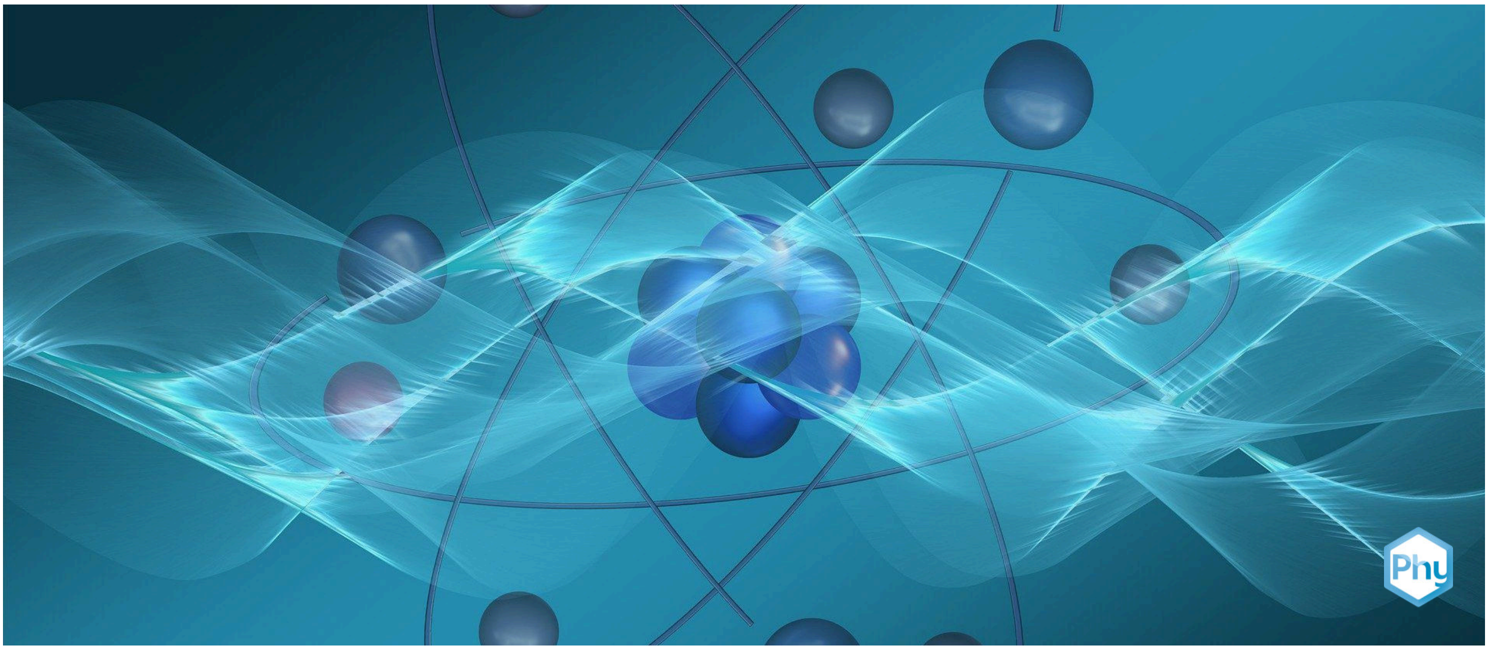
Standing waves



Physics | Acoustics | Wave Motion

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/5f5134cd739d0a0003ee3f35

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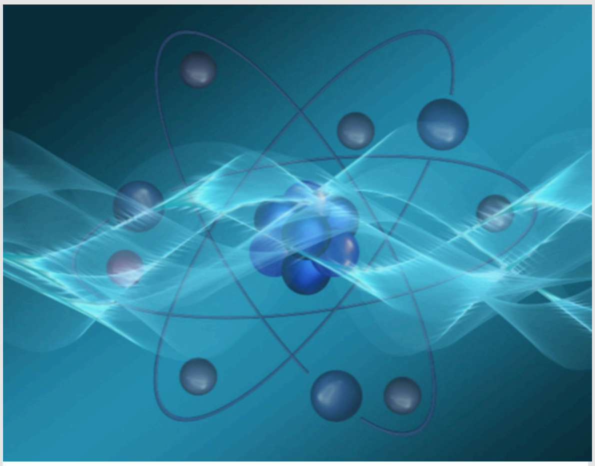
Teacher information

