PHYS 1320 (Spring 2024) Sonnenfeld Online HW #1 Waves

**Problem 1:** Sound travels at a speed of $v$ = ***1490*** m/s in water. While underwater a student hears a $f$ = ***1.5*** kHz note in a whale song.

**Randomized Variables**

$v$ = ***1490*** m/s
$f$ = ***1.5*** kHz
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**Part (a)** Input an expression for the wavelength of the sound wave in water $\lambda_w$.
**Expression** :
$\lambda_w$ = ________________________________________

Select from the variables below to write your expression. Note that all variables may not be required.
**α, β, θ, a, d, f, g, h, j, k, m, P, S, t, v**

**Part (b)** What is the wavelength in meters?
**Numeric** : A numeric value is expected and not an expression.
$\lambda_w$ = ________________________________________

**Problem 2:** Two waves on a string are moving towards each other as shown in the figure.
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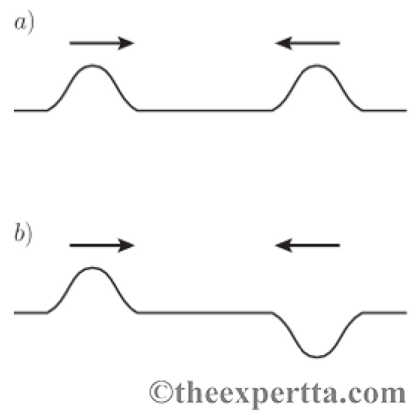
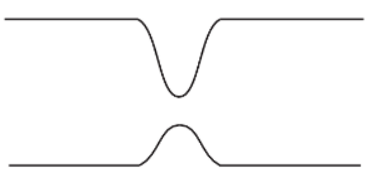
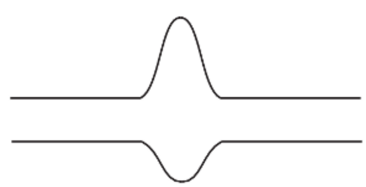
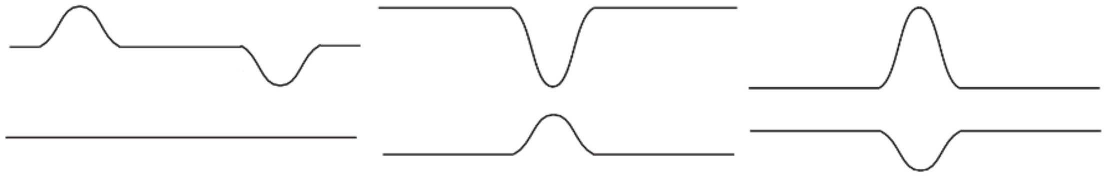





**Part (a)** What will the string look like from figure (a) at the moment their peaks collide?
**SchematicChoice** :

**Part (b)** What will the string look like from figure (b) at the moment their peaks collide?
**SchematicChoice** :



**Problem 3:** Special sections of roadway are sometimes paved with "rumble strips" to alert inattentive drivers. In a particular case the grooves are spaced $L = 0.26$ m apart and the depth of each groove is $d = 0.45$ cm. As you drive over this rumble strip, the tires of your car oscillate about their equilibrium positions with a frequency of $f = 67$ Hz. Refer to the figure, which is not drawn to scale.

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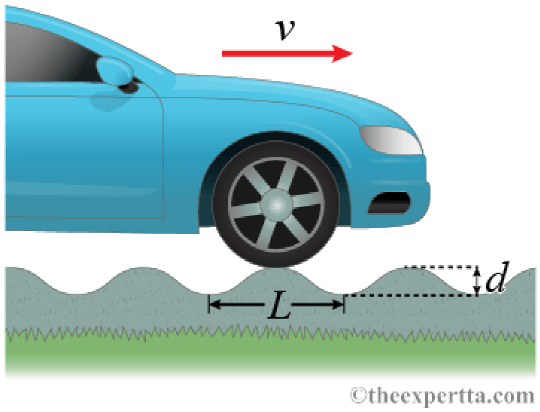




**Part (a)** Enter an expression that describes the vertical position, $y(t)$, of one of the car tires as a function of time, $t$, in terms of the defined quantities. Assume the motion is sinusoidal, with its argument in radians and the positive $y$-axis up. Take the tire's equilibrium position as $y = 0$ and take $y(0) = 0$ and increasing.
**MultipleChoice** :

