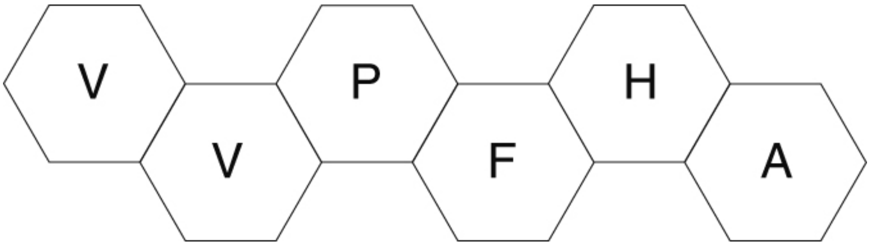
Name ______________________ Class __________ Date ___________

1



a What V make sounds?

b What V describes how loud a sound is?

c What P describes how low or high a sound is?

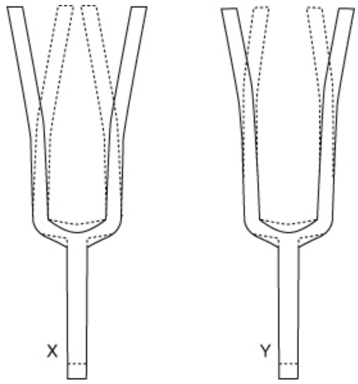
d What F describes the number of vibrations per second?

e What H is the unit for the number of vibrations per second?

f What A is the size of the vibrations?

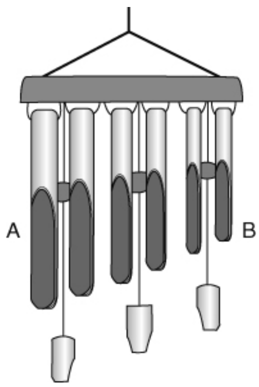
2 Underline the correct words to complete these sentences.

a The sound made by tuning fork X is (louder/quieter) than the sound made by Y, because the (amplitude/frequency) of the vibrations is (bigger/smaller).



b The wind chimes at A make a (higher/lower) sound than the ones at B because they are (longer/shorter).

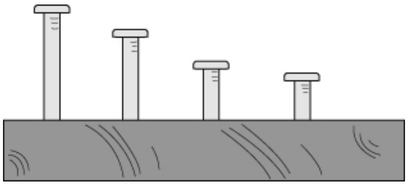
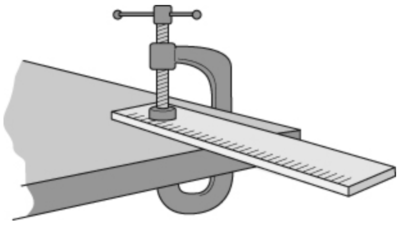
Long chimes vibrate more (quickly/slowly) than short ones, so the sound they make has a (lower/higher) frequency and a (higher/lower) pitch.



I can…

- recall the meanings of some words connected with sound
- explain how to change the pitch or volume of some sounds.

Aim: You are going to find out how the length of an object affects the sound it makes.

A Blow across the top of the empty bottle. Add some water to the bottle and blow across the top again. Repeat with even more water in the bottle	**1** What is vibrating to make the sound? **2** How does the sound depend on the amount of water in the bottle? **3** What should you keep the same to make the test fair?
B Tap the different nails. 	**4** How does the sound depend on the length of the nails?
C Tap the wind chimes.	**5** How does the sound depend on the length of the wind chime?
D Drop each piece of wood onto the floor. Be careful not to drop them on your feet!	**6** What do you have to keep the same to make this a fair test? **7** How does the sound made by the wood depend on the size of the wood?
E Twang each rubber band.	**8** How does the sound depend on the thickness of the rubber band?
F Twang the ruler against the edge of the table.  Change the length of the ruler and make it vibrate again.	**9** How does the sound change when you change the length of the ruler?

Considering your results/conclusion

10 Write a conclusion that sums up all your findings.

I can…

- make careful observations
- draw a conclusion.

Aim

To investigate whether the sound of a bird call depends on the size of the bird.

Hypothesis

The pitch of a bird call depends on the size of the bird.

Prediction

If a bird is larger it will have lower-pitched calls.

The internet has lots of information about different birds, and recordings of their songs.

Planning

Think about these questions to help you to decide how you are going to find out whether or not the hypothesis is correct.

1 Some websites give you information such as the length of a bird (usually ignoring the tail feathers and beak), the wingspan and the mass.

- **a** Which of these will you use for the ‘size’ of your bird?
- **b** Why do you think this is the best of these measures to use?
- **c** What will you do if the information is a range of sizes (such as ‘mass = 1500–2000 g’)?

2 You can often look for patterns in data by plotting a graph. However you can only listen to the bird calls – you do not have any numbers to describe what they sound like. The tables below show you two ways in which you could compare your data.

A

	Large birds	Small birds
High pitch		wren
Low pitch	raven	

B

In order of size	In order of pitch
wren	wren

- **a** If you use method A, what would you expect to find if the hypothesis is correct? Explain your answer.
- **b** Explain what you would expect to find using method B.

3 How will you make sure you have enough information to test the hypothesis properly? How many different birds will you investigate? The box shows some birds you could investigate to get you started.

blackbird	buzzard	heron	jackdaw	raven	red kite	robin
swift	tawny owl	wren				

Useful websites: www.garden-birds.co.uk and www.rspb.org.uk/wildlife/birdguide/name/a/

Presenting your results

4 Present your results in one of the ways shown in question 2.

Considering your results/conclusions

5 Write a conclusion for your investigation. Explain your conclusion if you can.

6 Is the hypothesis correct? Explain your answer.

Evaluation

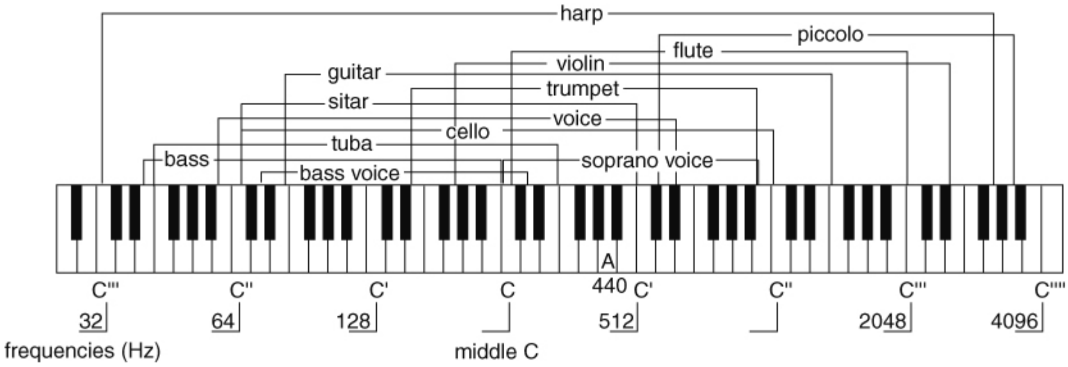
7 Is there any way you could improve your investigation? Explain your answer.

I can…

- obtain data from secondary sources
- draw conclusions from data.

Most music is based on a scale of notes, which are arranged with rising or falling pitch. Western music is based on notes named using the first seven letters of the alphabet – A, B, C, D, E, F, G. The difference between two notes of the same name, such as C to C, is called an octave. Two Cs one octave apart have frequencies where the higher C is twice that of the lower C.

Different musical instruments can play different ranges of notes. The diagram shows the range of some instruments compared to a piano.



1 Explain what high- and low-pitched sounds are and give an example of each.

2 What is the link between frequency and pitch?

3 Look at the diagram of the piano keyboard.

a What are the two missing frequencies?

b What is the frequency of the note an octave higher and an octave lower than the A note shown?

4 a Name two instruments with overlapping frequencies.

b Name two instruments that do not have overlapping frequencies.

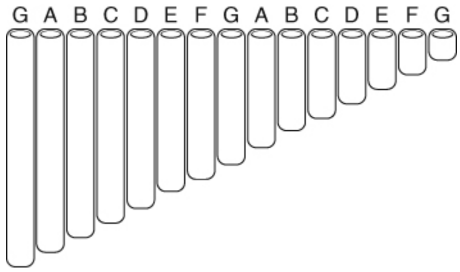
c Apart from the piano, which instrument has the greatest range?

5 Pan pipes have been known for over 2000 years. They are played by blowing across the individual tubes.

a How many octaves do these pan pipes have?

b How many notes can you play on the pan pipes?

c What vibrates to create the sound?



I can…

- relate the pitch of a note to its frequency
- obtain information from a diagram.

Cut out the cards. Write down the card or cards that matches each statement. Some statements have more than one answer, and each card can be used more than once.

I can…

- recall the meanings of words connected with sound
- recall the ways in which animals make and use sounds.

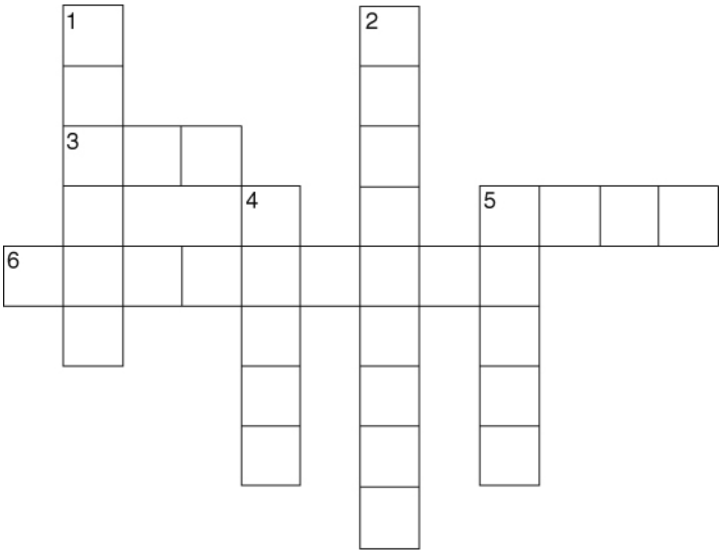
amplitude	canary
frequency	gorilla
grasshopper	intensity
lion	loudness
pitch	volume

1 I make a loud noise.
2 I make a noise by hitting things.
3 I make a noise by rubbing things together.
4 I make a noise using parts of my body.
5 I make high pitched sounds.
6 I make low pitched sounds.
7 I depend on how fast an object vibrates.
8 I depend on how large the vibrations are.
9 I am the number of vibrations per second.
10 I am the size of vibrations.
11 I am another way of describing intensity.
12 I am measured in hertz.

