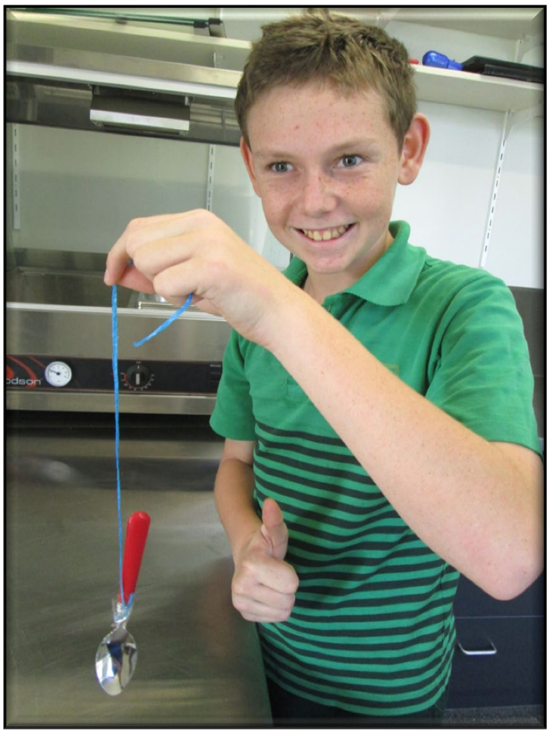
Dangerous Science – Sound

Some sounds are NOT SAFE – they can explode windows and shatter eardrums!
#DangerousScienceDeadlySound



Suggested Outcomes

(NOTE: This is by no means an exhaustive list of possible outcomes, neither is it intended that ONLY these outcomes can or should be met. Science is a deeply interrelated activity, and you may find cross curriculum links you can and should use.)

Science content

- Physical science 1: Light and sound are produced by a range of sources and can be sensed.
- Physical science 9: Forms of energy can be transferred in a variety of ways through different mediums.

Science inquiry skills

- Science inquiry skills: Question, plan, process, evaluate, communicate.

Science as a human endeavour

- Nature and development of science 3: Science involves making predictions and describing patterns and relationships

Science vocabulary words

Tier 1 (Everyday words) = sound, vibration.

Tier 3 (Specialised vocabulary)

- Vibration – a movements forwards, through, and back to the start again.
- Amplitude – how high and low a wave can go.
- Frequency – how often the waves form, or in other words, how close they are.

Warning

- While the noises here are fairly benign, silly or irresponsible behaviour can harm. Remind students on correct use of safety conscious behaviours.
- Some outdoor activities are required here; please use hat, sunscreen, and all appropriate caution.

Preparation

- Gather plenty of string and a metal coat hanger for each student.
- You may also need plastic cups (and a way to put a hole safely in them). Some water, a turning fork, coat hangers (be careful of sharp edges).

Suggestions for other year levels

As always, more material is presented here than can be used by the average class during the average lesson time. However, since the students questions can and should guide student learning, more material is presented for you convenience. Remember, it is not uncommon for students to only remember those points which answered their personal questions.

Younger:

This activity is well suited to this age group. Children at this age can have difficulty with focus. Avoid tangents into interesting side tracts if you're attempting to make a key point. They may indeed be able to experience and explain the phenomenon of sound travelling much slower than light, but might struggle to see the need or develop the ability to calculate the speed of sound.

Middle:

Help students to calculate sound, and to understand it by having them experience waves and wave motion. You might also like to illustrate sound waves with a deflating balloon, and tell the students that they need to imagine the air also waving around in a series of spherical sound waves in just the same way that the balloon nozzle jumps around to make the silly balloon deflating noise.

Teen:

Challenge students further my having them develop their own experiments for the speed of sound, and encourage them to be more precise than the activity here discussed. Help them understand that while the 'already know' the speed of sound, the point is to try and practice effective experimentation, and to see that there's often a lot of confounding variables and arbitrary decisions that need to be made just to answer a straight forward questions such as 'how fast is sound'. Can they develop a reliable test for the speed of sounds in liquids?

Learning Intent (student friendly)

'We are learning to' (WALT) – respect sound, and measure how fast it is.

Success criteria

'What I'm looking for' (WILF) – a reasonable estimate for the speed of sound.

