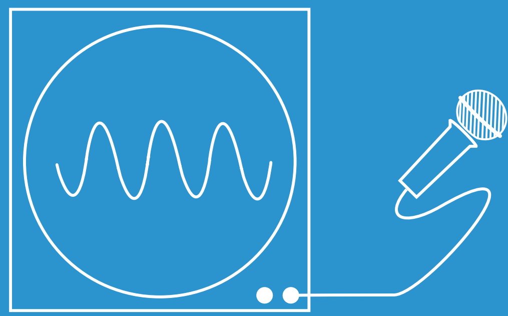
Pull out and keep!

Teaching sound waves



What's inside

Sounds confusing?

Sound is a topic that gives rise to many misconceptions. Our everyday language is littered with deceptive phrases like “the sound was carried on the air” and “listening to the radio”. So when students get to secondary school, they are likely to have a confused idea of what a sound wave is.

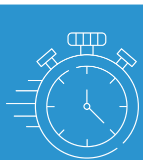
Asking them to draw diagrams for situations where sound is involved can be revealing. Some will avoid using diagrams altogether; others will represent sound as a single entity, for example a line that travels from a source to a detector. Most will struggle to represent sound accurately.

Effective teaching strategies for 11-14 year olds include re-enforcing the source, medium and detector model, and using experiments where there is no obvious source of moving air (see Activity 1). As they progress, they learn about the longitudinal nature of the waves. However, many 14-16 year olds find it difficult to conceptualise this type of motion. The fact that an oscilloscope trace for a sound wave looks like a transverse wave only adds to their confusion.

A good teaching sequence for 14-16 year olds is to introduce waveforms using the slink-o-scope demonstration before exploring sounds using a real oscilloscope (Activity 2).

Other common misconceptions and suggestions on how to address them are shown in the adjacent table.

Misconception	How to address it	Try this
Sound can travel through empty space	**Demonstrations in which the air surrounding the sound source is removed**	· A bell in a bell-jar. · A buzzer in a vacuum coffee saver. The sound from the bell or buzzer gets quieter as the air is removed.
Sound is something that is carried by individual particles	**Class activities that explore sound travelling through solids**	· Cups and strings. · Listening by resting an ear on the desk whilst a neighbour delicately scratches the bench. Emphasise that the individual particles in a solid can't move from one end to the other.
Sound travels more slowly in a solid than a gas	**Models that show that a disturbance travels faster in denser materials**	· Use standing dominoes or Jenga blocks arranged in two rows. One row has the dominoes with twice the spacing of the other. When students knock over the starting domino, the disturbance will travel faster through the more densely packed dominos.



New quick practicals on IOPSpark

The class practical and demonstrations featured in this issue are part of our new collection on IOPSpark at **spark.iop.org/quick**

Ages 11-14

Activity 1: Dancing sprinkles

This class practical shows that a loud sound is capable of making grains jump. You can use it to introduce the idea that sound is a vibration of the air.

Equipment

Each group of students will need:

- Bowl
- Cling film
- Hundreds and thousands sprinkles of the type used for cake decorations
- Metal baking tray to make a loud noise
- Large metal spoon or drumstick

Instructions

Ask the students to:
1. Cover the top of the bowl with cling film. Stretch it tightly.
2. Shake some of the sprinkles onto the cling film.
3. Hold the baking tray close to – but not touching - the cling film and strike it sharply with the spoon.

Discussion

Ask students: "Why do you think the sprinkles move when they haven't been touched by anything?"

Highlight what is the source, medium and detector in this experiment (baking tray, air and cling film respectively) and introduce the idea that sound is a vibration of the air in your explanation.

When the metal sheet is struck it vibrates and these vibrations are transmitted through the air to the cling film. The sprinkles on the surface of the cling film help us to see its motion.

Extension idea

Students could investigate how changes in volume and pitch affect the motion of the sprinkles (see worksheet on page 12).

more...
spark.iop.org/dancing-sprinkles

Speedy phones

You can measure the speed of sound using two smartphones with the PhyPhox app. Watch the video at **bit.ly/PhyPhoxSound** and download the app at **phyphox.org**

Laptop oscilloscopes

There are a number of free software packages to turn a laptop into an oscilloscope. Download onto multiple laptops for class practicals. For example, Soundcard Oscilloscope, available from **zeitnitz.eu/scope**, allows you to pause the trace so that you can discuss key features.

Make 'em sing

Bring a bit of *The X Factor* into your classroom by combining oscilloscope activities with karaoke! As well as singing along to their favourite songs, you could challenge students to sing a single note. Alternatively, ask students to bring their musical instruments to provide a purely instrumental sound source.

