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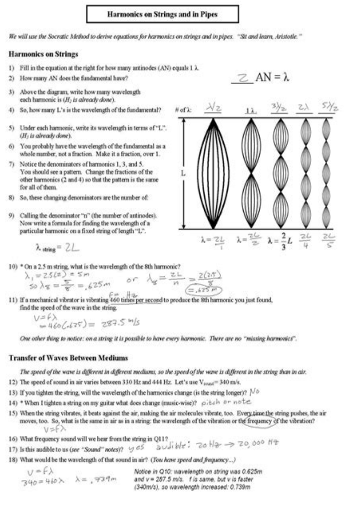

Harmonics on Strings and in Pipes

We will use the Socratic Method to derive equations for harmonics on strings and in pipes. "Sit and learn, Aristotle."

Harmonics on Strings

1) Fill in the equation at the right for how many antinodes (AN) equals 1 λ.
2) How many AN does the fundamental have?
3) Above the diagram, write how many wavelength each harmonic is (*H₁ is already done*).
4) So, how many L's is the wavelength of the fundamental?
5) Under each harmonic, write its wavelength in terms of "L". (*H₁ is already done*).
6) You probably have the wavelength of the fundamental as a whole number, not a fraction. Make it a fraction, over 1.
7) Notice the denominators of harmonics 1, 3, and 5. You should see a pattern. Change the fractions of the other harmonics (2 and 4) so that the pattern is the same for all of them.
8) So, these changing denominators are the number of:
9) Calling the denominator "n" (the number of antinodes). Now write a formula for finding the wavelength of a particular harmonic on a fixed string of length "L".

$\lambda_{string} = 2L$

2 AN = λ

10) * On a 2.5 m string, what is the wavelength of the 8th harmonic?
11) If a mechanical vibrator is vibrating 460 times per second to produce the 8th harmonic you just found, find the speed of the wave in the string.

One other thing to notice: on a string it is possible to have every harmonic. There are no "missing harmonics".

Transfer of Waves Between Mediums

The speed of the wave is different in different mediums, so the speed of the wave is different in the string than in air.

12) The speed of sound in air varies between 330 Hz and 444 Hz. Let's use V_{sound} = 340 m/s.
13) If you tighten the string, will the wavelength of the harmonics change (is the string longer)? No
14) * When I tighten a string on my guitar what does change (music-wise)? pitch or note
15) When the string vibrates, it beats against the air, making the air molecules vibrate, too. Every time the string pushes, the air moves, too. So, what is the same in air as in a string: the wavelength of the vibration or the frequency of the vibration?
16) What frequency sound will we hear from the string in Q11?
17) Is this audible to us (*see "Sound" notes*)? yes audible: 20 Hz → 20,000 Hz
18) What would be the wavelength of that sound in air? (*You have speed and frequency...*)

Notice in Q10: wavelength on string was 0.625m and v = 287.5 m/s. f is same, but v is faster (340m/s), so wavelength increased: 0.739m

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