Describing sounds

Name ________________________________ **Class** _____________ **Date** ______________

1 Use the clues to complete the crossword.



Across

3 A sound wave with a low frequency makes a sound with a ____ pitch.

5 A loud sound has a ________ volume

6 A word that describes the size of vibrations.

Down

1 Another word for the intensity of a sound.

2 A word that describes the number of vibrations per second.

4 A word that describes how high or low a note sounds.

5 The unit for measuring the number of vibrations per second.

2 A bell makes a sound when you hit it.

a How can you make a louder sound? ____

b How does this change the vibrations of the bell? ________________________________

3 You make a sound using a xylophone by hitting bar Y.

a How will it sound different if you hit bar X?

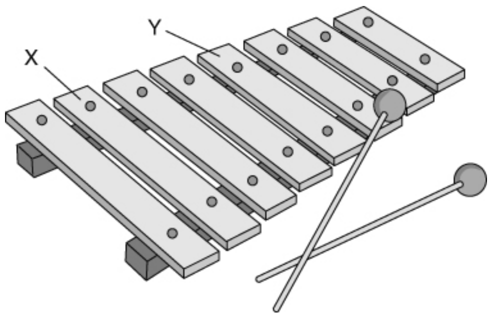
____

b Will bar X or bar Y vibrate with the higher frequency? __________________________

c Explain your answer to part b.

____

____

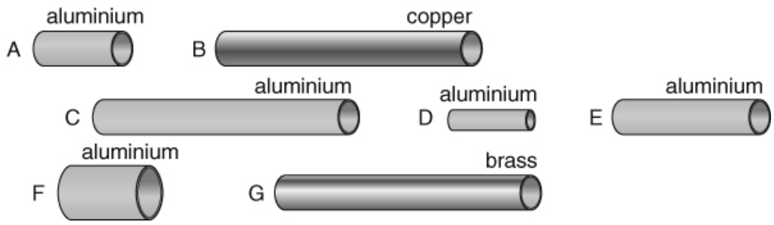


I can...

- recall some words connected with sound
- describe how to make sounds louder or higher.

Amir and Bev are investigating how the size and material of a metal tube affects the sound it makes when it is tapped.

They are given these tubes:



1 Which tubes do they need to investigate to find out how the sound is affected by:

- **a** the length of the tube
- **b** the diameter of the tube
- **c** the material of the tube?

2 Explain your answers to question 1.

3 Amir and Bev used a digital meter to find the frequency of the note made by each tube. The table shows their results.

Write conclusions to explain how the frequency of the sound is affected by:

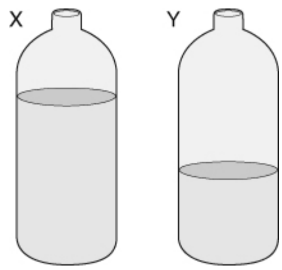
- **a** the length of the tube
- **b** the diameter of the tube
- **c** the material of the tube.

Tube	Frequency (Hz)
A	1500
B	400
C	400
D	1500
E	660
F	1500
G	400

4 How do their results show which tube (or tubes) will make the highest pitched note?

You can make music using bottles with different amounts of water in them. When you blow across the top of the bottle, the air inside the bottle vibrates.

5 Which bottle will make the highest note? Explain your answer.



6 The music shows the first line of the nursery rhyme 'Twinkle, twinkle little star'. The higher up the note on the music, the higher the pitch of the note.

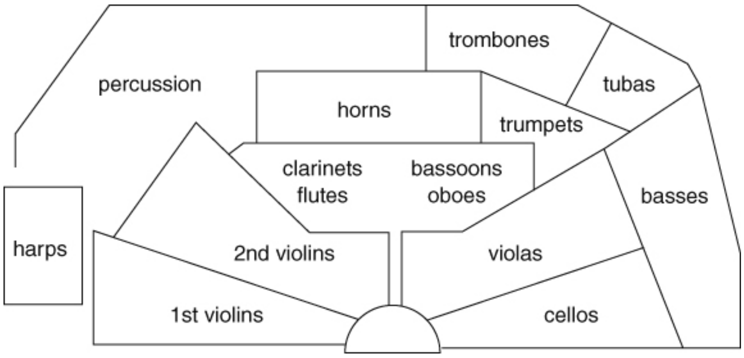
Draw *three* bottles, and show the amount of water you would put in each one to allow you to play this tune. Label the bottles and explain which order you would blow across them.

I can…

- choose which objects to investigate for a fair test
- relate the size of an object to the pitch and frequency of the sound it makes.

An orchestra is a group of musicians who play music together.

The orchestra contains stringed instruments such as violins, violas, cellos and basses. The sounds are produced by bowing the strings of the instrument or by plucking the strings (called pizzicato). Behind the string section is the woodwind section and behind that is the brass section. The final part of the orchestra is the percussion section containing the drums and cymbals. One cymbal crash can be louder than the whole orchestra!



When the musicians play their instruments, it is very important that the notes they play match with each other. For example, the note ‘A’ played by a violin should be exactly the same pitch as the same ‘A’ note played by a flute, a cello or any other instrument.

Before playing together, musicians ‘tune’ their instruments, to make sure that if they all play the same note, all their notes are the same pitch. A small group of musicians might tune their instruments using a tuning fork but orchestras solve this problem in a different way. Before a conductor comes to the podium, the oboe player tunes their oboe so that their ‘A’ note has a frequency of 440 Hz. The player is asked to play that note. The oboe is chosen to play this note as it holds the pitch most consistently. The other musicians then play an A and adjust the pitch of their instruments up and down until they hear their note is exactly the same pitch as the oboe’s.

‘International standard pitch’ is when the ‘A’ note above ‘middle C’ is tuned to 440 Hz. It was only adopted by western orchestras in 1939. Before this, a number of different pitches were used.

In 1859, a French law fixed concert A at 435 Hz. This was a compromise between the audience’s favourite of 450 Hz, which was too high for singers, and 422 Hz, which was the value used by composers such as Mozart and Handel. This law meant that many new wind instruments and tuning forks had to be made.

In 1896, the London Philharmonic Orchestra used scientific knowledge to establish its own preferred value of 439 Hz. They believed that when the French set their concert A at 435 Hz, it was to be played at a room temperature of 59 °F (degrees Fahrenheit – equivalent to 15 °C). However, normal room temperature is 68 °F (20 °C) and the frequency of a sound wave produced by an oboe increases as temperature increases. So they did some calculations to work out what the sound wave frequency of concert A was at 68 °F. They found that it was 439 Hz.

The BBC tried to broadcast an electronic version of this note to help orchestras to tune. However, their equipment was based on a crystal that vibrated at 1 000 000 hertz. Using the technology of the time, they could only produce sound waves with frequencies where this number could be divided or multiplied with whole numbers (integers). Dividing 1 000 000 by 1000, and then multiplying by 11 and dividing by 25 got as close as they could – 440 Hz. So 440 Hz was broadcast and it has stuck ever since.

1 What is an orchestra?

2 The vibrations that produce concert A have a frequency of 440 Hz. Explain what this means.

3 Why do musicians have to tune their instruments before they play together?

4 Why is the oboe used to produce the concert pitch 'A' that everyone tunes to?

5 **a** What are the four different sections of an orchestra?

b Choose *one* instrument from each section and explain what vibrates to produce the sound in each case.

c Which section of the orchestra produces sound waves with the greatest amplitude?

6 **a** List *three* instruments in an orchestra that produce low-pitched sounds.

b What can you say about the frequency of the sounds produced by these instruments?

7 Explain the significance of the following notes:

a 435 Hz

b 450 Hz

c 422 Hz

d 439 Hz

e 440 Hz.

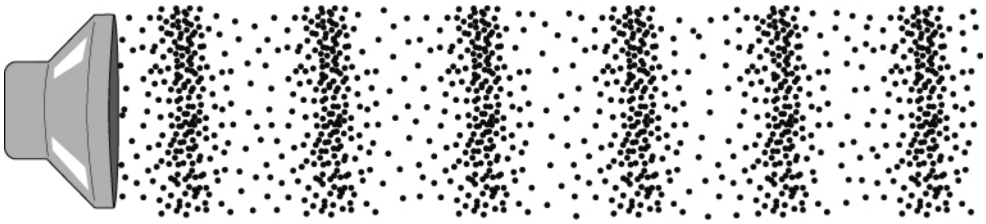
8 Could the London Philharmonic have been seen as being 'unethical' by trying to change the value for concert pitch? If so, why?

I can…

- obtain information from text
- relate pitch and loudness to frequency and amplitude.

Name ______________________________ Class ____________ Date _____________

1 The drawing shows a sound wave moving through air particles.



Draw a C where the particles are closer together than normal.

Draw an F where the particles are further apart than normal.

2 Join each word to its correct meaning.

sound wave	the distance that particles move when a sound wave passes
medium	vibrations passing through a solid, liquid or gas
amplitude	the number of waves per second
frequency	a substance (a solid, liquid or gas)

3 What does a sound wave transfer? Tick *one* box.

☐ particles ☐ a medium ☐ energy

4 The drawing shows a lion roaring.

Complete the sentences using letters from the drawing.

The sound will be loudest at ______ and quietest at ______.

I can…

- describe how sound moves through materials
- recall some words connected with sound.

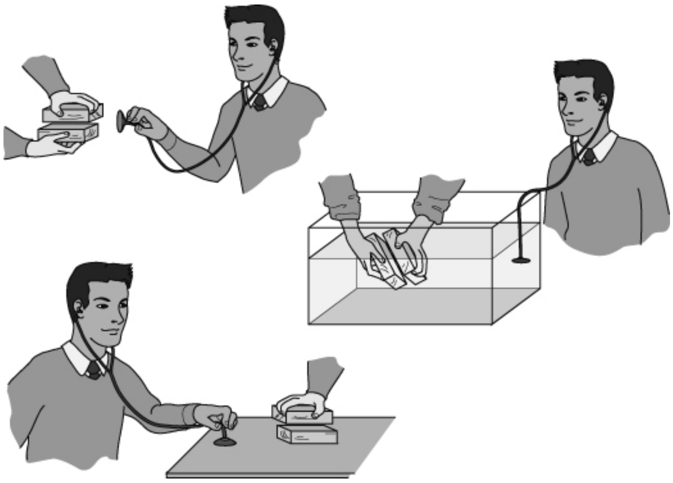
Name ______________________ Class __________ Date ___________

Your teacher may watch to see if you can:

- follow instructions carefully.

Aim: To investigate how well sounds travel through the different states of matter.

Method



Apparatus

- stethoscope
- 2 pieces of wood
- plastic tank of water

⚠ Make sure that the earpieces in the stethoscope are kept very clean, or use disposable earpieces. Use only soft sounds in this investigation. Loud sounds can damage your ears.

Fill in the gaps in these sentences using words from the box. You do not need all the words.

gas	gases	hear	liquid	solid
solids	stethoscope	water	wood	

I will knock the pieces of __________ together, or knock the wood on the bench. I will use the ______________ to listen to the sound. I will record how well I can __________ the sound travelling through different materials. I will investigate how well sound travels through solids, liquids and ______________ .