Student learning goals

Help students make a self-monitored learning goal for this lesson.

Evidence of learning

How will you know when the learning goal is achieved? What EVIDENCE do you have that your students have met or exceeded the learning expectations? – they have a demonstrated report or discussion on not only their estimate for the speed of sound, but how they arrived at that conclusion. They need to be able to defend their result.

Engage

- ⇨ Note the Learning Intention of this lesson for students.
- ⇨ Make sure all students write down any questions they may have generated during this phase regarding the topic for today.

Tap a metal object, like a coat hanger, and ask students if they can hear the sound it makes. Invariably they will say yes, but do they know they are actually only hearing the sound the table makes when a hanger hits it? The hanger actually makes a sound like a gong: booooooooing.

Ask: students if they can hear the sound of the 'boooooing'.

Explore

Here is how to hear the coat hanger makes:

- Hang the hanger from a piece of string.
- Wrap the string around your finger (Congratulations, you just built what I call the Pching!)
- Put your finger in your ear and tap the coat hanger on something solid.

Students will be amazed once they hear the noise.

Ask: why does this happen?

- ⇨ Encourage and validate student explanations of this phenomenon. You may like to ask students to write or draw their explanation personally to avoid embarrassment to students unfamiliar with this material. Remember, 'I don't know' is a valid explanation in science – it is the beginning of learning new things!

Explain

Sound travels like a wave. Those waves actually travel better through solids and liquids than through the air, because the air is so thin and the particles so spread apart. That is why when you hold the piece of string to your ear you can hear the sound the coat hanger makes, and why you cannot when the sound is trying to reach you through the air.

See some more description in the appendix.

Elaborate

⇨ Ask students if they can design new ways to test this explanation, is it really sufficient? Can they think of further or better explanations, and the experiments needed to test them?

Try seeing what else can be attached to the string so that you can hear the noise it makes. Wooden coat hangers? Or how about pressing the string to windows or metal railing – is the noise any different?

Splash cup

- Get a tuning fork (even a spoon or coat hanger will do, but turning forks are especially effective).
- Tap it firmly, and put tough it gently to the top of a glass of water.
- Students will see the waves that result from the movement of the fork. The air is doing almost exactly the same thing, but we cannot see it!

Sound moves me

- Get a tube of cardboard.
- Stretch a balloon skin over 1 end.
- Glue a little mirror or piece of reflective foil on the outward facing balloon skin.
- Shout / scream down the tube at the balloon (not too close, you don't want to form an airtight seal so that the balloon is forced to pop off).
- Now anyone looking at their reflection in the mirror will see it shake to the sounds!

Extra extension: Finding the harmonic

Did you know that you can make the motion extra powerful if you find the harmonic frequency of the tube – the special note at which the sound waves will amplify each other and be especially loud. Sometimes you can find it by hitting the tube on the end, like a thongophone, and trying to sing that note. Knowing the harmonic frequency of an object is super-dooper useful in society!

- Ever been splashing in a bath and noticed there is a certain pace at which the waves seem to re-enforce each other to make super big splashes! That's the harmonic frequency. You can also find it running your hands in a tub of water (and it's a little less messy).
- Knowing the frequency of waves is used in everything from generating electricity to building safe bridges.
- Glockenspiels and vibraphones are built with long tubes under each note that have a frequency the same as the bar above them, increasing the volume of the note quite a bit!
- Ever notice how a noise can sound particularly loud in a given area? Sometimes it's due to echo, something the sound really is just loud. But sometimes you've found the harmonic frequency of the room…

Or you can build a cup phone or cluk cup from the appendix below.

Evaluate

- ⇨ Review with students what the felt they learnt from this lesson. Did they have any questions at the start that they feel were answered?
- ⇨ What are some ways to make our speed of sound experiment more accurate?

Success criteria

- ⇨ Review the Learning Intentions of this lesson with students. Was it met?

At the end of each class, review the learning objective and see how we did. Ask:

- Did you achieve your learning goal?
- What did You learn?
- What worked to help you achieve it?
- What might you do better next time?
- (If needed) where can you go for extra help or information?

Assessment

Prior Learning:

Ask: What is the shape of sound?