Credit: Shutterstock

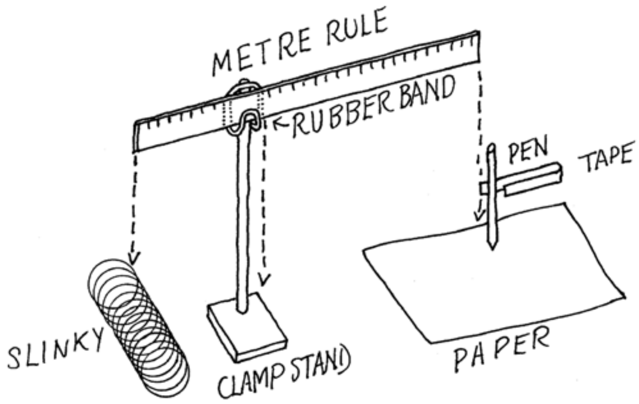
Ages 14-16

Activity 2: Slink-o-scope

This activity introduces sound wave traces on an oscilloscope using a mechanical analogue.

Equipment

- Slinky spring
- Metre rule
- Rubber band
- Clamp stand
- Felt tip pen
- Sticky tape
- Graph or squared paper



Preparation

Building and testing a slink-o-scope takes about 10 minutes. For instructions, see diagram above or watch the video at at **spark.iop.org/slink-o-scope**

Test your slink-o-scope by placing paper underneath the pen. When you send longitudinal waves down the slinky, the metre rule should pivot around the rod of the clamp and the pen should move up and down on the paper.

Demonstration procedure

1. Appoint an assistant to hold the paper under the pen.
2. Hold one end of the slinky in place and move the other back and forth to generate longitudinal waves. Show the result to the class – the pen should trace a straight line.
3. Now ask the assistant to move the paper at a steady speed in a straight line towards the clamp stand as you send waves down the slinky.
4. Display the resulting trace to the class – they should see a curve with a shape close to a sine wave.

Discussion

Ask students: "What labels should I add to the vertical and horizontal axes?"
Encourage them to think about what causes the motion of the pen across the paper. The up and down motion is driven by the slinky. The vertical axis shows the displacement of the coils. In the sideways direction, the paper was pushed at a steady speed. Emphasise that the horizontal axis shows time: the distance between two peaks is the time-period (not wavelength).

Then ask: "How would the graph change if I moved the coil back and forth by a greater amount? More quickly?"
If the coils move back and forth by a larger amount, ie you increase the amplitude of the waves, the size of the peaks will get bigger. If they move more quickly, ie you increase the frequency, the peaks on the graph will get closer together.

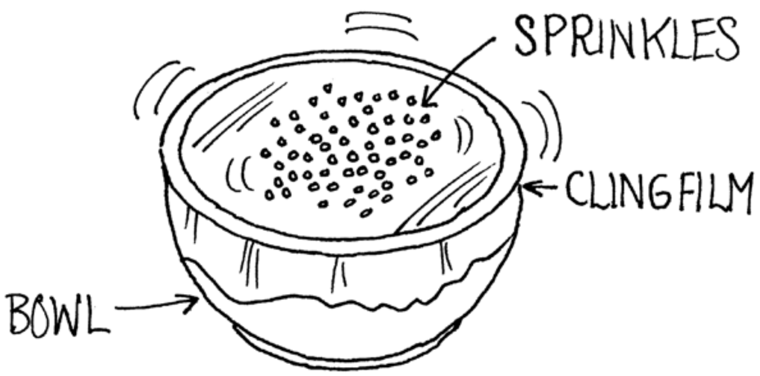
Slink-o-scope vs oscilloscope

Change in oscilloscope setting	Slink-o-scope model
Turn time base on	Move paper at steady speed
Increase time base setting	Increase speed of the paper to new steady speed
Increase vertical sensitivity setting	Increase pen to pivot distance

more...
For a teachers' introduction to the controls on an oscilloscope see **bit.ly/IOPoscilloscope**

Student sheet

More dancing sprinkles



What to do:

1. Shout at the sprinkles going from a loud to quiet voice (ie change volume).
2. Shout "boo" in a deep voice and "me" in a high voice (ie change pitch).
3. Record your observations below.

		Effect on sprinkles	
Volume of shouting (high/low)	**Pitch of shouting (high/low)**	**Height of movement (higher/lower)**	**Speed of movement (faster/slower)**

4. Complete the following sentences using these words (some more than once, some not at all):

waves · air · amplitude · frequency · vibrate · backwards · forwards · lower · higher · faster

When you make an object vibrate, this motion is passed on to the ________ surrounding the object.

The molecules which make up the air ________ and hit other air molecules. This creates sound ________ that travel through the air.

The sound waves strike the cling film and cause it to ________ , which causes the sprinkles to move.

When you shout, the difference in high and low sounds is caused by variations in in the sound wave you produce:

A higher ________ is due to air waves fluctuating more rapidly and the sprinkles bounce up and down ________ . With fewer fluctuations per second the pitch is lower and the sprinkles bounce up and down more slowly.

The ________ of the sound determines how loud it is. With louder shouting, the sprinkles jump ________ .