Recording your results

Material	Solid, liquid or gas	How well I could hear

Considering your results/conclusions

Fill in the gaps in these sentences using words from the word box above.

I could hear the sound best through the ______________. I could hear sound least well through the ______________. This tells me that sound travels best through the ______________ and least well through the ______________.

I can…

- make careful observations
- draw conclusions.

Aim: You are going to find out if sound travels best through a solid, a liquid or a gas using the apparatus provided.

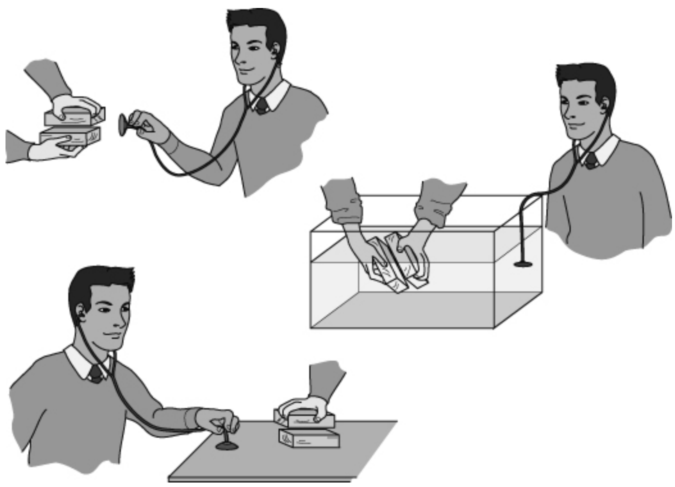
Hypothesis

Sound will travel better through some materials than through others.

Prediction

1 Which materials do you think will be the best at allowing sound waves to travel through them? Explain your prediction if you can.

Method



Apparatus

- stethoscope
- 2 pieces of wood
- plastic tank of water

⚠ Make sure that the earpieces in the stethoscope are kept very clean, or use disposable earpieces. Use only soft sounds in this investigation. Loud sounds can damage your ears.

2 How will you use the pieces of wood to produce sounds?

3 How will you listen to the sounds?

4 How will you record how well you can hear the sounds that are produced?

Recording your results

5 Draw a table to record your results.

Considering your results/conclusions

6 Through which material could you hear the sound best?

7 Through which material could you hear the sound least well?

8 What do your results tell you about how well sound travels in different states of matter?

Evaluating

9 Which variables were difficult to control in your investigation?

10 How could you improve your investigation? Give reasons for your suggested changes.

I can...

- make careful observations and record them clearly
- draw conclusions
- evaluate my working method.

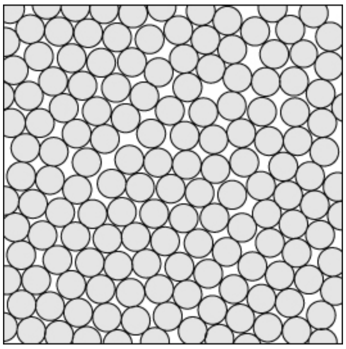
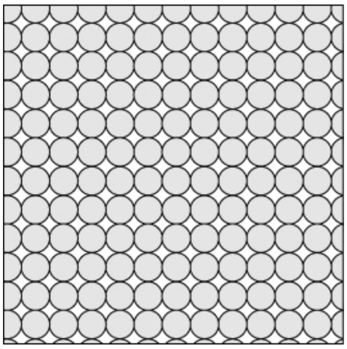
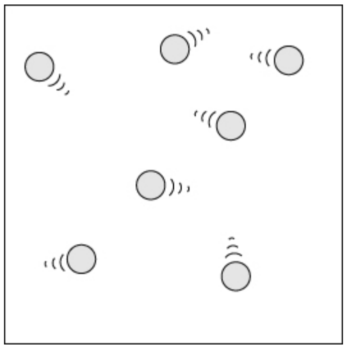
Particle revision

All materials are made of particles. The particles have different arrangements in solids, liquids and gases.

Cut out the cards below and match them up. Ask your teacher to check them, and then stick the cards into your book.

I can…

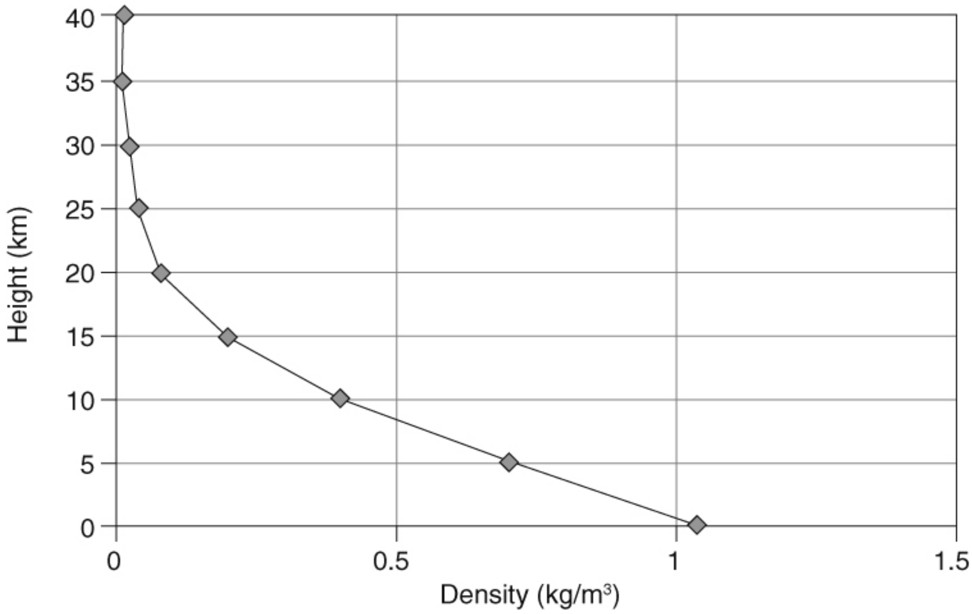
- recall the arrangement and movement of particles in solids, liquids and gases.

solid	liquid	gas
A 	**B** 	**C** 
D The particles are a long way apart.	**E** The particles are held together by very strong forces.	**F** The particles are moving around freely.
G The particles are held together, but they can move around.	**H** The particles are very close together.	**I** The particles are held together by strong forces.
J There are only very weak forces between the particles.	**K** The particles are quite close together.	**L** The particles are held together in a fixed arrangement.

The Earth's atmosphere extends from the surface to more than 100 km high. The table shows how the density, temperature and speed of sound change as you get higher.

Height (km)	Density (kg/m^3)	Temperature (°C)	Speed of sound (m/s)
0	1.03	15	340
5	0.70	–18	320
10	0.40	–51	300
15	0.20	–56	295
20	0.08	–56	295
25	0.04	–51	298
30	0.02	–47	302
35	0.01	–38	308
40	0.01	–23	316

The graph shows how the density of the air changes as you go up.



Normally we plot the independent variable (height, in this case) on the horizontal axis. However as we are looking at going up into the atmosphere, most people find graphs like this easier to understand if they are plotted with height on the vertical axis.

1 **a** Plot a line graph to show how the speed of sound changes as you get higher.

b Describe the shape of the graph you have plotted.

2 Compare the shape of your graph to the graph showing how density changes. Do you think that the speed of sound in the atmosphere depends on the density? Explain your answer.

3 Plot a line graph to show how the temperature of the air changes as you get higher.

4 Compare the graphs you plotted for questions 1 and 3.

a What can you say about the shapes of the two graphs?

b What do you think this means?

We can use scatter graphs to find out if there is a **correlation** between two variables. Your answer to question 4 should have told you that the speed of sound in the atmosphere might be linked to temperature but is probably not linked to density. We can check this by drawing scatter graphs.

5 Draw a scatter graphs to see if there is a correlation between the following variables. You are trying to find out what the speed of sound depends on, so the speed of sound is the dependent variable. The dependent variable is usually plotted on the vertical axis.

- **a** temperature against speed of sound.
- **b** density against speed of sound.

6 If there is a relationship between two variables, a scatter graph usually has points that form a straight line.

- **a** Do you think that the speed of sound depends on the temperature of the air? Explain your answer.
- **b** Do you think that the speed of sound depends on the density of the air? Explain your answer.

I can…

- plot line graphs and scatter graphs
- use a scatter graph to investigate the relationship between variables.

Sound on the move

Name ______________________ Class ____________ Date ____________

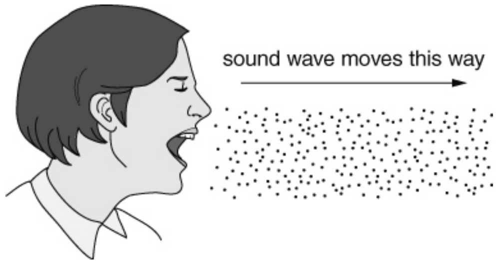
1 Why do astronauts in space need to use radios to talk to each other?

____

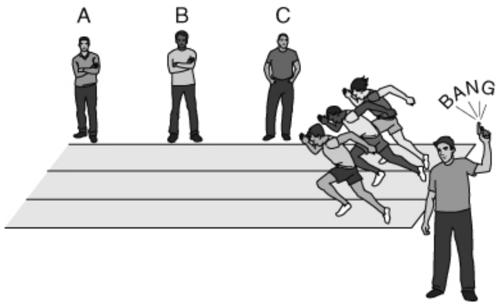
2 What does 'frequency' mean?

____

3 The drawing shows some particles in air. A sound wave travels through the air. Draw an arrow on *one* of the particles to show how it will move as the sound wave passes.



4 The drawing shows the start of a race, and three people watching (labelled A, B, C).



a Which person will hear the starting gun first? _______

b Explain your answer. ______________________

____

____

c Which person will hear the loudest sound from the starting gun? ______________________

d Explain your answer. ______________________

____

____

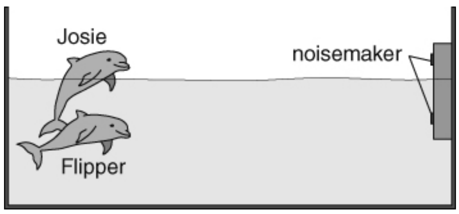
____

5 These dolphins are part of an aquarium show. The noise maker machine tells them when to start their tricks. The machine makes a noise at the same time in the air and in the water.

Which dolphin will hear the noise first? Explain your answer. ______________________

____

____



I can…

- recall how sound moves through a medium
- describe how sound changes as you get further from the source
- recall how fast sound travels in liquids and gases.