1) $y(t) = \frac{1}{2}dcos(2\pi ft)$
2) $y(t) = \frac{1}{2}dsin(2\pi ft)$
3) $y(t) = dsin(ft)$
4) $y(t) = dsin(2\pi ft)$
5) $y(t) = dcos(ft)$
6) $y(t) = dcos(2\pi ft)$

**Part (b)** Find the vertical position of the tire, in centimeters, at the time $t = 1.1$ seconds.
**Numeric** : A numeric value is expected and not an expression.
$y(t)$ = ____________________________________________ cm

**Part (c)** With your tire oscillating at a frequency of $f = 67$ hertz and the distance between grooves $L = 0.26$ m, what is the speed of your car, in kilometers per hour?
**Numeric** : A numeric value is expected and not an expression.
$v$ = ____________________________________________ km/h

**Problem 4:** "Noise cancelling headphones" are a kind of headphones which decrease the amount of background noise that get into your ears when you wear them.

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On what physical phenomena do these headphones depend on?
**MultipleChoice** :

1) destructive interference
2) constructive interference
3) the Doppler Effect
4) beat frequency

**Problem 5:** The speed of a wave on a string depends on specific properties of the string.
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Which of the following ratios represent characteristics of a medium that determine wave speed? Select all that apply.
**MultipleSelect** :

1) inertia/density
2) bulk modulus/Young's modulus
3) restoring force/density
4) Young's modulus/density
5) resistance to deformation/(mass/volume)
6) bulk modulus/density

**Problem 6:** A traveling wave along the $x$-axis is given by the following wave function

$$\psi(x, t) = 3.6 \cos(1.1x - 11t + 0.56),$$

where $x$ in meter, $t$ in seconds, and $\psi$ in meters. Read off the appropriate quantities for this wave function and find the following characteristics of this plane wave:
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**Part (a)** The amplitude in meters.
**Numeric** : A numeric value is expected and not an expression.
***a*** = ____________________________________________

**Part (b)** The frequency, in hertz.
**Numeric** : A numeric value is expected and not an expression.
***f*** = ____________________________________________

**Part (c)** The wavelength in meters.
**Numeric** : A numeric value is expected and not an expression.
$\lambda$ = ____________________________________________

**Part (d)** The wave speed, in meters per second.
**Numeric** : A numeric value is expected and not an expression.
$v$ = ____________________________________________

**Part (e)** The phase constant in radians.
**Numeric** : A numeric value is expected and not an expression.
$\beta$ = ____________________________________________

**Problem 7:** A string is under a tension of $T$ = ***124*** N. The string has a mass of $m$ = ***7*** g and length $L$. When the string is played the velocity of the wave on the string is $V$ = ***296*** m/s.

**Randomized Variables**

$T$ = ***124*** N

$m$ = ***7*** g

$V$ = ***296*** m/s
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**Part (a)** What is the length of the string, in meters?
**Numeric** : A numeric value is expected and not an expression.
$L$ = ____________________________________________

**Part (b)** If $L$ is one wavelength, what is the frequency, in hertz?
**Numeric** : A numeric value is expected and not an expression.
$v$ = ____________________________________________

**Problem 8:** Using special techniques called *string harmonics* (or "flageolet tones"), stringed instruments can produce the first few overtones of the harmonic series. While a violinist is playing some of these harmonics for us, we take a picture of the vibrating string (see figures). Using an oscilloscope, we find the violinist plays a note with frequency $f$ = ***760*** Hz in figure (a).
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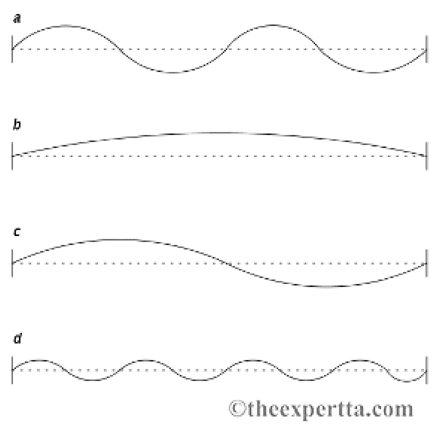




