3 \text{ Pa})}{1.00 \times 10^3 \text{ kg/m}^3} - 2(9.80 \text{ m/s}^2)(4.20 \text{ m} + 0.90 \text{ m})\right] \left[\left(\frac{5.00}{1.20}\right)^4 - 1\right]^{-1}} = \boxed{0.116 \text{ m/s}}$$

4. (a) **Strategy** As Arnold falls, gravity does $mgh = (82 \text{ kg})(9.80 \text{ m/s}^2)(10 \text{ m}) = 8.0 \text{ kJ}$ of work on him, so each of his legs must absorb about 4.0 kJ of energy when he lands; that is, each leg must do work $W = F_{\text{av}} \Delta y$ to bring him to rest.

Solution Compute the compressive stress on Arnold's legs.

The average force on each femur is $F_{\text{av}} = \frac{W}{\Delta y} = \frac{4000 \text{ J}}{0.005 \text{ m}} = 8.0 \times 10^5 \text{ N}$. So, the compressive stress on each

femur is $\frac{F_{\text{av}}}{A} = \frac{8.0 \times 10^5 \text{ N}}{5 \times 10^{-4} \text{ m}^2} = 2 \times 10^9 \text{ N/m}^2$. Since the compressive stress on each femur exceeds the maximum ultimate strength for compression, **Arnold's femur will break**.

- (b) **Strategy and Solution** This time, Arnold has 30 cm instead of 5 mm to come to a stop, and it is the snow that does the work. So, the average force is $\frac{4000 \text{ J}}{0.30 \text{ m}} = 1.3 \times 10^4 \text{ N}$ and the compressive stress is

$\frac{1.3 \times 10^4 \text{ N}}{5 \times 10^{-4} \text{ m}^2} = 3 \times 10^7 \text{ N/m}^2$. This time, the compressive stress is less than the maximum ultimate strength for compression, therefore, **Arnold's femur will not break**.

5. **Strategy** Use Eqs. (10-20a), (10-21), and (10-22), and Newton's second law.

Solution The normal force on the 1.0-kg block m_1 is $N = m_1g$. So, the force of friction on m_1 is $f = \mu N = \mu m_1g$.

Find the maximum acceleration that the top block can experience before it starts to slip.

$$\Sigma F = f = m_1a, \text{ so } a = \frac{f}{m_1} = \frac{\mu m_1g}{m_1} = \mu g.$$

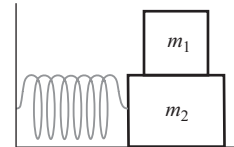
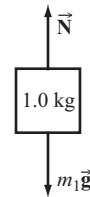
For SHM, the maximum acceleration is $a_m = \omega^2 A = \frac{k}{m} A$, which in this case is equal to

$$\frac{kA}{m_1 + m_2}. \text{ Equate the accelerations and solve for } A.$$

$$\frac{kA}{m_1 + m_2} = \mu g, \text{ so } A = \frac{\mu(m_1 + m_2)g}{k}.$$

The maximum speed is $v_m = \omega A$. Compute the maximum speed that this set of blocks can have without the top block slipping.

$$v_m = \omega A = \sqrt{\frac{k}{m_1 + m_2}} \left[\frac{\mu(m_1 + m_2)g}{k} \right] = \mu g \sqrt{\frac{m_1 + m_2}{k}} = 0.45(9.80 \text{ m/s}^2) \sqrt{\frac{1.0 \text{ kg} + 5.0 \text{ kg}}{150 \text{ N/m}}} = \boxed{0.88 \text{ m/s}}$$



6. **Strategy** Use Eq. (12-13) and conservation of energy.

Solution Find the maximum speed of the child, which occurs at the lowest point of her swing.

