Reflection and absorption of sound

Physics | Acoustics | Sound generation & propagation

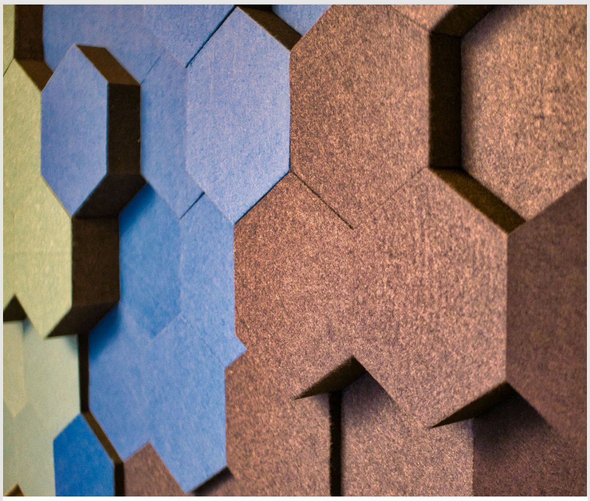
Difficulty level	Group size	Preparation time	Execution time
easy	1	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/5f514374739d0a0003ee3f92

Teacher information

Application



Sound insulation and damping is used in many areas

In acoustics, a distinction is made between sound insulation and sound absorption. Sound insulation concerns the passage of sound through walls. On solid walls, for example, the sound is reflected optimally.

Sound absorption is important in room acoustics to prevent reverberation. Sound is absorbed (damped) in porous materials such as cotton wool, felt, wood fibre materials, glass or rock wool. For optimal solutions, both methods are often combined in practice.

The principles of sound insulation and soundproofing are worked out here by the students in various experiments.

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Other teacher information (1/2)

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Prior knowledge

This experiment is designed for grades 7-10. The students should know that sound propagates as a wave and is reflected on surfaces. It is an advantage if the measure Acoustics program has already been used, but this is not necessary.

Scientific principle

In this experiment, the students test different materials and geometric structures for their ability to dampen or absorb sound. First, they test how well the sound is reflected by a CD cover. Then the students test the absorption behavior of various constructions made of felt. The sound is generated and recorded using the measure Acoustics software.

Other teacher information (2/2)

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Learning objective

Smooth walls are very suitable for sound insulation. This is because the sound is reflected very well from them. Felt is well suited for sound insulation because its structure absorbs sound well. The thicker the layer of felt, the better the sound absorption. If the felt is placed so that the sound hits it at an acute angle, the damping is also better.

Tasks

1. Investigate how well a CD jewel case is suited for sound insulation.
2. Use the CD case to reflect the sound and test how well this reflection is attenuated by various constructions made of felt.

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Instructions for carrying out the experiment

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- For the experiments a sequence of 8 tone pulses is output. When a key is pressed, a tone pulse is recorded. The sequence of 8 tone pulses is programmed in such a way that a single pulse consists of a short sine wave with a range of maximum relative amplitude of about 1 ms. The time difference between two pulses is approx. 100 ms, so that generally only one pulse can be seen on the diagram.
- The maximum of a pulse is measured to evaluate the experiments. The volume of the headphones and the sensitivity of the microphone have a very large influence on the size of the recorded signal, i.e. on the relative amplitude measurements. The measured values given in the tables belong to an example measurement. Actual measurements can deviate considerably from this. However, the relationships between the measured values and the conclusions remain the same.

Instructions for carrying out the experiment

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- In the first part, the sound pulse is very much attenuated as it passes through the CD cover. Therefore the ambient noise during the measurement of this pulse should be as low as possible. Otherwise the fluctuations of the baseline could interfere with the measurement of the signal.
- In the second part, the sound insulation of different wall structures is investigated by reflection measurements. The first pulse is the direct signal from the headphones, the other three pulses are based on reflections (echoes) at the ends of the tube. Since the microphone is not placed directly in front of the headphones, but at the side and slightly behind them, the first pulse is not measured under the same conditions as the other pulses. Its maximum amplitude changes with the position of the microphone and is often smaller than the echo. This is not important for carrying out the experiment, but may give rise to discussions. The student's text therefore describes a placement of the headphones and microphone that is as accurate as possible, where the first and second pulses are about the same size when reflected from the CD cover.

