Ch 15 HW

Due: 4:20pm on Monday, August 31, 2015

You will receive no credit for items you complete after the assignment is due. Grading Policy

Exercise 15.1

Description: The speed of sound in air at 20 degree(s) C is 344 m/s. (a) What is the wavelength of a sound wave with a frequency of 784 Hz, corresponding to the note G_5 on a piano? (b) How many milliseconds does each vibration take? (c) What is the wavelength ...

The speed of sound in air at 20 $^{\circ}$C is 344 m/s.

Part A

What is the wavelength of a sound wave with a frequency of 784 Hz, corresponding to the note G_5 on a piano?

ANSWER:

$\lambda =$ 0.439 m

Part B

How many milliseconds does each vibration take?

ANSWER:

$T =$ 1.28 ms

Part C

What is the wavelength of a sound wave one octave higher than the note in part A?

ANSWER:

$\lambda =$ 0.219 m

Exercise 15.3

Description: On December 26, 2004, a great earthquake occurred off the coast of Sumatra and triggered immense waves (tsunami) that killed some 200000 people. Satellites observing these waves from space measured 800 km from one wave crest to the next and a period...

On December 26, 2004, a great earthquake occurred off the coast of Sumatra and triggered immense waves (tsunami) that killed some 200000 people. Satellites observing these waves from space measured 800 kmfrom one wave crest to the next and a period between waves of 1.0 hour.

Part A

What was the speed of these waves in m/s?

Express your answer using two significant figures.

ANSWER:

v = 220 m/s

Part B

What was the speed of these waves in km/h?

Express your answer using two significant figures.

ANSWER:

v = 800 km/h

Part C

How does your answer help you understand why the waves caused such devastation?

ANSWER:

3723 Character(s) remaining

Since the wave speed is very high, the wave strikes with

Exercise 15.4

Description: Ultrasound is the name given to frequencies above the human range of hearing, which is about 20000 Hz. Waves above this frequency can be used to penetrate the body and to produce images by reflecting from surfaces. In a typical ultrasound scan, the...

Ultrasound is the name given to frequencies above the human range of hearing, which is about 20000 Hz. Waves above this frequency can be used to penetrate the body and to produce images by reflecting from surfaces. In a typical ultrasound scan, the waves travel with a speed of 1500 m/s. For a good detailed image, the wavelength should be no more than 1.0 mm.

Part A

What frequency is required?

ANSWER:

f = 1.50×10^{6} Hz

Exercise 15.8

Description: A certain transverse wave is described by y(x, t)=B cos (2 pi ((x/L) - (t/tau))),where B=## mm, lambda=## cm, and T=## s. (a) Determine the wave's amplitude. (b) Determine the wave's wavelength. (c) Determine the wave's frequency. (d)...

A certain transverse wave is described by

$$y(x,t)=B\cos[2\pi(x/L-t/\tau)],$$

where B = 6.60 mm , L = 25.0 cm , and $\tau = 3.90\times10^{-2}$ s .

Part A

Determine the wave's amplitude.

ANSWER:

$A = B = 6.60\times10^{-3}$ m

Part B

Determine the wave's wavelength.

ANSWER:

$\lambda = \lambda = 0.250$ m

Part C

Determine the wave's frequency.

ANSWER:

$f = \frac{1}{T} = 25.6$ Hz

Part D

Determine the wave's speed of propagation.

ANSWER:

$v = \frac{\lambda}{T} = 6.41$ m/s

Part E

Determine the wave's direction of propagation.

ANSWER:

- +*x* direction
- -*x* direction

Exercise 15.12

Description: The equation y(x,t)=A cos 2 pi f ((x/v)-t) may be written as y(x, t)=A cos (((2 pi)/(lambda))(x-vt)). (a) Use the last expression for y(x,t) to find an expression for the transverse velocity v_y of a particle in the string on which the wave...