As the child swings toward the whistle (1), $v_o < 0$. As she swings away (2), $v_o > 0$.

$$1.040 = \frac{f_1}{f_2} = \left(1 + \frac{|v_o|}{v} \right) f_s \left[\left(1 - \frac{|v_o|}{v} \right) f_s \right]^{-1} = \frac{v + |v_o|}{v - |v_o|}, \text{ so}$$

$$1.040(v - |v_o|) = v + |v_o|, \text{ or } |v_o| = \frac{0.040v}{2.040} = \frac{0.040(343 \text{ m/s})}{2.040} = 6.7 \text{ m/s}.$$

At the lowest point of the swing, the kinetic energy is at its maximum and the potential energy is at its minimum. Find how high the child is swinging; that is, her maximum height.

$$mgh_{\max} = \frac{1}{2}mv_{\max}^2, \text{ so } h_{\max} = \frac{v_{\max}^2}{2g} = \frac{(6.7 \text{ m/s})^2}{2(9.80 \text{ m/s}^2)} = \boxed{2.3 \text{ m}}.$$

7. (a) **Strategy** Use Eq. (11-7).

Solution Compute the wave speed for each traveling wave.

$$v_{\text{I}} = \frac{\omega_{\text{I}}}{k_{\text{I}}} = \frac{6.00 \text{ s}^{-1}}{4.00 \text{ cm}^{-1}} = 1.50 \text{ cm/s} \text{ and } v_{\text{II}} = \frac{\omega_{\text{II}}}{k_{\text{II}}} = \frac{3.00 \text{ s}^{-1}}{3.00 \text{ cm}^{-1}} = 1.00 \text{ cm/s}.$$

Eq. I has the fastest wave speed of $\boxed{1.50 \text{ cm/s}}$.

- (b) **Strategy** Use Eq. (11-7).

Solution Compute the wavelengths for each traveling wave.

$$\lambda_{\text{I}} = \frac{2\pi}{k_{\text{I}}} = \frac{2\pi}{4.00 \text{ cm}^{-1}} = 1.57 \text{ cm} \text{ and } \lambda_{\text{II}} = \frac{2\pi}{k_{\text{II}}} = \frac{2\pi}{3.00 \text{ cm}^{-1}} = 2.09 \text{ cm}.$$

Eq. II has the longest wavelength of $\boxed{2.09 \text{ cm}}$.

- (c)
- Strategy**
- Use Eq. (10-21).

Solution Compute the maximum speed of a point in the medium for each traveling wave.

$$v_{\text{Im}} = \omega_{\text{I}} A_{\text{I}} = (6.00 \text{ s}^{-1})(1.50 \text{ cm}) = 9.00 \text{ cm/s} \quad \text{and} \quad v_{\text{IIIm}} = \omega_{\text{II}} A_{\text{II}} = (3.00 \text{ s}^{-1})(4.50 \text{ cm}) = 13.5 \text{ cm/s}.$$

Eq. II has the fastest maximum speed of a point in the medium of 13.5 cm/s.

- (d)
- Strategy and Solution**
- $kx - \omega t$
- indicates a wave is moving in the positive
- x
- direction and
- $kx + \omega t$
- indicates a wave is moving in the negative
- x
- direction. So,
- Eq. II
- is moving in the positive
- x
- direction.

8. (a)
- Strategy**
- Use Eq. (10-26a) and
- $\omega = 2\pi f$
- .

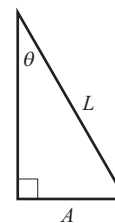
Solution Compute the frequency of the Foucault pendulum.

$$f = \frac{\omega}{2\pi} = \frac{1}{2\pi} \sqrt{\frac{g}{L}} = \frac{1}{2\pi} \sqrt{\frac{9.80 \text{ m/s}^2}{14.0 \text{ m}}} = \boxed{0.133 \text{ Hz}}$$

- (b)
- Strategy**
- Find the amplitude of the oscillation and use it and the frequency to find the maximum speed. Use Eq. (10-21).