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Instructions for carrying out the experiment

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The "wall constructions" of the second part differ in that felt is placed in various forms in front of a reflective wall (in this case the CD case).

A sound pulse is sent and reflected on this wall. The smaller the echo, the better the sound insulation of the wall. The relative amplitudes of the first echoes (second recorded pulse in fig. 8) for the different "walls" are compared.

The test conditions must therefore always be the same, i.e. the headphones, microphone and glass tube should not move against each other. A possible control for an unchanged setup is the measurement of the first pulse (direct signal from the headphones), it should always be the same size in all partial experiments.

Instructions for carrying out the experiment

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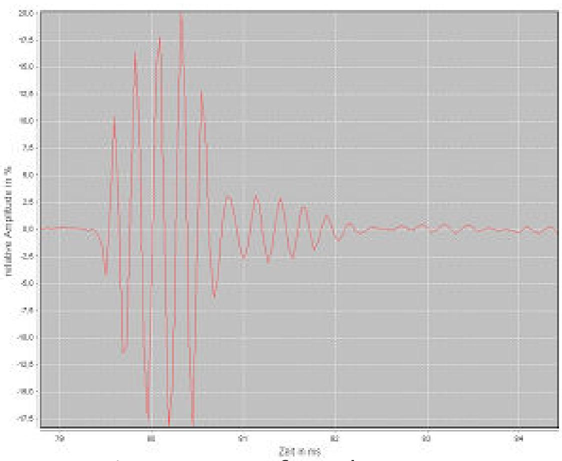
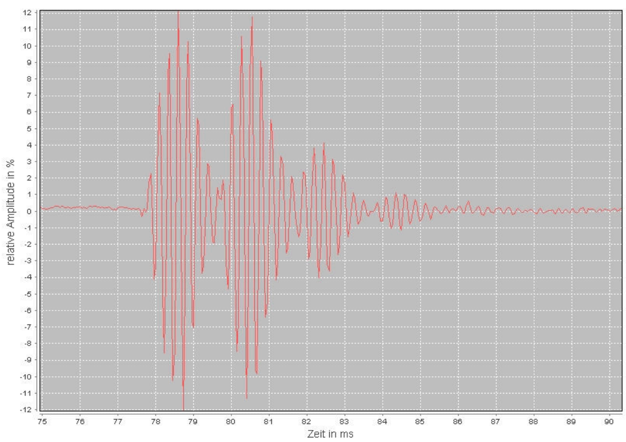
Sample measurements for the two part experiments.



Part 1: Time course of a pulse



Part 2: Pulse with three echoes

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Instructions for carrying out the experiment

All measured values given are examples from a measurement carried out. The values measured by the students may deviate more from these (especially the first pulse from part 2). However, the ratios of the measured values to each other remain similar and therefore the conclusions are the same.

Reasons for deviating measured values:

- Even a small change in the distance between the headphones and the microphone leads to significant changes in the measured value.
- Headphones or microphones other than those used in the current experiment may have a different sensitivity and thus produce different pulse heights.

The measurement of the maximum is a fast but simple method for determining the pulse height, which was chosen because it is only a qualitative comparison and the values are sufficiently reproducible under stable geometric conditions.

Safety instructions

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

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Student Information

Motivation

Material for sound insulation

In our everyday life there are different types of noise. Often it is generated by others and therefore disturbs us. Sometimes, however, it is also the noise we ourselves produce that reverberates too loudly in a room. There are therefore two ways of attenuating sound: sound insulation and sound absorption. Sound insulation reduces the passage of sound through a wall so as not to disturb the neighbour. This is mainly achieved by reflection of the sound at the wall, absorption in the wall is negligible with sound insulation. In contrast to sound insulation: An empty room with well reflecting walls, floor and ceiling is very loud, therefore for good room acoustics sound absorbing objects (furniture, carpet) or wall coverings are brought in. In concert halls or recording studios, the sound absorption on or in front of the walls is optimized, e.g. by a suitable arrangement of porous insulating materials.

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Tasks

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1. Measure the sound transmission through solid walls of paper or cardboard.
2. Measure the reflection of a sound pulse on a solid wall and investigate the influence of felt arrangements in front of the wall.

