This print-out should have 26 questions, check that it is complete. Multiple-choice questions may continue on the next column or page: find all choices before making your selection. The due time is Central time.

Chapters 16 and 17 problems.

001 (part 1 of 2) 0 points
A wave moving along the $x$ axis is described by

$$y(x, t) = A e^{-\frac{(x+vt)^2}{b}}$$

where $x$ is in meters and $t$ is in seconds. Given $A = 4$ m, $v = 5$ m/s, and $b = 4$ m$^2$.

Determine the speed of the wave.

Correct answer: 5 m/s.

Explanation:

$y(x, t)$ is of the form $y(x, t) = f(x + vt)$ so it describes a wave moving in the negative $x$ direction at

$$v = 5 \text{ m/s}.$$

002 (part 2 of 2) 0 points
Determine the direction of the wave.

1. $-y$ direction
2. $+y$ direction
3. $-x$ direction correct
4. $+x$ direction

Explanation:

003 (part 1 of 5) 2 points
The wave function for a linearly polarized wave on a taut string is

$$y(x, t) = A \sin(\omega t - k x + \phi),$$

where $A = 0.57$ m, $\omega = 9.3$ s$^{-1}$, $k = 4.9$ m$^{-1}$, $\phi = 0.55$, $t$ is in seconds and $x$ and $y$ are in meters.

What is the speed of the wave?
Correct answer: 1.89796 m/s.

Explanation:

Basic Concepts:

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

$$k = \frac{2\pi}{\lambda},$$

$$f = \frac{\omega}{2\pi}$$

Solution: For the propagation speed of a wave we have

$$v = \frac{\omega}{k} = \frac{(9.3 \text{ s}^{-1})}{(4.9 \text{ m}^{-1})} = 1.89796 \text{ m/s}.$$
006 (part 4 of 5) 2 points
What is the frequency of the wave?
Correct answer: 1.48014 Hz.

**Explanation:**
Since \( \omega = 2 \pi f \), we have

\[
f = \frac{\omega}{2 \pi} = \frac{(9.3 \text{ s}^{-1})}{2 \pi} = 1.48014 \text{ Hz}.
\]

007 (part 5 of 5) 2 points
What is the maximum magnitude of the transverse speed of the string?
Correct answer: 5.301 m/s.

**Explanation:**
Taking derivative of \( y \) over \( t \), we find magnitude of the transverse speed of the string:

\[
v_y = \frac{\partial y(x,t)}{\partial t} = A \omega \cos(\omega t - k x + \phi).
\]

Thus \( v_{y,\text{max}} \) assumes its maximum value when

\[
\omega t - k x + \phi = 2 \pi n, n = 0, 1, 2, \ldots; \ i.e., \ \cos(\omega t - k x + \phi) = 1,
\]

so

\[
v_{y,\text{max}} = A \omega = (0.57 \text{ m}) (9.3 \text{ s}^{-1}) = 5.301 \text{ m/s}.
\]

008 (part 1 of 3) 0 points
A string of length 2.7 m consists of two sections. The left half has mass per unit length 0.000205 kg/m, while the right has a mass per unit length 0.000615 kg/m. Tension in the string is 855 N. Notice from the data given that this string has the same total mass as a uniform string of length 2.7 m and mass per unit length 0.00041 kg/m.

Find the speed at which transverse wave pulses travel in the left section.
Correct answer: 2042.24 m/s.

**Explanation:**

The speed of wave in the left section of mass per unit length \( \mu_1 \) is

\[
v_1 = \sqrt{\frac{F}{\mu_1}} = \sqrt{\frac{855 \text{ N}}{0.000205 \text{ kg/m}}} = 2042.24 \text{ m/s}.
\]

009 (part 2 of 3) 0 points
Find the speed at which transverse wave pulses travel in the right section.
Correct answer: 1179.09 m/s.

**Explanation:**

The speed of wave in the right section of mass per unit length \( \mu' \) is

\[
v_2 = \sqrt{\frac{F}{\mu_2}} = \sqrt{\frac{855 \text{ N}}{0.000615 \text{ kg/m}}} = 1179.09 \text{ m/s}.
\]

010 (part 3 of 3) 0 points
Find the time required for a pulse to travel from one end of the string to the other.
Correct answer: 0.00180599 s.