Solution The amplitude of the oscillation is $A = L \sin \theta$. The maximum speed of the pendulum is

$$v_{\text{m}} = \omega A = \sqrt{\frac{g}{L}} L \sin \theta = \sqrt{gL} \sin \theta = \sqrt{(9.80 \text{ m/s}^2)(14.0 \text{ m})} \sin 6.10^\circ = \boxed{1.24 \text{ m/s}}.$$



- (c)
- Strategy**
- The maximum speed and tension occur at the equilibrium position. Use Newton's second law.

Solution Find the maximum tension.

$$\Sigma F_y = F - mg = ma_r = m \frac{v^2}{r} = m \frac{v_{\text{m}}^2}{L}, \text{ so}$$

$$F = m \left(g + \frac{v_{\text{m}}^2}{L} \right) = (15.0 \text{ kg}) \left[9.80 \text{ m/s}^2 + \frac{(1.24 \text{ m/s})^2}{14.0 \text{ m}} \right] = \boxed{149 \text{ N}}.$$



- (d)
- Strategy**
- Use Eqs. (11-2) and (11-13).

Solution Find the fundamental frequency of the wire.

$$f_1 = \frac{v}{2L} = \frac{1}{2L} \sqrt{\frac{FL}{m}} = \sqrt{\frac{F}{4Lm}} = \sqrt{\frac{149 \text{ N}}{4(14.0 \text{ m})(0.0100 \text{ kg})}} = \boxed{16.3 \text{ Hz}}$$

9. (a)
- Strategy**
- Use Eqs. (11-2) and (11-13).

Solution Find the tension in the guitar string.

$$f_1 = \frac{v}{2L} = \frac{1}{2L} \sqrt{\frac{FL}{m}} = \sqrt{\frac{F}{4Lm}}, \text{ so } F = 4Lmf_1^2 = 4(0.655 \text{ m})(0.00331 \text{ kg})(82 \text{ Hz})^2 = \boxed{58 \text{ N}}.$$

- (b)
- Strategy**
- Use Eqs. (11-4) and (11-13).

Solution Find the length of the lowest frequency string when it is fingered at the fifth fret.

$$f_1 = \frac{v}{2L} = \frac{1}{2L} \sqrt{\frac{F}{\mu}}, \text{ so } L = \frac{1}{2f_1} \sqrt{\frac{F}{\mu}} = \frac{1}{2(110 \text{ Hz})} \sqrt{\frac{58 \text{ N}}{0.00331 \text{ kg}/(0.655 \text{ m})}} = \boxed{49 \text{ cm}}.$$

10. **Strategy** Use Eq. (11-4) and $\Delta x = v\Delta t$.

Solution Find the time it takes for the wave pulse to travel from one child to the other.

$$\Delta t = \frac{\Delta x}{v} = \Delta x \sqrt{\frac{\mu}{F}} = (12 \text{ m}) \sqrt{\frac{0.0013 \text{ kg/m}}{8.0 \text{ N}}} = \boxed{0.15 \text{ s}}$$

11. **Strategy** For two adjacent steps, the extra distance traveled by the wave reflected from the upper step is twice the tread depth. For the waves to cancel, they must be one-half wavelength out of phase or an odd multiple of one-half wavelength. Therefore, the minimum tread depth is half of one-half wavelength or one-quarter wavelength.

Solution Find the minimum tread depth d_{\min} .

$$\lambda = \frac{v}{f}, \text{ so } d_{\min} = \frac{\lambda}{4} = \frac{v}{4f} = \frac{343 \text{ m/s}}{4(400.0 \text{ Hz})} = \boxed{21.4 \text{ cm}}.$$

12. (a) **Strategy** First, treat the brick wall as the observer. Next, treat the wall as the source. Use Eq. (12-12).