Application



Residence probability of electrons

In this experiment the subject of standing waves and thus also the natural frequencies is approached. Standing waves occur when waves are reflected at two opposite ends whose distance is in a certain ratio to the wavelength. Different distances are required depending on the type of reflection (fixed/loose end). This knowledge is not only applied in acoustics, but also in quantum mechanics. In acoustics it is important for understanding the functioning of musical instruments, in quantum mechanics it is needed, for example, for the model of the potential well.

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Other teacher information (1/2)

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Prior knowledge

Before conducting the experiment, students should know that sound propagates in air at a speed of 340 meters per second. They should also be familiar with the reflection of waves.

Scientific principle

In this experiment, the students observe how standing waves are created in a glass tube for certain frequencies. They measure the positions of the nodes and bellies and, in the evaluation, work out the conditions for the natural frequencies of a hollow body.

Other teacher information (2/2)

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Learning objective

Waves have as a characteristic property the wavelength. In a hollow body standing waves can arise. A prerequisite for this is that the distance between the two ends of the body corresponds to a multiple of half the wavelength. Frequencies at which standing waves are generated in a hollow body are natural frequencies of this body.

Tasks

The students first investigate sound propagation without hollow bodies. They then generate a standing wave in a hollow body and investigate the conditions under which standing waves are generated.

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Safety instructions

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

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Student Information

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Motivation

Standing waves in the construction of musical instruments

When the sound wave of a sound propagates in air, this wave causes all air particles it reaches to vibrate. If the sound is produced continuously, then all particles are in constant motion. In this experiment, investigate how there can be places in a hollow body where no sound can be heard despite continuous sound production. In such a case, in which air particles apparently no longer oscillate in some places, i.e. they come to a "standstill" so to speak, one also speaks of a standing wave.

Tasks

1. observe the sound propagation without hollow body

2. create a standing wave in a hollow body (glass tube)

Materials

3. investigate the conditions under which standing waves are generated.

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Equipment

Position	Material	Item No.	Quantity
1	Software "Measure Acoustics", single user license	14441-61	1
2	Metal angle bracket for glass tube o.d. = 44 mm	13289-16	2
3	Beaker, 100 ml, plastic (PP)	36011-01	1
4	Glass tube, d(outside) = 44 mm, l = 340 mm	13289-20	1
5	Measuring tape, l = 2 m	09936-00	1

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Additional equipment

Position	Equipment	Quantity
1	Microphone	1
2	Headphones	1
3	PC	1
4	Adhesive tape	1

Set-up

- Connect the headphones and microphone correctly to the computer. Place the glass tube on the two metal brackets.
- 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 PC. Adjust the output volume to the maximum and adjust the balance so that the output is only through the headphones attached to the cup.
- Lay out the measuring tape parallel to the glass tube. The zero point of the scale should be at one end edge of the tube.

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Procedure Part 1 (1/2)

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Part 1: Sound propagation without hollow bodies

- First place the cup with the headphones next to the glass tube. The headphone should be at the zero point of the scale. Place the microphone in front of the headphone.
- Start the measure Acoustics software.
- Open the experiment "2.6 Standing waves".

Help 1: Open the experiment overview (menu item "File" → "Open experiment" or select "Open experiment" from the menu bar). Select the experiment "2.6 Standing waves" from the folder "2 Physical Basics: Vibrations and Waves"..

