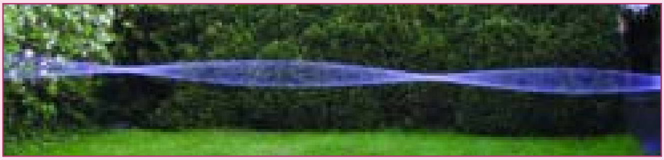
Standing waves in elastic

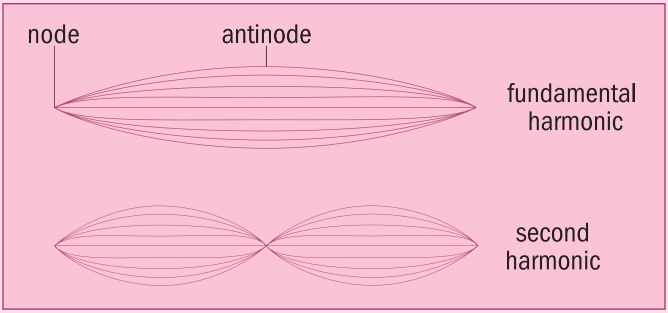
The Czech Republic/Spain

Standing waves in an elastic string

You will need...

- ✔ a battery-operated fan or toothbrush
- ✔ some plastic tubing
- ✔ a matchstick
- ✔ some hat elastic (~1.5 m)





Background

The term standing wave is applied to a resonant mode of an extended vibrating object. The resonance is created by the constructive interference of two waves travelling in opposite directions, but the visual effect is that of an entire system moving in simple harmonic motion.

Follow these steps

1 Insert a piece of match into the tube on the fan/ toothbrush so that it wobbles.
2 Attach one end of the thread to the vibrating end of the toothbrush/fan and the other to a fixed object.
3 Apply tension to the thread by pulling on it with your finger and thumb.
4 Using varying degrees of tension, set up a standing wave on the thread to demonstrate nodes and antinodes.

So what happened?

This shows how standing waves can be set up on the strings of musical instruments. Different modes of vibration can be obtained by varying the type of thread/string used, the degree of tension applied and the length of the thread/string.

The flame tube

Germany

Standing waves in a tube of gas

Safety note

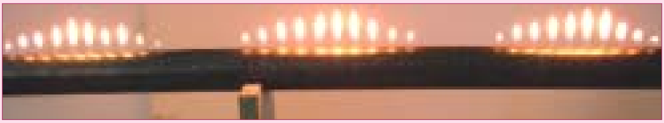
Once the gas is on, light the jets to prevent unburned gas from escaping and open the lab door to vent any fumes.

You will need...

- ✔ a metal pipe (2 m long, 3 cm wide)
- ✔ some flammable gas (e.g. natural, butane)
- ✔ an end cap
- ✔ some hosing
- ✔ a flow valve
- ✔ a signal generator
- ✔ a loudspeaker (3 cm in diameter)
- ✔ a rubber diaphragm (e.g. a latex glove)
- ✔ wooden supports
- ✔ a microphone
- ✔ an amplifier

Background

An acoustic standing wave is set up in a pipe with regions of low and high pressure. The pipe is filled with gas that escapes through evenly spaced holes. The escaping gas is ignited to show a flame pattern of varying heights along the pipe.



Follow these steps

1 Drill some holes (1–2 mm wide) on one side of the pipe.
2 Place the pipe (holes upwards) onto the supports.
3 Weld an end cap onto one end of the pipe, with a connector to attach the hosing and flow valve to the gas cylinder.
4 Fix the diaphragm to the other end of the pipe and position the loudspeaker against it.
5 Connect the loudspeaker to the signal generator.
6 Open the flow valve to fill the pipe with gas.
7 Wait 10 s or so until the gas has displaced the air.
8 Light all of the gas jets.
9 Turn on the signal generator and set it at maximum amplitude.
10 Adjust the gas flow until you see a reasonable variation in flame height.
11 Vary the driving frequency and observe different resonant frequencies.

So what happened?

About 2 to 10 wave crests are observed in the 200–600 Hz range. The maximum flame height shows a region of maximum displacement and minimum pressure – an antinode. The opposite situation is a node.

The separation between the nodes equals half a wavelength of the standing wave and depends on the frequency of the sound wave. The pipe is closed at each end, so nodes should be observed at both.

What next?

Both rhythm and frequency response can be seen nicely in music. An oscillator or a voice introduced using a microphone and amplifier can be used as a simple source for the loudspeaker.

You can measure the velocity of sound in a gas by recording the wavelength, λ, of the standing wave at different resonant frequencies, f ($v = f \times \lambda$).