Speed depends on the time taken to cover a certain distance. It can be calculated using this formula:

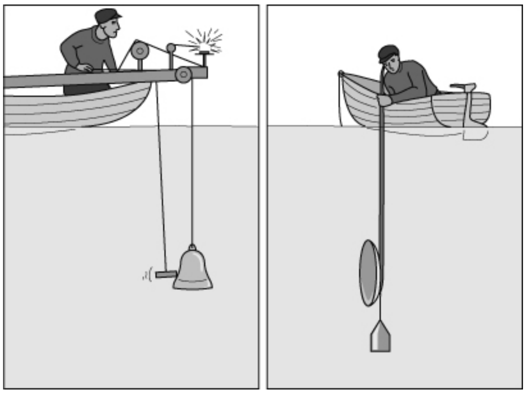
$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

The formula for working out speed can be rearranged like this:

$$\text{distance} = \text{speed} \times \text{time} \qquad \text{time} = \frac{\text{distance}}{\text{speed}}$$

You can use echoes to find the speed of sound in air. You need a large wall or cliff, and quiet surroundings! Make a sudden noise, such as a clap, and listen for the echo. If you can measure the time between the clap and the echo you can find the speed of sound:

$$\text{speed (metres/second)} = \frac{\text{twice the distance between you and the wall (in metres)}}{\text{time between clap and echo (in seconds)}}$$



It is not quite so easy to measure the speed of sound in water. Properties of the water such as its saltiness or temperature can affect the speed of sound.

In 1820 Francois Buedant measured a speed of 1500 metres per second in the Mediterranean Sea. In 1826 Daniel Colladon and Charles Strum measured the speed of sound in Lake Geneva in Switzerland. They had two boats 16 km apart. A bell hanging beneath one boat was struck at the same time as some gunpowder in the boat was lit. The observers in the second boat timed the delay between seeing the flash from the gunpowder and hearing the sound of the bell underwater. They obtained a value of 1435 m/s.

1 Explain why you must double the distance between you and the wall when you are measuring the speed of sound in air.

2 You are standing 50 m from a wall. You measure the time between a clap and its echo five times. The results are shown in the table below.

1st go	2nd go	3rd go	4th go	5th go
0.30 s	0.35 s	0.31 s	0.29 s	0.31 s

a Which result might be a mistake?

b Calculate the mean of the times. Ignore the one you identified in part **a**.

c Calculate the speed of sound.

3 Suggest *two* reasons why Colladon and Strum obtained a different value for the speed of sound in water than Buedant. (*Hint:* think about how seawater is different from the water in lakes.)

4 Calculate how long it took for the sound to travel between the two boats used by Colladon and Strum. (Convert the distance into metres first.)

5 **a** If Buedant also used two boats 16 km apart, calculate how long the sound would have taken to travel between them.

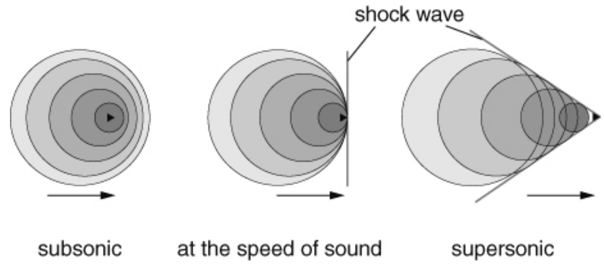
b How far apart would his boats have been if the sound only took 5 seconds to travel between them?

I can…

- use data to calculate the speed of sound.

Mach number

When an object moves through the air, the disturbance it causes spreads out all around it. This disturbance is a sound wave, although we cannot usually detect it with our ears. If an object is moving at **subsonic** speeds (less than the speed of sound) the disturbance can spread ahead of it. If it is moving at **supersonic** speeds the air ahead does not get disturbed. As the object passes, some of the properties of the air change very suddenly, and a **shock wave** forms.

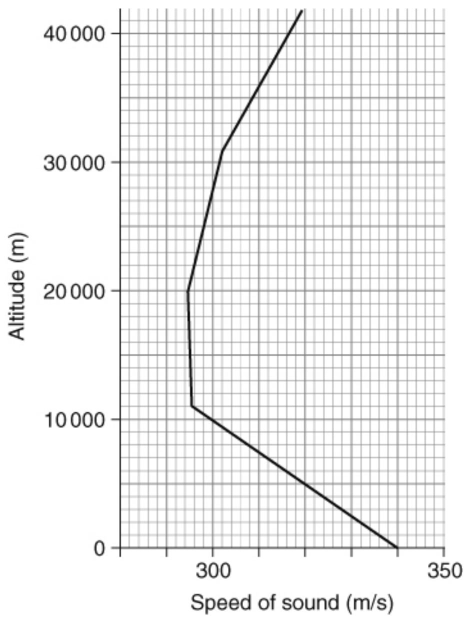


The air moving over an aircraft's wings and fuselage has different effects when the aircraft is flying at subsonic speeds and when it is flying supersonically. These effects change as the aircraft accelerates from subsonic to supersonic speeds region. For this reason, aeronautical engineers often need to think about the aircraft's speed in comparison to the speed of sound, rather than thinking of speed in metres per second. The ratio of the speed of the aircraft through the air to the local speed of sound is the **Mach number**.

$$\text{Mach number} = \frac{\text{speed relative to the air}}{\text{local speed of sound}}$$

An aircraft flying at the speed of sound is flying at Mach 1.

The graph shows how the speed of sound changes as you get higher in the atmosphere. This means that an aircraft flying at a steady speed in metres per second can be flying at different Mach numbers at different altitudes.



1 Explain the terms in **bold** in the text.

2 Explain why Mach number does not have units.

3 An airliner has a cruise speed of 890 km/h (247 m/s) at 10 000 m.

- **a** What is its Mach number at this height and speed?
- **b** Explain why its Mach number would be lower if it flew at this speed at 5000 m.

4 Why do you think the formula for calculating the Mach number uses:

- **a** the *local* speed of sound?
- **b** the objects speed *relative to the air* (*Hint*: think about the effect of wind on the speed over the ground.)

5 Which is flying fastest relative to the air around it? Aircraft A, flying at Mach 2 at 20 000 m, or aircraft B flying at Mach 1.5 at 5000 m? Show your working.

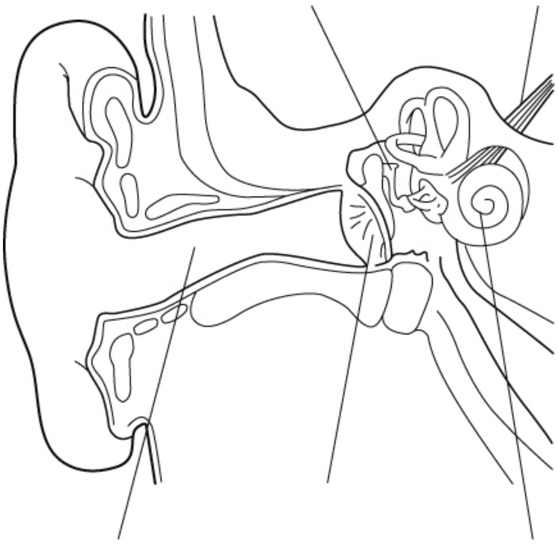
I can…

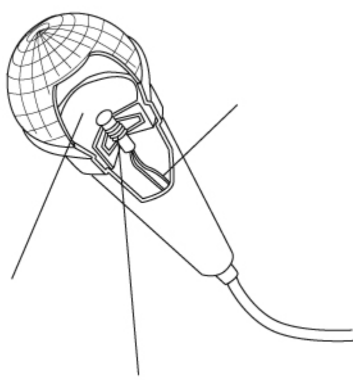
- use information from text and graphs
- carry out calculations using a formula
- change the subject of a formula.

The diagrams show an ear and a microphone. Cut out the diagrams and stick them in the middle of a sheet of paper. Cut out the labels and stick them around the diagrams. Draw lines to connect the labels with the parts of the ear and microphone.

I can…

- describe the parts of the ear and their functions.





ear canal – channels sound into the head	cochlea – turns the vibrations into nerve impulses	diaphragm – vibrates when sound waves reach it	ear bones – pass on the vibrations and amplify them
electronics – convert vibrations into changing electrical currents	auditory nerve – takes nerve impulses to the brain	ear drum – vibrates when sound waves reach it	wires – take electrical signals to recording device

Name ______________________________ **Class** ____________ **Date** _____________

Your teacher may watch to see if you can:

- carry out an investigation safely.

Introduction: Materials that are good at reducing sound levels are usually soft. They are called sound insulators.

Aim: To find the best material for use as soundproofing.

Prediction

1 I think the best material for soundproofing will be __________________, because it is the

____

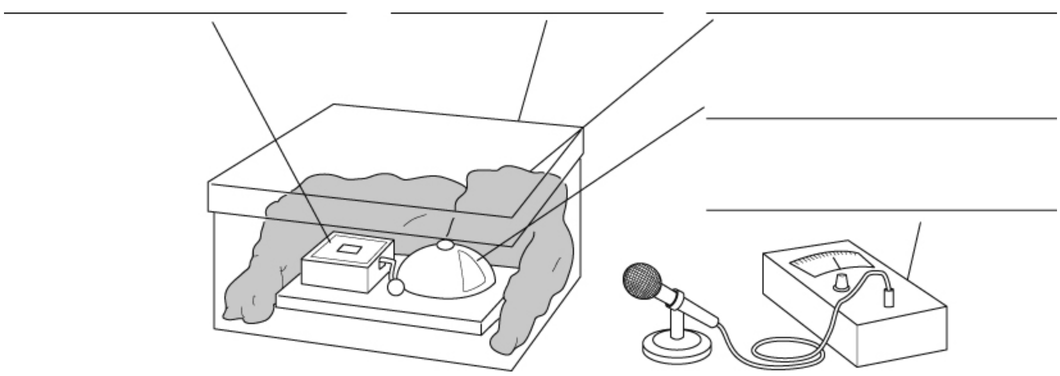
____

Method

Apparatus

- electric bell
- cardboard box
- materials to test
- sound intensity meter
- large sheet of paper
- cells or power pack
- connecting wires

2 Label the diagram using words from the apparatus list.



A Place your bell in the box without any other material and place it on the large sheet of paper. Put the sound intensity meter on the paper as well and draw around both of them. This is to make sure you always measure the sound in the same place.

B Take a reading with your sound intensity meter before you turn your bell on.

C Switch the bell on and use the sound intensity meter to take a reading.

D Put the lid on the box and take another reading.

E Open the box and turn off the bell. Use one of the materials to line the inside of the box as well as you can. Don't forget to cover the top of the bell too but make sure the material is not actually touching the bell.

F Switch the bell on again and put on the lid. Take another reading using your sound intensity meter.