Procedure Part 1 (2/2)

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- Start playback in the diagram "Spectrum of the signal at the audio output (loudspeaker or headphones)". A preset sound is output at a frequency of 470 Hz.

Help 2: Select "Start" in the corresponding diagram.

- Observe the relative amplitude over time as you remove the microphone from the headphones along the tape measure.
- Change the frequency of the sound once to 300 Hz and once to 700 Hz.

Help 3: Right click on "Sound" of the preset sound and select the "Tone Generator" menu.

- Repeat the procedure. The value of the relative amplitude should always be 100%.

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Procedure Part 2 (1/2)

Part 2: Sound propagation in hollow bodies

- Now place the headphones in the middle of the opening of the glass tube at the zero point of the scale.
- Remove the microphone from its holder and push it through the free opening of the glass tube to the front of the headphones.

Procedure Part 2 (1/2)

- Reset the frequency of the sound to 470 Hz and the relative amplitude to 100% (see Help 3) and start playback (see Help 2).
- Observe the relative amplitude over time as you slowly pull the microphone along the tape measure to the other end of the tube.
- Change the frequency of the sound once to 300 Hz and once to 700 Hz (see Help 3) and repeat the procedure.
- The value of the relative amplitude should always be 100%.

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Procedure Part 3

Part 3: Sound bellies and sound nodes

- Note for a sound frequency of 470 Hz at which points in the tube the relative amplitude at the microphone becomes maximum (belly) and minimum (nodes).
- Repeat this measurement for the next integer multiples of this frequency: 940 Hz, 1410 Hz, 1880 Hz

Report

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Task 1

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Drag the words to the right place

Outside the tube, as the distance from the microphone increases, the relative amplitude becomes ______. Inside the tube, on the other hand, there are places near the microphone where the amplitude is ______, and places further away from the microphone where it is ______. Places with maximum amplitude are called bellies, places with amplitude equal to zero nodes.

maximum

zero

lower

Check

Task 2

PHYWE

Specify the positions of the bellies and nodes for the different frequencies.

Knot 1 Belly 1 Knot 2

Belly 2 knots 3

Belly 3 knots 4

Belly knot 4 5

470 Hz									
940 Hz									
1410 Hz									
1880 Hz									

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Task 3

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Does the frequency of the sound wave play a role in the formation of a standing wave?

- Yes, standing waves only occur in the glass tube at certain frequencies.
- No, the frequency only determines the position and number of bellies and nodes.

Task 4

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How many oscillations do the different sound waves pass through before the reflected wave reaches the headphones again?

940 Hz: ______ vibrations. 1410 Hz: ______ vibrations. 1880 Hz: ______ vibrations.

Check

The distance

$$\lambda = \theta * T = \frac{heta}{f}$$

that a wave travels during an oscillation period is called wavelength. Calculate the respective wavelengths for the four frequencies at which you have examined the standing waves.

	940 Hz	1410 Hz	1880 Hz
Wavelength in cm			

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Task 5

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Under which wavelength condition are standing waves generated in a hollow body (length L)? What must then apply to the frequency?

Formula for the wavelength

λ

$= \frac{\quad\quad}{\quad}$

2 L k

Check

Formula for the frequency

$f = \frac{\quad\quad}{\quad\quad}$

2 L k θ

Check

Task 6

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Calculate for the different frequencies, in which distance two nodes of the standing waves occurred. Compare these node distances with the respective wavelengths. What do you notice?

- The wavelength is exactly twice the distance between the nodes.
- The wavelength is exactly half the distance between the nodes.
- The wavelength is exactly the distance between the nodes.

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Slide	Score / Total
Slide 18: Change of amplitude	**0/3**
Slide 20: Frequency of the sound wave	**0/3**
Slide 21: Vibration runs	**0/3**
Slide 22: Multiple tasks	**0/8**
Slide 23: Node spacing	**0/2**

Total amount **0 / 19**

Solutions Repeat Exporting text

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