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Equipment

Position	Material	Item No.	Quantity
1	Felt sheet, 100 x 100 mm	04404-20	1
2	Metal angle bracket for glass tube o.d. = 44 mm	13289-16	2
3	Glass tube, d(outside) = 44 mm, l = 340 mm	13289-20	1
4	Beaker, 100 ml, plastic (PP)	36011-01	1
5	Silk thread, l = 200 m	02412-00	1
6	Software "Measure Acoustics", single user license	14441-61	1

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Additional equipment

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Position	Equipment	Quantity
1	Microphone	1
2	Speaker	1
3	PC	1
4	sheet of paper	1
5	adhesive tape approx. 5cm	1

Set-up

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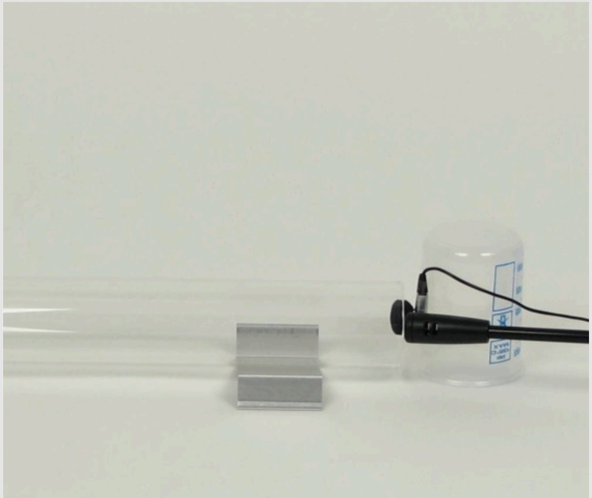

Glass tube, headphone and microphone

- Connect the headphones and microphone correctly to the computer.
- Place the beaker on the table with the opening facing down and attach one of the headphones to the beaker with a strip of adhesive tape (height in the middle of the glass tube).
- Open the audio settings of the computer. Set the output volume to maximum and shift the balance so that the output is only through the headphones on the cup.

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Structure part 1

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Sound transmission through walls

- Place the microphone approx. 2 mm in front of the headphones. The distance should be chosen so that the thin cardboard of the CD case fits as a "wall" between the microphone and the headphones for the later measurement. However, the test is first carried out without this wall.

- Start the measure Acoustics software.

Procedure (1/3)

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- Open the experiment "3.6 Sound insulation".

Help 1: Open the experiment overview (menu item "File" → "Open experiment" or select "Open experiment" from the menu bar). Select the experiment "3.6 Sound insulation" from the folder "3 Applications from medicine, music and everyday life".

- Start playback in the diagram "Spectrum of the signal at the audio output (loudspeaker or headphones)". After 2 seconds, a sequence of eight tones is played.

Help 2: In the diagram window, select "Spectrum ... (Speakers or Headphones)" "Start".

- Restart playback (see Help 2). Now freeze the temporal course of the sound recording so that you can see one of the eight sound pulses completely in the diagram window "Time function ... (Microphone)" diagram window.

Help 3: Select "Activate/Freeze Diagram" in the "Time Function of Signal at Audio Input (Microphone)"

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Procedure (2/3)

- Adjust the frozen section of the diagram so that you can clearly see the recorded sound signal. Repeat the process until a sound signal is successfully recorded.

Help 4: Select "Automatic adjustment of the diagram section". If necessary, use the "Zoom" magnifying glass and, with the help of a left click, draw a rectangle around the area you want to enlarge.

- Read the maximum relative amplitude and note the value in Table 1.

Help 5: Select "Time function ... (Microphone)" to determine the y-value (here: relative amplitude) at the position of the crosshairs by reading it at the bottom of the screen in the status bar.

Procedure (3/3)

- Set the standard section again for further measurements.

Help 6: Select "Standard cutout".