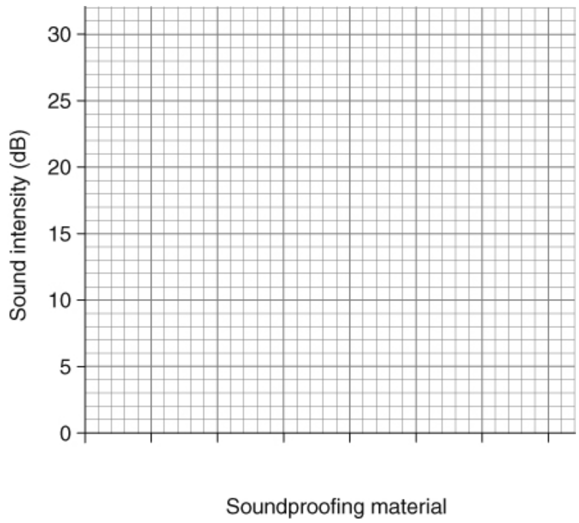
G Repeat steps E and F using each different material you have been given. Try to use the same thickness of material each time.

Recording your results

Sound level with the bell switched off ______________________

Material	Sound level in decibels

3 Draw a bar chart to show your results.



Considering your results/conclusion

4 The material with the lowest sound recorded was ________________________. I think this was a good sound insulator because it was (hard/soft).

Evaluation

5 I could have improved my experiment by ____

____

____

____

I can…

- carry out an investigation
- make careful observations
- present data as a bar chart
- evaluate my findings.

Your teacher may watch to see if you can:
- carry out an investigation safely.

Introduction: Materials that are good at reducing sound levels are usually soft and have many layers. They are called sound insulators.

Aim: to find the best material for use as soundproofing.

Prediction

1 Which of your materials do you think will be best for soundproofing? Explain your reasoning.

Planning

Apparatus
- something to make a sound
- cardboard box
- assorted materials
- sound intensity meter

2 Decide which materials you will use for soundproofing your box.

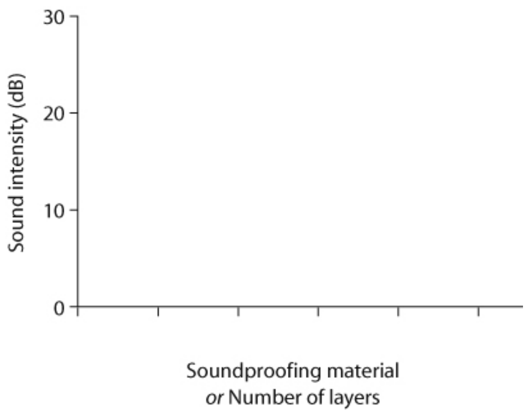
3 Write a method for your investigation. You will need to think about these things:
- How much of each material will you use?
- Are you going to compare different materials or different numbers of layers of the same material?
- What will you use to make a sound?
- How far away will you hold the sound intensity meter?
- How often will you repeat the measurements?
- Which variables will you have to keep the same in order to do a fair test?
- Ask your teacher for any other apparatus you think you need.

4 Show your method to your teacher before you begin.

Recording your results

5 Record your results neatly in a table.

6 Plot a chart to show your results, using axes like these.



Considering your results/conclusion

7 Describe any patterns you can see on your chart or graph.

8 Did everyone have similar results or was there a range of different results?

9 Was this what you expected to find? Did this agree with your prediction?

Evaluation

10 Were any of the results surprising?

11 How could you improve your experiment?

I can…
- plan and carry out an investigation and make predictions using scientific ideas
- present data in tables and charts
- draw conclusions
- evaluate my investigation.

Hearing – true or false?

Name ______________________ **Class** __________ **Date** ___________

These statements are about detecting sounds, but they are not all correct. Write T (for true) or F (for false) next to each one, and fill in the circle with a face to show how sure you are about your answer.

I'm sure | Not very sure | No idea!

	Before the lesson		After the lesson	
	T or F?	How sure?	T or F?	How sure?
1 You need bones to help you to hear.				
2 Hearing can be damaged by loud noises.				
3 Elephants can hear very well because they have large ears.				
4 Your eardrum vibrates to make noise.				
5 Hard, stiff materials are good at absorbing sounds.				
6 Some animals can hear sounds that we cannot.				
7 Ears and microphones both convert energy transferred by sound into energy transferred by electricity.				
8 Sound is measured in decibels (dB): the higher the number the quieter the sound.				

Write correct versions of any false statements here:

____

____

____

____

I can…

- recall some facts about the way we detect sound.

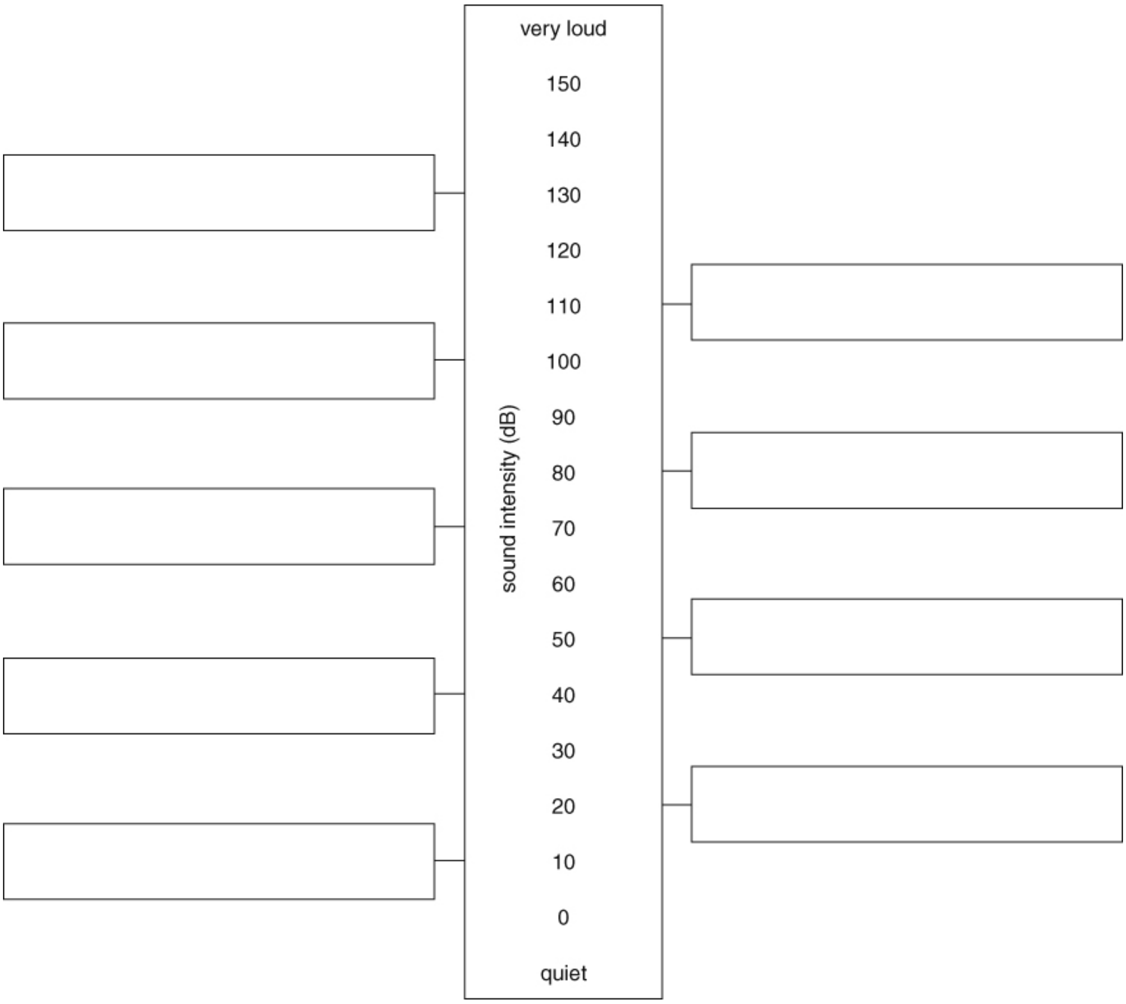
Decibel scale

1 Cut out the boxes below and place them on the sound level chart.

2 Use reference books or the internet to check your answers before you stick them down.

I can…

- use the decibel scale to describe the loudness of some sounds.



bird singing	military jet take-off	traffic
front row at rock concert	motorcycle	vacuum cleaner
leaves rustling	normal conversation	whisper

Hearing loss

Our hearing can be damaged in several different ways. Some of these are due to infections or the body not working properly, and some are caused by external factors such as noise. These are just some of the ways in which hearing can be reduced or lost.

A The ear can get blocked by wax which can stop sounds reaching the eardrum and can also stop the eardrum vibrating. The wax needs to be softened by putting drops of olive oil into the ear, then a nurse can wash it out.

B In ‘glue ear’, a liquid builds up behind the eardrum. If this condition lasts for more than a few months, a doctor may insert a tiny tube in the eardrum to allow the fluid to drain.

C The cochlea can be damaged by loud noise, for example from nightclubs or wearing personal stereos that are too loud. There is no cure for this.

D Accidents (including poking things like earbuds into the ear) or a sudden loud noise can damage the eardrum. This may repair itself.

E The middle ear (where the eardrum and bones are) can get infected. Ear infections can be treated by antibiotics.

F As people get older the tiny bones in their ears can fuse together and so don’t vibrate.

G Sometimes the nerve cells in the cochlea do not work as well when you get older so the signals are not sent to the brain.

1 Which of the ear problems listed may be only temporary, and which are permanent? Explain your answers.

This flowchart shows what happens inside the ear.

sound waves detected → vibrations amplified (made bigger) → vibrations converted to electrical signals → signals sent to brain

2 For each of these problems, explain which stage of hearing is affected. Some problems may affect more than one stage.

a A

b C

c F

d G

3 Suggest why glue ear affects hearing. You may need to look at a diagram of the ear and to think about the difference between air resistance and water resistance.

4 Optional extra: If you fly in an airliner, you may experience pain in your ears when the aircraft ascends or descends. This is due to changes in air pressure. Find out:

- why changes in pressure can cause pain in the ear
- why swallowing or sucking can sometimes relieve this pain
- why you may sometimes get a similar ear pain when you have a cold.

I can…

- explain some ways in which hearing can be damaged.

