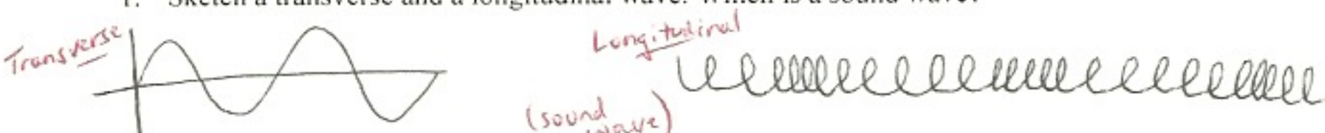
Physics: Sound

Conceptual Questions:

1. Sketch a transverse and a longitudinal wave. Which is a sound wave?



2. Amplitude controls what part of a sound?

   Volume

3. Frequency controls what part of a sound?

   Pitch or note

4. Why can't we hear sounds in outer space?

   Sound must travel through a medium and there is nothing to vibrate in space - no air

5. What factors can affect the speed of sound?

   ① Temperature: Colder = Slower
   ② Particle Density: Denser = Faster
   ③ Elasticity: More Rigid = Faster more Rubbery = Slower

6. What is the Doppler effect? How does this change the sound you hear?

   Doppler Effect is a change in frequency based on the movement of the source or the observer

   - As a source or you move towards a sound - you should hear a higher freq.
   - As a source or you move away from a sound - you should hear a lower freq.

7. What is the difference between constructive and destructive interference?

   Constructive - Two waves come together and create a larger amplitude

   Destructive - Two waves come together and create a smaller amplitude

8. What is beat frequency? What does it tell you?

   It is the throbbing sound produced by two sounds that are close in frequency, but not exactly the same. This tells you how far apart in Hertz the sounds are.

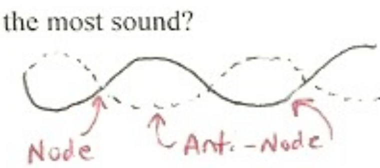
9. What makes a musical instrument different from a tuning fork?

   Musical instruments can produce their fundamental frequency along with others called the harmonics. The harmonics give each instrument its unique voice or timbre. Tuning forks produce only one freq. alone.

10. What are the two parts of a standing wave? Which part can create the most sound?

   There are Nodes = little to no movement

   Anti-Nodes = Max movement



11. What is the limitation of pipes open at one end?

   We can only hear the ODD harmonics - not EVEN

12. If the speed of sound is approximately 335 m/s on a cold day, what is the frequency of a sound wave with a wavelength 1.90 m long?

$v = 335\ m/s$

$\lambda = 1.90\ m$

$f = ?$

$v = \lambda \cdot f$

$335 = (1.90) \cdot f$

$f = \frac{335}{1.90}$

$f = 176.316\ Hz$

$f \approx 176\ Hz$

13. The intensity of sound waves from an airplane taking off is $4.20 \times 10^{-3}\ W/m^2$ at a distance 135 m away. Assume that the sound is radiating out as spheres in all directions.
    A. What is the power of the sound produced by this plane?
    B. How far away would an observer need to be from the same sound to hear a sound intensity of $3.60 \times 10^{-3}\ W/m^2$?

A.) $I = \frac{P}{4\pi r^2}$

$4\pi r^2 \cdot I = \frac{P}{4\pi r^2} \cdot 4\pi r^2$

$4\pi r^2 \cdot I = P$

$P = 4\pi (135)^2 \cdot (4.20 \times 10^{-3})$

$P = 961.893\ W$

$P \approx 962\ W$

B.) Power of the source is the same $P = 962\ W$. But are looking for a distance, so r.

$4\pi r^2 \cdot I = \frac{P}{4\pi r^2} \cdot 4\pi r^2$

$4\pi r^2 \cdot I = P$

$r^2 = \frac{P}{4\pi \cdot I}$

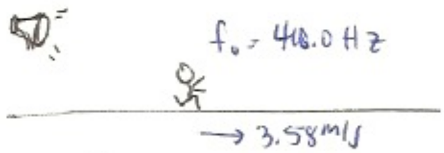
$r = \sqrt{\frac{P}{4\pi \cdot I}}$

$r = \sqrt{\frac{962}{4\pi \cdot (3.60 \times 10^{-3})}}$

$r = 145.825\ m$

$r \approx 146\ m$

14. You are an acoustic engineer, running around, getting a venue ready for a concert that night. A speaker is going through a sound test as you run away from the sound at about 3.58 m/s. The frequency *you hear* from the sound test is 410.0 Hz. What is the actual frequency of the speaker?



$f_s = ?$

$f_o = 410$ Hz

$v = 343$

$v_o = 3.58$ m/s

$v_s = 0$ m/s

$$f_o = f_s\left(\frac{v +/- v_o}{v +/- v_s}\right)$$

$$410 = f_s\left(\frac{343 - 3.58}{343 +/- 0}\right)$$

$$410 = f_s\left(\frac{339.42}{343}\right)$$

$$410 = f_s(0.9895)$$

$$\boxed{f_s = 414 \text{ Hz}}$$

15. The diagram shown represents a rope along which two pulses of equal amplitude, A, approach point P. What the two pulses meet at P, the vertical displacement of the rope at point P will be...