Ask: How fast can sound travel?

Formative:

As students are learning, help them self-monitor their own learning and achievements.

Summative:

Help students consider ways they can communicate their new understanding to others, just as scientists need to do.

- Try having students to verbally explain to the processes of making sound waves.
- Have students draw the unseen sound waves as they move through the air.

Creating science

Science content

As we made light and sound, and saw how fast they can travel, we saw that;

- Physical science 1: Light and sound are produced by a range of sources and can be sensed.
- Physical science 9: Forms of energy can be transferred in a variety of ways through different mediums.

Science inquiry skills

Thought experimentally determining the speed of sound, we were using our:

- Science inquiry skills: Question, plan, process, evaluate, communicate.

Science as a human endeavour

As we predicted how fast sound was, and used our experimental results to discuss the distance of far away events and objects such as lightning, we were;

- Nature and development of science 3: Science involves making predictions and describing patterns and relationships

So what?

Everything we hear happened just a fraction of time ago. Our brains compensate for that over close distances.

Some sounds are so loud they can harm us.

Appendix: The worlds loudest sounds

From http://listverse.com/2007/11/30/top-10-loudest-noises/ 16 aug 18

10. Rock Concert/Speakers Speakers. A 400,000 Wat rock concert or a similar set of speakers mounted in a vehicle can reach ear-splitting decibel levels. Is it any reason most promoters recommend you wear ear protection to stave off the 135-145 decibel sound waves?

9. Fireworks. Though not typically heard up close, fireworks are still explosions and are very loud. The sound heard from the sky is pretty loud, though not damaging, but at the bursting point the decibel levels reach a staggering 145-150. Even tests are performed under strict sound proofing to avoid any ear injury.

8. Gunfire. For anyone unfortunate enough to be standing near it can be quite damaging to the ears registering at a quite loud 145-155 decibels. This is the very reason why you should always wear ear protection when on a firing range.

7. NHRA Dragsters. A dragster as it fires up its engines and screams down the raceway can be more than just loud; it can be damaging to your entire body. At the 155-160 Decibel range not only will it severely to permanently damage your hearing, but it also vibrates your vision and makes it temporarily difficult to swallow. That's why no one stands next to them.

6. Space Shuttle Launch. When the rockets fire, it is wise and, in fact, fully enforced, that you stand at least a half-mile away lest you get inundated by 165-170 decibels of painful sound. Unlike many other loud noises, the shuttle rocket sound is constant as it creates the thrust necessary to lift it from the ground.

5. The Blue Whale Whales mostly emit very loud, highly structured, repetitive low-frequency rumbling sounds that can travel for many miles underwater. These songs may be used for communicating with other blue whales, especially in order to attract and find mates. The call of the blue whale reaches levels up to 188 decibels. This extraordinarily loud whistle can be heard for hundreds of miles underwater. The whale is the loudest, and, the largest animal on earth.

4. Volcano – Krakatoa. The 1883 the Krakatoa eruption ejected more than 25 cubic kilometres of rock, ash, and pumice and generated the loudest sound historically reported at 180 Decibels: the cataclysmic explosion was distinctly heard as far away as Perth in Australia approx. 1,930 miles (3,110 km), and the island of Rodrigues near Mauritius approx. 3,000 miles (5,000 km).

3. 1-Ton TNT Bomb. Standing as close as 250 feet away from the impact, the resulting explosion from a 1 ton bomb creates a decibel count of 210. Without sufficient hearing protection, not to mention a complete sound-resistant bunker surrounding you, you could quite literally die from the intense vibrations that would literally shake you apart. Unless, of course, you were under the bomb.

2. 5.0 Richter Earth Quake. A sufficient enough quake to rend the ground in twain and destroy buildings, whole rock, and human life reaches a decibel level of 235. If you are caught in the epicenter and are unlucky enough to not be above the ground in a plane or helicopter, the intense noise and vibrations could kill you long before death by any falling object.

1. Tunguska Meteor. The Tunguska event was a massive explosion that occurred near the Podkamennaya (Under Rock) Tunguska River in what is now Krasnoyarsk Krai of Russia, at 7:40 AM on June 30, 1908. The explosion was most likely caused by the air burst of a large meteoroid or comet fragment at an altitude of 5 to 10 kilometers (3–6 mi) above Earth's surface. It was measured with the similar impact of a 1000-Mega-ton bomb with a decibel rating 300-315. This is often considered to be the loudest single-event in history.