Ears and noise

Name ______________________ **Class** __________ **Date** ____________

1 The box shows the names of some parts of your ears. Write them in the order that they pass on the vibrations, starting with the ear canal.

bones
cochlea
ear canal
eardrum

____

2 Use the words in the box to help you to answer these questions.

a Which part vibrates when sound waves in the air reach it? ____________

b Which part converts vibrations into nerve impulses? ____________

c Which part helps to make the vibrations bigger? ____________

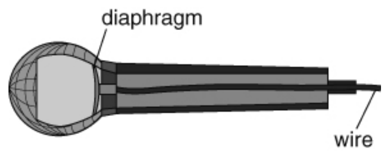
3 Write down *one* way in which a microphone and the ear are:

a similar ______________________________

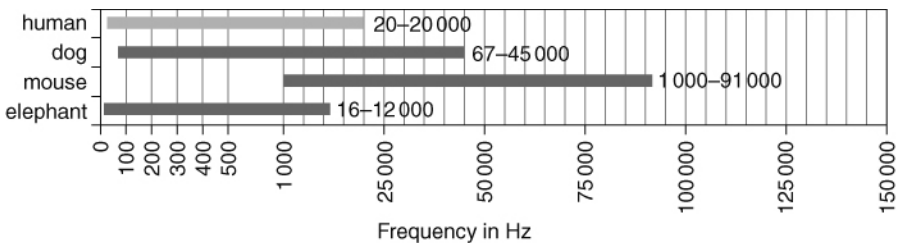
____

b different ______________________________

____



The diagram shows the frequencies of sounds that some animals can hear.



4 Which animal (or animals) can hear:

a lower frequency sounds than humans? ____________

b higher frequency sounds than humans? ____________

5 Write down a frequency of sound that:

a a dog can hear but a mouse cannot. ____________

b a mouse can hear but a dog cannot. ____________

6 Which kinds of materials are best at absorbing sounds?

____

I can…

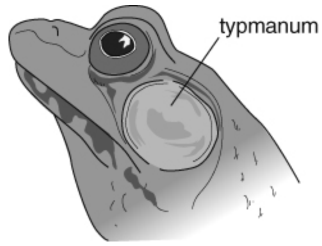
- describe the parts of the ear and their functions
- describe how microphones convert sound into electrical signals
- recall that different animals have different hearing ranges.

Most animals have similar ears to humans – an ear canal in the outer ear, a middle ear with eardrum and tiny bones, and the inner ear that converts vibrations into nerve impulses. Frogs are unusual, as they have a membrane called a tympanum on the surface of their bodies.

However not all frogs have a tympanum. Gardiner's frogs live in the Seychelles islands, and are one of the smallest species of frog in the world. They do have an inner ear, but do not have any of the parts of a middle ear.

Scientists did not know how these frogs could hear, because 99% of the sound reaching an animal's body is reflected by the skin. This would not leave enough energy reaching the inner ears of Gardiner's frogs for them to detect. However they knew that the frogs *could* hear because male frogs would answer when the scientists replayed recordings of their calls.

Scientists wondered if sounds were reaching the frogs' inner ears through their bones, or perhaps through the air in their lungs. In 2013, after comparing X-ray images of different frogs, they worked out that the frogs hear through their mouths! Gardiner's frogs have adapted to have much thinner body tissues between the inside of their mouth and the inner ear than other species of frog. The shape and size of their mouth allows the sound to resonate (bounce backwards and forwards), which helps to amplify it.



Most frogs have a tympanum behind their eyes.

A Gardiner's frog

1 Explain how the scientists knew that Gardiner's frogs *can* hear.

2 **a** Give *two* reasons why frogs make noises.

b Suggest *one* reason why frogs that cannot hear might still make calls.

3 Gardiner's frogs do not have a 'middle ear'.

a Which parts of the ear are missing, compared to most other frogs?

b Which parts are missing compared to humans?

4 **a** What does the 'middle ear' do in humans?

b Why is it harder for Gardiner's frogs to hear without 'middle ears'?

c What *two* adaptations help the frogs to hear?

5 Many animals, including humans, have the 'working' parts of their ears inside their skulls, with an external ear flap.

a Suggest how having the working parts of the ear inside the skull is a benefit.

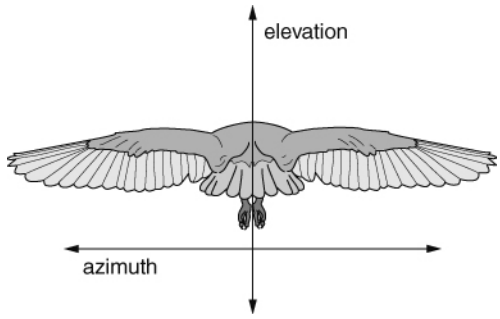
b Why do you think many animals have external ear flaps?

I can…

- recalling parts of the ear and their functions
- extract information from texts.

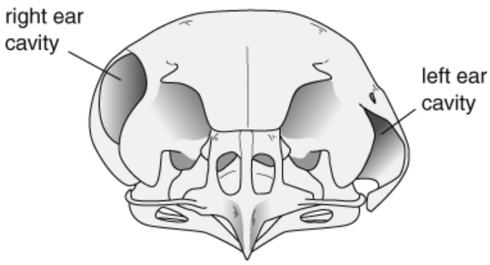
Owls and ears

Many animals, including ourselves, can work out the direction a sound is coming from. We can do this because our brains can detect the difference in the time at which a sound reaches our two ears. Our brains can also detect the difference in intensity of the sound arriving at each ear, and probably use a combination of timing and intensity to work out the direction. However this does not let us locate the source of the sound precisely – we cannot tell the difference between a sound from the ground behind us or one from above and behind unless we tip our heads to one side.



Some species of owl are nocturnal predators and have adaptations to help them find their prey. They often hunt in woodland where there are many obstacles to avoid. Although they have quite large eyes to help them see in dim light, some owls can also hunt in complete darkness using their sense of hearing. To do this, they need to know where a sound is coming from in elevation (vertically) as well as in azimuth (horizontally).

Some species of owl, such as the barn owl, have asymmetrical ear openings. The skull shown here has the right ear cavity higher than the left. This means that a sound from above will arrive at the right ear before the left one, and will also be louder in the right ear than the left one.



The owl's brain interprets the timing information to locate the sound in a horizontal direction, and uses the intensity differences to work out where the sound is coming from in a vertical direction.

1 How do humans detect where a sound is coming from?

2 Suggest why very small animals, such as flies, are not very good at working out the direction from which a sound is coming.

3 Why is it easier to locate a short, sharp sound (like a hand clap) than a longer sound such as someone humming?

4 **a** An owl detects a sound from something in front of it that is a little louder in its left ear than its right, but arrives at its right ear first. Explain where the sound is coming from.

b An owl hears a sound from its right and a long way above it. How will this sound be different to the one described in part **a**?

5 Many animals rely on their sense of hearing to detect prey or to warn them of approaching predators. Most of these animals (such as cats or deer) have external ears that can be pointed in different directions. Suggest how this helps the animals.

6 Optional extra: Barn owls do not have external ears. Find out how the shape of their face helps their hearing.

I can…

- interpret information from a text
- use knowledge about the way sound travels.

Name ______________________ Class __________ Date __________

The sentences describe some ways in which humans and animals make use of sounds. Join up the boxes to make sentences.

Humans and animals use sound	or absorb sound.
Sound waves can be transmitted	to relieve pain.
Some materials reflect	through materials.
Energy transferred by sound waves	using echolocation.
Physiotherapists use energy transmitted by sound waves	an echo.
Reflected sound is called	for communication.
Bats and dolphins find prey	to find the depth of the sea.
Sonar uses ultrasound	can be used to clean delicate objects.

I can…

- recall some ways in which sound is used.

In 1793, Lazzaro Spallanzani (1729–1799) noticed that bats could avoid obstacles when flying in total darkness. Spallanzani blinded some bats and noticed that they could still fly around obstacles. However, he found that bats wearing hoods that covered their ears could not fly properly. Spallanzani wrote a letter to the Geneva Natural History Society suggesting that bats used their ears and not their eyes to 'see'.

This letter caught the attention of a Swiss scientist called Charles Jurine (1751–1819). In 1794, Jurine used a painless way of blocking the bats' ears to show that they did indeed use their ears to navigate. He wrote to Spallanzani, who repeated Jurine's work but could not explain it. For over a century, their work was ignored and even laughed at by scientists.

The mystery was solved in 1938 by biologist Donald Griffin (1915–2003) and physics professor G.W. Pierce (1872–1956). They worked together and used modern technology to show that bats use sounds to find their way around.

1 How did Spallanzani and Jurine show that bats use their ears to 'see'?

2 **a** What was Jurine's conclusion?

b How did Jurine arrive at this conclusion?

3 **a** How did Spallanzani and Jurine communicate with each other and with other scientists?

b How do scientists communicate with each other today?

c Why is it important that scientists communicate with each other?

4 Do you think that Spallanzani was right to blind the bats?

5 Why do you think the question of how bats 'see' in the dark was not solved until 1938?

Research questions

6 Find out which types of bats do not use echolocation, and why these species do not need it.

7 Echolocating bats are adapted to produce and detect ultrasounds. Find out what other adaptations they have to help them with echolocation.

I can…

- use information from texts
- explain how and why scientists communicate with each other.

Dolphins and sound

In 1953 the underwater explorer Jacques Cousteau (1910–1997) observed that when his boat was heading along a deep channel in murky water, porpoises would follow. If he steered off course, the porpoises also steered off course but then quickly went back to following the channel. He thought that the porpoises could detect the channel (the best route to take) without being able to see it. Other scientists had also come up with this theory.

In 1960 Kenneth Norris (1924–1998) showed that this theory was correct. He put suction cups over the eyes of a dolphin and found that it could still find its way through a maze. Since then, many scientists have become interested in the different high-frequency ‘clicks’ and lower-frequency ‘whistles’ that these creatures make.

Today we know that dolphins produce clicks using nasal sacs. The sounds reflect off objects and are picked up again in the dolphin’s lower jaw. The reflected sound waves travel through a channel filled with fat and then into the ear. Sound waves can be focused, and dolphins have a ‘lens’ made of fat that they use to focus sound waves. Dolphins can find food buried in sand, and they may even be able to detect whether or not a shark has a full stomach!

This is similar to the way in which ultrasound is used in hospitals. An ultrasound scanner sends ultrasound waves into people, and detects the sound that is reflected off different layers inside the body. The timing of the echoes is used to help a computer to build up a picture of what is inside the body. Ultrasound scans are often used to look at unborn babies inside pregnant women, because the ultrasound does not harm the fetus.

The military have trained dolphins to find underwater objects like mines. There have also been rumours that the military have trained dolphins to carry explosives to ships to blow them up.