The equation $y(x,t)=A\cos 2\pi f(x/v-t)$ may be written as $y(x,t)=A\cos[2\pi/\lambda(x-vt)]$.

Part A

Use the last expression for $y(x,t)$ to find an expression for the transverse velocity v_y of a particle in the string on which the wave travels.

Express your answer in terms of the variables A, v, λ, x, t, and appropriate constants.

ANSWER:

$v_y = \frac{2\pi v}{\lambda} A \sin\left(\frac{2\pi}{\lambda}(x - vt)\right)$

Part B

Find the maximum speed of a particle of the string.

Express your answer in terms of the variables A, v, λ, x, t, and appropriate constants.

ANSWER:

$v_{max} = \frac{2\pi v}{\lambda} A$

Exercise 15.16

Description: (a) With what tension must a rope with length L and mass m be stretched for transverse waves of frequency f to have a wavelength of lambda?

Part A

With what tension must a rope with length 2.80 m and mass 0.135 kg be stretched for transverse waves of frequency 45.0 Hz to have a wavelength of 0.720 m ?

ANSWER:

$T = \frac{m}{L}(f\lambda)^2 = 50.6$ N

Exercise 15.18

Description: A l-m string of weight w is tied to the ceiling at its upper end, and the lower end supports a weight W. Neglect the very small variation in tension along the length of the string that is produced by the weight of the string. When you pluck the...

A 1.70-m string of weight 0.0127 N is tied to the ceiling at its upper end, and the lower end supports a weight W. Neglect the very small variation in tension along the length of the string that is produced by the weight of the string. When you pluck the string slightly, the waves traveling up the string obey the equation
$y(x,t) = (8.50\text{mm})\cos(172\text{rad}\cdot\text{m}^{-1}x - 2730\text{rad}\cdot\text{s}^{-1}t)$
Assume that the tension of the string is constant and equal to W.

Part A

How much time does it take a pulse to travel the full length of the string?

ANSWER:

$t = \frac{l \cdot 172}{2730} = 0.107$ s

Part B

What is the weight *W*?

ANSWER:

$W = \frac{\frac{w}{9.8}}{l}\left(\frac{2730}{172}\right)^2 = 0.192$ N

Part C

How many wavelengths are on the string at any instant of time?

ANSWER:

$n = \frac{\frac{l}{2}}{\pi} \cdot 172 = 47$

Part D

What is the equation for waves traveling *down* the string?

ANSWER:

- $y(x,t)=(8.50\text{mm})\cos(172\text{rad}\cdot\text{m}^{-1}x-2730\text{rad}\cdot\text{s}^{-1}t)$
- $y(x,t)=(8.50\text{mm})\cos(172\text{rad}\cdot\text{m}^{-1}x+2730\text{rad}\cdot\text{s}^{-1}t)$
- $y(x,t)=(10.5\text{mm})\cos(172\text{rad}\cdot\text{m}^{-1}x+2730\text{rad}\cdot\text{s}^{-1}t)$
- $y(x,t)=(10.5\text{mm})\cos(172\text{rad}\cdot\text{m}^{-1}x-2730\text{rad}\cdot\text{s}^{-1}t)$

Exercise 15.20: Weighty Rope

Description: One end of a nylon rope is tied to a stationary support at the top of a vertical mine shaft of depth h. The rope is stretched taut by a box of mineral samples with mass m_1 attached at the lower end. The mass of the rope is m_2. The geologist at the...

One end of a nylon rope is tied to a stationary support at the top of a vertical mine shaft of depth 80.0 m . The rope is stretched taut by a box of mineral samples with mass 21.0 kg attached at the lower end. The mass of the rope is 2.10 kg . The geologist at the bottom of the mine signals to his colleague at the top by jerking the rope sideways. (Do *not* neglect the weight of the rope.)

Part A

What is the wave speed at the bottom of the rope?

ANSWER:

$v = \sqrt{\frac{m_1}{m_2} gh}$ = 88.5 m/s

Part B

What is the wave speed at the middle of the rope?