Bonus: Lake Taupo Eruption. Lake Taupo is a large lake in the middle of the North Island of New Zealand. The lake is the caldera that resulted from a massive volcanic eruption in 180 AD. It is New Zealand's largest eruption in 20,000 years. It ejected around 120 cubic kilometers of material, of which 30 cubic kilometers were ejected in the space of a few minutes. It is believed that the eruption column was 50 kilometres high, twice as high as the eruption column from Mount St. Helens in 1980. The resulting ash turned the sky red over Rome and China. This eruption was reportedly heard in China. Lake Taupo today, is one of New Zealand's popular tourist attractions for its beauty and swimming. The fact that the lake is the largest fresh water lake in Australasia, and approximately the same size as Singapore, ensures it is a huge 'must do' component to many tourists.

Sonic Boom

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A sonic boom can be over 200 decibels, shaking windows for miles around!

Under the right conditions the pressure wave can be seen forming a cloud.

Measuring the Speed of Sound

You will need:

- Something that can be loud – an airhorn, gong, or even car horn will do.
- Some kind of visual signal that the noise is being made – a wave of an arm, a jump in the air, or flashing a light, for instance.
- At least 300 meters distance, the more the better, but you need to be able to hear the noise.
- (You might like a phone or walkie talkie to communicate over that distance)
- A very accurate means of measuring time, such as a stopwatch to hundredths of a second.

The technique:

- Have everyone stand at one point, say, the side of an oval.
- Have your noisemaker at the other end of the oval.
- Have the person who makes the noise give the visual signal at the same time.
- Have everyone else try to measure the time between the visual signal and the time it takes to hear the noise. Remove outliers and average out the results.

Advice and tips:

- If you have about 300 meters, it'll only take 1 second between the visual signal and the time the sound reaches you. It can be tough to measure things over such a short time, but it does give you an appreciation of how long a second can sometimes be.
- If you're a kilometre away, it'll take 3 seconds for the sound to reach you. It can be very hard to see a visual signal a kilometre away.
- It's true – the light takes time to reach the observers as well. But at 300,000 kilometres in only **one second**, we can ignore that for this experiment.

Calculate the speed of sound:

Speed of sound = Distance in meters / Time in seconds X 3.6 (to covert to Kmph)

- What do you think is the speed of sound?
- How can you make your results more accurate? (better stop watches, electronic detection rather than human response time)
- What factors might affect the speed of sound? (humidity, altitude)

The official speed of sound in air is 330 meters per second – do you think that is correct?

Can you measure the speed of sound over a long, metal fence? Is it faster or slower than in air?

Note: While sound can travel at around 1000 kilometres every hour, it's still SLOWER than the speed at which the earth is turning around!

What happens when things travel faster than the speed of the sounds they are making?

All the sound waves get bunched up into a HUGE pressure wave. This results in an enormous bang, like thunder. With something as small as a fighter jet this soundwave can still break windows several kilometres away.

Sometimes this pressure wave can create a cloud in the local air, as the sudden low pressure allows water to collect into droplets.

The Chebuskal meterorite was much larger, and hit the atmosphere at several times the speed of sound. It knocked over entire walls with nothing but the soundwaves.

That meteorite had the power of several atomic bombs (but was much ‘cleaner’) Any atomic bomb or large meteorite can create a pressure wave of air, which could be referred to as sound, that is so powerful that it can knock over entire buildings, shatter solid steal, and flatten mountains.

The Pching (AKA coat hanger banger)

Sound travels at about 330 meters in one second right? Only in air!

How fast does it travel in string, stone or wood? What if I told you it was twice and even up to ten times as fast in solid objects! Sound also travels a lot better through solid objects in a lot of other ways – try this simple demonstration to help you experience just how.

1. Tap an object, listen to the sound.
2. Now tie a loop in the end of a piece of string.
3. Hang the object from that loop, or press the string to the object.
4. Wrap the string around your finger and put your finger in your ear. Tap again.
5. Does it sound any different now? How, and in what ways?

