1. A sonar unit on a submarine sends out a pulse of sound into seawater. The pulse returns 1.500 seconds later. What is the distance (in meters) to the object that reflects the pulse back to the submarine? Assume the velocity of sound in water is 1500 m/s.

\[ x = \frac{1}{2} vt \]

\[ x = 1130 \text{ m} \]

2. The linear density of a string on a violin is \( 6.2 \times 10^{-4} \text{ kg/m} \). A wave on the string has a frequency of 520 Hz and a wavelength of 50 cm. What is the tension (in Newtons) in the string?

\[ v = \sqrt{\frac{F}{m/L}} \]

\[ v = f \lambda \]

\[ F = \frac{v^2}{L} \cdot \frac{m}{L} = f^2 \lambda^2 \left( \frac{m}{L} \right) \]

\[ F = 42 \text{ N} \]

(10) Not enough information
3. A loudspeaker at the base of a cliff emits a pure tone of frequency 3500 Hz. A dog jumps from rest from the top of the cliff and safely falls into a net below. How far (in meters) has the dog fallen at the instant that the dog hears a frequency of the tone as 3718 Hz? Assume the speed of sound is 343 m/s.

\[ f_o = f_s \left( 1 + \frac{V_o}{V} \right) \]

\[ V_{o,bs} = V \left[ \frac{f_o}{f_s} - 1 \right] \]

\[ v^2 = \frac{V_{o,bs}^2}{2 \alpha} + 2 \alpha \chi \]

\[ \chi = \frac{v^2}{2 \alpha} = \frac{V_{o,bs}^2}{2 \alpha} \left[ \frac{f_o}{f_s} - 1 \right]^2 \]

\[ \chi = -23.3 \text{ m} \]

4. A transverse periodic wave described by the expression

\[ y = \sin[2 \pi \left( \frac{x}{2} + \frac{t}{10} \right)] \]

(where \( x \) and \( y \) are in meters and \( t \) is in seconds) is established on a string. Which one of the following statements concerning this wave is false?

(1) The wave is traveling in the negative \( x \) direction
(2) The amplitude is 1.0 m
(3) The frequency of the wave is 0.10 Hz
(4) The wavelength of this wave is 2.0 m
(5) The wave travels with speed 5.0 m/s

\[ A = 1 \]
\[ f = 0.1 \text{ Hz} \]
\[ \lambda = 2 \text{ m} \]
\[ v = f \lambda = 0.2 \text{ m/s} \]
5. A 1.0 kg wheel in the form of a hoop rolls along a horizontal surface with a speed of 6.0 m/s. What is the total kinetic energy?

\[ KE = \frac{1}{2} m v^2 + \frac{1}{2} I \omega^2 \]

\[ v = \omega R \quad \Rightarrow \quad \omega = \frac{v}{R} \]

\[ I_{\text{hoop}} = mR^2 \]

\[ KE = \frac{1}{2} m v^2 + \frac{1}{2} m R^2 \frac{v^2}{R^2} \]

\[ KE = m v^2 = 36 \]

6. A system containing an ideal gas at a constant pressure of \(1.23 \times 10^5\) Pa gains 1970 J of heat. During the process, the internal energy of the system increases by 2320 J. What is the change in volume (in m\(^3\)) of the gas?

\[ \Delta U = Q - W = Q - P \Delta V \]

\[ \Delta V = \frac{Q - \Delta U}{P} = -2.85 \times 10^{-3} \text{ m}^3 \]

(1) \(4.82 \times 10^2\)
(2) \(-2.85 \times 10^{-3}\)
(3) \(-4.82 \times 10^2\)
(4) \(2.28 \times 10^{-1}\)
(5) \(-1.48 \times 10^3\)
(6) \(-2.28 \times 10^5\)
(7) \(1.48 \times 10^{-1}\)
(8) \(3.49 \times 10^2\)
(9) \(2.85 \times 10^{-3}\)

(10) There is no change in volume
7. The surface of the sun has a temperature of about $6.0 \times 10^3$ K. This hot gas contains hydrogen atoms (mass = $1.67 \times 10^{-27}$ kg). Find the rms speed (in m/s) of these atoms.

\[ v = \sqrt{\frac{3kT}{m}} \]

(1) 2.4 x 10^4
(2) 0
(3) 0.92 x 10^4
(4) 23.0 x 10^4
(5) 0.73 x 10^4
(6) 0.023 x 10^4
(7) 0.060 x 10^4
(8) 5.3 x 10^4
(9) 48.0 x 10^4
(10) 1.2 x 10^4

8. Calculate the final velocity (in m/s) of a 120 kg football player initially running at 9.00 m/s who collides head on with a padded goalpost and experiences a backward force of $1.86 \times 10^4$ N for $6.50 \times 10^{-2}$ seconds.

\[ \Delta \rho = F \Delta t \]

\[ m (v_f - v_i) = F \Delta t \]

\[ v_f = \frac{F \Delta t + v_i}{m} \]

(1) 10.8 m/s
(2) 9.00 m/s
(3) 0.42 m/s
(4) 0.665 m/s
(5) 1.08 m/s
(6) 0.800 m/s
(7) 0 m/s
(8) 8.8 m/s
(9) 0.186 m/s
(10) not enough information

\[ \text{direction of } F \text{ neg, } v_i \text{ pos.} \]

\[ \text{or} \]

\[ \text{direction of } F \text{ pos, } v_i \text{ neg} \]

depends on which or in which direction the player is initially running.
9. The coefficient of linear expansion of steel is $12 \times 10^{-6}/\degree C$. A railroad track is made of individual rails of steel 0.75 km in length. By what length (in meters) would these rails change between a cold day when the temperature is $-20 \degree C$ and a hot day when the temperature is $40 \degree C$?

\[
DL = \alpha L_0 \Delta T
\]

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10. The design of a flat circular roof (radius of 5 meters) allows it to withstand a maximum net outward force of 20000 N. The density of air 1.29 kg/m³. At what wind speed (in m/s) will this roof blow off?

\[
\begin{align*}
\rho_1 - \rho_2 &= \frac{1}{2} \rho \left( V_z^2 - V_i^2 \right) = \frac{1}{2} \rho V_z^2 \\
\frac{F_{\text{net}}}{A} &= \frac{1}{2} \rho V_z^2 \\
V_z &= \sqrt{2 \frac{F_{\text{net}}}{\rho A}} \\
A &= \pi r^2
\end{align*}
\]

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