Solution The motion of Akiko is in the direction of sound propagation, so $v_{\text{Akiko}} > 0$.

$$f_{\text{wall}} = f_o = \frac{1}{1 - \frac{v_s}{v}} f_s = \frac{1}{1 - \frac{v_{\text{Akiko}}}{v}} f_{\text{Akiko}}$$

Now, since the wall and Haruki are stationary, there is no further Doppler effect. So,

$$f_{\text{Haruki}} = f_{\text{wall}} = \frac{1}{1 - \frac{v_{\text{Akiko}}}{v}} f_{\text{Akiko}} = \frac{1}{1 - \frac{7.00 \text{ m/s}}{343 \text{ m/s}}} (512.0 \text{ Hz}) = \boxed{522.7 \text{ Hz}}.$$

- (b) **Strategy** The situation is similar to that of part (a), but instead of a stationary Haruki, we have Junichi as an observer moving in the direction of propagation of the sound reflected from the wall ($v_{\text{Junichi}} > 0$). Use Eq. (12-13).

Solution

$$f_{\text{Junichi}} = f_o = \left(1 - \frac{v_o}{v}\right) f_s = \left(1 - \frac{v_{\text{Junichi}}}{v}\right) f_{\text{wall}} = \left(1 - \frac{2.00 \text{ m/s}}{343 \text{ m/s}}\right) (522.67 \text{ Hz}) = \boxed{519.6 \text{ Hz}}$$

13. **Strategy** The frequency of the sound is increased by a factor equal to the number of holes in the disk. Use Eq. (11-6).

Solution The frequency of the sound is

$$f = 25(60.0 \text{ Hz}) = \boxed{1500 \text{ Hz}}.$$

Compute the wavelength that corresponds to this frequency.

$$\lambda = \frac{v}{f} = \frac{343 \text{ m/s}}{1.50 \times 10^3 \text{ Hz}} = \boxed{22.9 \text{ cm}}$$

14. **Strategy** Use Eqs. (11-4) and (11-13).

Solution Find the frequency in terms of the tension.

$$f_1 = \frac{v}{2L} = \frac{1}{2L} \sqrt{\frac{F}{\mu}}$$

Form a proportion to find the new fundamental frequency.

$$\frac{f_2}{f_1} = \frac{1}{2L} \sqrt{\frac{3F}{\mu}} \left(2L \sqrt{\frac{\mu}{F}} \right) = \sqrt{3}, \text{ so } f_2 = \sqrt{3} f_1 = \sqrt{3}(847 \text{ Hz}) = \boxed{1470 \text{ Hz}}.$$

15. **Strategy and Solution** There are 1000 cm^3 in 1 L. The heart pumps blood at a rate of

$\frac{80 \text{ cm}^3}{\text{s}} \times \frac{60 \text{ s}}{1 \text{ min}} = 4800 \text{ cm}^3/\text{min}$. Since $5 \text{ L} = 5000 \text{ cm}^3 \approx 4800 \text{ cm}^3$, it takes about 1 minute for the medicine to travel throughout the body.

16. **Strategy** Use Eq. (11-6).

Solution

(a) The initial wavelength is $\lambda = \frac{v}{f} = \frac{341 \text{ m/s}}{1231 \text{ Hz}} = \boxed{27.7 \text{ cm}}$.

(b) The frequency of the sound in the wall is the same as it was in the air. Therefore, the wavelength of the sound in the wall is $\lambda = \frac{v}{f} = \frac{620 \text{ m/s}}{1231 \text{ Hz}} = \boxed{50 \text{ cm}}$.

(c) The frequency and the speed of sound are the same as before they entered the wall, so the wavelength is 27.7 cm.

17. **Strategy** The source is moving in the direction of propagation of the sound, so $v_s > 0$. The observer is moving in the direction opposite the propagation of the sound, so $v_o < 0$. Use Eq. (12-14).

Solution Find the frequency heard by the passenger in the oncoming boat.

$$f_o = \frac{v - v_o}{v - v_s} f_s = \frac{343 \text{ m/s} - (-15.6 \text{ m/s})}{343 \text{ m/s} - 20.1 \text{ m/s}} (312 \text{ Hz}) = \boxed{346 \text{ Hz}}$$

18. (a) **Strategy** The wavelength of the diaphragm is 0.20 m. The frequency of the gas in the tube is the same as that of the diaphragm. Use Eq. (11-6).