**Part (a)** How many nodes does the standing wave in figure (a) have?
**Numeric** : A numeric value is expected and not an expression.
$N$ = ____________________________________________

**Part (b)** How many antinodes does the standing wave in figure (a) have?
**Numeric** : A numeric value is expected and not an expression.
***n*** = ____________________________________________

**Part (c)** The string length of a violin is about L = 33 cm. What is the wavelength of the standing wave in figure (a) in meters?
**Numeric** : A numeric value is expected and not an expression.
$\lambda$ = ____________________________________________

**Part (d)** The fundamental frequency is the lowest frequency that a string can vibrate at (see figure (b)). What is the fundamental frequency for our violin in Hz?
**Numeric** : A numeric value is expected and not an expression.
$f_1$ = ____________________________________________

**Part (e)** In terms of the fundamental frequency $f_1$, what is the frequency of the note the violinist is playing in figure (c)?
**Expression** :
$f_c$ = ____________________________________________

Select from the variables below to write your expression. Note that all variables may not be required.
**β, γ, θ, b, c, d, $f_1$, g, h, j, k, m, n, P, S**

**Part (f)** Write a general expression for the frequency of any note the violinist can play in this manner, in terms of the fundamental frequency $f_1$ and the *n*, the number of antinodes on a standing wave.
**Expression** :
***f*** = ____________________________________________

Select from the variables below to write your expression. Note that all variables may not be required.
**β, γ, θ, b, c, d, $f_1$, g, h, j, k, m, n, P, S**

**Part (g)** What is the frequency, in hertz, of the note the violinist is playing in figure (d)?
**Numeric** : A numeric value is expected and not an expression.
$f_d$ = ____________________________________________

**Problem 9:** A guitar string of length *L* = ***0.75*** m is oriented along the x-direction and under a tension of *T* = ***108*** N. The string is made of steel which has a density of $\rho$ = 7800 kg / $m^3$. The radius of the string is *r* = ***8.4*** x $10^{-4}$ m.
A transverse wave of amplitude *A* = 0.0020 m is formed on the string.
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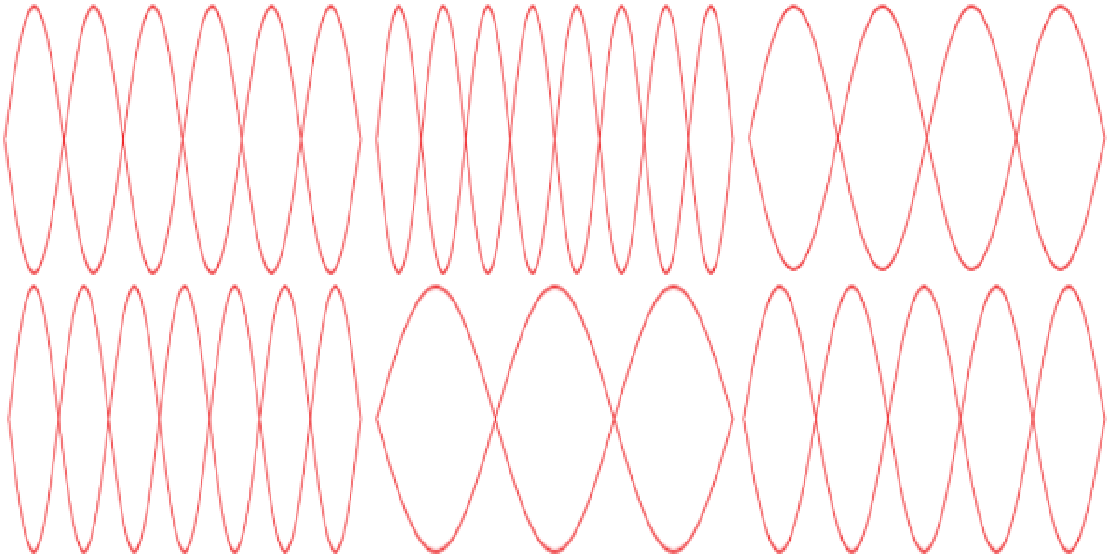
**Part (a)** Calculate the mass per unit length $\mu$ of the guitar string in kg/m.
**Numeric** : A numeric value is expected and not an expression.
$\mu$ = ____________________________________________