- Repeat the experiment with the following changes in the setup and measure the maximum relative amplitude each time.
  - headset/microphone pickup
  - thin wall of CD case between headphones and microphone

CD cover as thin wall

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Body part 2

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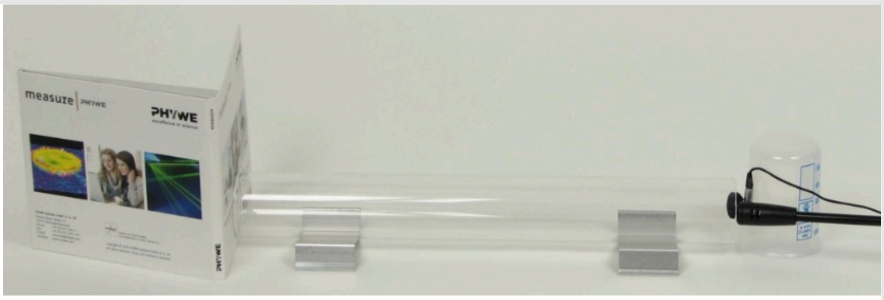
Reflection of sound at

different wall surfaces



- Place the glass tube on the two metal brackets
- Place the CD jewel case so that the thin wall is vertical and the opening of the tube is well sealed.
- Place the headphone and microphone together directly in front of the other opening of the tube. The headphone should be pushed about 2 mm into the glass tube and point directly towards the tube, the microphone should be placed as straight as possible, directly at the end of the tube, so that headphone signal and echo are about the same.

Procedure (1/2)

Hint: Hold the glass tube tightly during later changes between the series of measurements so that the glass tube, headphones and microphone do not shift against each other during the experiment and all series of measurements are comparable. As a check: For all measurements for experiment 2, the relative amplitudes of the first pulse should be approximately the same.

- Start the output of the sound pulses (see help 2) and freeze the time course (see help 3). Adjust the diagram section (see Help 4).
- Read the maximum relative amplitude at the first and second pulses (see Help 5) and note the values in Table 2.
- Reset to the standard cutout (Help 6).

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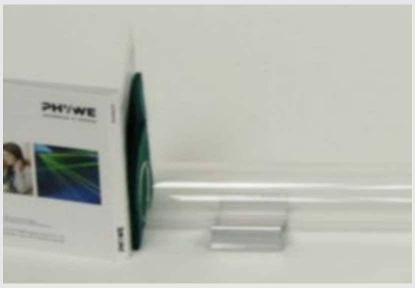
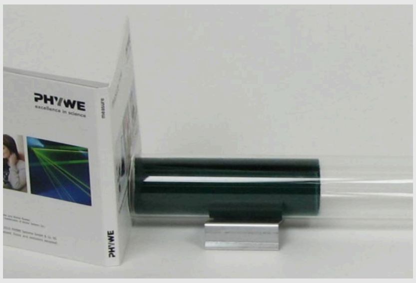
Procedure (2/2)

- Repeat the measurements with the following changes at the reflective end of the tube:
  - Finish with felt plate in front of the wall of the CD case.
  - Felt plate on the inner wall at the end of the glass tube, ending with the wall of the CD case.



  - Place the felt funnel (Fig. 6) in the glass tube directly in front of the final CD case so that the sound "runs into" the funnel. The funnel should be closed at the thin end if possible.



Report

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Task 1

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Part 1: Sound transmission through walls

Complete the table.

	Without wall	Sheet of paper	CD
Pulse in %			

Part 2: Sound reflection from different wall surfaces

Complete the table.

	only CD-case only	with felt plate	with felt roll	with felt funnel
First pulse in	only		roll1	
Second pulse in %	only		roll2	

Task 2

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Compare the maximum relative amplitudes of the pulses of the first part of the experiment from a sheet of paper and the CD case with the value without a "wall". Which "wall" has the greater sound insulation?

- The piece of paper.
- The CD cover

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Task 3

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What do you observe in the second part of the experiment?

The ______ reflects sound better than the ______. That's because wherever there are holes in the felt, the sound can be reflected ______.
The felt roll reflects sound ______ than the funnel. That's because the sound is reflected back from the funnel at a different angle, and thus returns to the microphone ______.

- better
- CD cover
- worse
- worse
- felt wall

Check

Slide	Score / Total
Slide 26: Sound insulation	0/2
Slide 27: Sound reflection	0/5

Total amount 0/7

Solutions   Repeat   Exporting text

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