Determining the wavelength of standing sound waves

Objects of the experiments

- Detecting the antinodes and nodes of standing sound waves by means of a microphone.
- Determining the wavelength λ from the distances between the antinodes at different excitation frequencies *f*.
- Determining the velocity of sound c

Principles

The distance between two antinodes of a standing sound wave is equal to half the wavelength. In terms of the distance *d* between the first and the *n*-th antinode, the wavelength λ is given by

$$\lambda = 2 \cdot \frac{d}{n-1} \quad \text{(I).}$$

Given the excitation frequency *f* of the wave, the relation

$$c = \lambda \cdot f \quad \text{(II),}$$

which is generally valid for waves, leads to the velocity of the wave

$$c = 2 \cdot \frac{d}{n-1} \cdot f \quad \text{(III).}$$

In the experiment, a speaker, which emits a harmonic sound wave (sinusoidal wave) with an adjustable frequency *f,* is placed in front of a reflecting plane wall at a distance large enough for the wave to be approximately plane when it arrives at the wall. As a result of the reflection off the wall, a reverse travelling-wave is generated, which interferes with the incoming wave to form a standing wave. For the detection of the standing wave a microphone is used, the rectified output signal of which is measured with a voltmeter.

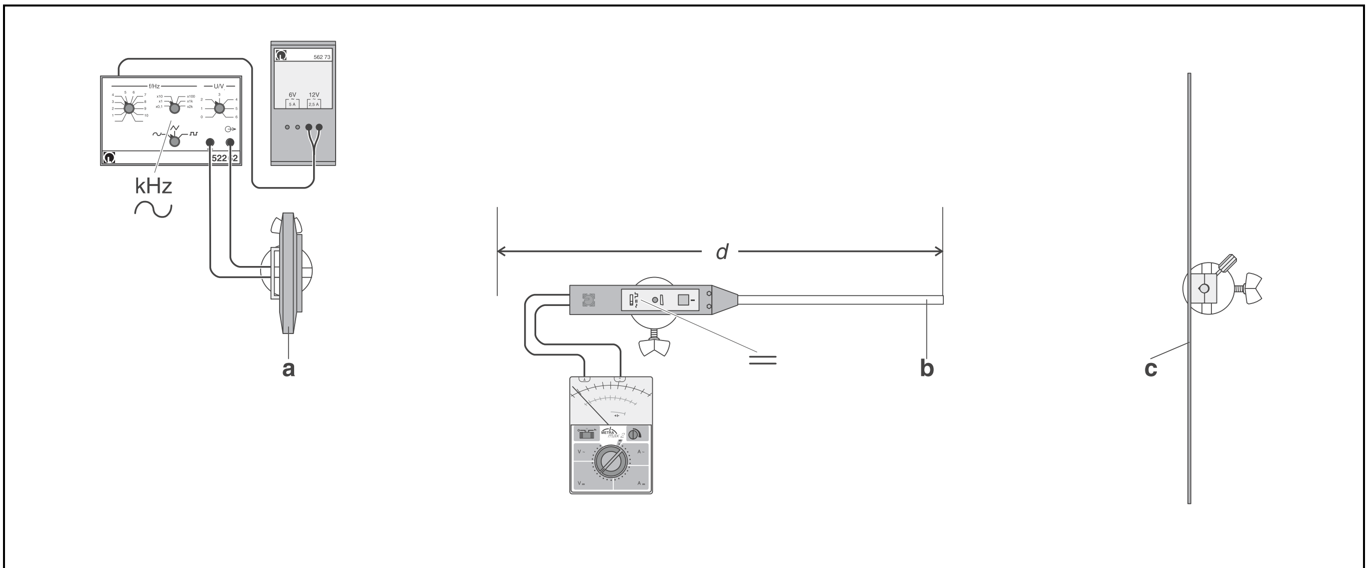
Setup

Note:

Reflections of the sound waves off of objects in the vicinity and the experimenter as well as possible sound waves from neighbouring experiments may distort the standing sound waves which are to be observed by interference.

Arrange the experimental setup in surroundings that are as free as possible and, if necessary, shield the experiment, for example, with sound absorbing cloth.

Fig. 1 Experimental setup for the determination of the wavelength of standing sound waves (top view)
a broad-band speaker with function generator
b multi-purpose microphone with voltmeter
c reflection plate



Apparatus

1 multi-purpose microphone		586 26
1 broad-band speaker		587 08
1 reflection plate		587 66
1 function generator S12		522 62
1 transformer, 6 V~, 12 V~/30 VA		562 73
1 voltmeter, U < 3 V DC	f.e.	531 100
1 steel tape measure, 2 m		311 77
3 saddle bases		300 11
connection leads		

The experimental setup is illustrated in Fig. 1.