**Part (b)** Calculate the velocity (in m/s) of a traveling transverse wave on the guitar string.
**Numeric** : A numeric value is expected and not an expression.
***v*** = ____________________________________________

**Part (c)** Choose the image that represents the fourth harmonic.
**SchematicChoice** :



**Problem 10:** Two transverse waves travel along the same taut string. Wave 1 is described by $y_1(x, t) = A \sin(kx - \omega t)$, while wave 2 is described by $y_2(x, t) = A \sin(kx + \omega t + \varphi)$. The phases (arguments of the sines) are in radians, as usual, and $A$ = ***2.7*** cm and $\varphi$ = ***0.15***π rad.

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**Part (a)** Choose the answer that correctly describes the waves’ directions of travel.
**MultipleChoice** :

1) Wave 1 travels in the positive *x*-direction, while wave 2 travels in the negative *x*-direction.
2) There is not enough information.
3) Both waves travel in the negative *x* direction.
4) Both waves travel in the positive *x*-direction.
5) Due to the $\varphi$ term in the phase of wave 2, it does not travel. Wave 1 travels in the positive *x*-direction.
6) Wave 1 travels in the negative *x*-direction, while wave 2 travels in the positive *x*-direction.
7) Due to the $\varphi$ term in the phase of wave 2, it does not travel. Wave 1 travels in the negative *x*-direction.

**Part (b)** What form do the wave functions take at the position $x = 0$?
**MultipleChoice** :

1) There is not enough information.
2) $y_1 = 0$, $y_2 = 0$
3) $y_1 = A \sin(-\omega t)$, $y_2 = A \sin(\omega t + \varphi)$
4) $y_1 = A \cos(-\omega t)$, $y_2 = A \cos(\omega t + \varphi)$
5) $y_1 = A \sin(k - \omega t)$, $y_2 = A \sin(k + \omega t + \varphi)$
6) $y_1 = A \sin(-\omega t)$, $y_2 = A \cos(\omega t)$
7) $y_1 = A$, $y_2 = 0$
8) $y_1 = A \sin(-\omega t)$, $y_2 = A \sin(\omega t)$
9) $y_1 = 0$, $y_2 = A$

**Part (c)** Use the trigonometric identity $\sin\alpha + \sin\beta = 2\cos\frac{\alpha-\beta}{2}\sin\frac{\alpha+\beta}{2}$ to find the correct function of time for the total displacement of the string at the position $x = 0$.
**SchematicChoice** :

$y(t) = 2A\sin\frac{\varphi}{2}\cos\left(\omega t + \frac{\varphi}{2}\right)$ $y(t) = 2A\sin\frac{\varphi}{2}\sin\left(\omega t + \frac{\varphi}{2}\right)$ $y(t) = 2A\cos\frac{\varphi}{2}\sin\left(\omega t + \frac{\varphi}{2}\right)$

$y(t) = A\sin\frac{\varphi}{2}cos\left(\omega t + \frac{\varphi}{2}\right)$ $y(t) = 2\sin\frac{\varphi}{2}\cos\left(\omega t + \frac{\varphi}{2}\right)$ $y(t) = 2A\sin\varphi\cos(2\omega t + \varphi)$

$y(t) = 2A\cos\frac{\varphi}{2}\cos\left(\omega t + \frac{\varphi}{2}\right)$

**Part (d)** With $A$ = ***2.7*** cm and $\varphi$ = ***0.15***$\pi$; rad, calculate the total displacement of the string, in centimeters, at the position $x = 0$ at time $t = 0$.
**Numeric** : A numeric value is expected and not an expression.
***y*(0)** = ____________________________________________

**Part (e)** If, instead, you are given $\varphi = 0$, what will be the total displacement of the string at the position $x = 0$ as function of time, $t$.
**MultipleChoice** :

1) The displacement will be $y = 0$ for all $t$.
2) There is not enough information.
3) The displacement will be $y = A\sin(\varphi)$ for all $t$.
4) The displacement will be $y = 2A$ for all $t$.
5) The displacement will vary between $-2A$ and $2A$ at a rate given by the period, $2\pi/\omega$.
6) The displacement will be $y = A$ for all $t$.
7) The displacement will vary between $-A$ and $A$ at a rate given by the period, $2\pi/\omega$