Kundt's tube: determining the wavelength of sound with the cork-powder method

Objects of the experiment

- To visually demonstrate the oscillation nodes and antinodes of a standing sound wave.
- To compare the positions of the oscillation node and antinode for reflection at an open and a closed end.
- To determine the wavelength λ from the powder figures.

Principles

In a tube, a sound wave propagates as a planar wave along the tube axis when the diameter is less than half the wavelength. The sound wave is reflected at the open or closed end of the tube. The interaction of the two waves traveling in opposite directions produces a standing wave in the tube.

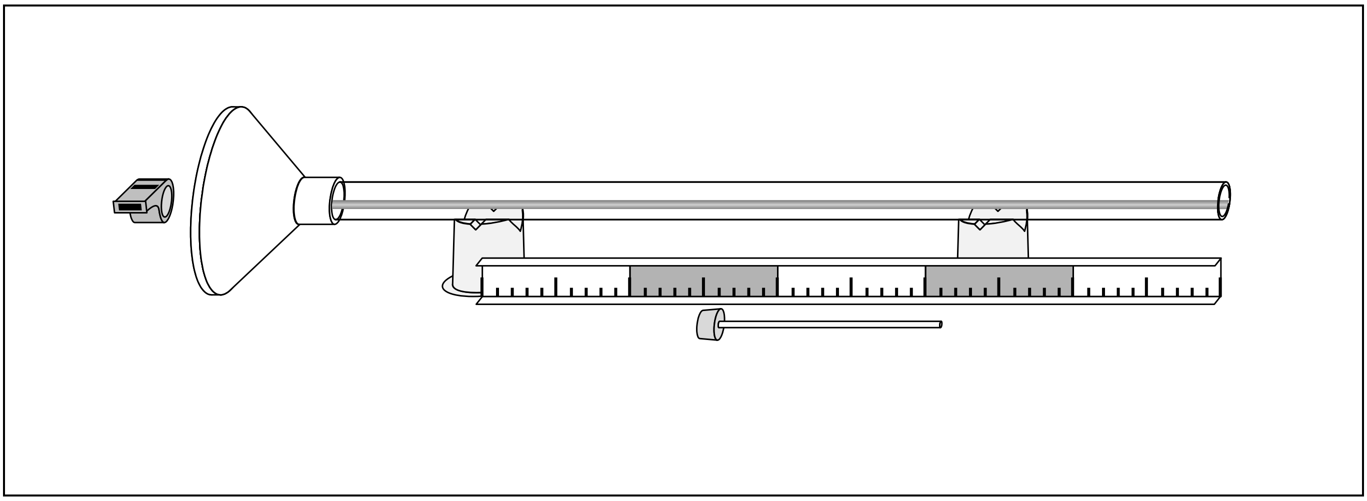
The cork powder is stirred up in the antinodes by the oscillation of the air molecules, and makes the standing waves visible. Additionally, transverse stripes form in the antinodes, caused by the circulation flow between the wall of the tube and the tube axis.

The distance between two oscillation nodes or two antinodes corresponds to one-half the wavelength. Thus, from the distance d between the first and the nth node, we can calculate the wavelength λ according to the formula:

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

The experiment is carried out using a whistle, and initially both ends of the tube are open. A tube with a closed end is created using movable plunger.

Fig. 1: Setup for determining the wavelength λ of sound waves using the cork-powder method



Apparatus

1 Kundt's tube 413 01
1 Scaled metal rail, 500 mm long 460 97

Setup

Note: the glass tube must be completely dry before starting the experiment.

– Place a small quantity (two knife-tips) of cork powder in the tube and shake the tube so that the powder is distributed in an even line over the entire length of the tube.
– Place the glass tube on its supports and attach the funnel.
– Turn the tube slightly, so that the cork powder just adheres to the side of the tube.
– In the beginning, do not insert the tuning plunger in the tube.

Carrying out the experiment

a) Reflection at an open end:

– Hold the whistle perpendicular to the glass tube and blow it directly in front of the funnel.
– Observe the lines of cork powder.

b) Reflection at a closed end:

– Distribute the cork powder evenly and insert the tuning plunger.
– Hold the whistle perpendicular to the glass tube and blow it directly in front of the funnel.
– Observe the line of cork powder and compare your observations with experiment part a).
– Count the number of nodes *n* and measure the distance between the first and last nodes.

Measurement example

a) Reflection at an open end:

A measurement example is shown in Fig. 2, top.

b) Reflection at a closed end:

A measurement example is shown in Fig. 2, bottom.

Number of nodes: $n = 7$

Distance between first and last node: $d = 39$ cm

Evaluation and results

a) Reflection at an open end:

Wreath-like powder figures are formed. An antinode is located at the open end. The transverse stripes in the oscillation antinodes are particularly easy to see at a high sound intensity.

b) Reflection at a closed end:

The dust figures, particularly the transverse stripes, are even more clearly defined than for the reflection at an open end, as the energy loss is less. An oscillation node is located at the closed end.

Using (I), we can calculate the wavelength as $\lambda = 13$ cm. At a sound velocity of $c = 340\ \mathrm{m\ s^{-1}}$, this corresponds to a frequency of $f = 2600$ Hz.

Supplementary information

In addition to the whistle, other sound sources may be used, e.g. the tuning fork 1700 Hz (411 81) or the broad-band speaker (587 08) in conjunction with a sinusoidal generator.

In the case of the tuning fork, the length of the glass tube (L = 60 cm) fulfills a resonance condition for this frequency: it is three times the wavelength λ. When the funnel is removed, an oscillation node is present at both open ends.

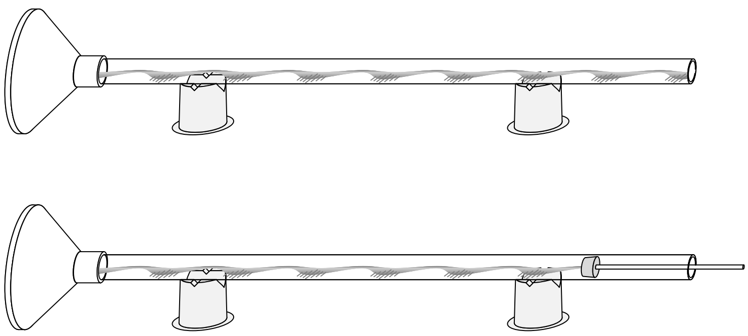


Fig. 2: Distribution of the cork powder for reflection of the sound at the open end (top) and the closed end (bottom).