You will need stopwatches, a trundle wheel and two wooden blocks to hit together. Students should ideally have a stopwatch each but the practical will be conducted as an entire class.

1. Take students to a large outdoor space with a large, flat wall.
2. Get them to line up in a single line parallel to the wall, each with a stopwatch. You should stand towards the middle of this line.
3. Ask two students to measure the distance to the wall and back with a trundle wheel (or pre-measure this distance and have cones/chalk to mark the line to stand at).
4. If multiple students measure the distance, you can discuss taking the mean.
5. Demonstrate making the sound (make a sharp sound such as banging two bits of wood together once) and listening for the echo so students know what it will sound like.
6. Then demonstrate when you would start and stop your stopwatch by shouting 'start' and 'stop' as you make the noise and hear the echo.
7. Get students to practise starting and stopping the stopwatches at the right time.
8. Do three 'official' trials where students note down their measured times on the *Practical worksheet*.
9. On returning to the classroom, demonstrate calculating the mean time (if necessary) and ask students to use this along with the mean distance to calculate the speed of sound.
10. Ask students to complete the independent practice questions on the *Practical worksheet*.

P5.3 Microphones and ultrasound

Students' learning objective: *I am learning about technological applications of sound so I can explain the link between technology and science.*

In this topic, students will apply their knowledge of sound and how it is produced and detected to some technological applications in microphones, speakers and then ultrasound echolocation.

Knowledge check

After working through the *General science quiz*, display the *Knowledge check* slide and, using MWBs, deliver the questions one by one, reteaching concepts as necessary.

	Question	Answer	Notes
1	What is oscillating in a sound wave travelling through the air?	The particles in the air	
2	What type of wave is sound?	Longitudinal	
3	How is a sound wave produced by a drum?	When hit, the drum skin vibrates, colliding with particles in the air, making them oscillate	As it asks for how a *sound wave* is produced, we need students to say more than the skin vibrates.
4	How do our ears detect sound?	When a sound wave hits our ear drum, the ear drum vibrates. Our cochlea turns this vibration into an electrical signal.	

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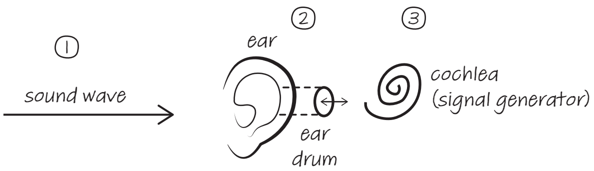
	Question	Answer	Notes
5	What is an echo?	A reflected sound wave	
6	When do echoes occur?	Whenever a sound wave reaches a change in medium	Ensure students know what medium means.

Guided explanation

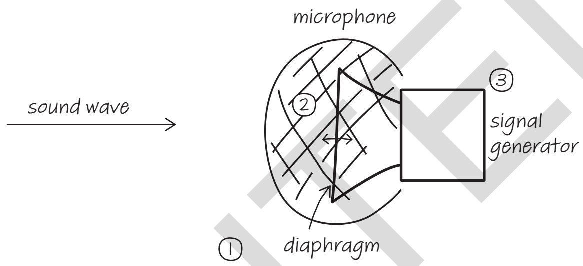
How do microphones work?

Introduce the topic by explaining that microphones behave in an almost identical way to the ear. Draw the diagram below of a simple model of the ear as a reminder, accompanied by an explanation, similar to the one that follows.



1 As a sound wave travels through the air, the oscillations of particles in the air force the ear drum to vibrate.
2 This vibration of the ear drum is turned into an electrical signal by the cochlea.
3 This electrical signal travels down the auditory nerve to the brain.

Draw the following diagram of a microphone to show a direct comparison, accompanied by an explanation, similar to the one that follows.



1 Inside a microphone there is a thin, stretchy sheet of elastic. We sometimes call this a membrane, but we will refer to this as a *diaphragm*.
2 This acts just like the ear drum – it vibrates when it is hit by the particles in the air that oscillate because of a sound wave.
3 And just like in the ear, where the cochlea turned the vibration of the ear drum into an electrical signal, a microphone does the same thing with a signal generator.

Check for understanding

Display the *CFU* slide and, using MWBs, ask questions like the ones below.

