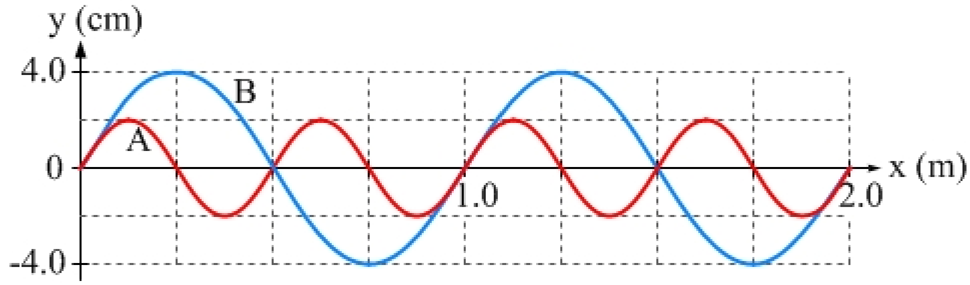
PROBLEM 1 – 10 points

The drawing shows two waves, both traveling to the right at the same speed of 4.0 m/s along identical strings.



(a) [2 points] Determine the wavelength of each wave.

A: 0.5 m
B: 1.0 m

(b) [2 points] Determine the amplitude of each wave.

A: 2.0 cm
B: 4.0 cm

(c) [2 points] Determine the frequency of each wave.

$f = v/\lambda$**, so,**
A: f = 4.0 m/s / 0.5 m = 8.0 Hz
B: f = 4.0 m/s / 1.0 m = 4.0 Hz

(d) [2 points] How much time passes before the two strings look exactly the same as the picture above?

A goes through exactly two cycles in the time it takes B to go exactly one cycle, so we just have to wait for one cycle of B for the strings to look the same as shown above. The time for one cycle of B is the inverse of B's period, which is 0.25 s.

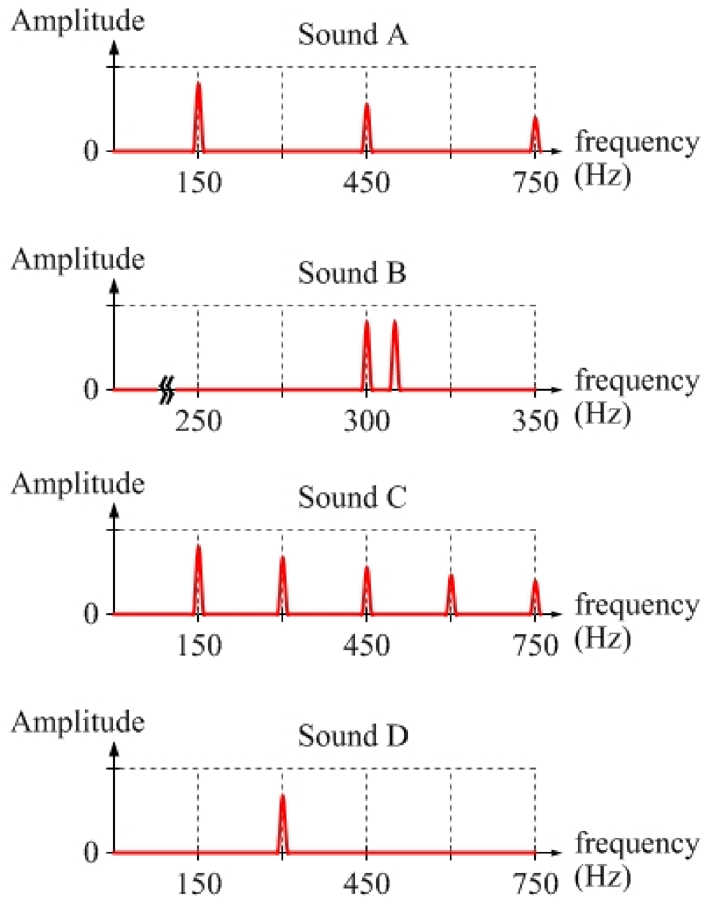
(e) [2 points] For which wave is the maximum transverse speed of a particle on the string larger?