ANSWER:

$v = \sqrt{\frac{m_1 + \frac{m_2}{2}}{m_2} gh}$ = 90.7 m/s

Part C

What is the wave speed at the top of the rope?

ANSWER:

$v = \sqrt{\frac{m_1 + m_2}{m_2} gh}$ = 92.9 m/s

Exercise 15.25

Description: A jet plane at take-off can produce sound of intensity I at r away. But you prefer the tranquil sound of normal conversation, which is 1.0 mu (W/m)^2. Assume that the plane behaves like a point source of sound. (a) What is the closest distance you...

A jet plane at take-off can produce sound of intensity 10.0 W/m2 at 30.1 m away. But you prefer the tranquil sound of normal conversation, which is 1.0 μW/m2. Assume that the plane behaves like a point source of sound.

Part A

What is the closest distance you should live from the airport runway to preserve your peace of mind?

Express your answer using two significant figures.

ANSWER:

$r = round\left(\frac{r\sqrt{I \cdot 1000000}}{1000}\right)$ = 95 km

Part B

What intensity from the jet does your friend experience if she lives twice as far from the runway as you do?

Express your answer using two significant figures.

ANSWER:

I = 0.25 μW/m2

Part C

What power of sound does the jet produce at take-off?

Express your answer using two significant figures.

ANSWER:

P = $round\left(Ir^2 \cdot 4 \cdot 3.14, 4\right)$ = 1.1×10^5 W

Exercise 15.26

Description: You are investigating the report of a UFO landing in an isolated portion of New Mexico, and encounter a strange object that is radiating sound waves uniformly in all directions. Assume that the sound comes from a point source and that you can ignore...

You are investigating the report of a UFO landing in an isolated portion of New Mexico, and encounter a strange object that is radiating sound waves uniformly in all directions. Assume that the sound comes from a point source and that you can ignore reflections. You are slowly walking toward the source. When you are 7.5 m from it, you measure its intensity to be 0.11W/m2.

Part A

An intensity of 1.0W/m2 is often used as the "threshold of pain". How much closer to the source can you move before the sound intensity reaches this threshold?

Express your answer using two significant figures.

ANSWER:

d = 5.0 m

Exercise 15.29

Description: At a distance of r from a star, the intensity of the radiation from the star is I. (a) Assuming that the star radiates uniformly in all directions, what is the total power output of the star?

At a distance of 9.00×10^{12} m from a star, the intensity of the radiation from the star is 15.2 W/m2 .

Part A

Assuming that the star radiates uniformly in all directions, what is the total power output of the star?

Express your answer with the appropriate units.

ANSWER:

P = $4\pi r^2 I$ = 1.55×10^{28} W

Exercise 15.33

Description: Two triangular wave pulses are traveling toward each other on a stretched string as shown in the figure . Each pulse is identical to the other and travels at 2.00 cm/s. The leading edges of the pulses are 1.00 cm apart at t = 0. (a) Sketch the shape...

Two triangular wave pulses are traveling toward each other on a stretched string as shown in the

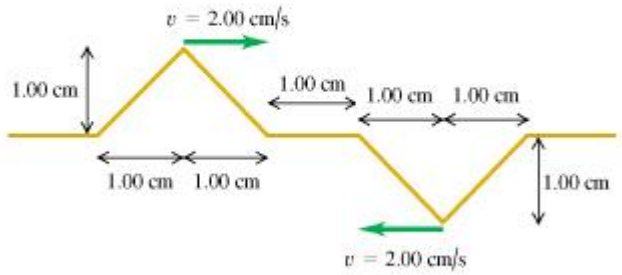
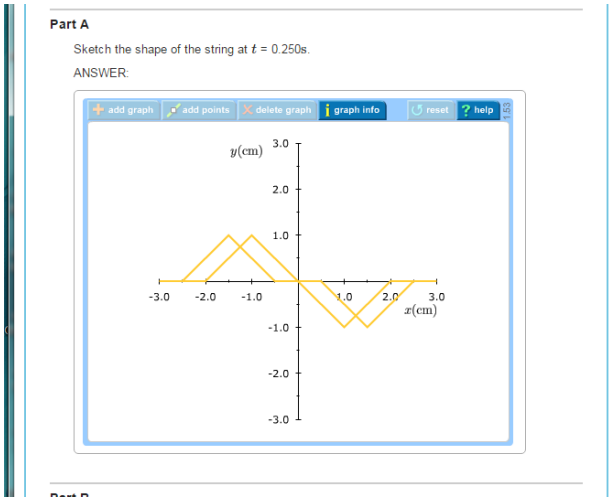


