  Graphical Analysis 33

Speed of Sound

Compared to most things you study in the physics lab, 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 stopwatch 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. In this experiment, you will use the echo technique with a microphone connected to data collection software 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 data-collection software 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.

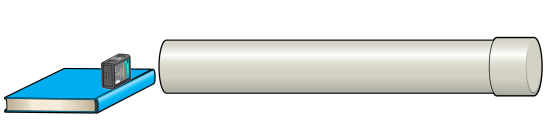


Figure 1

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.

MATERIALS

Chromebook, computer, or mobile device

Graphical Analysis 4 app

Go Direct Sound

thermometer or Temperature Probe

tube, 1–2 meters long

book

book or cap to cover end of tube

meter stick or tape measure

(optional) dog training clicker

PRELIMINARY QUESTIONs

1. How fast is sound? Does it seem to be instantaneous? Refer to your own experience as a basis for your answer.
2. What is an echo? When you hear an echo, is there a delay between making a sound and hearing the echo? Why do you think that is?

PROCEDURE

1. Use the thermometer or Temperature Probe to measure the air temperature of the classroom.
2. Record the room temperature in your data table.
3. Launch Graphical Analysis. Connect Go Direct Sound to your Chromebook, computer, or mobile device.
4. Set up the interface to trigger on the first loud sound the microphone detects.
   1. Click or tap Mode to open Data Collection Settings.
   2. Change Start Collection to start data collection on a triggering event rather than manually.
   3. Then, adjust the triggering settings so that data collection starts when the microphone reading is increasing across 0.1. Click or tap Done.
5. Close the end of the tube. This can be done by putting on a cap or standing a book against the end so it is sealed. Measure the length of the tube and record in the data table.
6. Place the microphone as close to the end of the long tube as possible, as shown in Figure 1. Position the microphone so that it can detect the initial sound and the echo coming back down the tube.
7. Click or tap Collect to start data collection. Snap your fingers or click the dog training clicker near the opening of the tube. This sharp sound will trigger the data-collection software to begin collecting data.
8. If you are successful, the graph will resemble the one in Figure 2. You may not see a third reflection. The first peak is the initial sound, the second is the first reflection, and the third is a second reflection. Repeat data collection if necessary.

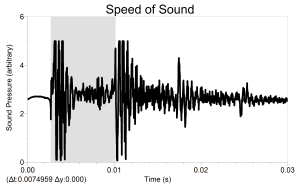


Figure 2

1. Determine the time interval between the start of the first vibration and the start of the echo vibration.
   1. Select the region of the graph from the start of the sound to the start of the echo. Note: You can also adjust the Examine line by dragging the line.
   2. Click or tap Graph Tools, , and choose View Statistics.
   3. In the data table, record the time interval (Δx) displayed in the Statistics box.
2. Repeat the measurement for a total of five trials.

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 average time interval between the sound and its echo using the time intervals in your data table.
2. Calculate the speed of sound. Remember that your average time interval represents the time for sound to travel down the tube and back.
3. 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 using 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. 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.