- What vibrates in a microphone to detect sound?
- What is a diaphragm?
- What does the signal generator do?
- Which part of the ear is the diaphragm similar to?
- Which part of the ear is the signal generator similar to?

Independent practice review

Student Practice Book questions 115–23 (page 103).

Q	Notes
118	Ensure students are using the mathematical word 'parallel'.
121	Includes content from Unit P3.

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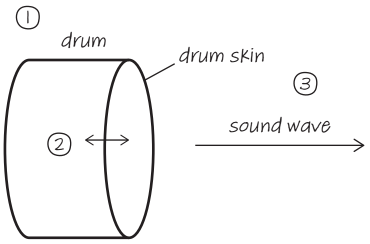
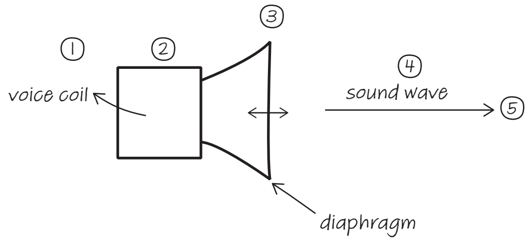
How do speakers work?

Draw the diagram below of a drum as a reminder, accompanied by an explanation, similar to the one that follows.



1 The skin of a drum vibrates when it is hit.
2 This vibration makes the particles in the air oscillate.
3 A sound wave travels out from the drum.

Draw a similar diagram of a speaker as shown here, accompanied by an explanation, similar to the one that follows.



1 Whereas a drum needs to be hit to cause a vibration, a speaker has a mechanism like a microphone in reverse.
2 An electrical signal (the information about the music) is passed to a voice coil (like a backwards signal generator)
3 This voice coil moves left and right and causes the diaphragm (a thin elastic sheet at the front of the speaker) to vibrate.
4 The vibration makes the particles in the air oscillate.
5 A sound wave travels out from the speaker.

Check for understanding

Display the *CFU* slide and, using MWBs, ask questions like the ones below.

- What vibrates in a speaker to make the sound?
- What causes the diaphragm to vibrate?
- How is a speaker similar to a drum?
- How is a speaker different to a drum?
- How is a speaker similar to a microphone?
- How is a speaker different to a microphone?

Independent practice review

Student Practice Book questions 124–30 (page 104).

Q	Notes
127	No explicit calculations using the EVERY method are needed.
130	Ensure students set out their working using the EVERY method.

Before we move on to explore ultrasound, a knowledge check must be conducted to ensure students remember how we measure sounds by their frequency and what humans can hear.

Knowledge check

Display the *Knowledge check* slide and, using MWBs, deliver the questions one by one, reteaching concepts as necessary.

	Question	Answer	Notes
1	What are the units we use to measure frequency?	Hertz (Hz)	
2	What is vibrating in our ears to allow us to hear?	Ear drum	
3	What is the lowest frequency of sound wave that humans can hear?	20 Hz	Ensure students give units.
4	What is the highest frequency of sound wave that humans can hear?	20 000 Hz	

Guided explanation

What is ultrasound?

Display the slide, which shows the hearing range of different animals, including humans. Explain that anything above the higher limit of human hearing (above 20 000 Hz) is called *ultrasound*. It has a special name simply because we cannot hear it. However, it is exactly the same as a 'regular' sound wave, with oscillations of particles parallel to the direction of the wave. The only difference is that these oscillations are at a very high frequency (more than 20 000 oscillations per second). We cannot hear it because our hearing system cannot pick up oscillations that are that fast.

Check for understanding

Display the *CFU* slide and, using MWBs, ask questions like the ones below.

- Where is ultrasound here?
- Which animals can hear ultrasound?
- Why can we not hear ultrasound?
- Above which frequency is sound considered to be ultrasound?
- How is ultrasound similar to 'regular' sound?
- How is ultrasound different to 'regular' sound?

Independent practice review

Student Practice Book questions 131–37 (pages 104–105).

Q	Notes
132	No explicit calculations using the EVERY method are required here.
137	Ensure students have not picked up any misconceptions about sound being a 'different thing' that travels between particles.

Guided explanation

How do we use ultrasound?

Display the first slide and discuss some places where ultrasound is used.