figure . Each pulse is identical to the other and travels at 2.00 cm/s. The leading edges of the pulses are 1.00 cm apart at $t = 0$.

Part A

Sketch the shape of the string at $t = 0.250$s.

ANSWER:



Part B

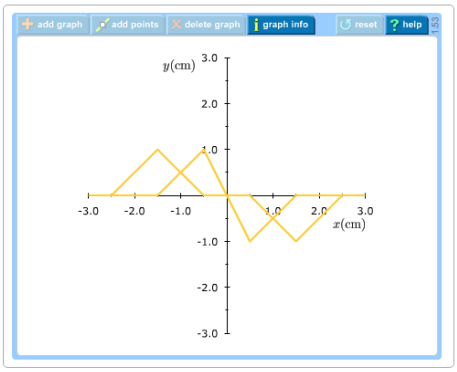
Sketch the shape of the string at $t = 0.500$s.

ANSWER:

Part B

Sketch the shape of the string at t = 0.500s.

ANSWER:



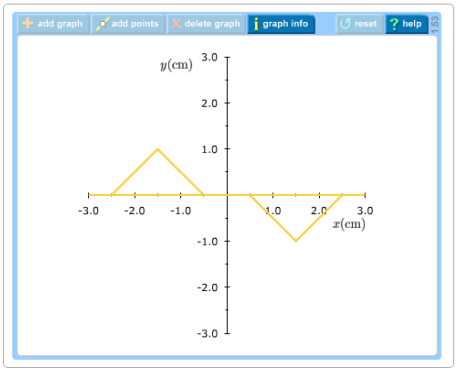
Part C

Sketch the shape of the string at t= 0.750s.

ANSWER:

Sketch the shape of the string at t= 0.750s.

ANSWER:



Part D

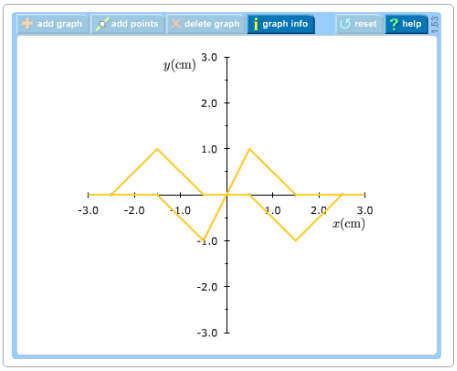
Sketch the shape of the string at t = 1.000s.

ANSWER:

Part D

Sketch the shape of the string at t = 1.000s.

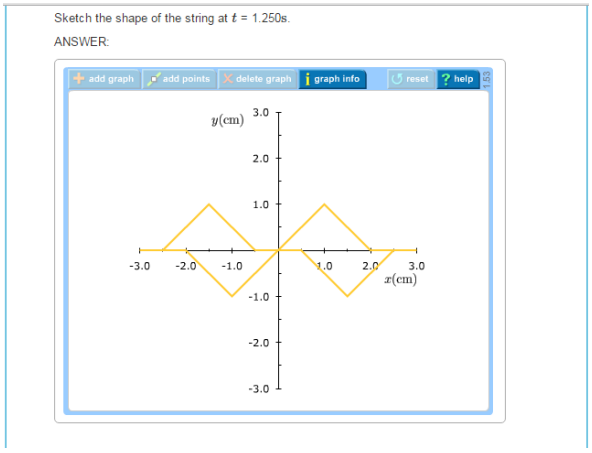
ANSWER:



Part E

Sketch the shape of the string at t = 1.250s.