Solution Find the speed of sound in the gas.

$$v = f\lambda = (1457 \text{ Hz})(0.20 \text{ m}) = \boxed{290 \text{ m/s}}$$

- (b) **Strategy and Solution**

The piles of sawdust represent displacement nodes: regions where the air remains at rest. They also represent pressure antinodes.

19. (a) **Strategy** Use the continuity equation for incompressible fluids and Bernoulli's equation.

Solution Let the lower end be 1 and the upper end be 2. Find the speed of the water as it exits the pipe.

$$A_1 v_1 = A_2 v_2, \text{ so } v_2 = \frac{A_1}{A_2} v_1 = \frac{r_1^2}{r_2^2} v_1 = \left(\frac{10.0}{6.00}\right)^2 (15.0 \text{ cm/s}) = \boxed{41.7 \text{ cm/s}}.$$

Find the pressure at the lower end.

$$P_1 + \rho g y_1 + \frac{1}{2} \rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2} \rho v_2^2$$

$$P_1 = P_2 + \rho g (y_2 - y_1) + \frac{1}{2} \rho (v_2^2 - v_1^2)$$

$$P_1 = 101.3 \text{ kPa} + (1.00 \times 10^3 \text{ kg/m}^3) \left\{ (9.80 \text{ m/s}^2)(1.70 \text{ m}) + \frac{1}{2} \left[\left(\frac{10.0}{6.00}\right)^4 - 1 \right] (0.150 \text{ m/s})^2 \right\}$$

$$P_1 = \boxed{118 \text{ kPa}}$$

- (b) **Strategy** Use the equations of motion for a changing velocity.

Solution Find the time it takes for the water to fall to the ground.

$$\Delta y = v_i \sin \theta \Delta t - \frac{1}{2} g (\Delta t)^2$$

$$0 = g (\Delta t)^2 - 2 v_i \sin \theta \Delta t + 2 \Delta y$$

$$\Delta t = \frac{2 v_i \sin \theta \pm \sqrt{4 v_i^2 \sin^2 \theta - 8 g \Delta y}}{2 g}$$

$$\Delta t = \frac{2(0.4167 \text{ m/s}) \sin 60.0^\circ \pm \sqrt{4(0.4167 \text{ m/s})^2 \sin^2 60.0^\circ - 8(9.80 \text{ m/s}^2)(-0.300 \text{ m})}}{2(9.80 \text{ m/s}^2)}$$

$$\Delta t = 0.287 \text{ s} \quad (-0.213 \text{ s is rejected, since time is positive.})$$

The horizontal distance from the pipe outlet where the water lands is

$$\Delta x = v_i \cos \theta \Delta t = (41.7 \text{ cm/s}) \cos 60.0^\circ (0.287 \text{ s}) = \boxed{5.98 \text{ cm}}.$$

20. **Strategy** The standing wave is the first harmonic, f_2 . The wave is in position B one-quarter period after it is in position A. It is in position C one-half period after it is in position A. Use Eqs. (11-4) and (11-13).

Solution

The speed of the wave on the string is $v = \sqrt{\frac{F}{\mu}}$, so $f_2 = \frac{v}{L} = \frac{1}{L} \sqrt{\frac{F}{\mu}}$.

The period is $T = \frac{1}{f_2} = L \sqrt{\frac{\mu}{F}} = (0.720 \text{ m}) \sqrt{\frac{0.200 \times 10^{-3} \text{ kg/m}}{2.00 \text{ N}}} = 7.20 \text{ ms}$.