[ ] wave A [ ] wave B [**X**] neither, they're equal

Explain: **The maximum transverse speed is given by the product of the amplitude and the angular frequency. A has half the amplitude of B, but twice the angular frequency, so the maximum transverse speed is the same for both.**

PROBLEM 2 – 10 points

The graphs show the frequency spectra of four different sounds – match the sound to its description.



[2 points] (a) A sound with a beat frequency of 10 Hz.

[ ] Sound A [X] Sound B

[ ] Sound C [ ] Sound D

Sound B shows tones of 300 Hz and 310 Hz, which would give a 10 Hz beat frequency.

[3 points] (b) A pure tone (single frequency).

[ ] Sound A [ ] Sound B

[ ] Sound C [**X**] Sound D

State the value of that single frequency:

_____300 Hz_______

[2 points] (c) The sound from a tube that is open at one end, and closed at the other.

[**X**] Sound A [ ] Sound B [ ] Sound C [ ] Sound D

For a tube open at one end and closed at the other, we expect the harmonic to be odd-integer multiples of the fundamental frequency. Spectrum A shows a fundamental frequency of 150 Hz, with harmonics 3 times and 5 times larger.

[3 points] (d) The sound coming from strumming a single string on a guitar.

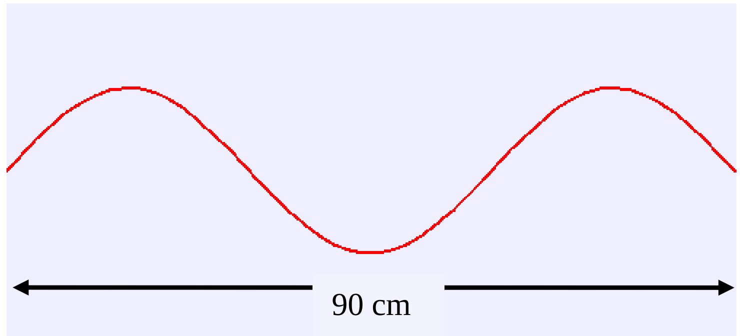
[ ] Sound A [ ] Sound B [**X**] Sound C [ ] Sound D

State the value of that string's fundamental frequency: _____150 Hz_______

In general, for a guitar string, strumming the string will result in exciting the fundamental and the even and odd harmonics. That is what is shown in spectrum C, with a fundamental of 150 Hz, and odd and even multiples of 150 Hz.

PROBLEM 3 – 10 points

The picture shows a particular standing wave on a guitar string at one particular instant in time. At the anti-nodes, the oscillations have an amplitude of 4.0 mm. The wave speed on the string is 360 m/s, and the string has a length of 90 cm.



[2 points] (a) Determine the wavelength of this wave.

60 cm. All we need to do is to look at the picture. One wavelength is two-thirds of the length of the string. Two-thirds of 90 cm is 60 cm.

[2 points] (b) Calculate the frequency of this standing wave.

Here, we can apply the equation: $f = \frac{v}{\lambda} = \frac{360 \text{ m/s}}{0.60 \text{ m}} = 600 \text{ Hz}$

[2 points] (c) This standing wave is formed by a superposition of two identical traveling waves, one moving left and one moving right. The amplitude of each of these traveling waves is

[ ] 1.0 mm [**X**] 2.0 mm [ ] 4.0 mm [ ] 8.0 mm

We are given that the amplitude of the oscillations at the anti-nodes is 4.0 mm. At the anti-nodes, maximum amplitude is reached when two peaks (or two troughs) from the left-going and right-going waves line up. If they add together to give 4.0 mm, they must each have an amplitude of half of this, or 2.0 mm.

[2 points] (d) Compared to the frequency of the standing wave shown above, the fundamental frequency for this particular string is ….

[ ] larger by a factor of 3 [**X**] smaller by a factor of 3

[ ] equal to the frequency of the wave shown

The standing wave shown above is the third harmonic, so it has three times the frequency of the fundamental. Thus, the fundamental frequency is one-third of the frequency of the wave shown above.

[2 points] (e) If the tension of the string is increased, this string's fundamental frequency …

[**X**] increases [ ] decreases [ ] remains the same

Increasing the tension increases the wave speed, but the wavelength remains the same, because that is set by the length of the string, which is unchanged. Thus, the fundamental frequency increases because, with wavelength unchanged, frequency is proportional to wave speed.