Determination of the speed of sound

Physics > Acoustics > Sound generation & propagation

Difficulty level	Group size	Preparation time	Execution time
easy	1	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/6164162e374f4f00038cbae5

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General information

Application

Experiment setup

Sound propagates at different speeds in different media. One of the most important propagation speeds is through the air, as it has the most influence on everyday life.

It enables people to assign sounds to a direction and plays a very important role in modern aviation, as well as in various other fields.

In this experiment, the students determine the speed of sound in air. To do this, they measure the difference in time of flight of a sound signal from two spatially offset stereo loudspeakers using the measure Acoustics software.

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Other teacher information (1/3)

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Previous knowledge

Before conducting the experiment, students should know the definition of velocity and how to calculate an average velocity from distance and time.

Scientific principle

In this experiment, students will digitally record several sound signals from different distances and use the travel distance differences to determine the speed of sound.

Other teacher information (2/3)

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Learning objective

In this experiment, the pupils learn a simple but effective method for determining the speed of sound.

Tasks

In this experiment, students determine the speed of sound in air using stereo speakers and a microphone.

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Other teacher information (3/3)

Notes on structure and implementation

- The quality of the pulses played depends on the loudspeakers used. Some, mostly very inexpensive products emit less sharply defined pulses with sometimes very long transients. The signal from the rear speaker in particular may then be of insufficient quality when it reaches the microphone.
- Careful alignment of the two loudspeakers and the microphone clearly influence the quality of the displayed pulses. The microphone and loudspeakers should be aligned as far as possible and the microphone should be aligned approximately horizontally to the base.
- Alternatively, the speed of sound can be determined from the transit time of the reflected pulse divided by twice the tube length using the setup of experiment P6011200 "Reflection and Echo".

Safety instructions

The general instructions for safe experimentation in science lessons apply to this experiment.

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Student Information

Motivation

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A thunderstorm

We know from thunderstorms that sound travels at a limited speed. We see the lightning, but the associated thunder takes a few seconds, depending on the distance of the lightning, until we can hear it.

The same concept allows us to determine the direction of the sound source by hearing, since the sound wave takes less time to reach one ear than the other.

In this experiment, you will perform your own method to determine the speed of sound in air quite accurately.

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Tasks

The experimental setup

In this experiment, determine the speed of sound in air using stereo speakers and a microphone.

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Equipment

Position	Material	Item No.	Quantity
1	Software "Measure Acoustics", single user license	14441-61	1

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Structure (1/2)

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Figure 1

- Connect the stereo speakers and microphone to the computer correctly.
- Place the speakers next to each other and the microphone about 5 cm in front of one of the speakers (Fig. 1). Open the audio settings of the PC.
- Adjust the balance so that the output is only through the speaker in front of the microphone. Then set the output volume to the maximum.

Structure (2/2)

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- Start the measure Acoustics software.
- Open the experiment overview (menu item "File" → "Open experiment" or select "Open experiment" in the menu bar).
- Select the experiment "2.4 Speed of sound" from the folder "2 Basic physics: oscillations and waves".

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Procedure (1/5)

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1.In the diagram "Spectrum of the signal at the audio output (loudspeaker or headphones)", start playback. After 2 seconds, eight tones are output in close succession.

To do this, select "Spectrum ..." in the diagram window. (speakers or headphones)" "Start".

2.Start the playback again. But now freeze the time course of the sound recording so that one of the played eight tones is visible in the diagram section.

To do this, select "Time function of the signal at the audio input (microphone)" "Activate/freeze the diagram" in the diagram window.

Procedure (2/5)

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3.Adjust the frozen diagram section so that you can clearly see the recorded audio signal. If necessary, repeat the process until an audio signal is successfully recorded.

To do this, select "Automatic adjustment of the diagram section". In addition, use the magnifying glass "Zoom" and left-click to draw a rectangle around the area you want to zoom in on.

4.Read the duration of a pulse and note the value.

To do this, use the crosshairs "Mark" in the diagram window "Time function ... (microphone)" to determine the x-value (here: time in ms) at the position of the crosshairs by reading it from the status bar at the bottom of the screen.