**Explanation:**

The time for a pulse traveling through the string is

\[
t = \frac{L}{2 v_1} + \frac{L}{2 v_2} = \frac{2.7 \text{ m}}{2 (2042.24 \text{ m/s})} + \frac{2.7 \text{ m}}{2 (1179.09 \text{ m/s})} = 0.00180599 \text{ s}.
\]

011 (part 1 of 5) 2 points
A sinusoidal wave traveling in the \(-x\) direction (to the left) has an amplitude of 16.7 cm, a wavelength of 15.8 cm and a frequency of 14.1 Hz. The displacement of the wave at \( t = 0 \) and \( x = 0 \) is \( y = -4.8 \text{ cm} \) and has a positive velocity here.

Find the angular wave number of the wave.
Correct answer: 39.767 \text{ rad/m}.
Explanation:
For a sinusoidal wave with wavelength \( \lambda \) and frequency \( f \), the angular wave number
\[
k = \frac{2 \pi}{\lambda} = \frac{(2)(100) \pi}{15.8 \text{ cm}} = 39.767 \text{ rad/m}.
\]

\[012\] (part 2 of 5) 2 points
Find the period of the wave.
Correct answer: 0.070922 s.
Explanation:
The period is
\[
T = \frac{1}{f} = \frac{1}{14.1 \text{ Hz}} = 0.070922 \text{ s}.
\]

\[013\] (part 3 of 5) 2 points
Find the angular frequency of the wave.
Correct answer: 88.5929 rad/s.
Explanation:
The angular frequency is
\[
\omega = 2 \pi f = 2 \pi (14.1 \text{ Hz}) = 88.5929 \text{ rad/s}.
\]

\[014\] (part 4 of 5) 2 points
Find the phase velocity of the wave.
Correct answer: 2.2278 m/s.
Explanation:
The phase velocity is
\[
v = f \lambda
\]
\[
= (14.1 \text{ Hz})(15.8 \text{ cm})(0.01 \text{ m/cm})
\]
\[
= 2.2278 \text{ m/s}.
\]

\[015\] (part 5 of 5) 2 points
Find the magnitude of the phase constant of the wave.
Correct answer: 16.7039 °.
Explanation:
A sinusoidal wave traveling in the \(-x\) direction can be written as
\[
y = A \sin(k x + \omega t - \phi),
\]
so at \( t = 0 \) and \( x = 0 \) we have
\[
y = A \sin(-\phi)
\]
which gives the phase constant
\[
\phi = \sin^{-1} \left[ -\frac{y}{A} \right] = \sin^{-1} \left[ -\frac{(-4.8 \text{ cm})}{(16.7 \text{ cm})} \right] = 16.7039°.
\]

\[016\] (part 1 of 5) 0 points
A sinusoidal wave train is described by
\[
y = (0.25 \text{ m}) \sin \left[ (0.3 \text{ m}^{-1}) x - (40 \text{ s}^{-1}) t \right],
\]
where \( x \) and \( y \) are in meters and \( t \) is in seconds.
Determine for this wave the amplitude.
Correct answer: 0.25 m.
Explanation:
For a sinusoidal wave described by
\[
y = A \sin(k x + \omega t),
\]
where its amplitude is \( A = 0.25 \text{ m} \), angular wave number \( k = 0.3 \text{ m}^{-1} \), angular frequency \( \omega = 40 \text{ s}^{-1} \), wavelength \( \lambda = \frac{2 \pi}{k} = 20.944 \text{ m} \) and wave speed \( v = \frac{\omega}{k} = 133.333 \text{ m/s} \).

\[017\] (part 2 of 5) 0 points
Determine for this wave the angular frequency.
Correct answer: 40 s\(^{-1}\).
Explanation:
See Part 1.

\[018\] (part 3 of 5) 0 points
Determine for this wave the wave number.
Correct answer: 0.3 m\(^{-1}\).
Explanation:
See Part 1.