1 How did Norris’ experiment show that dolphins did not need their eyes to navigate?

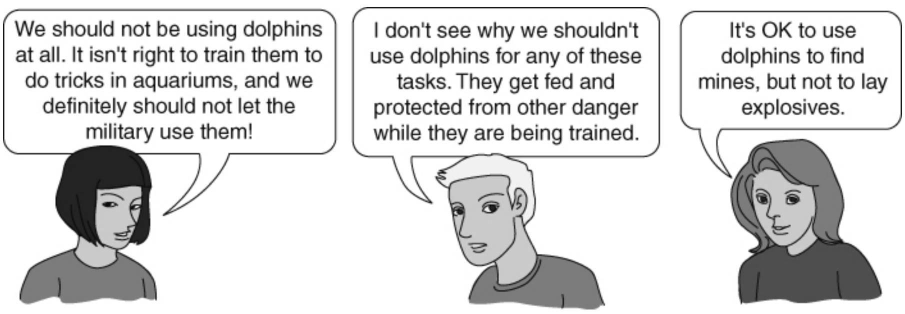
2 What do dolphins use to generate clicks?

3 What is the evidence to suggest that dolphins can use ultrasound like an ultrasound scanner?

4 What advantage would there be if a dolphin could see inside a shark’s stomach to find out if it was empty or full?

5 Why are dolphins good at finding objects such as mines that might be buried in sand?

6 Here are some opinions about using dolphins.



Which opinion do you agree with? Explain your answer.

I can…

- use information from texts
- discuss whether or not some uses of animals should be allowed.

Name ________________ **Class** __________ **Date** __________

You have 90 seconds to learn all these sentences, and then you will be asked to write them out from memory.

1 It was a fair price to pay

2 The biggest one is by the River Thames.

3 Many tomatoes are squashed.

4 Granny thinks he needs a haircut.

5 Old car bumpers used to be covered in rubber.

6 I'll wave this at the match.

7 A cow has died.

8 Rats are a menace.

I can…

- use different techniques to help me to remember lists or ideas.

EXPLORING SCIENCE WORKING SCIENTIFICALLY 7 Ld-4 Remember this…

Name ________________ **Class** __________ **Date** __________

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6 I'll wave this at the match.

7 A cow has died.

8 Rats are a menace.

I can…

- use different techniques to help me to remember lists or ideas.

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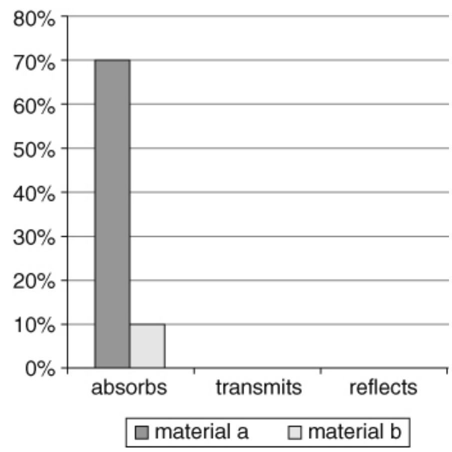
Uses of sound 1

Name ______________________ **Class** __________ **Date** __________

The table shows how much sound different materials absorb, transmit and reflect.

	Material A	Material B
absorbs	70%	10%
transmits	10%	20%
reflects	20%	70%

1 Complete the bar chart by drawing in the bars for transmitting and reflecting.



2 Draw lines to match up the words to their meanings:

absorbs	a sound that has reflected from something
transmits	takes sound energy in and does not let it out again
reflects	lets energy pass through it
echo	when waves bounce off something

3 Which material would be best to use for soundproofing a room? ______________

Explain your answer. ______________________________

4 Complete the sentences to explain which material would be the easiest for bats to detect.

Bats use ____________________ to find their prey and avoid flying into things.

Material ________ would be the easiest to detect because ______________

5 Name *one* other animal that uses echoes to find prey. ______________

6 The drawing shows people using bat detectors.

a Why do humans need to use special equipment to listen to bats?

____

____

b Why do bats and some other animals use echolocation to find prey?

____

____

I can…

- recall the meanings of some words connected with sound
- use information in a bar chart
- describe how echolocation works.

Table A shows how much sound different materials absorb, transmit and reflect.

	Material A	Material B	Material C
absorbs	60%	10%	
transmits			10%
reflects	20%	80%	30%

Table A

1 **a** Explain what ‘absorb’, ‘transmit’ and ‘reflect’ mean.

b What do we call a reflected sound?

2 Copy the table and fill in the missing values.

3 **a** Draw a bar chart to show this information.

b Explain why it is useful to show information as bar charts.

Table B shows how loud the traffic sounds inside a house during one morning.

Time	0600	0700	0800
Loudness	20 dB	30 dB	50 dB
Time	0900	1000	1100
Loudness	50 dB	40 dB	40 dB

Table B

4 **a** Draw a line graph to show how the noise level changes during the day.

b Which of the materials in Table A would be best to use to reduce the noise levels inside the house? Explain your answer.

c Sketch a line on your graph to show how the sound might change during the morning if this material were used in the construction of the house. Note: you don't have to do any calculations for this sketch.

5 The drawing shows people using bat detectors.

a Why do humans need to use special equipment to listen to bats?

b Why do bats and some other animals use echolocation to find prey?

c Which of the materials in Table A would these animals detect the easiest? Explain your answer.

6 Describe what sonar is used for and how it works.

7 Describe two ways in which humans use the energy transferred by sound.

I can…

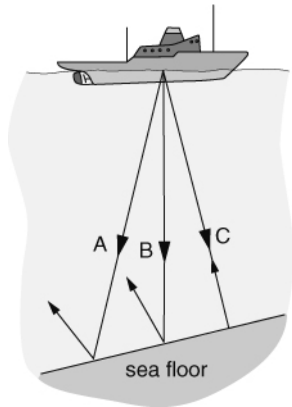
- present data in bar charts and line graphs
- use information from tables and bar charts
- explain how sonar and echolocation work.

Mapping the deep

People have been making maps of the surface of the Earth for thousands of years. Maps of the sea floor are more difficult to make. Until about the 1920s, soundings were made using a weight on the end of a rope. The weight was lowered over the side of a ship and the rope let out until the weight hit the bottom. The length of rope that had been let out was the depth of the water.

This method worked well for taking soundings in shallow water around ports and harbours, but it was more difficult to measure the depth of the oceans. It could take several hours to lower the weight, and it was not always easy to tell when the weight hit the bottom as a long rope is also heavy. Waves and currents moving the ship and the rope also contributed to inaccuracies.

The first seafloor chart was published in 1855, but it was not until the 1920s that the invention of echo-sounding equipment made it possible to take readings much faster and so to produce much more detailed mapping of the ocean floors. However even echo-sounding equipment can be inaccurate, as waves move the ship up and down by a few metres. Calculating the depth from echo times relies on knowing the speed of sound in sea water, and the standard value of 1500 m/s can be in error by up to 4%, depending on changes in temperature and salinity (saltiness). Readings taken over steep ground can also produce inaccurate depths.



The strongest echo will be from the part of the sound wave that hits the sea bed at right angles.

1 Explain how not being able to tell when the weight on a sounding line has touched the bottom can result in measurements that are

a too deep **b** too shallow?

2 A ship is using a line to take a sounding, but is blown from its initial position by the wind while the line is being lowered. Explain how this will affect the depth measured.

3 Waves are moving a ship up and down by 3 metres while it is echo-sounding, so the depth could be wrong by plus or minus 3 m. What percentage error is 3 m.

$$\text{percentage error} = \frac{\text{size of error}}{\text{depth of water}} \times 100\ \%$$

a 300 m deep **b** 5 km deep?

4 The diagram above shows that the strongest echo will be received from the part of the sound wave labelled C. If the echo-sounding equipment works out the depth based on the strongest echo, how will this affect the depth that it measures?

5 A ship measures an echo time of 0.4 seconds.

a What depth will the echo-sounder calculate? (Remember the sound has to go down to the sea bed and back up again.)

distance = speed × time

b If the speed of sound in the water is actually 1550 m/s, will the real depth be greater or less than the calculated depth? Explain your answer.

c What percentage error is this? (*Hint*: work out the correct depth first.)

6 Which is the possible source of the largest errors in depth measurement: waves or changes in the speed of sound?

7 The properties of the water could be measured to work out the true speed of sound. How well do you think this would solve the problem?

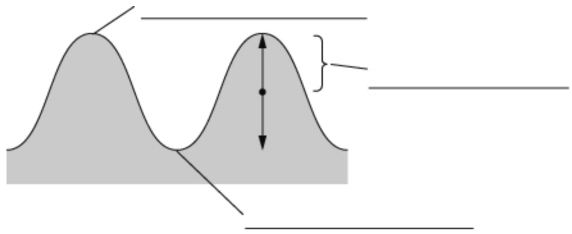
I can…

- calculate depths from speeds and times
- calculate percentage changes
- consider the effects of different sources of error.

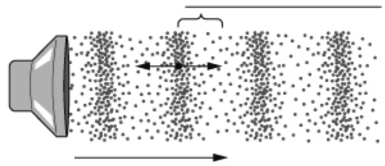
Name ______________________ **Class** __________ **Date** __________

1 The diagrams show two waves. Label the waves using words from the box. You may need some labels more than once.

amplitude	crest	longitudinal	transverse	trough



______________ wave



______________ wave

2 Fill in the gaps in these sentences using words from the box.

amplitude	at right angles	bigger	energy	longitudinal
no	same	spreading	transverse	water

Waves on the surface of water are ______________ waves, because the particles are vibrating ______________ to the direction the waves are travelling. Sound waves are ______________ waves, because the particles vibrate in the ______________ direction as the waves travel.

All waves transfer ______________. Waves on a pond do not transfer ______________ across the pond.

The ______________ of waves gets less as they get further from the source. This is because the energy is ______________ out.

When two waves meet their effects can add up to make a ______________ wave, or they can cancel out to give ______________ wave.

I can…

- describe longitudinal and transverse waves
- compare sound waves and waves on water
- describe what happens to the intensity of waves as they spread out
- describe what happens when two waves arrive in the same place.

Spot the mistakes

Name ______________________________ **Class** ____________ **Date** ____________

Here are some revision notes made by a student.

1 Underline the mistakes in the passage.

> Sound is made by vibrating things. High notes have a high amplitude, and low notes have a low amplitude. The frequency is the number of waves per hour and is measured in hertz. The higher the frequency the more energy the wave is transferring.
>
> Sound waves travel fastest through gases and slowest through liquids. They do not travel at all in space, because space is very cold.
>
> We hear using our ears. Sound waves make the diaphragm vibrate, and these vibrations are passed on to the cochlea and then to the ear bones. Nerve impulses are sent to the brain.
>
> Loud noises can damage our ears. The best materials for sound proofing are hard, shiny materials.
>
> Sounds that are too high for humans to hear are called infrasound. Sounds that are too low for us to hear are called ultrasound. Dolphins and bats can hear infrasound, and they use this to find prey.
>
> We can use the energy transferred by infrasound in physiotherapy and for cleaning things. Sonar systems use echoes from the sea bed to work out the depth of the sea.

2 Write out a correct version below.

____

____

____

____

____

____

____

____

____

____

____

____

____

____

I can…

- describe sound waves
- recall the names and functions of the parts of the ear
- state what ultrasound is and describe how it can be used.