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Implementation (3/5)

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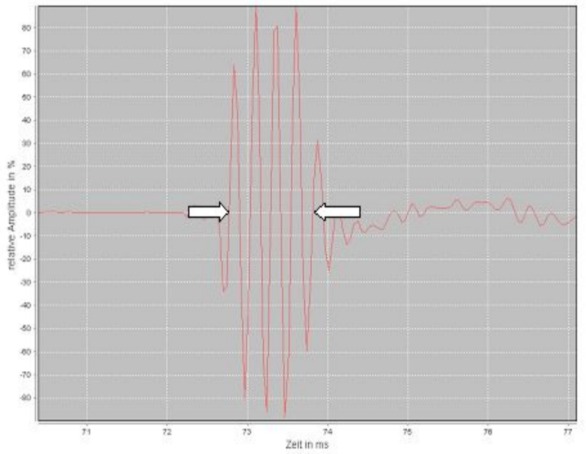

Figure 2

Note: Determination of the pulse duration

Figure 2 shows one of the eight pulses. Due to the restriction of the displayed time interval to 100 ms, usually only one or at most two pulses are shown in the diagram. The oscillation and decay processes, which are usual for a sinusoidal oscillation and are also hardware-related, must be neglected when determining the pulse duration.

The pulse starts with the first oscillation with a significantly larger deflection, i.e. when passing through the x-axis before this deflection. Accordingly, the pulse ends after the last oscillation with a significantly larger deflection. Both points are marked with arrows in the graph.

Procedure (4/5)

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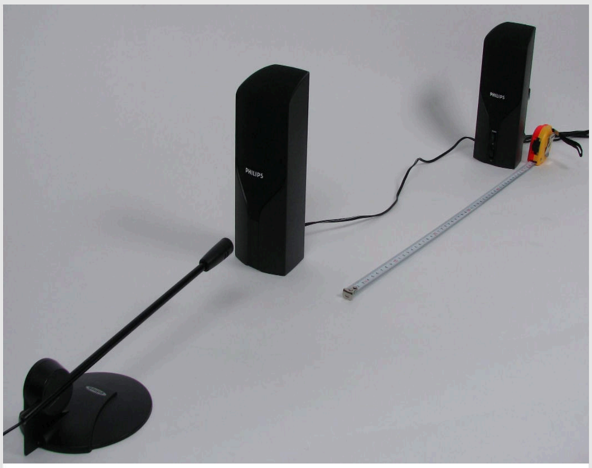

Figure 3

5.Open the audio settings of the PC again and adjust the balance so that both speakers output an equally loud signal.

6.Now place the two speakers about 50 cm apart. They should still point in the same direction, just slightly offset from each other (Fig.3).

7.Measure the distance between the two speakers with a tape measure and note the value. Place the microphone as horizontally as possible to the base about 10 cm in front of the front speaker.

8.Set the standard section again for further measurements and activate the diagram.

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Procedure (5/5)

9.Start the output of the eight sound pulses again and freeze the time course. You should now see two sound pulses, one from each speaker.

10. Use the crosshairs to determine the temporal distance between the two pulses. Read off the times at which the pulses begin. Record your result in the experiment protocol.

Report

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Task 1

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Why were two clearly distinguishable pulses recorded in the program, even though both speakers produced the sound at the same moment?

- The program displays pulses individually, since the individual characteristics of each pulse are no longer discernible in the case of overlays.
- The program shows the pulses as a function of time. The second pulse was heard as later by the microphone and arrived correspondingly later at the microphone.
- The program shows the pulses depending on the room. The second pulse is further to the right and the shift is due to the fact that both speakers are not perfectly in line with each other.

Task 2

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Which statements about sound waves are true?

- [ ] High tones spread faster than low tones.
- [ ] With dry air and a temperature of 20° Celsius, sound propagates with 343 $\frac{m}{s}$ off.
- [ ] The speed of sound varies with the medium, external temperature, air pressure and sound frequency.
- [ ] The speed of sound in air is constant.

Check

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Task 3

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A sound wave travels at 357 meters per second due to the weather. You are 10 kilometres from the source of the sound.

After how many seconds would you hear the sound wave?

The sound wave is audible after ______ seconds.

Check

Slide	Score / Total
Slide 19: Different pulses	**0/1**
Slide 20: Sound waves	**0/3**
Slide 21: Calculation task	**0/1**

Total **0/5**

Solutions   Repeat

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