\[019\] (part 4 of 5) 0 points
Determine for this wave the wavelength.
Correct answer: 20.944 m.
Explanation:
\[
\lambda = \frac{2 \pi}{k} = \frac{2 \pi}{(0.3 \text{ m}^{-1})} = 20.944 \text{ m}.
\]
020 (part 5 of 5) 0 points
Determine for this wave the wave speed.
Correct answer: 133.333 m/s.
Explanation:
\[ v = \frac{\omega}{k} = \frac{40 \text{ s}^{-1}}{0.3 \text{ m}^{-1}} = 133.333 \text{ m/s}. \]

021 (part 1 of 1) 10 points
Given: The speed of the lightwaves in air is \( 3 \times 10^8 \) m/s. The speed of sound waves in air is 333 m/s.
What is the time lapse between seeing a lightening strike and hearing the thunder if the lightening flash is 24 km away?
Correct answer: 72.072 s.
Explanation:
The time for the light to travel 24 km is
\[ t_1 = \frac{d}{v_1} = \frac{24 \text{ km}}{3 \times 10^8 \text{ m/s}} = 8 \times 10^{-8} \text{ s}. \]
The time for the sound to travel 24 km is
\[ t_2 = \frac{d}{v_2} = \frac{24 \text{ km}}{333 \text{ m/s}} = 72 \text{ s}. \]
Thus, the time lapse is
\[ \Delta t = t_2 - t_1 = 72.072 \text{ s}. \]

022 (part 1 of 3) 0 points
A sinusoidal sound wave is described by the displacement
\[ s(x, t) = s_m \cos(kx - \omega t), \]
where \( s_m = 4.59 \) µm, \( k = 14 \) rad/m, and \( \omega = 977 \) rad/s.

023 (part 2 of 3) 0 points
Determine the instantaneous displacement of the molecules at the position \( x = 0.0626 \) m at \( t = 3.82 \) ms.
Correct answer: −4.40375 µm.
Explanation:
Directly from the formula for the displacement given
\[ \alpha = kx - \omega t = (14 \text{ rad/m})(0.0626 \text{ m}) - 977 \text{ rad/s} \times 0.00382 \text{ s} = -2.85574 \text{ rad}, \]
therefore
\[ s = s_m \cos(kx - \omega t) = 4.59 \mu m \cos(-2.85574 \text{ rad}) = -4.40375 \mu m. \]

024 (part 3 of 3) 0 points
Determine the maximum speed of the molecules’ oscillatory motion.
Correct answer: 0.00448443 m/s.
Explanation:
Differentiating the equation given with respect to time and setting the sin function equal to 1 (maximum), we obtain for the maximum speed (absolute value of the maximum velocity)
\[ v_{\max} = s_m \omega = (4.59 \mu m)(977 \text{ rad/s}) = 4484.43 \mu m/s = 0.00448443 \text{ m/s}. \]
025 (part 1 of 2) 5 points
In order to be able to determine her speed, a skydiver carries a tone generator. A friend on the ground at the landing site has equipment for receiving and analyzing sound waves. While the skydiver is falling at terminal speed, her tone generator emits a steady tone of 1260 Hz.

Assume: The air is calm and that the sound speed is 343 m/s, independent of altitude.

If her friend on the ground (directly beneath the skydiver) receives waves of frequency 2890 Hz, what is the skydiver’s speed of descent?
Correct answer: 193.457 m/s.

Explanation:
Since the diver, who is the source of the sound waves, is moving towards her friend on the ground, who is the receiver of the waves, the Doppler formula takes the form

\[ f_g = f_e \frac{v}{v - v_{\text{diver}}} \]

So

\[ 1 - \frac{v_{\text{diver}}}{v} = \frac{f_e}{f_g} \]

Solving for \( v_{\text{diver}} \), we have

\[ v_{\text{diver}} = v \left[ 1 - \frac{f_e}{f_g} \right] \]

\[ = (343 \text{ m/s}) \left[ 1 - \frac{(1260 \text{ Hz})}{(2890 \text{ Hz})} \right] \]

\[ = 193.457 \text{ m/s} \]

026 (part 2 of 2) 5 points
If the skydiver were also carrying sound-receiving equipment sensitive enough to detect waves reflected from the ground, what frequency would she receive?
Correct answer: 4520 Hz.

Explanation:
If the waves are reflected, and the skydiver is moving towards them, we have

\[ f_{\text{rec}} = f_g \left[ \frac{v + v_{\text{diver}}}{v} \right] \]

\[ = (2890 \text{ Hz}) \]