ANSWER:



Exercise 15.46

Description: One string of a certain musical instrument is l long and has a mass of m. It is being played in a room where the speed of sound is 344 m/s. (a) To what tension must you adjust the string so that, when vibrating in its second overtone, it produces...

One string of a certain musical instrument is 73.0 cm long and has a mass of 8.74 g . It is being played in a room where the speed of sound is 344 m/s.

Part A

To what tension must you adjust the string so that, when vibrating in its second overtone, it produces sound of wavelength 0.758 m ? (Assume that the breaking stress of the wire is very large and isn't exceeded.)

ANSWER:

$T = \frac{\frac{m}{\lambda^2} \cdot 344^2 \cdot 4}{9} l$ N

= 584

Part B

What frequency sound does this string produce in its fundamental mode of vibration?

ANSWER:

$f = \frac{\frac{344}{\lambda}}{3}$ Hz

= 151

Exercise 15.40

Description: A rope of length L is stretched between two supports with a tension that makes the transverse waves have a speed of v. (a) What is the wavelength of the fundamental harmonic? (b) What is the frequency of the fundamental harmonic? (c) What is the...

A rope of length 1.60 m is stretched between two supports with a tension that makes the transverse waves have a speed of 47.9 m/s .

Part A

What is the wavelength of the fundamental harmonic?

ANSWER:

$\lambda = 2L$ = 3.20 m

Part B

What is the frequency of the fundamental harmonic?

ANSWER:

$f = \frac{v}{2L}$ = 15.0 Hz

Part C

What is the wavelength of the second overtone?

ANSWER:

$\lambda = \frac{2L}{3}$ = 1.07 m

Part D

What is the frequency of the second overtone?

ANSWER:

$f = \frac{3v}{2L} = 44.9$ Hz

Part E

What is the wavelength of the fourth harmonic?

ANSWER:

$\lambda = \frac{2L}{4} = 0.800$ m

Part F

What is the frequency of the fourth harmonic?

ANSWER:

$f = \frac{4v}{2L} = 59.9$ Hz

Exercise 15.42

Description: A piano tuner stretches a steel piano wire with a tension of 800 N. The steel wire is 0.400 m long and has a mass of 3.00 g. (a) What is the frequency of its fundamental mode of vibration? (b) What is the nurmber of the highest hamonic that could ...

A piano tuner stretches a steel piano wire with a tension of 800 N. The steel wire is 0.400 m long and has a mass of 3.00 g.

Part A

What is the frequency of its fundamental mode of vibration?

ANSWER:

$f = 408$ Hz

Part B

What is the nurmber of the highest hamonic that could be heard by a person who is capable of hearing frequencies up to 10000 Hz?

ANSWER:

$N = 24$

Problem 15.77

Description: A uniform cylindrical steel wire, l long and d in diameter, is fixed at both ends. (a) To what tension must it be adjusted so that, when vibrating in its first overtone, it produces the note [...] of frequency 311 Hz? Assume that it stretches an...

A uniform cylindrical steel wire, 58.0 cm long and 1.19 mm in diameter, is fixed at both ends.

Part A

To what tension must it be adjusted so that, when vibrating in its first overtone, it produces the note D# of frequency 311 Hz? Assume that it stretches an insignificant amount. (*Hint:* The density of the steel is 7800kg/m3.)

Express your answer using two significant figures.

ANSWER:

$T =$ $round\left(7800 \cdot 3.14 \left(\frac{d}{2}\right)^2 \cdot 311^2 l^2, 1\right)$ $= 280$ N

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