– Place the broad-band speaker in front of the reflection plate at a distance of about 1.5 m; connect the speaker to the function generator (mode: sinusodial, frequency range: kHz) and turn it towards the reflection plate.
– Connect the multi-purpose microphone (mode: “=”) to the voltmeter (measuring range: 3 V–); place it near the connecting line between the broad-band speaker and the reflection plate and turn it towards the reflection plate.

Carrying out the experiment

– Set the function generator to the excitation frequency *f* = 9 kHz.
– Switch the microphone and the voltmeter on, and use the microphone to find a voltage maximum.
– Adjust the volume by varying the output amplitude of the function generator so that the display does not exceed 3 V.
– Move the microphone away from the wall; note the maxima and minima of the voltage, and mark the positions of the voltage maxima.
– Measure the distance *d* between the first and the n-th maximum with the steel tape measure and record it.
– Repeat the measurement at the frequencies 7, 5, 3, 2 and 1 kHz.

Measuring example and evaluation

Table 1: Measuring values for the distance *d* between the first and the n-th antinode and the resulting wavelengths λ (I) and the wave velocity *c* (III) as functions of the excitation frequency *f*

$\frac{f}{\text{kHz}}$	*n*	$\frac{d}{\text{cm}}$	$\frac{\lambda}{\text{cm}}$	$\frac{c}{\text{m} \cdot \text{s}^{-1}}$
1	5	69.5	34.8	348
2	7	50.0	16.7	334
3	7	33.5	11.2	336
5	13	43.0	7.2	360
7	17	37.5	4.7	329
9	21	36.5	3.65	329

Results

A standing wave is produced if a plane sound wave runs against a reflecting wall. A standing wave is characterized by nodes and antinodes, the distance between two nodes or antinodes being equal to half the wavelength.

The wavelength λ decreases with an increasing frequency *f*. According to Eq. (II), the values lie on a hyperbola (see Fig. 2). The wave velocity *c* (velocity of sound) does not depend on the frequency *f*. At room temperature (about 20 °C) it is approximately 340 m s^{-1}.

Fig. 2 The wavelength λ of the sound waves as a function of the excitation frequency *f*

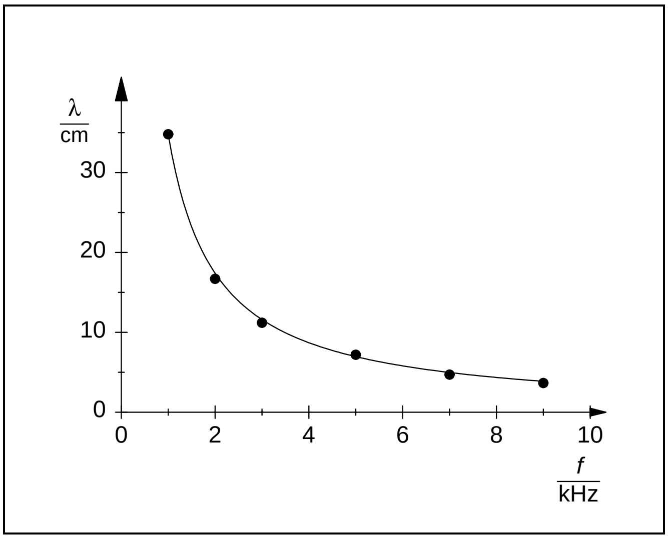
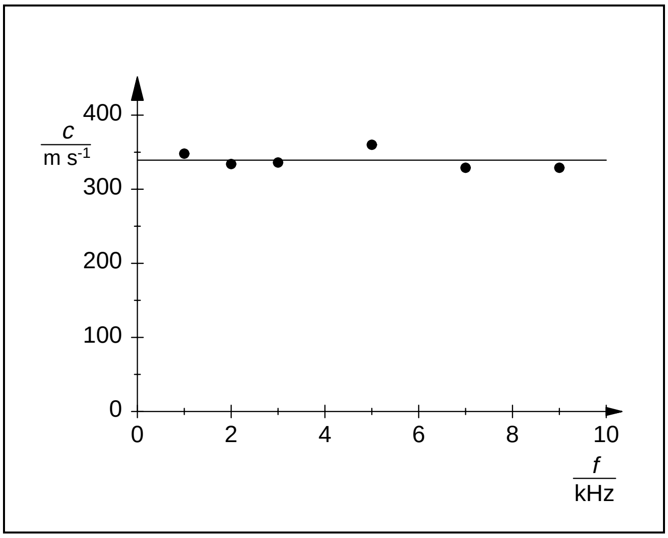


Fig. 3 The wave velocity *c* of the sound waves as a function of the excitation frequency *f*



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