Since the string is at A when $t = 0$, it will be at least one period before a photo of the string can be taken at position A; then it will be another period before the second photo can be taken. Therefore, the two earliest times after $t = 0$ that the string can be photographed in position A are $\boxed{7.20 \text{ ms and } 14.4 \text{ ms}}$. Unlike positions A and C, which only appear once per period, position B occurs twice per period. The string is at position B one-quarter period ($T/4$) after it is at position A, and it will be at position B again an additional one-half period later ($T/4 + T/2 = 3T/4$); therefore, the two earliest times after $t = 0$ that the string can be photographed in position B are $\boxed{1.80 \text{ ms and } 5.40 \text{ ms}}$. The string is at position C one-half period ($T/2$) after it is at position A, and it will be at position C again an additional period later ($T/2 + T = 3T/2$); therefore, the two earliest times after $t = 0$ that the string can be photographed in position C are $\boxed{3.60 \text{ ms and } 10.8 \text{ ms}}$.

MCAT Review

1. **Strategy** The buoyant force on the brick is equal in magnitude to the weight of the volume of water it displaces.

Solution The brick is completely submerged, so its volume is equal to that of the displaced water. The weight of the displaced water is $30\text{ N} - 20\text{ N} = 10\text{ N}$. Find the volume of the brick.

$$\rho_w g V_w = \rho_w g V_{\text{brick}} = 10\text{ N}, \text{ so } V_{\text{brick}} = \frac{10\text{ N}}{\rho_w g} = \frac{10\text{ N}}{(1000\text{ kg/m}^3)(10\text{ m/s}^2)} = 1 \times 10^{-3}\text{ m}^3$$

The correct answer is .

2. **Strategy** The expansion of the cable obeys $F = k\Delta L$.

Solution Compute the expansion of the cable.

$$\Delta L = \frac{F}{k} = \frac{5000\text{ N}}{5.0 \times 10^6\text{ N/m}} = 10^{-3}\text{ m}$$

The correct answer is .

3. **Strategy** Solve for the intensity in the definition of sound level.

Solution Find the intensity of the fire siren.

$$\text{SL} = 10 \log_{10} \frac{I}{I_0}, \text{ so } I = I_0 10^{\text{SL}/10} = (1.0 \times 10^{-12}\text{ W/m}^2) 10^{100/10} = 1.0 \times 10^{-2}\text{ W/m}^2.$$

The correct answer is .

4. **Strategy and Solution** The two centimeters of liquid with a specific gravity of 0.5 are equivalent to one centimeter of water; that is, the 6-cm column of liquid is equivalent to a 5-cm column of water. Therefore, the new gauge pressure at the base of the column is five-fourths the original. The correct answer is .

5. **Strategy** The wavelength is inversely proportional to the index n . Let $\lambda_n = 8\text{ m}$ and $\lambda_{n+2} = 4.8\text{ m}$.

Solution Find n .

$$L = \frac{n\lambda_n}{4} = \frac{(n+2)\lambda_{n+2}}{4}, \text{ so } \frac{\lambda_n}{\lambda_{n+2}} = \frac{n+2}{n} = 1 + \frac{2}{n}, \text{ or } n = 2 \left(\frac{\lambda_n}{\lambda_{n+2}} - 1 \right)^{-1}.$$

Compute L .

$$L = \frac{n\lambda_n}{4} = 2 \left(\frac{\lambda_n}{\lambda_{n+2}} - 1 \right)^{-1} \frac{\lambda_n}{4} = \frac{1}{2} \left(\frac{8\text{ m}}{4.8\text{ m}} - 1 \right)^{-1} (8\text{ m}) = 6\text{ m}$$

The correct answer is .

6. **Strategy** The wave may interfere within the range of possibility of totally constructive or totally destructive interference.

Solution For totally constructive interference, the amplitude of the combined waves is $5 + 3 = 8$ units. For totally destructive interference, the amplitude of the combined waves is $5 - 3 = 2$ units. The correct answer is .

7. **Strategy and Solution** As the bob repeatedly swings to and fro, it speeds up and slows down, as well as changes direction. Therefore, its linear acceleration must change in both magnitude and direction.

The correct answer is D .

8. **Strategy** Since $K \propto v^2$ and $v \propto r^{-4}$, $K \propto r^{-8}$.