Sound travels much better in solid objects than in air. Why? Mostly because air is so thin – the particles are spread out 100 times more than in a solid or liquid. Whales can make use of this, when at certain depths and temperatures their songs can be heard half way across the world!!!

Try making a Pching – tie two strings to the end of a coat hanger (so as to get the stereo effect), wrap them, tap them, and listen to the sounds!

MAKE SURE you don't let the string touch your clothing or hair, or the sound waves will be absorbed and you won't get much noise at all!

Cup Phones

Here's another way that solid objects can be used to move sound.

1. Cut a small hole in the bottom of two plastic cups.
2. Thread a long piece of string through the holes and tie a big, thick knot in each end so that the thread doesn't slip out.
3. You've just made a cup phone! You can use it to talk to your friends, even around corners, but it only works when the string is held tight!

What else can you do with your cup phone?

- Will it work if the string from two phone lines are crossed? Can four people speak at once? More?
- How can you store you cup phone best so that it doesn't become permanently tangled?
- If you tie your string to a match stick instead of just tied in a knot, does it work even better or worse? What about gluing instead of knotting?
- How LONG can a cup phone line be before it's not longer useful?
- Do thick or thin cups or lines work best? What's the difference?

Maybe you can think of some others?

How does it work? Any suggestions?

One reason could be that the bottom of the cup, while attached to the string, acts as an amplifier turning the tiny vibrations in the string into much larger vibrations in the air – that's why you can hear it better at the cup end and not half way along the string (though the sound is still there!) Like to see this at work once more? Try making: Cluck Cup

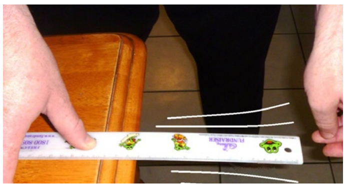
Tie a string to the inside of another cup, tie a small cleaning rag to the other end of the string, wet the rag and then pull it along the string while holding it tightly. This should make a loud clucking noise like a chicken – any ideas why? How does friction help? Are vibrations being created to make a sound? What do you think?

Vibrations

Sound (and light) are made up of vibrations. A vibration is when something moves back and forwards, back and forwards. We can hear vibrations from about 20 times a second, which is a very deep note, to 20,000 times a second which is very high! Bats can hear up to 40,000 times! (that's a very high note!) Want to hear a low note?

Place a ruler on the edge of the table

Pluck it. As it vibrates, it makes a note



Move the ruler out till the note is too deep to hear

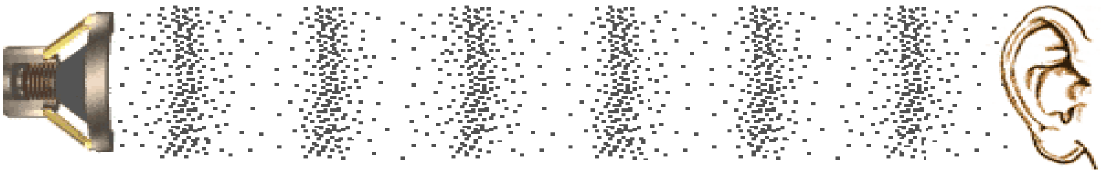
Don't get mixed up! You can still hear the noise as the ruler hits the table, and you can still hear the noise as you finger plucks the ruler, but the main note, the loudest note, seems to disappear…

Actually, it's still there, your ears just can't respond to it. But an elephant could, they can hear and make notes too deep for humans to hear!

Sound travels as waves

Sound vibrations move along very much like ripples in pond. In the air, the sound waves spread out in every direction, even turning around corners

(which is why you can hear around walls).



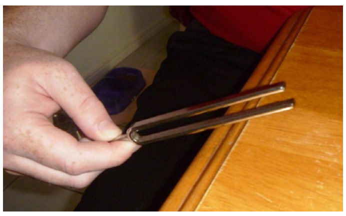
Did you know sound travels much faster in solids or liquids than in the air?

It is possible to make sound waves you can see:

(Ps, it is possible to use a solid steal knife instead, if you hold it just right: so that it rings for a long time!)

Get a cup and turning fork

Strike the fork, place it on the cup



And watch the sound waves!