1. We can use it to detect things inside the human body.
2. Animals use ultrasound to communicate and to find the location of objects.
3. We can use it to image babies in the womb.

Explain that all these examples involve finding the location of an object. We sometimes call this process *echolocation* as we are using the echo from an object to locate that object.

Tell students that ultrasound reflects from a change in medium, just like sound, and just like any other wave. When we measured the speed of sound in Topic P5.2, we used a similar technique to how ultrasound is used to locate *where* objects are.

Display the second slide, which shows a ship using echolocation, accompanied by an explanation, similar to the one that follows.

1. We know the speed of ultrasound in almost every material.
2. So we know how many metres ultrasound will travel every second – this is the speed.
3. If we time how long it takes ultrasound to get somewhere, we can work out how far away something is.
4. For example, if ultrasound travels at 200 m/s and it takes 4 s for it to travel from A to B, then the distance from A to B is 800 m.
5. So we can emit an ultrasound and start a stopwatch.
6. The sound will travel a certain distance through a medium.
7. It echoes from a surface and travels back.
8. We detect the echo and stop the stopwatch.
9. We can then work out how far away the surface was that the ultrasound reflected from.

Check for understanding

Display the *CFU* slide and, using MWBs, ask questions like the ones below.

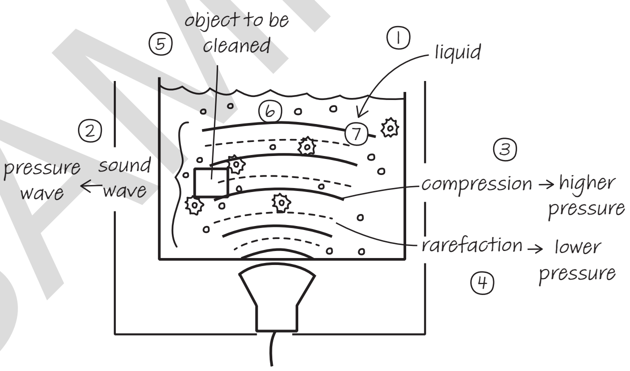
- Why does ultrasound echo off things?
- What do we need to know to work out how far away things are with ultrasound?
- If ultrasound travels at 400 m/s and it takes 2 s for ultrasound to get from A to B, what is the distance from A to B?

The independent practice for this section is included in the questions that follow the guided explanation below.

Guided explanation

What else do we use ultrasound for?

Display the slide, which shows an example of ultrasound being use for cleaning purposes. Add to the slide as shown below, accompanied by an explanation, similar to the one that follows.



1. We can play ultrasound through a bath of liquid for cleaning purposes.
2. Sound waves are sometimes also called *pressure waves*. Like all waves, they transfer energy from place to place, but not matter.
3. This is because the air pressure is changing slightly – where the sound wave has a compression, the air pressure is slightly higher as more particles are packed closer together.
4. Where the sound wave has a rarefaction, the air pressure is slightly lower as fewer particles are packed close together.
5. We often use high pressure liquid for cleaning, e.g. using a pressure washer to clean a car or the pavement. The high pressure of the water can force dirt off a surface easily. Ultrasound can be used in a similar way, but is much safer than using high pressure water as there is less chance of damage.

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6 (Add some bubbles to the diagram.) If we pulse ultrasound through a liquid, the compressions and rarefactions that occur at high frequencies lead to tiny bubbles forming.

7 (Alter the diagram so that some of the bubbles 'pop'.) The bubbles eventually pop and can remove dirt as they do so.

Explain that the bubbles can remove stains and dirt from things such as jewellery and metallic surfaces if they are left in the ultrasonic bath for long enough. This technique can be used in physiotherapy to help the body heal soft tissue damage such as sprains or repair muscles.

Check for understanding

Display the *CFU* slide and, using MWBs, ask questions like the ones below.

- Why are sound waves sometimes called pressure waves?
- If we want to wash some dirt off a plate, do we turn the tap to high pressure or low pressure?
- How can ultrasound waves help to clean?
- What else can we use ultrasound for?

Independent practice review

Student Practice Book questions 138–47 (page 105).

Q	Notes
140a	We are not rearranging yet, so students just need to listen carefully to the units and appreciate what m/s means to get this.

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