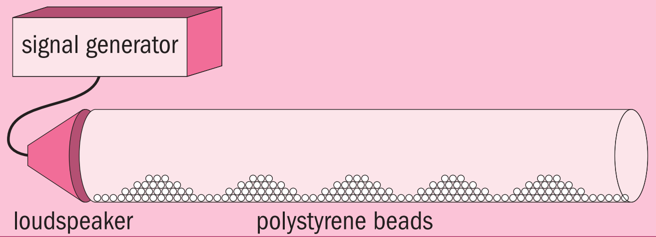
Kundt's tube

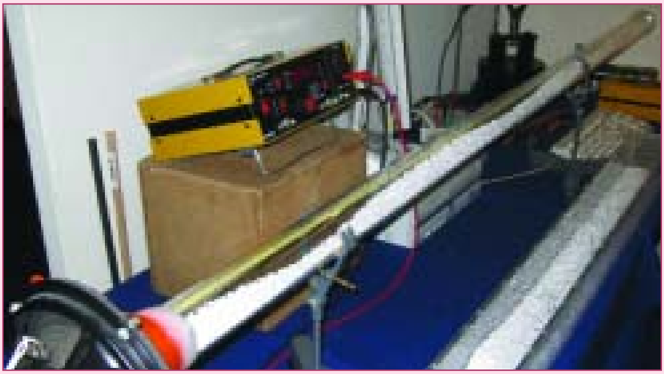
Luxembourg

Standing waves in a column of air

You will need...

- ✔ a sound/signal generator
- ✔ a loudspeaker
- ✔ a transparent plastic pipe (50–100 cm)
- ✔ some small polystyrene beads (at least 2 mm in diameter)
- ✔ a filter funnel
- ✔ an adjustable plunger
- ✔ dry cork dust or lycopodium powder
- ✔ a metal rod with an end cap
- ✔ a piece of leather cloth coated with resin





Follow these steps

1 Scatter a thin layer of polystyrene beads as uniformly as possible inside the pipe along its length.
2 Attach the loudspeaker to one end of the pipe and close the other end with an adjustable plunger (the pipe is closed so that the resonances exist at odd multiples of one-quarter wavelength).
3 Switch on the signal generator at maximum amplitude and then vary the frequency.
4 Observe the standing waves in the air column.

Background

This is a dramatic demonstration and is effective in providing an introduction to standing sound waves.

So what happened?

The driving frequency forms standing wave patterns in the air column inside the tube. The beads show the position of the nodes and antinodes by forming piles at the node locations.

What next?

Try using dry cork dust or lycopodium powder instead of polystyrene beads.

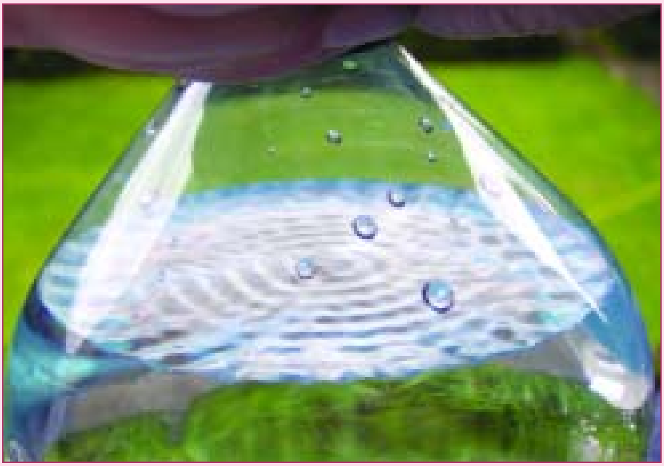
Vibrations can also be generated by fitting a metal rod with an end cap into the tube and stroking the end with a piece of leather cloth coated with resin, or stroking the tube with a violin bow.

This set-up can be used to measure the velocity of sound in air by recording the wavelength (λ) of the standing wave at different frequencies (f) ($v = f \times \lambda$).

A storm in a bottle of water

UK

Interference in an everyday context



You will need...

- ✔ a 2 litre bottle of water (in our experience, River Rock works best)

Background

This demonstrates standing waves in two dimensions.

Follow these steps

1 Hold the bottle by the neck with one hand.

2 Give the bottle a firm knock about midway along its length using the knuckles of your other hand.

So what happened?

A definite note is both felt and heard, but more dramatically a beautiful interference pattern can be seen on the surface of the water inside the bottle.

What next?

See whether it matters if the cap is removed or the water level changed.