What kind of wave?

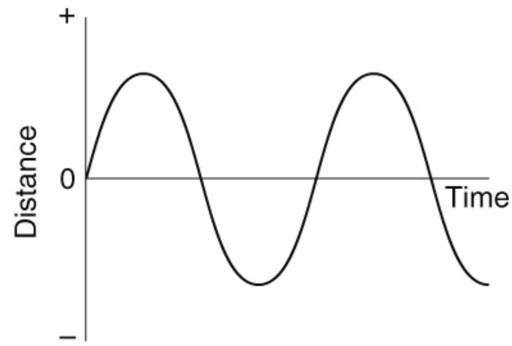
Graph A shows how far particles are displaced from their undisturbed positions as a wave passes.

1 Why are there plus and minus directions on the graph?

2 Explain why you cannot tell from this graph whether the wave is a transverse or longitudinal wave.

3 Copy the graph and draw another line on it to show how far the particles would move if the wave had a larger amplitude. Label the new line.

4 Make another copy of the graph, and show how the particles would move if the wave had a lower frequency.



Graph A

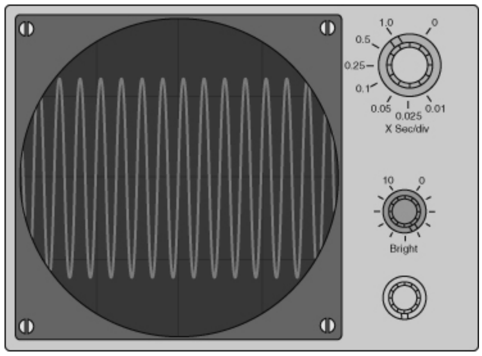
The drawing shows the trace produced on an oscilloscope when it is connected to a microphone. The oscilloscope shows how the pressure of the air changes with time.

5 Does this trace represent a transverse or longitudinal wave? Explain your answer.

6 Describe how the trace would look different if the sound:

a were quieter

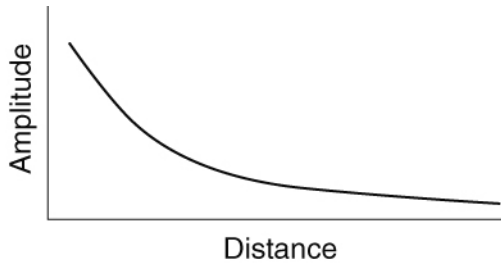
b were at a lower pitch



Graph B shows how the height of waves on water changes as the waves get further from their source.

7 Describe what the graph is showing.

8 Explain why this happens.



Graph B

I can…

- use graphs to help to describe longitudinal and transverse waves
- explain why the amplitude of a wave decreases as it gets further from its source.

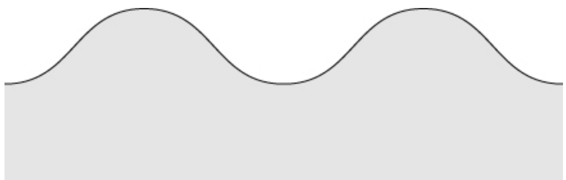
Water and sound waves

Name ______________________________ **Class** ____________ **Date** _____________

1 The table shows some characteristics of waves. Tick the boxes to show which waves each statement is describing. Each row could have one tick, two ticks, or no ticks at all.

Statement	**Applies to sound waves**	**Applies to waves on water**
a particles move at right angles to the way the wave is moving		
b can be reflected		
c particles move in the same direction as the wave is moving		
d can involve solids, liquids or gases		
e transverse wave		
f spreads out from source in all directions		
g transfers energy		
h transfers matter		
i longitudinal wave		

2 Sam dropped a small stone into a pond. It made some waves. The drawing shows part of the wave travelling across the pond.



a Draw another line on the drawing to show how big the waves would be if Sam had dropped a much bigger stone into the water.

b What happens to the amplitude of the waves as they move further from the place the stone landed?

____

3 The effects of waves can add up or cancel out.

a What happens if the peaks of two waves arrive at one point together?

____

b What happens if a peak from one wave arrives with the trough of another wave?

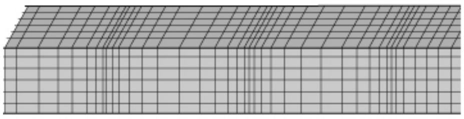
____

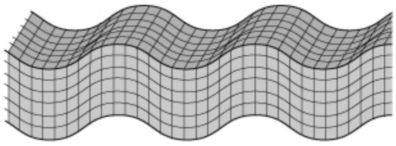
I can…

- describe sound waves and waves on water
- use the term 'amplitude' to describe waves
- describe what happens if two waves arrive at the same place.

Earthquakes and tsunamis 1

Earthquakes happen when forces within the Earth push rocks and they move with a sudden jerk. Energy from the earthquake spreads out in all directions from the location of the earthquake. There are two types of earthquake waves, called P-waves and S-waves, shown in the diagram below. P-waves travel faster than S-waves.


P-wave

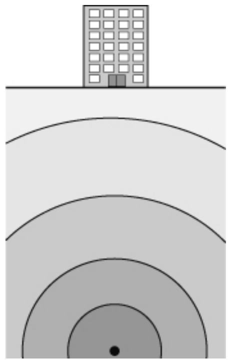

S-wave

1 Which of these waves is a sound wave? Explain your answer.

2 a Which of these waves is most like the waves on the surface of water?

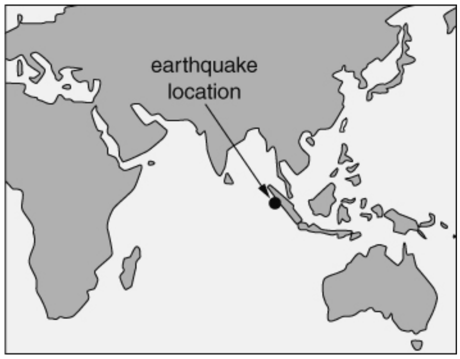
b In what ways is this wave *not* like waves on the surface of water?

3 The drawing shows waves from an earthquake spreading out towards a building on the surface. Will the building first start shaking up and down or side to side? Explain your answer.



4 Earthquakes can also be caused by explosions. Explain why you would feel the earth shaking before you heard the sound of an explosion.

A tsunami is a large wave, or series of waves, that is caused by an earthquake on the sea bed, or by a large landslide falling into the sea. In 2004 a tsunami just off the coast of Sumatra in the Indian Ocean killed over 200 000 people. In some places the wave reached a height of nearly 30 metres. The wave was 1.5 m high in South Africa, and only 1 m high in Antarctica.



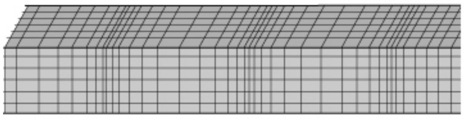
5 Where do you think the 30 m high waves were experienced? Explain your answer.

6 Explain why the waves were different heights in different places.

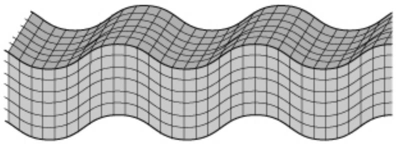
I can…

- describe longitudinal and transverse waves
- apply my knowledge of waves to new situations.

Earthquakes happen when forces within the Earth push rocks and they move with a sudden jerk. Energy from the earthquake spreads out in all directions from the location of the earthquake. There are two types of earthquake waves, called P-waves and S-waves, shown in the diagram below.



P-wave



S-wave

1 Which of these waves is a sound wave? Explain your answer.

2 **a** Which of these waves is most like the waves on the surface of water?

b In what ways is this wave *not* like waves on the surface of water?

3 Mrs Jones was sitting at home when there was a small earthquake 10 miles away.

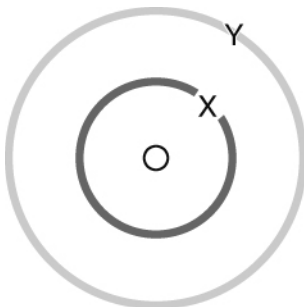
> I felt the house shake, and there was a loud bang. Nothing was damaged, but it was a little frightening.

Mrs Jones heard a bang because the air was vibrating.

a Explain why these vibrations could not have travelled through the air from the site of the earthquake.

b Describe how the vibrations reached the air in Mrs Jones' house.

When a stone is dropped into water, the energy transferred to the water spreads out as waves. The diagram shows that wave Y is twice as far from the original splash as wave X. The total length of the ripple is twice as long, so the energy per metre of wave Y is only half as much as wave X.

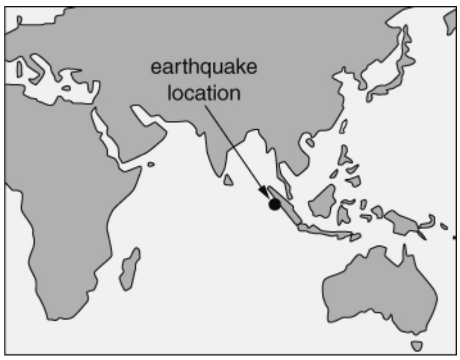


4 Wave X is transferring 300 J of energy per metre of wave.

a How much energy is being transferred per metre of wave by wave Y?

b Wave Z is three times as far from the original splash as wave X. How much energy is it transferring per metre of wave?

A tsunami is a large wave, or series of waves, that is caused by an earthquake on the sea bed, or by a large landslide falling into the sea. In 2004 a tsunami just off the coast of Sumatra in the Indian Ocean killed over 200 000 people. In some places the wave reached a height of nearly 30 metres. The wave was 1.5 m high in South Africa, and only 1 m high in Antarctica.



5 Where do you think the 30 m high waves were experienced? Explain your answer.

6 Explain why the waves were different heights in different places.

7 If you could calculate the distance from the earthquake location to the places mentioned above and work out what the wave heights should be, you would find that they did not exactly follow the rule explained before question 4. Suggest why the rule does not work for tsunami waves.

When a wave spreads out on the surface, the total length of the wave halves when the distance from the source is doubled. When a wave spreads out in three dimensions, such as from an underground earthquake, the energy transferred by each part of the wave decreases faster. For double the distance the energy is $^1/_4$ of the original, and for 3 times the distance the energy is only $^1/_9$ of the original.

8 Earthquake waves 5 km below the surface are 1 km from the location of the earthquake. They are transferring 5000 MJ of energy per square metre of the wave.

- **a** How much energy per square meter will there be when the waves are 2 km from the earthquake location?
- **b** How much energy per square meter will there be when the waves are 3 km away?

9 Why is damage to buildings much worse close to the location of an earthquake than it is further away?

I can…

- apply my knowledge of waves to new situations
- explain why the intensity of waves decreases with distance from the source.