Speed of Sound

PHYS 211L – H02

Tuesday 10:05am – 12:05pm

Everything hurts

Stop this physics

No more

Please

Abstract

In this lab, we determined the speed of sound in air at room temperature using a resonating air column. We adjusted the length of the air column and found various resonance lengths, and from out measurements, we found that the speed of sound in air at room temperature is 347.1 m/s.

Introduction/Background

While the speed of light and sound are both absurdly fast and seemingly reach your ears and eyes instantaneously, they do have a measurable speed. In the correct conditions, we can see that these two speeds are indeed different. As it turns out, the speed of light knocks the speed of sound out of the water. But how do we measure the speed of sound?

The first person to attempt to measure the speed of sound was [1] Pierre Gassendi in 1635. For his calculations, he measured the time difference between the explosion of a cannon and the arrival of the sound from a distance. His measurements, for how primitive they were, were extremely accurate and resulted in a calculation within 0.5 meters per second of the actual speed.

However, in our experiment, and in most modern measurements, our calculations used waves to determine the speed of sound. Because we know the frequency of the wavelengths created by the tuning fork, we can use the formula **.** Measuring several distances of tubing to search for a resonance frequency allows us to determine a wavelength to use in our formula. Help he has a gun

Procedure

Materials used: Tube, clamps, flexible tubing, water, a thermometer, water jug, meter stick, and two tuning forks.

First, we recorded the temperature of the room, which was 26°C. Then, we recorded the radius of the tube, which was 0.015 meters.

We filled the tube with water and then struck one of the tuning forks against the heel of someone’s hand. While holding the tuning fork approximately two centimeters from the open end of the tube with the tines perpendicular to tube’s axis, we began adjusting the water level, thus increasing the length of the air column. While doing this, we listened for sudden increases in sound intensity and, when found, we marked their location by placing a rubber band around the tube at the height of the water and measured that distance from the top of the tube. We did this two more times and then repeated the process with the other tuning fork.

FOOKIN DIAGRAM

Clamps

Water Jug with Water

Tube with Water

Meter Stick

Flexible Tubing

Results/Analysis/Physics

To create a graph of the frequency versus the reciprocal of the wavelength, we obviously need both of those values. To find the wavelength at each resonance length, we used the equation , where L is the resonance length. Before making the calculation, we added six-tenths of the radius of the tube to the resonance length in order to find the correct wavelength. For our frequency, we calculated it at each resonance length using the properties of a closed cylinder air column. The fundamental frequency for a closed cylinder air column is the speed of sound divided by the wavelength[2]. First we obtained the speed of sound found by measuring the temperature of the room (26°C) and plugging it into v(T) = (331.5 +0.6T). By treating each resonance length as its own closed cylinder air column, we calculated the fundamental frequency for each length. We then graphed the quantities and the slope of the resulting line gives us the speed of sound in air since it models the equation .