Solution Compute the ratio of kinetic energies.

$$\frac{K_2}{K_1} = \left(\frac{2}{1}\right)^{-8} = \frac{1}{256} = \frac{1}{4^4} \text{ or } K_2 : K_1 = 1 : 4^4.$$

The correct answer is B .

9. **Strategy** The buoyant force on a ball is equal to the weight of the volume of water displaced by that ball.

Solution Since B_1 is not fully submerged and B_2 and B_3 are, the buoyant force on B_1 is less than the buoyant forces on the other two. Since B_2 and B_3 are fully submerged, the buoyant forces on each are the same.

The correct answer is B .

10. **Strategy and Solution** Ball 1 is floating, so its density is less than that of the water. Since Ball 2 is submerged within the water, its density is the same as that of the water. Ball 3 is sitting on the bottom of the tank, so its density is greater than that of the water. The correct answer is A .

11. **Strategy** The supporting force of the bottom of the tank is equal to the weight of Ball 3 less the buoyant force of the water.

Solution Compute the supporting force on Ball 3.

$$\begin{aligned} \rho_{\text{Ball 3}} g V_{\text{Ball 3}} - \rho_{\text{water}} g V_{\text{Ball 3}} &= g V_{\text{Ball 3}} (\rho_{\text{Ball 3}} - \rho_{\text{water}}) \\ &= (9.80 \text{ m/s}^2)(1.0 \times 10^{-6} \text{ m}^3)(7.8 \times 10^3 \text{ kg/m}^3 - 1.0 \times 10^3 \text{ kg/m}^3) = 6.7 \times 10^{-2} \text{ N} \end{aligned}$$

The correct answer is B .

12. **Strategy** The relationship between the fraction of a floating object's volume that is submerged to the ratio of the object's density to the fluid in which it floats is $V_f/V_o = \rho_o/\rho_f$. So, the fraction of the object that is not submerged is $V_{\text{ns}} = 1 - V_f/V_o = 1 - \rho_o/\rho_f$.

Solution Find the fraction of the volume of Ball 1 that is above the surface of the water.

$$1 - \frac{\rho_{\text{Ball 1}}}{\rho_{\text{water}}} = 1 - \frac{8.0 \times 10^2 \text{ kg/m}^3}{1.0 \times 10^3 \text{ kg/m}^3} = \frac{1}{5}$$

The correct answer is D .

13. **Strategy** The pressure difference at a depth d in water is given by $\rho_{\text{water}} g d$.

Solution Compute the approximate difference in pressure between the two balls.

$$\rho_{\text{water}} g d = (1.0 \times 10^3 \text{ kg/m}^3)(9.80 \text{ m/s}^2)(0.20 \text{ m}) = 2.0 \times 10^3 \text{ N/m}^2$$

The correct answer is C .

- 14. Strategy** For the force exerted on Ball 3 by the bottom of the tank to be zero, Ball 3 must have the same density as the water.

Solution Find the volume of the hollow portion of Ball 3, V_H .

$$\rho_{\text{Ball 3}} = \frac{m_{\text{Ball 3}}}{V_{\text{Ball 3}}} = \frac{\rho_{\text{Fe}} V_{\text{Fe}}}{V_{\text{Ball 3}}} = \rho_{\text{water}} \quad \text{and} \quad V_H = V_{\text{Ball 3}} - V_{\text{Fe}}, \quad \text{so}$$

$$V_H = V_{\text{Ball 3}} - \frac{\rho_{\text{water}}}{\rho_{\text{Fe}}} V_{\text{Ball 3}} = V_{\text{Ball 3}} \left(1 - \frac{\rho_{\text{water}}}{\rho_{\text{Fe}}} \right) = (1.0 \times 10^{-6} \text{ m}^3) \left(1 - \frac{1.0 \times 10^3 \text{ kg/m}^3}{7.8 \times 10^3 \text{ kg/m}^3} \right) = 0.87 \times 10^{-6} \text{ m}^3.$$

The correct answer is C.