A. A

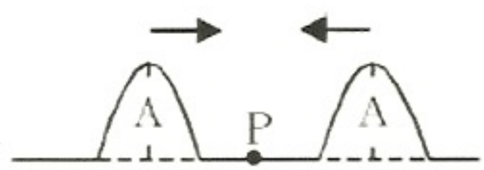
B. 2A

C. 0

D. ½ A

Constructive Interference

(Two waves will become taller)



16. A piano tuner hears one beat every 2.00 seconds when trying to adjust two strings, one of which is sounding at 440 Hz. How far off in frequency is the other string?

1 Beat in 2.00 s → one rise and fall of volume every 2.00 s.
But frequency is how many cycles in 1 second.

$$\frac{1 \text{ Beat}}{2 \text{ seconds}} = \frac{x \text{ Beats}}{1 \text{ second}}$$

$$2 \cdot x = 1$$

$$x = \frac{1}{2}$$

½ Beat every second.

* Sounds are separated by ½ Hz

440 Hz → 439.5 Hz or 440.5 Hz

17. A musician is tuning a string on a harp. When she plays her string with a 196 Hz tuning fork, she hears a beat frequency of 2. When she plays her string with a 206 Hz tuning fork, she hears 8 beats. What is the frequency of the string?

196 Hz (2 Beats) → 194 Hz or 198 Hz

206 Hz (8 Beats) → 198 Hz or 214 Hz

198 Hz

18. The A string of a violin is 32.0 cm long between fixed points with a fundamental frequency of 440.0 Hz and a linear density of 5.50 x 10^{-4}kg/m.
   A. What is the velocity of the string?
   B. What is the tension in the string?

$L = 32.0\ cm = 0.32m$

$f_1 = 440\ Hz$

$m/L = 5.50 \times 10^{-4}\ kg/m$

A.) $v = \sqrt{\frac{F_T}{m/L}}$

$f_n = n\left(\frac{v}{2 \cdot L}\right)$

*we don't have F_T, so we can't use $v = \sqrt{\frac{F_T}{m/L}}$ so use $f_n = n\left(\frac{v}{2L}\right)$

$f_n = n\left(\frac{v}{2 \cdot L}\right)$

$f_1 = 1\left(\frac{v}{2(0.32)}\right)$

$440 = \frac{v}{2(0.32)}$

$v = 440 \cdot 2 \cdot 0.32$

$v = 282\ m/s$

B.) $v = \sqrt{\frac{F_T}{m/L}}$

$(282)^2 = \left(\sqrt{\frac{F_T}{5.50 \times 10^{-4}}}\right)^2$

$(282)^2 = \frac{F_T}{5.50 \times 10^{-4}}$

$(282)^2 \cdot 5.50 \times 10^{-4} = F_T$

$F_T = 43.7N$

19. An organ pipe is open at both ends. It is producing a sound where its seventh harmonic is a frequency of 427 Hz.
   A. What is the fundamental frequency?
   B. What is the length of the pipe?

$f_7 = 427\ Hz$

Open at Both ends

A.) the seventh harmonic is the fundamental x 7

$f_7 = 7 \cdot f_1$

$427 = 7 \cdot f_1$

$f_1 = \frac{427}{7}$

$f_1 = 61\ Hz$

B) $f_n = n\left(\frac{v}{2L}\right)$

$f_1 = 1\left(\frac{343}{2 \cdot L}\right)$

$61 = \frac{343}{2 \cdot L}$

$61 \cdot 2L = 343$

$L = \frac{343}{(61)(2)}$

$L = 2.81\ m$

20. A closed-ended organ pipe is used to produce a mixture of sounds. The third and fifth harmonics in the mixture have frequencies of 1100 Hz and 1833 Hz respectively.
   A. What is the frequency of the first harmonic played by the organ pipe?
   B. What is the length of the vibrating column of air?

$f_3 = 1100$ Hz

$f_5 = 1833$ Hz

A.) $f_1 = ?$

$f_3 = 3 \cdot f_1$

$1100 = 3 \cdot f_1$

$f_1 = \frac{1100}{3}$

$f_1 = 366.7$ Hz

$f_5 = 5 \cdot f_1$

$1833 = 5 \cdot f_1$

$f_1 = 366.7$ Hz

B.) $f_n = n\left(\frac{v}{4 \cdot L}\right)$

$f_1 = 1\left(\frac{343}{4 \cdot L}\right)$

$366.7 = \frac{343}{4 \cdot L}$

$366.7 \cdot 4L = 343$

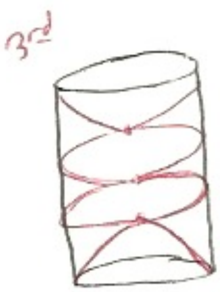
$L = \frac{343}{(366.7)(4)}$

$L = 0.234$ m

21. Sketch the third harmonic for the following situations:
   A. A vibrating string
   B. A pipe open at both ends
   C. A pipe only open at one end

A.)

B.)



C.)