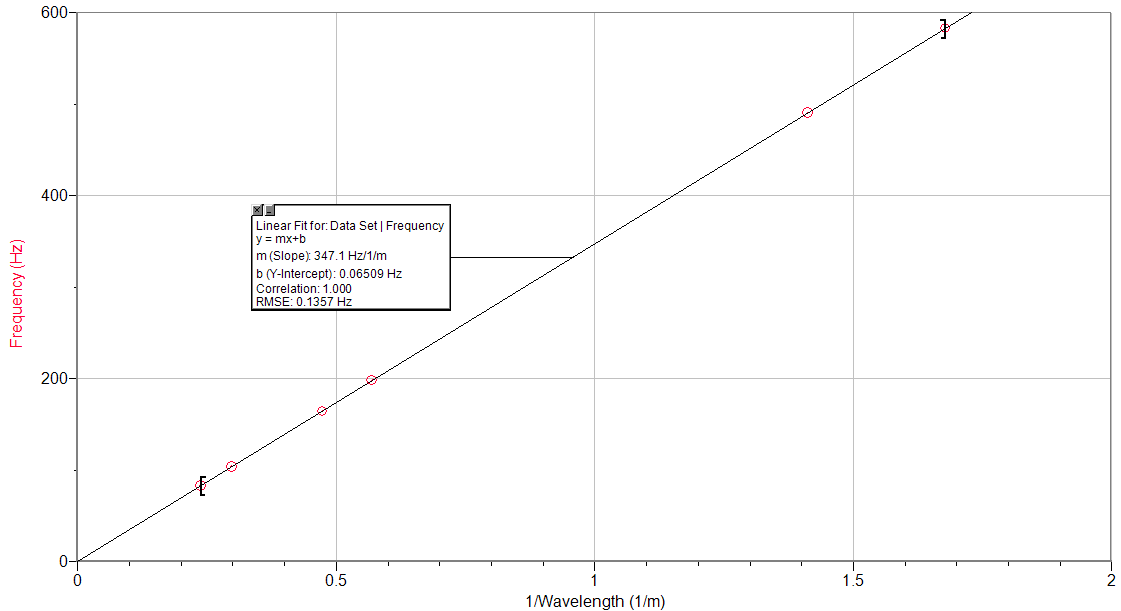
Measurements

|  |  |  |  |
| --- | --- | --- | --- |
| Tuning Fork 1 Resonance Lengths (m) | Tuning Fork 1 Wavelengths (m) | Tuning Fork 2 Resonance Lengths (m) | Tuning Fork 2 Wavelengths (m) |
| 0.168 | 0.708 | 0.14 | 0.596 |
| 0.52 | 2.116 | 0.43 | 1.756 |
| 1.04 | 4.196 | 0.83 | 3.356 |

Frequencies

|  |  |
| --- | --- |
| Tuning Fork 1 (Hz) | Tuning Fork 2 (Hz) |
| 490.254 | 582.383 |
| 164.036 | 197.665 |
| 82.722 | 103.504 |

Graph of Frequency vs. 1/Wavelength



Conclusion

[*What was* learned] From this experiment, we were able determine what the speed of sound is in room temperature conditions. This lab proves that the formula for the speed of a wave, **,** is applicable in a real-life setting. Because we know the frequency of the sound wave due to the properties of our tuning fork, determining wavelength allows us to find the velocity of the wave. Resonance occurs when the antinode of the sound wave aligns with the end of the tube and can be observed by an increase in the volume of the sound made by the tuning fork held over the tube. By consistently altering the effective length of the tube using water and gravitational potential, we can listen for a fluctuation in the volume of the sound. By finding other tube lengths that result in resonance, we can compare these to determine a wavelength and thus solve for the velocity. [*Uncertainties*] The sources of uncertainty in this experiment are the result of unideal conditions. Being able to hear the slight increase in volume during resonance was *extremely* difficult in a loud classroom setting. This resulted in many failed trials and the necessity of repeated results beyond the normal. Slight fluctuations in temperature could have also impacted the results of our data as people move around and increase the temperature in the classroom or the air conditioning turns on and decreases it.

[*First Universal Question*] Our data was relatively accurate to the expected results given our circumstances and the conditions of our experiment. We were able to observe results with a <1% inaccuracy to the known speed of sound in room temperature with a speed of 347.1 m/s where we expected 343 m/s. [*Second Universal Question*] The idea that speed has a certain speed through air is present every time you open your mouth to speak. Although almost imperceptible, there is an ever-so-brief delay between when someone speaks and when the listener hears. At such a close distance, this time frame is basically negligible. When we can get a better understanding of the speed of sound is on the Fourth of July. When you observe fireworks from a significant distance, you are able to perceive the firework’s shape, light, and color, but not sound until after a small instance of time.

Lab Questions

2. From the slope of the graph, we found that the speed of sound is 347.1 m/s. From the given formula v(T) = (331.5 +0.6T), and from our measured value of T = 26°C, we found that v = 347.1 m/s. These values are identical.

3. The speed of sound in air decreases as the temperature decreases. Our measurements of where we found resonance would be closer together since there is a shorter wavelength because of the formula . The speed would be decreasing, and the frequency doesn’t change since we’d be using the same tuning forks, so the wavelength must also decrease.

4. Well, since we know that sound travels faster in water, and we know the frequency of the tuning fork won’t change, the wavelength must increase. Thus, the measurements of the resonance points will be further apart.

5. Well, if you’re on the Moon there is no sound since there’s no medium for it to travel through.

References

1. Megraw, Stan. "How Did Scientists Figure out the Speed of Sound and Light?" CurioCity. N.p., 23 Jan. 2012. Web. 14 Nov. 2016. <https://explorecuriocity.org/Explore/ArticleId/187/how-did-scientists-figure-out-the-speed-of-sound-and-light-187.aspx>.
2. Nave, C. R. "Closed Cylinder Air Column." Resonances of Closed Air Columns. Georgia State University, n.d. Web. 14 Nov. 2016.