

Speed of Sound

by

Nerik Yakubov

Introduction

Compared to most objects, sound waves travel very fast. It is fast enough that measuring the speed of sound is a technical challenge. One method you could use would be to time an echo. For example, if you were in an open field with a large building a quarter of a kilometer away, you could start a stop watch when a loud noise was made and stop it when you heard the echo. You could then calculate the speed of sound.

To use the same technique over short distances, you need a faster timing system, such as a computer. In this experiment you will use this technique with a Microphone connected to a computer to determine the speed of sound at room temperature. The Microphone will be placed next to the opening of a hollow tube. When you make a sound by snapping your fingers next to the opening, the computer will begin collecting data. After the sound reflects off the opposite end of the tube, a graph will be displayed showing the initial sound and the echo. You will then be able to determine the round trip time and calculate the speed of sound.

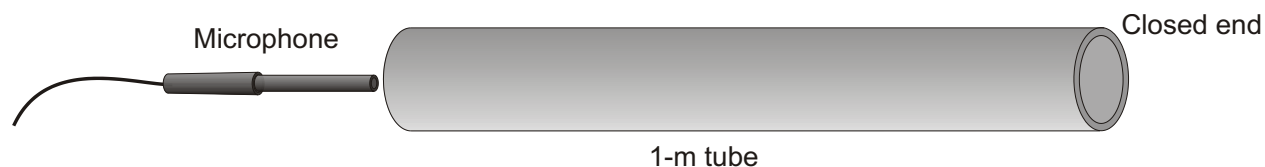


Figure 1

Background

Objectives

- Measure how long it takes sound to travel down and back in a long tube.
- Determine the speed of sound.
- Compare the speed of sound in air to the accepted value.

Equipment List

Power Macintosh or Windows PC
LabPro or Universal Lab Interface
Logger *Pro*
Vernier Microphone

tube, 1-2 meters long
book or plug to cover end of tube
thermometer or temperature probe
meter stick or tape measure

Did You Know!

1. A common way to measure the distance to lightning is to start counting, one count per second, as soon as you see the flash. Stop counting when you hear the thunder and divide by five to get the distance in miles. Use this information to estimate the speed of sound in m/s.

Procedure

1. Connect the Vernier Microphone to Channel 1 on the LabPro or Universal Lab Interface.
2. Open the file in the Experiment 24 folder of *Physics with Computers*. A graph of sound level vs. time will be displayed. The time of data collection will be 0.030 s.
3. Close the end of the tube. This can be done by inserting a plug or standing a book against the end so it is sealed. Measure and record the length of the tube.
4. Use a thermometer or temperature probe to measure the air temperature of the classroom and record the value in the data table.
5. Place the Microphone as close to the end of the long tube as possible, as shown in Figure 2. Position it so that it can detect the initial sound and the echo coming back down the tube.

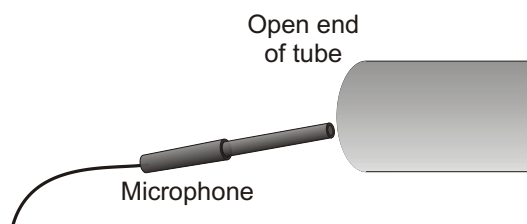
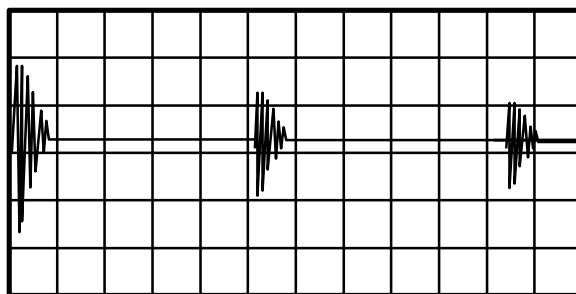


Figure 2

6. Click to begin data collection. Snap your fingers near the opening of the tube. You can instead clap your hands or strike two pieces of wood together. This sharp sound will trigger the interface to begin collecting data.
7. If you are successful, the graph will resemble the one below. Repeat your run if necessary. The second set of vibrations with appreciable amplitude marks the echo. Click the Examine button, . Move the mouse and determine the time interval between the start of the first vibration and the start of the echo vibration. Record this time interval in the data table.



8. Repeat the measurement for a total of five trials and determine the average time interval.

Data Table

| | |
|---------------------|----|
| Length of tube | m |
| Temperature of room | °C |

| Trial | Total travel time (s) |
|---------|-----------------------|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| Average | |
| Speed | m/s |
| | |

Analysis

1. Calculate the speed of sound. Remember that your time interval represents the time for sound to travel down the tube and back.
2. The accepted speed of sound at atmospheric pressure and 0 °C is 331.5 m/s. The speed of sound increases 0.607 m/s for every °C. Calculate the speed of sound at the temperature of your room and compare your measured value to the accepted value.

Extensions

1. Repeat this experiment, but collect data with a tube with an open end. How do the reflected waves for the closed-end tube compare to the reflections with an open-end tube? It might be easier to see any changes by striking a rubber stopper held next to the opening instead of snapping your fingers. Explain any differences. Calculate the speed of sound and compare it to the results with a tube with a closed end.
2. This experiment can be performed without a tube. You need an area with a smooth surface. Multiple reflections may result (floor, ceiling, windows, etc.), adding to the complexity of the recorded data.
3. Fill a tube with another gas, such as carbon dioxide or helium. Be sure to flush the air out with the experimental gas. For heavier-than-air gases, such as carbon dioxide, orient the tube vertically and use a sealed lower end. Invert the tube for lighter-than-air gases.
4. Use this technique to measure the speed of sound in air at different temperatures.

5. Develop a method for measuring the speed of sound in a medium that is not a gas.

References

- [1] K. Appel, J. Gasineau, C. Bakken, and D. Vernier, *Physics with Computers*, Vernier Software and Technology, Beaverton, Oregon, (2003).
- [2] P.W. Zitzewitz and R.F. Neff, *Merrill Physics Principles and Problems*, Glencoe/McGraw-Hill, Westerville, Ohio, (1995).